Sixth Edition

Treatment of Cerebral Palsy and Motor Delay

Sophie Levitt • Anne Addison

WILEY Blackwell

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SIXTH EDITION

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This sixth edition first published 2019 © 2019 Sophie Levitt and Anne Addison

Edition History [John Wiley and Sons 5e, 2010]

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John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Office
9600 Garsington Road, Oxford, OX4 2DQ, UK

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Library of Congress Cataloging-in-Publication Data

Names: Levitt, Sophie, author. | Addison, Anne (Anne Catherine), author.
Title: Treatment of cerebral palsy and motor delay / Sophie Levitt, Anne Addison.
Description: Sixth edition. | Hoboken, NJ : Wiley-Blackwell, 2019. | Includes bibliographical references and index. |
Identifiers: LCCN 2018025070 (print) | LCCN 2018026692 (ebook) | ISBN 9781119373889 (Adobe PDF) | ISBN 9781119373599 (ePub) | ISBN 9781119373865 (pbk.)
Subjects: | MESH: Cerebral Palsy–therapy | Child | Motor Skills | Motor Skills Disorders–therapy | Physical Therapy Modalities | Adolescent
Classification: LCC RJ496.C4 (ebook) | LCC RJ496.C4 (print) | NLM WS 342 | DDC 618.92/83603–dc23
LC record available at https://lccn.loc.gov/2018025070

Cover design: Wiley
Cover images: © FatCamera/Getty Images; © jarenwicklund/iStockphoto; © olesiabilkei/iStockphoto

Set in 10.5/12.5pt Minion by SPi Global, Pondicherry, India

10 9 8 7 6 5 4 3 2 1

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Foreword

It is a pleasure to welcome the sixth edition of this book. It is the distillation of the knowledge and practice of two distinguished therapists who have wide experience in all aspects of evaluating and treating children and young people with motor disorders, particularly cerebral palsy. The authors' approach is based on a modern understanding of what constitutes cerebral palsy, on the range of associated impairments that may be seen, on its natural history as affected children move into adult life, and on the range of relevant interventions that can be applicable.

The authors have a clear understanding of historical approaches to treatment but have moved on from these to detail the need for evidence-based practice so far as this is possible, and they rightly also emphasise the requirement to work collaboratively with children and their families and to base their aims and approaches on the World Health Organization's current International Classification of Functioning, Disability and Health.

For those involved, as either therapists or parents, in understanding, planning, providing interventions, and understanding and monitoring their effectiveness in motor disorders Sophie Levitt and Anne Addison have systematically taken their readers through the practical principles of assessment, the ranges of treatment approaches and their indications, and the relationships of these to function and activities of daily life. They rightly emphasise the importance of enabling children and their families and also of promoting their societal participation as basic tenets of the work of therapists in this field.

It is also helpful and appropriate in a book of this nature that the authors helpfully discuss the expanding scientific background that underpins our understanding of cerebral palsy, including how evidence can be evaluated and what can realistically be researched in children who have a wide variety of neurological impairments. What they have successfully achieved is to combine this approach with clear views on the practical interplay that experienced practitioners in a multidisciplinary team need to utilise when setting priorities for an individual child within the context of his or her family.

This book remains essential for those managing children with disability.

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Preface

The sixth edition of this book reflects where we have been and where we are now. Ideas are currently from both physiotherapy and occupational therapy as there are two co-authors. Ideas from the past are still prevalent today, but we fortunately have more studies that confirm the value of some of them. Research on others may not be easy or perhaps possible at this time. In order for this book to reflect both what we did and what we do now, we have learned from therapy colleagues and especially from the parents and families of children, adolescents, and adults with cerebral palsy. Listening attentively to these individuals, we have learned of their fundamental human needs for respect, for support, and for a sense of control of their lives. Their practical ideas, their courage, and their determination to do their best are inspiring. Parents and their children with disabilities taught us that they needed empathy not sympathy. How does one present therapy in this style? Did we have adequate professional knowledge to warrant the trust of parents, their children, adolescents, and adults with cerebral palsy?

Fortunately, we had, and still have, contact with many professionals in medicine, in therapy, including speech and language therapists, in education, in psychology, and in social work. This was as members of multidisciplinary and interdisciplinary teams in clinical work, schools, and postgraduate education. We are grateful to the many different professionals in various countries who have given generously of their knowledge and helped us to understand their views for the benefit of the whole person and their family. It was not always easy to incorporate their essential messages into our therapy as there are contradictions in the cultures of different disciplines. However, we have drawn on their fundamental concerns for whole individuals and tried to integrate them into the development of their abilities.

The first edition of this book (Levitt 1977) originally proposed an eclectic approach drawing on topics in neurology, orthopaedics, and typical and atypical child development. This was challenging, as it involved dealing with contradictory views in physiotherapy for cerebral palsy. Common ground was found between different therapy approaches and formed the basis of an eclectic approach. Mantovani and Scrutton (2014), in their chapter 'Historical perspective' in *Cerebral Palsy: Science and Clinical Practice,* quote this proposal of an eclectic approach by Levitt (1977). Since publication of earlier editions of this book it has been rewarding to find an increase in an eclectic viewpoint and in more functional physiotherapy, which were so frowned upon in the past.

Our eclectic approach draws on the Bobath approach, as well on many other approaches and therapy tools. The review of interventions for cerebral palsy by Novak *et al.* (2013) seriously disapproved of the neurodevelopmental treatment/Bobath approach. However, their review provoked considerable controversy and, in particular, Mayston and Rosenbloom (2014) pointed out that the interventions range from systems (such as Bobath) to specific procedures (such as selective dorsal rhizotomy),

which are hardly comparable, and that the 'traffic light' system used to rate the interventions is oversimplistic. They also highlight that the review was unable to make recommendations for intervention on the basis of age, Gross Motor Function Classification System level, or type of cerebral palsy.

In previous editions, there was always the recognition that children 'do not move by neurophysiology alone' but that learning processes enable a child to progress through stages of gross and fine motor development. The second and subsequent editions continued to include and elaborate learning principles to develop children's motor function. Functional therapy grew out of the question: 'How do parents and other adults learn?' Studies in adult education showed that people learn best what has meaning for them in their daily lives. Parents were clearly motivated to improve their child's daily function, which was so limited by cerebral palsy.

The third edition contained a specific chapter on a collaborative learning approach. This had developed over some years for working with parents, carers, and others involved with a child with cerebral palsy. This 'client-centred' approach depends on their participation in a learning process. Unlike some learning models, this model also includes the therapist's own participation in learning, as well as the emotional issues affecting learning of parent and therapist in collaborative work. This approach involves consideration of the views and needs of both of them.

This approach develops respect for a family's cultural and social values learned in Levitt's experience in developing countries and as a tutor/guest lecturer with international students in the Community-Based Rehabilitation Courses, Institute of Child Health, London, UK. The collaborative learning approach depends on daily tasks chosen by people with disabilities and their parents, carers, and teachers in different communities. This promotes *inclusion* in mainstream schools and in the specific cultural communities in which a child or older person finds themselves. The collaborative approach is a learning process that can allow parents and others involved to learn at their own pace, so adjusting their expectations and attitudes while maintaining hope.

Adolescents and adults. The fourth and fifth editions suggest the use of the framework of the collaborative learning approach with the older person (adolescent or adult) with cerebral palsy. The sixth edition discusses differences between adolescents and adults, and what is common to both age groups. Similarly, as with children and parents, it offers mutual respect between individuals and therapists and develops self-esteem and confidence in these individuals. Meaning is given by the procedures suggested for their participation in their daily life. Recreational therapeutic activities are included to add to their health-related quality of life.

Family-centred approach (care). This is also based on the 'client-centred' practice first originated by Carl Rogers in the 1960s, which formerly inspired the earlier collaborative learning approach published in 1990. Family-centred physiotherapy and occupational therapy emerged in 1998 and in recent years. This approach involves all the members of a cerebral palsy team and is a welcome development. However, in some places, this demands reflective learning and re-examination of long-held professional attitudes. 'We are doing this anyway' is often felt by genuinely well-meaning professionals, but given the new measures of what parents and families really experience from a service there is not necessarily agreement with this statement. References to such measures are given in this edition.

A framework for assessment, therapy, and management. This sixth edition crystallises ideas from earlier editions for further development of both physiotherapy and occupational therapy.

The collaborative learning approach has the following framework.

1. The task(s) (e.g. a daily activity, self-care, play, or social interaction) are chosen by the person with cerebral palsy, together with parents or other people involved in their familiar environments of home, school, and community.
2. The motor functions for the chosen task are selected.
3. The physiotherapy components (abilities, skills, prerequisites) of the motor function are analysed, for example specific postural mechanisms, voluntary movement, sensations, interpretation of sensations or perception, and understanding – both cognitive and emotional.
4. The neuromuscular impairments that constrain motor function are assessed and treated, for example limited joint ranges, weakness, atypical postural alignment, limited repertoire of movements, atypical movement patterns (synergies), or residual reflex reactions, as well as general health.
5. Occupational therapy focuses on the whole task, relating it to daily life occupations rather than to underlying impairments. Unique task analysis is still needed.
6. The non-motor impairments that constrain function and daily tasks are considered, for example problems of vision, perception, understanding, and especially communication.
7. The residual abilities in all areas are identified, so they can be augmented to increase achievement through different strategies.

The individuals and those enabling them in home, school, or community contribute most to items 1 and 2, while the physiotherapist and occupational therapist and their multidisciplinary colleagues contribute most to items 3–7. The clinician will find there are overlaps between items, which are addressed in the practical chapters.

Therapy goals. Therapy goals can be clarified in this framework so that methods can be selected to activate functions and minimise impairments *at the same time*. Postural control in the best possible alignments, movements, strengthening, joint ranges, and coordination are themselves improved if appropriately used while training function. A number of us have found that our previous focus on impairments did not always lead to function or participation in an individual's daily life. However, it is dependent on the severity of the condition of individuals as to when there is a need to add specific treatment and medical procedures for impairments.

In earlier editions a view was given that therapy goals focused on spastic hypertonus had more relevance to deformities than to direct causation of most of the motor dysfunction. If a deformity was developing, this could act as a block to function and needed therapy. There were very few studies on spasticity that could be found to support physiotherapy intervention. Today, there are many studies that have questioned the role of spasticity. For example, the studies on selective dorsal rhizotomies show that, although spasticity was removed, there was little change in overall function. In addition, since the fourth edition, studies have shown that weakness was more significant than spasticity for an individual's function. However, typical postural control or the postural mechanisms and voluntary movements that underlie function have been emphasised since the first edition. Many new studies are growing to assert the importance

of postural control or postural mechanisms for balance. More of these studies are included in this edition.

Strengthening procedures. In the past, the inclusion of strengthening methods was considered controversial. This book continues to suggest strengthening methods using manual resistance, selected from proprioceptive neuromuscular facilitation and additional motor functions involving lifting of heavy objects. The methods are selected for use in the context of developmental motor functions, for example maintaining a developmental posture against manual resistance. The treatment of deformities also continues to employ strengthening of agonists and antagonists.

Progressive strength training is included for older children, adolescents and adults.

Evidence-based practice. The National Institute for Health and Care Excellence (NICE) in the UK has published clinical guidelines on *Spasticity in Under 19s: Management* (NICE 2012) and on *Cerebral Palsy in Under 25s: Assessment and Management* (NICE 2017). They review the evidence upon which these guidelines are based. These are helpful for evidence-based practice. NICE is now working on a guideline for adults with cerebral palsy.

Unfortunately, in this complex field and with this heterogeneous population, reliable scientific evidence to support interventions that we make can be difficult to obtain. Therefore, we still rely on long experience and expert opinion, and especially clinical reasoning. Fortunately, research studies have increased and are becoming more rigorous, and we look forward to further clinical progress as a result. Chapter 8 in this edition contains an updated section on current 'Assessment and measurements' for evidence-based practice. It is worth pointing out that there is a tendency to overrate numerical data. However, while science may often involve numbers, this is not always necessary, but good research must always involve careful systematic observation and detailed analysis – that is a lot of hard thinking.

Again, even when the research is thorough, it may be reported in obscurely written papers where little attempt seems to be made to communicate the findings to clinicians who are seeking to use results to improve their practice. On behalf of therapists, we would plead with researchers to keep their findings clear and reasonably simple, and to realise that most practising therapists have little training in or aptitude for statistical analysis. Please spell out what your statistical tests are testing and also what assumptions are made. It is well known that medical research can be harmed by poorly applied statistics.

Suggestions not recipes. There remain methods suggested from long clinical experience that still await research studies as to their value for specific problems, at different ages or developmental stages. This is not a book of 'recipes' but of suggestions for therapy and daily management based on assessment of an *individual* person with cerebral palsy and/or motor delay. These are presented with any evidence that exists at this time. The suggestions are not prescriptive and need to be assessed as appropriate for an individual person with cerebral palsy, which involves clinical reasoning. Therapy methods based on research studies are desirable, and still need assessment with a particular person and with the views of parents and carers.

Not all methods are given, as some are difficult to describe and need demonstration. However, wherever possible, the principle has been given as to why, when, and when not to use methods, which also allows therapists to use and invent their own

methods besides those suggested in this book. Not all possibilities for each person with cerebral palsy can be covered, so therapists will also need to solve problems in each case and draw on their clinical experience. This book should be used *with practical courses, further study, and supervision by senior colleagues. The therapist needs to keep up to date with both clinical advances and the literature.*

Dynamical systems theory originated in the field of motor control, where it was hoped that making analogies with the physics of complex systems (a notoriously difficult subject we are told) would lead to advances. The main conclusion seems to be that 'we should be aware that many factors are involved in the development of motor function and activities of daily life'. This is an excellent notion. In fact, many thoughtful clinicians, particularly those working in interdisciplinary teams and in the community, have long been aware of this.

Dynamical systems theory needs to offer guidance as to which of the varied factors are most important and how they interact in any particular circumstance. In addition, some theories relate to typical individuals or to individuals with cerebral palsy who are in the mild classifications. Other contemporary theories are discussed at the end of Chapter 5.

Appendix 2 contains useful addresses for organisations that have information for therapists and families. Swimming, horse riding, skiing, abseiling, angling, wheelchair dancing, and other therapeutic and recreational leisure activities are highly recommended and the list of useful addresses include those specialising in these areas.

It is hoped that this book will respond to some extent to the remarks of our postgraduate students and colleagues:

> I agree with your eclectic approach and wish to extend my repertoire of methods.
>
> I have followed one system but am open to hearing other views.
>
> I wish to have more evidence for my clinical methods.

But especially to the remark:

> Teach me how to enable people with cerebral palsy, their parents, and their families.

Sophie Levitt and Anne Addison
London, UK

Acknowledgements

This sixth edition is updated with acknowledgements to the reviewers and colleagues who have given constructive criticism and much encouragement. It has been a pleasure and positive learning experience to have Anne Addison as a co-author. She has shared her experience in the community, educational, and acute hospital settings. Anne has a specialist role supporting children with communication difficulties.

We are grateful to Chris Smith of Kids Physio Works for observation and photographs of children and staff for the sixth edition.

My special thanks to my husband, Dr Richard Lovell (physicist), for his enormous patience and encouragement. He has been a great help and support in facing and critically appraising the huge number of research studies now available for physiotherapists and occupational therapists.

I wish to acknowledge useful discussions and encouragement for previous editions.

Dawn Pickering has stimulated me with useful discussions and her contributions. I thank her for her work and support for the fifth edition. I am grateful for useful clinical comments from Lyn Horrocks on the management of deformities in the fifth edition.

I would particularly like to thank Alison Wisbeach, paediatric occupational therapist, for most of the drawings and useful discussions over the years.

April Winstock and Lesley Carroll-Few have shared their useful discussions over the years on communication and feeding. Thanks for helpful discussions with physiotherapists Melissa Walk-Ley, Jeanne Hartley, Eva Bower, Helen Stevens, and Maria Ash. Thanks also to Katrin Stroh and the late Elinor Goldschmied and many of my postgraduate students both in the UK and overseas.

I feel privileged to have been awarded a Folke Bernadotte Fellowship supported by the paediatric group of the Swedish Physiotherapy Association and their chairperson Elisabeth Price in 1990. Their encouragement of my eclectic approach and work with parents has been an inspiration. My thanks are also due to Dr Patricia Sonksen, the late Dr Joan Reynell, Dr Pam Zinkin, and the late Mary Kitzinger, with whom I worked on severely visually impaired children at the Wolfson Centre, Institute of Child Health, London, UK.

This book was originally commenced when I was Director of Studies and Senior Physiotherapist at The Cheyne Centre for Children with Cerebral Palsy, London, UK, where I was given encouraging support from Dr John Foley and the staff. The foundation of this book was the correlation of the neurology of Dr Foley and Dr J. Purdon Martin with the child development studies of the late Dr Mary Sheridan.

I am grateful to the Leverhulme Trust Fund, which kindly awarded me a Research Fellowship for part of my studies on the synthesis of treatment systems in cerebral palsy, which formed the basis of this book in all its editions.

I remain particularly appreciative of the privilege of many observations, discussions, or courses in the past with Dr Phelps, Dr Fay, Dr Vojta, Maggie Knott, Eirene Collis, Dr and Mrs Bobath, Professor Guy Tardieu, Ester Cotton, and Dr Hari.

They have inspired and influenced me, and without them this book would not have been written.

Thanks for photographs to the Cheyne Centre; to Alison Wisbeach; to the Wolfson Centre; to Pam Stretch at the Indian Spastics Society; to the Foxdenton School, Lancashire; and to Ted Remington. Many photographs were taken by my late son, David Halpern, with enormous organisation by Helen Stevens, formerly Superintendent Paediatric Physiotherapist, Winchester and Eastleigh Healthcare NHS Trust, and wonderful cooperation of parents and young people.

I am deeply grateful to all the children, adolescents, and their parents who cooperated so amazingly with all the long sessions of photography used throughout the book. My special appreciation goes to all the children and adolescents with cerebral palsy, their parents, and their families with whom I have been privileged to work and from whom I have learned so much.

The publishers have been particularly kind, helpful, and sensitive and I thank James Watson, Loan Nguyen, Yoga Mohanakrishnan, and their staff at Wiley for all their help and support.

The late Professor Brian Neville had honoured and encouraged me by writing the Forewords for the last three editions and generously shared his ideas. I am particularly appreciative for the Foreword to this edition by Dr Lewis Rosenbloom, Consultant Paediatric Neurologist at Alder Hey Children's NHS Foundation Trust, Liverpool, UK.

Sophie Levitt
London, UK

Disclaimer: New research and experience may lead to changes in practice, use of equipment, treatment, and management. The treating practitioner is responsible for selecting the best treatment and management based on his/her expertise and knowledge of an individual patient. Practitioners should take responsibility for safety precautions. Readers should check the most up-to-date information from the literature and from manufacturers of equipment.

1

The clinical picture for therapy and management

Cerebral palsy, the most common cause of childhood disability, is the name for 'a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication and behaviour, by epilepsy and by secondary musculoskeletal problems' (Rosenbaum et al. 2007a). Parents, families, and children are likely to experience emotional and social difficulties. The severity of the cerebral palsy itself may range from total dependency, extremely limited communication, and immobility to the ability to talk, carry out independent self-care tasks, walk, and run. Mild to severe motor difficulties are usually experienced by children according to their severity. Many children and young people with a diagnosis of cerebral palsy are able to access mainstream primary, secondary, and further education. Changes to legislation, advances in technology, and increasing positive attitudes towards disability in society have resulted in opportunities for individuals with cerebral palsy.

Incidence of cerebral palsy

The prevalence of cerebral palsy has consistently been reported to be about 2–2.5 per 1000 live births (1 in every 400 children) over the last 20 years in the Western world. However, in some cases, motor delay that initially presents as cerebral palsy may not be 'cerebral palsy' but a more generalised developmental delay resulting from other conditions such as learning disabilities, progressive neurological conditions, and genetic conditions that can only be recognised later, when a definite diagnosis can be made (Cans 2000).

Motor dysfunction

The motor dysfunction results in disorganised and delayed development of the neurological mechanisms of postural control, balance, and movement. The muscles activated for these motor aspects are

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therefore inefficient and uncoordinated. Individuals have specific impairments of tone, weakness, atypical patterns of muscle activation, and excessive co-contractions. There are absent or poor isolated movements (poor selective motor control), atypical postures, and problems with the use of hands in daily tasks. Biomechanical difficulties result from both the neuromuscular dysfunction and secondary musculoskeletal problems, which add to this complex picture.

The motor dysfunction changes with both growth and the individual's whole development. Change particularly depends on how individuals use their bodies. Although the brain damage is not progressive, the motor and musculoskeletal problems may increase in late childhood, adolescence, and adulthood; physiotherapy and occupational therapy is needed to prevent or minimise these.

What matters most to a child, parents, and family is the child's difficulties in function and participation in daily life. Therapists need to address these difficulties together with a child and parents, or directly with an adolescent and older person with cerebral palsy (see Chapters 2, 3, and 4). Therapists will assess the motor abilities of an individual and detect emerging functional abilities that can contribute to functional activities. It is also encouraging to know that functional activities and participation in daily life can be developed and difficulties minimised even though basic impairments cannot strictly be cured.

Professionals also differ in their views as to which impairments can be minimised, and, if not, when to compensate for these, such as by using task adaptation or equipment to promote engagement in functional tasks. Views or opinions on the underlying motor dyscontrol can be controversial, which is not surprising given that not all the neurological mechanisms are fully understood. Research into the basic dyscontrol and its related biomechanics is continuing.

The first edition of this book (Levitt 1977) presented a synthesis of valuable contributions from different therapy systems, some of which had been regarded as mutually exclusive. This synthesis or eclectic approach has been further developed and continued with current contributions in the new edition of this book. As many colleagues are now not wedded to any one system of therapy, selections of their views are presented as well as those from our own studies and experience. Current research studies are also given as evidence for specific clinical techniques that need to be part of the eclectic approach.

As a child does not 'move by neurophysiology alone' various ideas of motor and other learning have been integrated into the general therapy framework. The influence of the environmental and social contexts of a child's function are considered as we know that learning takes place in a child's home, school, and community. A child learns best in a familiar environment when therapy is part of a child's activities that are meaningful to that child. It is primarily a child's own intrinsic motivation, encouraged and supported by people in a child's daily life as well as by therapists, that has a profound impact on the child's achievements. Adolescents and older individuals also need consideration of their specific contexts. Many individuals with cerebral palsy face physical indoor and outdoor environmental constraints, differing social attitudes, and sometimes poor availability of services, all of which can be a barrier to their functional abilities. Therapists, together with individuals and their parents, share their strategies to overcome barriers and provide facilitators throughout an individual's life.

Associated impairments and disabilities

Kilincaslan and Mukaddes (2009), in a large clinical trial, suggested that children with a diagnosis of cerebral palsy are also at risk for other neurodevelopmental disorders such as autism, which adds to parental concerns. Brain damage in cerebral palsy may also be responsible for severe cortical visual impairment (Dutton and Bax 2010; Dufresne et al. 2014) and hearing impairments. Many children are also found to have visual problems such as squint (strabismus) and short or long sight (Odding et al. 2006; Dufresne et al. 2014; Dutton et al. 2014). Hearing impairment is not as common (Odding et al. 2006). Children may have problems with non-verbal communication, speech, and language, as well as experiencing aberrations of perception. It is thought that visual perceptual difficulties may be experienced by around 50% of children with cerebral palsy (Ego et al. 2015). However, self-directed movement through space leads to the development of visual–spatial competencies (Campos et al. 2000; Coté 2015), which suggests that children with cerebral palsy are likely to develop these skills more slowly.

A number of children with cerebral palsy have difficulties performing certain movements, even though there is no paralysis, because the patterns have not developed. This is sometimes described using the umbrella term of *dyspraxia* (Lee 2004). This can involve movements of limbs, face, eyes, or tongue. There may be disorders of memory of motor sequences (Lesný et al. 1990). Tactile sensation, proprioception, two-point discrimination, and perception may be impaired (Odding et al. 2006). A study by Yekutiel et al. (1994) found sensory impairment in the hands of children, and more recent studies suggest that tactile deficits are prevalent in over 70% of children with unilateral cerebral palsy (Auld et al. 2012). Some children may also have various behavioural problems such as distractibility and hyperkinesis, which are linked to the brain damage. Emotional relationships and social factors may also give rise to behaviour difficulties. Specific behaviour problems and psychological difficulties are associated with epilepsy (Carlsson et al. 2008). Learning difficulties and various epilepsies (seizures) at birth, or appearing in later childhood, may be present (Himmelmann et al. 2006; Odding et al. 2006).

Not every child has some or all of these associated impairments. In some cases the associated impairments or disabilities may present greater problems than the motor conditions. Severity of epilepsy, cognitive difficulties, communication problems, and excessive behaviour problems are such examples. Some epilepsies can be controlled with medication, but others may be more challenging and severe.

Even if the motor impairments were the only concern, the resulting paucity of movement would prevent the child from fully exploring the environment. Therefore acquisition of sensations and perceptions of everyday things are limited. A child may then *appear* to have defects of perception, but these may not be due to the brain damage but caused by lack of experience. The same lack of everyday experiences may slow down the development of speech and language. General understanding may suffer, so a child appears to have an intellectual disability. This can go so far that good intelligence has been camouflaged by severe physical disability. Cognitive assessment is therefore crucial if we are to ensure that we neither under- nor overestimate a child's intelligence. Furthermore, the problems of movement can affect the general behaviour of a child due to the lack of satisfying emotional and social experiences for which

movement is necessary. However, positive attitudes in a family and a child's personality can encourage optimum emotional and social development. They, together with their therapists, will find experiences for the child's whole development.

The population of people with cerebral palsy is heterogeneous. Different individual impairments and dysfunctions in, say, cognition, language, or movement have the potential to contribute to reduced participation in daily life. The correlation between abilities and participation is therefore extremely individual and cannot be presumed.

Teamwork. In order to manage the multiple disabilities and lack of related learning experiences that interfere with a child's development, a physiotherapist or occupational therapist needs to be part of a team. Teams of different specialised professionals contribute programmes for impairments, motor functions, and daily tasks to increase participation by children and their families in daily life situations. Teamwork is discussed in Chapters 2, 3, 4, 8, 11, and 12.

Broad framework for therapy and management

The World Health Organization's (WHO) current International Classification of Functioning, Disability and Health (ICF) (WHO 2001, 2013) describes a person's functioning in terms body functions, body structures, activities, participation, environmental factors, and personal factors, which are defined below.

These components may all interact with each other but, in a particular situation, only a few interactions are likely to be important. The therapist needs to explore the components for an individual and consider if, and how, they interact.

Knowledgeable therapists have been taking account of all the ICF components for many years, although they often used different terminology in the past. The advantage of using the ICF model is that it provides a common language for use in different clinical disciplines, while also bringing clinicians together. Therapists need to focus more on the functional outcomes rather than only on reducing underlying impairments (Imms et al. 2016).

The ICF framework is relevant to many existing procedures in clinical practice, including assessment, goal setting, evaluating outcomes, and communicating with colleagues and with the person and everyone involved. The use of the ICF can encourage a more holistic and comprehensive assessment and management of people with health conditions.

Definitions used in the ICF

Functioning an umbrella term for body functions, body structures, activities, and participation. It denotes the positive aspects of the interaction between an individual and that individual's environmental and personal factors.

Body functions physiological functions of body systems.

Body structures anatomical parts of the body and limbs.

Activity the execution of a task or action by an individual such as walking or using hands. This includes daily living tasks such as eating and toileting. However, these tasks can also be participation in life situations.

Participation involvement in everyday life situations such as interactions with family members or friends. Participating at school and in a community is promoted. Activities and participation are often linked.

Disability an umbrella term for impairments, activity limitations, and participation restrictions. It denotes the negative aspects of the interaction between an individual and that individual's environmental and personal factors.

Impairments problems in body function or structure.

Activity limitations difficulties an individual may have in executing activities.

Participation restrictions problems an individual may experience in involvement in life situations.

Contextual factors

Environmental factors affect the individual's function and participation. These include family and social attitudes, architectural barriers, climate, and terrain.

Personal factors influence how disability is experienced by an individual. These include age, coping styles, and drive. Personal factors are not currently classified in the ICF as they can vary widely between different cultures.

The following examples are influenced by Schiariti et al. (2015), who derived core sets of the ICF for children and youth with cerebral palsy, which are shortlists of ICF categories that are considered most relevant. However, it should be noted that the introduction of a version of the ICF for children and young people has since been combined into the main ICF and therefore no longer exists as a separate framework.

Examples in cerebral palsy

Body functions

Physiology, neurophysiology, respiratory, genitourinary, vision, and other sensory systems (including proprioception). Sensation of pain. Fitness and strength. Muscle tone. Sleep. Range of motion. Control of balance, voluntary movement, and coordination.

Body structures

Anatomy. Musculoskeletal changes due to natural history and other factors.

Activity

Maintaining and changing head control, lying, sitting, squatting, kneeling, and standing. Mobility such as rolling, crawling, bottom-shuffling, walking forwards, backwards, and sideways (including cruising), running. Speed, distance, and endurance are considered. Arm and fine hand functions such as reach and grasp, pick up, release, manipulate. Achievement of eating, drinking, toileting, washing, playing. Therefore, development of activities both basic and complex in childhood are planned.

Participation

Involvement in the individual's community, taking part in school, sports, shopping, use of playgrounds, and social events. Relationships with parents, family members, and relatives. Using equipment, technology, and specialist equipment. Coping with transport. Learning to eat in a culturally appropriate way as well as culturally appropriate physical contact.

Environmental factors

These are external to an individual. Architectural barriers to access, terrain, and climate. Use of mobility aids in specific environments both indoor and outdoor. Family and social attitudes. Availability of health and rehabilitation services and of assistive equipment and technology.

Personal factors

Age, sex, personality, coping styles, drive, culture, character, overall behaviour, and self-perception or self-esteem. Past and current life experiences.

While quality of life and health-related quality of life are not directly included in the ICF, many researchers have demonstrated the link between increased participation, health, and well-being (Anaby et al. 2017). Bjornson et al. (2008), in their

research with young people aged 10 and over, emphasised participation. However, they found that 'functional level and performance did not influence quality of life'. Livingston et al. (2007) emphasise that quality of life is very subjective, as recognised by Albrecht and Devlieger (1999).

Practical application

The components of the ICF model are not sequential. Participation in society may not depend on improving impairments when a person's own functional strategies are used and when specialist equipment such as powered wheelchairs, computers, and other technology are provided. Depending on the severity of cerebral palsy, innovative functional strategies or motor compensations may allow independent function with little focus on impairments. There are a number of examples, such as the MOVE programme (Bidabe and Lollar 1990; Thomson 2005). There is also an independent functional programme within conductive education (Hari and Akos 1988). Many research studies in constraint-induced movement therapy (Charles et al. 2006; Wallen et al. 2011) and in hand–arm bimanual intensive therapy (Charles and Gordon 2006) showed that they did not change impairment but improved function in the arm and hand of children with hemiplegia and coordination between both upper limbs. However, Bjornson et al. (2013) in their research found that achievement of *capacity* in a structured clinical setting did not transfer to *participation* in everyday life.

There are three points supported by clinical experience:

1. owing to the brain damage, not all impairments can be minimised
2. when selected impairments have been minimised, this did not always carry over into daily activities
3. daily activities are especially linked with participation.

However, secondary impairments such as contractures and musculoskeletal pain may result from primary motor difficulties. Impairments such as specific weakness, poor balance, atypical coordination, and hypertonus may increase with time. These secondary impairments may limit independence of some activities and restrict participation in an individual's home and community over time.

The overall goal of those working with children and young people with cerebral palsy or motor delay is therefore understood to be increased participation in life situations. However, as individual therapists with different professional backgrounds we will work with the child towards this goal in different ways, and it is important that we are able to explain and promote the uniqueness of our professional role in order to demonstrate the value we bring to the multidisciplinary team.

The goals of therapy are to develop:

1. forms of communication (gesture, speech, and the use of alternative forms of communication with pictures, signs, or electronic aids)
2. independence in the daily activities of eating, drinking, dressing, washing, toileting, and general self-care with and without aids, such as adapted utensils, bath aids, and other specialist equipment
3. abilities to play and achieve hobbies and recreational activities with or without adapted toys and equipment
4. some form of locomotion and independent mobility, which may include walking aids, wheelchairs, pedal karts, tricycles; or adapted motor vehicles; powered wheelchairs and powered mobility equipment for very young children, usually from age 2 years or even 11–12 months, if there are no comorbidities.

All these goals need to be considered in terms of learning processes interacting with

neurological and orthopaedic aspects and environmental constraints. Communication between therapists and people with cerebral palsy is fundamental in therapy and learning processes. Therefore, all therapists draw on the fields of education and psychology and gain much from close teamwork with teachers, psychologists, social workers, and psychotherapists. The psychotherapists and social workers are important as learning is intimately involved with emotions. Learning models need to give adequate attention to this fact. Consideration of cultural factors in planning the programme is very important.

Aetiology of cerebral palsy

Premature infants, very low birth weight, multiple births, and intrauterine infection present a greater risk for cerebral palsy. There are many causal pathways rather than one cause for the brain damage. These include abnormal development of the brain, anoxia, intracranial bleeding, excessive neonatal asphyxia (hypoxic ischaemic neonatal encephalopathy), perinatal stroke, hypoglycaemia, or neurotrophic virus. The complexity of causes has been extensively discussed in the medical literature (Himmelmann et al. 2010; MacLennan et al. 2015; Hagberg et al. 2016).

Genetic causes

There are few known genetic causes for cerebral palsy (Rosenbaum and Rosenbloom 2012: chapter 3). Schaefer (2008) mentions genetic pathways that may predispose to cerebral palsy. However, there are other genetic progressive disorders that may seem to be cerebral palsy; for example, Lesch–Nyhan syndrome with symmetrical spastic paraplegia or dystonia, with or without dyskinesia, or Rett syndrome, which has some features seen in cerebral palsy. Global developmental delay or learning disabilities may result from a genetic cause and, as described above, the early motor delay may appear to be cerebral palsy. The Surveillance of Cerebral Palsy in Europe collaboration (Cans 2000) has a recommendation that a cerebral palsy diagnosis should be confirmed by the age of 4 years.

Causes in later childhood

Although the definition of cerebral palsy gives the impairment occurring in the fetal or infant brain, usually agreed to be up to 2 years, there are causes of brain damage in later childhood such as trauma, road accidents, anoxia as in near-drowning, choking, and from various infections, such as meningitis and cerebral malaria. The subsequent brain injuries share common features with cerebral palsy and as such require similar assessments and interventions as well as the provision of additional support for parents and families.

Therapists are not always guided by the aetiology in treatment planning. In some cases the cause is not certain, and in many cases knowing the cause does not necessarily indicate a specific diagnosis or specific treatment. Nevertheless, the therapist should be acquainted with the history of the case. Many of these children have been affected from infancy and have been difficult to feed and handle. Many hospitalisations and separations of babies from parents may happen in the early period. This may easily have influenced the parent–child relationships so essential for child development. Furthermore, the history of problems during neonatal or prematurity periods may sometimes give an indication of the causes of cerebral palsy. Early neuroimaging detects lesions likely to result in cerebral palsy.

Neuroimaging

The continuing advances in neuroimaging such as magnetic resonance imaging (MRI)

and computed tomography (CT) help in identifying the extent and site of the neurological lesions, with neuroimaging being abnormal in more than 80% of children with cerebral palsy (Himmelmann et al. 2017). There are variations in brain lesions due to the timing of the insult that relate to clinical motor severity and associated impairments (Krägeloh-Mann and Horber 2007; Korzeniewski et al. 2008). Brain scans locate lesions in the white matter that are described as periventricular leukomalacia. These lesions may be associated with spastic diplegia, a diagnosis that has a wide spectrum of disability. However, spastic diplegia (bilateral cerebral palsy with lower limbs more severely affected) is also related to other causes (Rosenbaum and Rosenbloom 2012: chapter 3). Although the diagnosing of cerebral palsy remains ultimately dependent on the history, regular observations by both parents and clinicians and careful clinical examinations by those with experience of working with children with cerebral palsy, the Surveillance of Cerebral Palsy in Europe collaboration has suggested the introduction of an MRI classification system that might support better understanding of the relationship between brain structure and functional abilities.

Clinical picture and development

It is important to recognise that the causes of cerebral palsy take place in the prenatal, perinatal, and postnatal periods. In all cases, it is an immature nervous system which suffers the insult and the nervous system afterwards continues to develop in the presence of the damage. Therapists must therefore not think of themselves as treating an upper motor neurone lesion in a 'little adult', nor can they regard the problem solely as one of delayed development. What the therapist faces is a complex situation of pathological symptoms within the context of a developing child (Illingworth et al. 2012; Sharma and Cockerill 2014 (an updated version of Mary Sheridan's work)).

There are six main aspects to the clinical picture, as follows.

1. Delay in the development of new skills expected at a child's chronological age.
2. Persistence of immature behaviours such as feeding difficulties and retained primitive reflexes that sometimes interfere with function.
3. Slow rate of progress from one developmental stage to the next.
4. A smaller variety of skills in comparison with a child who is developing typically.
5. Marked variations in the sequence of skills greater than that which we might see in typical development.
6. Atypical and unusual performance of skills.

In order to recognise any atypical motor patterns, therapists should know what a typical child does and understand the 'expected' patterns of behaviour at the various stages of child development. Reference will have to be made to the extensive literature on the field of child development. Typically developing children show variations from the 'normal' sequences and patterns of development that have been derived from the *average* child. Parents or family members may themselves identify differences in their child's development and want referral to professionals to discuss their concerns. Professional specialists in cerebral palsy will assess whether differences are in fact normal variations. Information on each individual child's developmental abilities and difficulties should be sought from the consultants, therapists, and others in the team.

Other variations need not necessarily convey a diagnosis of cerebral palsy.

Both the climate and cultural differences affect typical motor development (Solomons and Solomons 1975; Hopkins and Westra 1989; Leavitt 1999). However, in any culture, children with cerebral palsy will show additional variations due to neurological and biomechanical causes.

If one considers, say, the developmental scales of gross motor development, in cerebral palsy a child has frequently achieved abilities in motor functions at one level of development, omitted abilities at another level, and only partially achieved motor abilities and functional components at still other levels. There is thus often more of a scatter of abilities as well as whole motor functions than found in typical children. (Details of development are discussed in Chapters 7, 9, and 10.)

If the gross motor development is generally considered to be around a given age, the development of hand function, speech and language, and social, emotional, and intellectual levels may all be at different ages. None of these ages may necessarily coincide with the child's chronological age.

Although typical child development is the basis on which the atypical development is appreciated, it does not follow that assessment and treatment should rely upon a strict adherence to typical developmental schedules. Therefore, the developmental schedules in typical child development should only be used as *guidelines* in treatment, and adaptation should be made for each child's development, abilities, and individuality.

More attention is usually given to motor development than other avenues of development, as it is the motor dysfunction that characterises cerebral palsy. Here again, the therapist should remember that motor behaviour interacts with other functions. Each area of development – such as gross motor, manipulation, speech and language, perception, social and emotional adjustments, and cognition – interacts as well as having its own pattern or avenue of development. Furthermore, the potential for function is dependent not only on the abilities and disabilities present but also on a child's personality and 'drive' as well as a capacity to learn. Therefore, a total habilitation programme is necessary and should be planned to address the whole development of each child, adolescent, and adult.

While aiming to maximise functional abilities, the therapists concerned must take account of the *damaged* nervous system and adjust their expectations of achievements by individual children. Cerebral palsy cannot be cured. However, children will continue to develop to reach their own potential. The reliability of prognoses depends on a therapist's clinical experience as multiple factors are usually involved. Prognosis is discussed in Chapters 8 and 9.

Change at different ages

As the lesion is in a developing nervous system, the clinical picture is clearly not static. As more is demanded of the child, the degree of the disability appears to be greater. For example, a 3-year-old is expected to do more than a baby, and therefore the difficulties are greater for the same pathology.

In addition, the pathological symptoms may develop over time. Babies may often be hypotonic, becoming hypertonic later. Involuntary movements or dystonia may only appear at the age of 2 or 3 years, and ataxia may only be diagnosed when the child walks or when grasp is expected to become more accurate. Diagnoses may change as the baby develops to childhood, and especially as the child becomes more active. Cerebral palsies have an emerging diagnosis. Later, especially in adolescence, growth and increase in weight may contribute

to apparent deterioration. Recent research identifies that deterioration is not inevitable in all cases (see Chapters 4 and 9). Changes in function and health are also evident in adolescents and adults.

Treatment and management in infancy until age 2–3 years. The earlier the treatment is started, the more opportunity is given for whatever potential there may be for developing any abilities and for decreasing the movement and postural difficulties (Spittle et al. 2015; Morgan et al. 2016a), although at present there is limited empirical evidence regarding the effect of early intervention on motor skill development (Hadders-Algra et al. 2016). There has been an increase in specialised neonatal therapists (physiotherapists, occupational therapists, and speech and language therapists (SaLTs)) who have developed evidence-based assessments and therapy (see Chapter 8). Guidelines produced by the National Institute for Health and Care Excellence (NICE 2017) suggest means of recognising the early motor features of cerebral palsy and call for all children who are at risk of developing cerebral palsy to be referred for an urgent multidisciplinary assessment. A systematic review of the literature (Novak et al. 2013) also calls for a move away from 'conservative late diagnosis' in order that early intervention can be utilised to optimise neuroplasticity.

Therapists offer a variety of pleasurable and developmentally appropriate activities, including motor activities, enjoyed by both parent and baby. During intervention, therapists observe if babies or young children make their own efforts to move using compensatory or adaptive patterns that can be 'good enough' but block the development of more efficient patterns or result in 'learned disuse' of a body part. Any immobility threatens musculoskeletal growth and development, which can lead to later deformities. Early therapeutic input minimises such problems.

However, abnormalities detected in premature and term infants may be transient as some infants overcome them without intervention. Nelson and Ellenberg (1982), studying a large sample of infants suspected of cerebral palsy, found that many with marked neurological signs may later prove to be only mildly affected or go on to develop typically. It is possible to make a 'false-positive' early diagnosis (Bosanquet et al. 2013). De Groot (2000) made an intensive study of posture and motility in preterm infants. There are assessments of preterm, term, and young infants that predict cerebral palsy if used by therapists trained in these methods (Lacey et al. 2004; Einspieler et al. 2005). Marcroft et al. (2014) found few studies of value predicting cerebral palsy using the Lacey Assessment of Preterm Infants. We still need to know more about which babies are likely to 'come right' on their own or turn out to have a progressive neurological condition rather than cerebral palsy. Nevertheless it is better to provide them with the benefits of developmental therapy. Blauw-Hospers and Hadders-Algra (2005) found positive effects on babies at term, rather than preterm, with specific and general developmental early treatments in their systematic review of 12 studies. The value of early developmental intervention is to provide an increase in babies' sensory–motor and everyday experiences and especially develop interaction with their parent(s). However, there is a need to minimise sensory stimulation and handling if an infant is very preterm. The sooner a baby can be helped to move, the sooner there is exploration and experience for that baby. The therapist is in fact contributing to learning and understanding as well as enabling babies to bond with their parents or carers. The parents and family are assisted to cope with early rearing of an

infant who is developing atypically. There is clearly no doubt about its importance to the parents, who receive a great deal of practical advice and support from therapists. Parents need practical ideas for feeding, childcare, and playful activities for their child throughout any emerging diagnoses.

Treatment and management in childhood, adolescence, and adulthood. During these changes in the clinical picture, treatment and management programmes need to relate to an individual's wider environments of the playgroup, nursery, preschool, schools, adult day care centres, and work places as well as the individual's community. People with cerebral palsy at different ages also change through interaction with the variety of personnel in environments in which they find themselves. Physiotherapy and occupational therapy as well as other therapies are therefore being planned *across the lifespan of each person with cerebral palsy.* Management will include working with other allied health professionals such as SaLTs and orthotists, as well as orthopaedic surgeons and other medical consultants. Therapists will share selected skills and advice on equipment with a child's parents and anybody closely involved with any person with cerebral palsy and motor delay. Extra therapy sessions by professionals will not achieve as much as combining treatment with working with parents and family. Therapists need to carry out a detailed assessment of a child's function, identifying any motor impairments that are acting as a barrier to each activity. Consideration of a child's or young person's functional abilities and difficulties within their participation in their daily life is essential. Parents and teachers and others involved who know a child or youth will need to be consulted for their valuable observations. Therapists can then work out treatment programmes together with individuals and their family members.

Classification systems

The classifications describe and simplify the levels of function in cerebral palsy, and enable a quality of care and can aid selection of assessment tools. Their use of everyday language enables parents to participate in the development and use of the classifications. Each of the classification systems uses five levels (Paulson and Vargus-Adams 2017).

Gross Motor Function Classification System (GMFCS)

The complete Gross Motor Function Classification System (Palisano et al. 1997, 2008) can be downloaded from the CanChild website (www.canchild.ca).

This describes the level of functional ability, in a developmental picture, using age-dependent criteria. The descriptive features are reported at each level, saying what a child can do in self-initiated motor functions such as sitting, changing postures, crawling, standing, and walking. The level of function decreases from level I to V, with level V representing children with severe motor restrictions. The GMFCS level that is assessed is the performance that a person typically does in home, school, or community.

The classification system can be used to compare individual children of the same age with each other, as they can be functioning at different levels. All children with cerebral palsy are classified according to what they can do (Gorter et al. 2004). The quality of movement is not an important factor. In several centres, doctors and therapists, as well as parents, are consistent in their identification of the level of a child (Morris et al. 2006).

Classification of an individual child gives a shorthand description of a person with cerebral palsy and is particularly useful for communication between professionals and for generally relating therapy suggestions

to a level of ability and disability of an individual. There are increasing levels of function for ages 1–2 years (before second birthday); 2–4 years (between second and fourth birthdays); 4–6 years (between fourth and sixth birthdays); and 6–12 years (between sixth and twelfth birthdays). The classification system was expanded and revised in 2008 for ages 12–18 years (between twelfth and eighteenth birthdays) (Palisano et al. 2008).

The level assigned to a child is not 'set in stone', particularly if it is assigned before the second birthday. Wood and Rosenbaum (2000) carried out a historical study of children using the GMFCS. They followed changes in the GMFCS level from age 1–2 years to age 6–12 years. The data (their table IV) show that only about 40% of 78 children stayed in the same level, with about 20% improving and about 40% getting worse. Two children went up three levels and one child dropped three levels. So the figures show that, although the GMFCS levels of a *group* of children do not change much as they get older, the level of an *individual* child may change dramatically.

Gorter et al. (2009) found that only about 60% of children classified at age 18 months remained in the same level a year later. Therefore, all children should be reclassified after their second birthday.

Reclassifying at a much later age may also need to be considered, as intervention or ageing can have an effect. A study by McCormick et al. (2007) of the stability of the GMFCS in 103 adults showed that about 70% did not change level after age 12 (see their table IV). However, about 10% went up one level and about 20% went down one level.

Example of GMFCS levels

The following list relates to children between their sixth and twelfth birthdays.

Level I Walks at home, school, outdoors, and in the community; climbs stairs without using a railing. Performs gross motor skills such as running and jumping with limitations of speed, balance, and coordination. May participate in sports.

Level II Walks in most settings; difficulties in walking when carrying objects. Uses physical assistance, hand-held walking devices when there are difficulties with long distances, inclines, uneven terrain, confined space, and crowds. Climbs stairs using a railing. Children have at best only minimal performance of skills such as running and jumping. Adaptations needed for sports.

Level III Walks with hand-held mobility devices in most indoor settings; limitations in walking outdoors. Climbs stairs using a railing with supervision or assistance. Use of wheeled mobility over long distances and depending on arm function may self-propel a manual wheelchair for sports.

Level IV Walks short distances with physical assistance or uses powered mobility. When positioned, may use a body-support walker. At school and in the community children are transported in a manual wheelchair or use power mobility. Adapted seating is required. Independent floor mobility may be used at home. Physical assistance or powered mobility needed for sports.

Level V Transported in a manual wheelchair in all settings. Some achieve self-mobility using powered mobility with extensive adaptation of seating. Children have limited control of head, trunk, arms, and legs.

Manual Ability Classification System (MACS)

The complete Manual Ability Classification System for children with cerebral palsy 4–18 years (Eliasson et al. 2006, 2010) can

be downloaded from the MACS website (www.macs.nu).

This classification describes children's ability in self-initiated hand functions at home, school, or community. The MACS and GMFCS classifications do not give the reason for the levels of ability.

This is a valid and reliable way for therapists to classify hand function (Eliasson et al. 2006, 2010; McConnell et al. 2011; Öhrvall et al. 2014).

Level I Handles objects easily and successfully.
Level II Handles most objects but with somewhat reduced quality and/or speed.
Level III Handles objects with difficulty; needs help to prepare and/or modify activities.
Level IV Handles a limited selection of easily managed objects in adapted situations.
Level V Does not handle objects and has severely limited ability to perform even simple actions.

Eliasson et al. (2006) compared the GMFCS and MACS levels of 168 children and concluded that the GMFCS level agreed with that of the MACS in only around half of the children.

MACS is extended through the Mini-MACS, which is designed for children between the ages of 1 and 4 years; early studies of the Mini-MACS have demonstrated good inter-rater reliability (Eliasson et al. 2017) between parents and therapists and between therapists. It is necessary to ask a parent or someone who knows each child well rather than use a specific test.

In the Mini-MACS, levels I, II, and V are identical to the MACS but level III is just 'handles objects with difficulty' and level IV has 'simple actions' instead of 'adapted situations'.

Bimanual Fine Motor Function (BFMF) classification

The Bimanual Fine Motor Function classification (Beckung and Hagberg 2002; revised and validated by Elvrum et al. 2016) classifies fine motor function in children with cerebral palsy aged 3–18 years and has its own five levels.

Beckung and Hagberg (2002) compared the GMFCS and BFMF levels of 176 children and concluded that the GMFCS level agreed with that of the BFMF in just over half of the children. However, nearly 30% of the children were classified in level I for both GMFCS and BFMF.

Carnahan et al. (2007) present a retrospective study of 365 children with cerebral palsy, also showing that gross motor function and manual ability are often discrepant in children with cerebral palsy and that the patterns seem to vary across the different topographical classifications (see section 'Topographical classifications').

Communication Function Classification System (CFCS)

The complete Communication Function Classification System for individuals with cerebral palsy (Hidecker et al. 2011) can be downloaded from the CFCS website (www.cfcs.us). This classifies levels of everyday communication effectiveness.

Level I Sends and receives with familiar and unfamiliar partners effectively and efficiently.
Level II Sends and receives with familiar and unfamiliar partners but may need extra time.
Level III Sends and receives with familiar partners effectively, but not with unfamiliar partners.
Level IV Inconsistently sends and/or receives even with familiar partners.
Level V Seldom effectively sends and receives, even with familiar partners.

All methods of communication are considered such as speech, gestures, behaviours, eye gaze, facial expressions, and augmentative and alternative communication (AAC).

AAC includes manual sign pictures, communication boards, and talking devices (voice output communication aids or speech-generating devices).

Helen Cockerill (2011), a specialist speech and language paediatric therapist, has commented on the CFCS.

Eating and Drinking Ability Classification System (EDACS)

The Eating and Drinking Ability Classification System (Sellers et al. 2014) classifies the safety and efficiency of eating and drinking from age 3 years onwards. The usual performance is observed. Sellers et al. (2014) developed this classification, stating its reliability.

SaLTs have confirmed its reliability. This does not replace a comprehensive professional assessment by an individual's SaLT and may include videofluoroscopy assessment of dysphagia and oromotor measures.

Level I Eats and drinks independently with safety and efficiency with no difference from peers. May cough or gag with challenging food textures but manages a large range of textures.

Level II Eats and drinks safely with some food loss and more time needed to complete a meal than peers. Manages a large range of textures but coughs/gags on challenging food textures.

Level III Eats and drinks with some limitations to safety and efficiency. Coughs with fast flowing liquids or large food quantity and challenging food textures.

Level IV Significant safety risks, cannot swallow drink or food without risks of aspiration. Oral feeding is possible with mashed or pureed food.

Level V High risk of aspiration with feeding and drinking. Selected tube-feeding methods. Manages small tastes or flavours.

Efficiency refers to the length of time and effort required to eat or drink, as well as whether food or drink is kept in the mouth without loss. This avoids tiring during a meal.

Safety risks include choking when a piece of food becomes lodged in the airway as well as aspiration when food or fluid enters the lungs.

Levels of assistance required

1. Independent.
2. Requires assistance.
3. Totally dependent.

There is a review and commentary on EDACS by Sophie Scott (2014) in terms of risk and functional ability. She includes sucking, biting, chewing, swallowing, and keeping food and fluids in the mouth. Mention is made of different settings, skill, and the quality of the relationship with familiar/unfamiliar carers.

Association between the functional classifications

Compagnone et al. (2014) demonstrated a positive correlation between the GMFCS, MACS, and CFCS levels in 87 children, although the most significant association was specifically in the children in level V.

Topographical classifications

Bilateral cerebral palsy (affecting both sides of the body)

Involvement of all limbs and body. Arms are equally or more affected than the legs. Many are asymmetrical. *(Quadriplegia (tetraplegia) or triplegia is used in some research.)*

Involvement of limbs, with arms much less affected than legs and body. Asymmetry may be present. *(Diplegia is used in some research and by some clinicians.)*

Unilateral cerebral palsy

Limbs and body on one side are affected. (*Hemiplegia is used in some research and by some clinicians (Neville and Goodman 2001).*)

Gorter et al. (2004) found that hemiplegia was mainly in GMFCS level I, but others were in levels II–IV. Diplegia was found in all levels. Quadriplegia was mainly in levels IV and V but Gorter et al. found a substantial proportion were in levels I and II.

These topographical classifications can be imprecise, as they may change with a child's development. Active use of one upper limb together with both lower limbs or use of two upper limbs with one lower limb may convey a triplegia that could become quadriplegia. Upper limbs may appear unaffected, suggesting paraplegia, but being really a diplegia with only fine hand use being affected when this is later expected. There may be increasing disability in hand/arm function so that there is closeness from diplegia to quadriplegia. Individuals with hemiplegia may experience minor involvement on the unaffected side. Perceptual or motor planning difficulties may be found on the unaffected side. A monoplegia is rare, usually becoming a hemiplegia with increased active motor development. It is for these reasons that many clinicians are moving towards functional classifications that are based on a child's ability to engage in activities rather than on their specific physical impairments; this is discussed later in the chapter.

Additional descriptors of the motor type experienced by the child provide the clinician with additional information, for example *bilateral dyskinetic cerebral palsy* or *unilateral spastic cerebral palsy.* Comments on the presence of any asymmetry also help clinicians to share information about the child.

Classification of motor types of cerebral palsies

The predominant impairments will contribute to the diagnostic type referred for therapy and management. There are also mixed types of cerebral palsy where the characteristics of more than one type are present.

Spastic cerebral palsy

The main motor characteristics are as follows.

Spasticity. If spastic muscles are stretched at a particular speed, they respond in an exaggerated fashion. There is a movement block called a 'catch'. Spasticity is a velocity-dependent resistance of a muscle to stretch, and resistance differs with the direction of joint movement, for example flexion versus extension (Sanger et al. 2003). Second, resistance to externally imposed movement rises rapidly above a threshold speed or joint angle after the 'catch' is felt (Sanger et al. 2003).

There are increased tendon jerks, occasional clonus, and other signs of upper motor neurone lesion. Stiffness is not true spasticity and may accompany the hyperactive reaction to brisk passive stretch. Muscle and soft tissue changes are causes of stiffness with inertia of the limbs (Katz and Rymer 1989; Dietz and Berger 1995).

There are other important aspects that need consideration, such as the recognition of incoordinated movements, weakness and inefficient muscle work, as well as compensations for absent or atypical postural mechanisms. Later there is an increase in growth of the bones compared with short muscles failing to keep up.

Shortening hypertonic ('hypoextensible') muscles pull the joints into atypical

motor patterns involving the whole child or at least of the whole limb. Shortland et al. (2002) and Fry et al. (2004) have used ultrasound to study muscles in spastic cerebral palsy, and one finding was that weakness of muscles contributes to muscle shortening and atrophy. At first 'hypoextensible' muscles with or without hypertonic stiffness can be overcome in a young child, but later they can become fixed. In time, atypical postures and movements that are unfixed (dynamic) deformities may become fixed deformities (contractures) with shortening of ligaments, connective tissues, and tendons and decreasing joint ranges Subsequently this can lead to hip dislocations, scoliosis, and bony deformities. Atypical postures, deformities, and contractures, particularly in the upright positions, contribute to atypical gaits. Atypical gaits are described in more detail in Chapter 12 and gait analysis is described in Chapter 8.

Some clinicians may still use 'spasticity' and 'spastic muscles' as an umbrella term for stiffness of limbs, but it is important that the difference between physiological spasticity and stiffness is understood in order that the most effective treatment interventions can be offered from both a therapeutic and medical perspective. The hyperactive stretch reflex is *not* the cause of dysfunction but the coexisting motor disorders, particularly weakness, are significant (Lin 2004, 2011; Ross and Engsberg 2007). Movements are usually slower than the velocity needed to obtain the hyperactive stretch reflex.

Postural alignments (body shape) (see Figs 1.1–1.3*).* These are often extensors in the leg and flexors in the arm. However, the therapist will find *many* variations on this, especially when the child reaches different stages of development. The atypical limb postures become held by stiffness with shorter 'spastic hypertonic' muscles whose lengthened antagonists are weak, in that they cannot overcome the tight pull of the

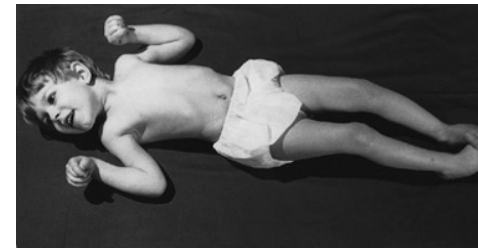

Figure 1.1. Child with bilateral spastic quadriplegia. Head preference to right, shoulders protracted, semiabduction, elbows flexed–pronated, wrists and fingers flexed, thumb adducted. Hips and knees flexed, tendency to internal rotation–adduction with feet in equinovarus, toes flexed.

Figure 1.2. Same child with bilateral spastic quadriplegia with postural changes in prone. Asymmetry of arms caught under body. Hips and knees flexed, feet in equinovarus. Head preference is now to left.

Figure 1.3. Same child being taught to sit by his father. Head preference to right, shoulders protracted, elbows flexed–pronated, hands flexed, knees and feet held symmetrical with hips. A symmetrical trunk.

shortened muscles and so correct the atypical postures. The short muscle groups are also weak and cannot easily assume a typical alignment.

Many children have floppiness of the head and trunk together with the stiff spastic hypertonic limbs. This is associated with delayed development of the mechanisms of postural stabilisation and postural adjustment of the head and trunk as well as the pelvic and shoulder girdles. Besides stiffness and weakness of limbs there are atypical compensations of all the postural mechanisms unavailable for balance control. In all editions of this book, the postural mechanisms are and were given more importance so that spasticity is not overemphasised as a cause of dysfunction. Lin (2011) has the same view of spasticity.

Muscle hypertonus is defined as resistance to externally imposed movement about a joint and there are different types of hypertonus. There is spastic hypertonus, rigid hypertonus or dystonic hypertonus, and mixed hypertonus, which are differentiated by Sanger et al. (2003). Spastic hypertonus particularly affects deformity but not motor function, which depends more on weakness. Rigidity is recognised by a continuous resistance to passive stretch throughout the full range of motion. This *lead pipe* rigidity is considered less common in cerebral palsy. If present it can be differentiated from dystonia as well as from spasticity (Lin 2004). Spasticity is not continuous but offers resistance at a point or small part in the speed of the passive range of motion. This is discussed further in section 'Dyskinetic cerebral palsy (dystonic and choreoathetotic)'. Drugs such as botulinum toxin A and oral and intrathecal baclofen are used to control spasticity and dystonia (Albright and Neville 2000; Lin 2004), together with a physiotherapy or occupational therapy programme (Novak et al. 2013). Focus on spasticity includes the use of neurosurgical selective dorsal rhizotomy (Peacock and Staudt 1991; McLaughlin et al. 2002; Tedroff et al. 2011; Josenby et al. 2012; Ailon et al. 2015).

The common atypical postures and movements in supine, prone, sitting, standing, walking, and hand function are described in more detail with therapy and management suggestions in Chapter 9.

Atypical postures and stiffness may increase with excitement, fear, or anxiety as well as when pain is present. Shifts in spastic hypertonus may occur in the same affected parts of the body or from one part of the body to another in, say, stimulation of remnants of reflex activity. Changes in hypertonus are seen with changes of position in some children. Position of the head and neck may affect the distribution of spasticity. Any sudden or fast movements, rather than slow movements, increase stiffness.

Voluntary movement. Spasticity does not necessarily mean paralysis. Voluntary motion is present and laboured. There may be weakness in the initiation of motion or during movement at different parts of its range. If spasticity is decreased or removed by treatment or drugs, the muscles have been found to be weak. For example, the removal of spasticity of the gastrocnemius with botulinum toxin A injection reveals weak plantarflexion.

The groups of muscles or *chains* of muscles used in the movement synergies (muscle activation patterns) are different from those used by typical children of the same age. Either the muscles which work in association with each other are stereotyped and are occasionally seen in typical infantile levels of movement or the association of muscles is atypical. For example, hip extension–adduction–internal rotation is normally used in creeping movements or within the push-off in walking but many other combinations must be used during the full execution of creeping and walking. This may be impossible and a child only uses the same pattern at all times in the

motor function. One example of a typical arm pattern is shoulder flexion–adduction with some external rotation for feeding or combing one's hair. In the case of a child with coexisting motor problems, the arm pattern is usually flexion–adduction with *internal* rotation and *pronation* of the elbow. The ability to fractionate movement is very difficult for a child; for example, to maintain flexion at the shoulder and extension of the elbow and wrist when reaching for an object. The arm pattern usually tends to persist in flexion at all joints.

Co-contraction of the agonist with the antagonist instead of the typical reciprocal relaxation persists. However, typical co-contraction is also evident in any typical person attempting a new and difficult skill with hands or legs. Before the postural control develops in typical infants there is a co-contraction response in weight bearing and early stages of walking in children without cerebral palsy. These patterns persist in children with motor problems (Lin 2004). The co-contraction provides some stability but, for a more flexible mature gait, postural control training is essential. Voluntary arm and leg movements are also directly affected by poor postural control, as this interferes with their efficiency, creating weakness of both postural muscles and voluntary movements. There is a lack of isolated or discrete movements (selective motor control) and fine motor coordination is delayed in younger typical children as well as persisting in the spastic type of cerebral palsy.

Associated impairments

1. Intelligence varies and is usually impaired in bilateral spastic quadriplegia.
2. Sensory loss occasionally occurs in unilateral hemiplegia with a visual field loss and lack of sensation in the hand (Yekutiel et al. 1994; Odding et al. 2006). Sensory dysfunction such as sensory discrimination and sensory integration rather more than sensory loss is present in individuals (Lesný et al. 1993). Lack of sensory awareness and sensory information for motor actions often relates to poor motor experience rather than loss of sensation. A child may be hyposensitive or hypersensitive to sensory input, so sensory–motor therapy needs to be carefully assessed.
3. Perceptual problems especially of body and spatial relationships, motor planning, and motor memory are more common in the spastic type of cerebral palsy. They relate to sensory dysfunction and cognitive problems as well as to poor sensory–motor experiences.
4. Poor respiration with later rib cage abnormalities may exist.
5. Feeding problems exist, particularly in bilateral spastic quadriplegia.
6. Growth of limbs in unilateral hemiplegia or severely affected lower limbs in bilateral cerebral palsy can be less than the other limbs.
7. Epilepsies are more common in bilateral spastic quadriplegia and unilateral hemiplegia but minimal in bilateral diplegia (Neville 2000).
8. A congenital suprabulbar palsy is found in some individuals with bilateral quadriplegias (Neville 2000). The Worster-Drought syndrome is a rare form of cerebral palsy with often mild motor problems, but often with severe difficulties with oral–motor skills for feeding, saliva control, and speaking.

Dyskinetic cerebral palsy (dystonic and choreoathetotic)

The main motor characteristics are as follows.

Involuntary movements – dyskinesia (athetosis). These are unusual, purposeless movements that may be uncontrollable. The involuntary movements may be slow or fast; they may be writhing, jerky, tremor, swiping, or rotary patterns or they may be

unpatterned. They are present at rest in some children. The involuntary motion is increased by excitement, any form of insecurity, and the effort to make a voluntary movement or even to tackle a mental problem. Factors which decrease dyskinesia (or athetosis) are fatigue, drowsiness, sleep, fever, prone lying, or the child's attention being deeply held. Involuntary motion may be present in all parts of the body, including the face and tongue. Involuntary excessive open mouth smiling often facilitates socialisation. Dyskinesia may appear only in hands or feet or in proximal joints, or in both distal and proximal joints. Generally the child finds great difficulty in being still.

Chorea is random ongoing sequences of involuntary movements or fragments of them. There is an overlap with athetosis termed choreoathetosis (Sanger et al. 2010).

Postural control. The involuntary movements or dystonic spasms may throw a child off balance. However, the well-known instability in children with dyskinesia is often directly connected with their postural mechanisms. A common pattern is to 'run headlong' using momentum as they cannot stand still on one leg or adjust their posture for slower walking. They run before they can walk.

There are also standing postures in late childhood, adolescence, and adulthood that usually involve backward lean with hip extension, knee semiflexion, lordosis, and kyphosis with chin jutting well forwards and arms held forwards. This is another compensation for instability (Fig. 1.4).

Voluntary movements. These are possible but there may be an initial delay before the movement is begun. The involuntary movement may partially or totally disrupt the willed movement, making it uncoordinated. There is a lack of finer movements and weakness. Manipulation and some simple hand actions may be difficult. Grasp and release have extreme flexion and extension movements that some older children learn to control for finer grasp or use of large keys on a computer.

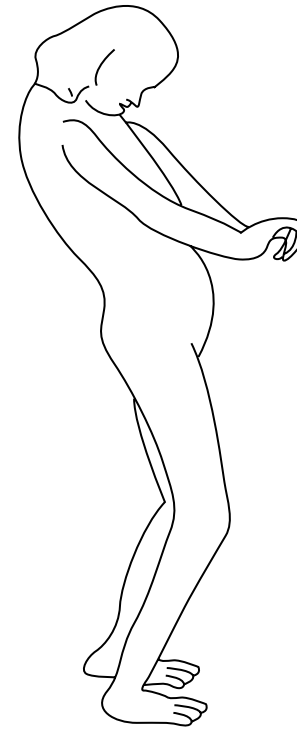

Figure 1.4. Person with dystonia/dyskinesia in standing or walking positions. In late childhood, adolescence, and adulthood posture is usually with extended hips, bent knees and pronated feet, and rounded back with arms and hands in front to avoid hyperextension.

Hypertonia exists or there may be fluctuations of tone. The rare rigid hypertonus is a 'lead pipe' rigidity. Dystonic hypertonia is present. Both show a continuous resistance to passive stretch throughout the full range of motion. Dystonic posturing can be particularly disabling, especially if combined with spasticity. Intended movement, especially in a specific task, triggers dystonia, which can be sustained or intermittent. The dystonic muscle contractions may create twisting into unusual postures and be repetitive. Rigidity is detected when movement is externally applied (Sanger et al. 2003, 2010). Arousal of emotions increases

dystonia and dyskinesia. Other triggers such as tactile stimulation, pain, constipation, and intolerance of orthoses and seating can cause dystonic posturing. Dystonic tremor may be present. Sudden flexion or extensor spasms could occur. Sudden wide opening of the mouth with spasm can take place. Sleep decreases spasms or dystonic postures. However, more severe dystonia may make sleep difficult. Deformities are less likely owing to the fluctuations of tone. There can be overlap of dystonia and dyskinesia.

Status dystonicus is rare and a medical emergency. Doctors need to educate therapists and parents well beforehand.

The athetoid dance. Some children with athetosis are unable to maintain weight on their feet and continually withdraw each foot either upwards or upwards and outwards, in an 'athetoid dance'. They may take weight on one foot while pawing or scraping the ground in a withdrawal motion with the other leg.

Paralysis of gaze movements may occur, so children with dyskinesia may find it difficult to look upwards and sometimes also to close their eyes voluntarily. Poor head control also disrupts use of the eyes. Jan et al. (2001) found severe dyskinetic eye movements in some children with dyskinesia, associated with variable and highly inefficient vision.

A dyskinetic presentation can change with time. Children may be floppy (hypotonic) in babyhood and only exhibit the involuntary movements when they reach 2 or 3 years of age. Most dystonia and dyskinesia are bilateral. There is a rare unilateral presentation. Some adults or adolescents learn to use muscle tension to control involuntary movements. Individuals may find their own ways of achieving function.

Associated impairments

1. Intelligence is frequently good and may be very high. However, intellectual impairment is still present in some individuals.
2. Hearing loss of a specific high-frequency type is associated with athetosis caused by kernicterus, although it is now a rare cause.
3. 'Drive' and outgoing personalities are often observed. Emotional lability is more frequent than in other types of cerebral palsies.
4. Articulatory speech difficulties and breathing problems may be present, and the child's oromotor problems create feeding difficulties. Tongue thrust and drooling may be particular problems. Poor hand and arm function affects the development of self-feeding.

Ataxic cerebral palsy

The main motor characteristics are as follows.

Disturbances of balance. There is poor stabilisation of the head and trunk and of the shoulder and pelvic girdles. Unsteady gaits are present. Some children with ataxia overcompensate for this instability by having excessive balance-saving reactions in the arms. Instability is also found in children with other classifications and may be called ataxia even when the child's presentation is primarily described as dyskinetic or spastic cerebral palsy, as pure ataxia is rarely diagnosed. Pure ataxia, called 'dysequilibrium syndrome' (Neville 2000), is understood to be of genetic origin.

Voluntary movements. They are present but clumsy or uncoordinated. The child overreaches or underreaches for an object and is said to have 'dysmetria'. This inaccurate limb movement in relation to its objective may also be accompanied by intention tremor. Children with ataxia often present

with all of their movements appearing disorganised or jerky. Poor fine hand movements occur when, for example, tying shoe laces, managing buttons, using a pencil, and drawing or writing.

Hypotonia is usual. There is excessive flexibility of joints and poor muscle power.

Nystagmus may exist.

Associated impairments

Intellectual impairment may exist, especially in regards to non-verbal cognitive skills such as visual and perceptual difficulties.

Common features observed in all presenting types of cerebral palsies

Postural mechanisms

The classification of tone and component gross and fine motor skills has tended to obscure the fact that there are important motor features that are common to all children with a diagnosis of cerebral palsy, for example delayed motor development. However, symptoms such as spasticity, sudden spasms, and the various involuntary movements only play a part in this disturbance of development. Delayed or atypical development of the postural balance mechanisms significantly disturbs motor development. Postural mechanisms are an intrinsic part of motor skills. When they are absent or atypical, this leads to absent or atypical motor skills.

Chapters 7 and 9 discuss these aspects in detail, as they are fundamental to the framework for therapy.

A common feature is also associated weakness of the neck, trunk, shoulder, and pelvic muscles, which are not activated by undeveloped postural mechanisms.

Infantile reflexes

Besides the desirable postural mechanisms, there are reflexes that have no predilection for any specific type of cerebral palsy. These are infantile reflexes that are present in the typical newborn and that become integrated or disappear as the baby matures. In cerebral palsy infantile reflexes may still present long after the ages when they should have become integrated within the nervous system. Some older children who do not yet have postural mechanisms activate some of these reflex responses in their efforts to balance and move as the infantile reactions can be their only way to function. These reactions may be stimulated by either peripheral or cortical activations. A therapist needs to include knowledge of how their peripheral stimulation and handling might cause residual reflex responses instead of developing more advanced motor control. Examples of the use of reflexes are as follows: a child may use grasp reflexes to hold a small object, a plantar grasp to grip the floor for stability, excessive neck righting reflex to roll, automatic stepping when the body is fully supported in a walker, and positive supporting reaction for standing in a standing frame. Children may use extensor thrusts or Moro reactions or Startle to communicate non-verbally. Feeding reflexes disrupt independent feeding development.

There are also the tonic reflexes, which are the tonic labyrinthine reflexes, the asymmetrical tonic neck reflex, and the symmetrical tonic neck reflexes. Some neurologists group these tonic reflexes among the infantile reflexes, whereas others argue that they are not present in the typical infant and are always pathological. Tonic reflexes are only seen in the most severely impaired children (Foley 1977), especially if obligatory. These tonic reflexes are sometimes called *postural reflexes* but they are *atypical* postural reflexes and should not be confused with the typical postural mechanisms as described by a number of neurologists and researchers (Belenkii et al. 1967; Martin 1967; Hadders-Algra and Carlberg 2008; Shumway-Cook and Woollacott 2017 among others).

The principle of treatment that therapists should follow in relation to the complicated collection of reflexes is *not* to go 'reflex hunting'. In the past, some therapists assessed directly for reflexes that might interfere with motor function and speech. However, the current approach is to examine the function of the child first and then plan therapy intervention that will support a child's functional development, which replaces the need for reflex reactions as compensation for lack of developmental motor control and function. Table 8.2 (see Chapter 8) of reflex reactions is given so that a therapist recognises any total or remnants of these reflex reactions in an individual.

Reflex reactions are not a substrate for motor control and are not reliable predictors of future motor development. Ideas on the theoretical bases of motor training disagree with therapy using the 'hierarchical lists' of primitive and tonic reflexes followed by more mature reactions (Cioni et al. 1992; Horak 1992; Prechtl 2001; Einspieler et al. 2005). These studies lend support to 'avoid reflex hunting' expressed in this book since the first edition in 1977.

Additional impairments

Individual children, particularly those with severe cerebral palsy, may have sleep problems, fatigue, feeding problems and poor nutrition, decreased bone mineral density, musculoskeletal pain or pain from hypertonus, or severe gastro-oesophageal reflux, and are less fit than their peers without physical disabilities. Most of these problems develop in later childhood and are managed by medical consultants. Therapists are involved with feeding problems, fitness, and bone mineral density. Therapists need to be aware of any additional impairments as they may impinge on the amount of energy a child has available for both functional activities and individualised therapy programmes. Parents are often short of sleep as they need to comfort, feed, or give medicines to their child at night. This impacts on their energy and ability to carry out a child's home therapy. The physical demands of caregiving have been shown to negatively impact on parents' physical and psychological well-being (Ward et al. 2014). Pain and decreased bone mineral density are treated with drugs and prevented to some degree by therapists using activities involving active weight bearing (NICE 2017). See assessment of pain in 'Specialised medical treatments' in Chapter 5.

Motor delay

Cerebral palsy consists of both motor delay and motor disorder. In Chapter 8 various assessments are described that can be used to assess motor delay. There are many other conditions that may also present with similar problems in regards to the development of motor skills or of delay and disorder. All these conditions are known as *developmental disabilities* (Levitt 1984).

They may be due to the following.

Intellectual impairment. This is caused by various metabolic disorders, chromosome anomalies, leukodystrophies, microcephaly and other abnormalities of the skull and brain, endocrine disorders, and the causes of brain damage given for the cerebral palsies. The latest version of the Diagnostic and Statistical Manual of Mental Health Disorders (DSM-V) includes functional difficulties as a criterion for a diagnosis of intellectual disability alongside cognitive ability as measured by an individual's IQ level.

Deprivation of stimulation associated with social, economic, or severe emotional problems.

Malnutrition alone, but usually together with deprived environments.

Once malnutrition is treated, lack of normal stimulation may still delay the child's development.

The presence of non-motor impairments. This may influence motor development and lead to delay, for example severe visual impairments. Children with delay in any developmental area are more likely to have an associated delay in motor development.

Presence of motor impairments other than the cerebral palsies. For example, spina bifida, the myopathies, myelopathies, and various progressive neurological diseases as well as congenital deformities may obviously delay development of fine and gross motor function.

Principles of treatment and organisation of treatment. These will be similar to those discussed in Chapters 1, 2, 3, and 4. *Specific problems* in the conditions above are considered in other publications (Levitt 1984; Campbell et al. 2011; Rodger and Kennedy-Behr 2017).

Summary

This chapter provides basic information for planning treatment and management.

1. The child with cerebral palsy has abilities and disabilities primarily in motor control and function, but may have individual associated difficulties in the areas of communication, cognition, sensory, and perceptual functions.
2. The motor and other functional disabilities are created by some of the impairments as well as by lack of many everyday learning experiences in various environments.
3. There is an interaction between the communication, intellectual, sensory, perceptual, and motor functions. Therapists therefore consider the influence of associated abilities and disabilities on therapy programmes.
4. Treatment is aimed at development and support of gross motor and fine motor functions to enable engagement in activities and increase participation.
5. Specific attention will need to be paid to the following:
   a. postural mechanisms of stability and balance
   b. voluntary movement patterns (synergies) of body, limbs, and hands
   c. strengthening for weakness of various kinds
   d. minimising hypertonicity, hypotonicity, and involuntary movements
   e. improving postural alignments and patterns of gait
   f. improving ranges of motion of muscles, joints, and soft tissues.

   Therapists also need to reflect on the relationships of these aspects.
6. Therapy programmes should not have a strict adherence to specific diagnostic classifications as there can be clinical changes. Aetiology may not always influence therapy.
7. Therapy includes:
   a. Assessment and management based on the perspectives of an individual, the family, and others involved with that individual. Consideration of attitudes in the family and society that facilitate or act as barriers to an individual's function and participation.
   b. Focus on developmental therapy, minimising impairments *within the functions*.
   c. Therapists always recognising the emerging functional *abilities and whole functions* within each child's development.
   d. Assessment and prevention of secondary and increasing impairments.

   e. Encouragement of the positive attributes of individuals with cerebral palsy and of their families.
   f. Promoting positive motor experiences as key for motivating the best therapy.
8. Typical developmental schedules are only guides and need to be carefully adapted.
9. Management and therapy are planned from infancy throughout an individual's lifespan to take account of clinical change and different circumstances in an individual's home, schools, and community. Management focuses on educating all those primarily involved with a person with cerebral palsy.
10. Therapists need to integrate learning principles that encompass emotional, cultural, and social issues.
11. Treatment and management need to commence as early as possible for parental support, parent–child relationships, and to promote a child's activities as well as minimise any musculoskeletal problems.

The model suggested by the ICF provides a framework for understanding disability and health in the twenty-first century. It acts as a general guide to assessment and planning of therapy and management, which matches many discussions in this book.

2

A collaborative learning approach

This chapter describes the collaborative learning approach with parents and children. Chapter 3 focuses more on children, and Chapter 4 focuses on adolescents and adults.

Working with parents within a family framework

Therapists now recognise the importance of working with the parents of each child, and for some time parents have been shown home programmes or home exercises (Collis 1947; Finnie 1997; Finnie updated by Bower (2009) among others). This chapter emphasises client-centred or person-centred therapy and learning (Rogers 1983, 2003), which may not necessarily be used by those physiotherapists who devise home programmes for parents. A more parent-centred view presenting home programmes is given in a book for carers and parents of children with multiple disabilities (Levitt 1994).

When considering both parents and family members as adult learners, it is useful to draw on the studies of Rogers (1983, 2003), Knowles et al. (2015), and others in adult education. Rogers developed ideas on human behaviour and the process of learning, including within psychotherapy. Similar concepts underlie the collaborative learning model that one of us (S.L.) developed from practical work as a physiotherapist together with individual children and parents. This approach has also been compared with enabling individuals to learn in small interactive groups of parents, therapists, or other disciplines as well as in multidisciplinary workshops. In order to change traditional therapist behaviour, we considered that the members of the group needed to have interactive and experiential learning rather than only lectures (Levitt and Goldschmied 1990). This followed practical experience since the 1980s to develop this style of working as a physiotherapist and a small group tutor in the field of disability.

In this approach, all the participants share responsibility in assessments, therapy plans, methods, and evaluations (Levitt and Goldschmied 1990; Levitt 1991a, 1999: pp. 153–155). Ross and Thomson (1993) recommended this specific collaborative approach (outlined in Levitt and Goldschmied 1990) following their studies on the evaluation of parents' involvement

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in physiotherapy. Piggot et al. (2002, 2003) also refer to this approach. They have similar views, which are supported by their qualitative research project on parental adjustment and participation in home therapy. There are also now a number of research studies by occupational therapists supporting similar views and home therapy for parents (Ziviani et al. 2014; Kessler and Graham 2015; Graham et al. 2016). Hinojosa et al. (2002) surveyed 199 American paediatric occupational therapists relating to parents and finding positive changes and challenges. These therapists spent 60–70% of their time training parents and carers.

The idea of joint goal setting and involving the parents and child in the shared decision-making process is now accepted.

This collaborative learning approach is a creative learning process, not only for a child and parents but also for any therapist. The therapist learns what the hopes and expectations of a child and parents are and what they already know and can do. Using these resources, therapists are better able to draw on their technical expertise for a more relevant programme. The respect and trust given to what parents and child already understand, and can manage, develop their confidence. More positive relationships grow between parents, child, and therapist. There is more motivation as parents and child respond positively to a therapist who appreciates their desires and their ideas for managing some of their own difficulties. It is the quality of the parent and child relationship with a therapist that is crucial for learning and collaboration.

The collaborative plans are agreed between parents, child, and therapist; this is also called a *contract* between them. The contract is made in the early sessions of the assessments, during which there are clarifications of what the child and parents want and what the therapist can offer them to meet their wishes, as well as of everyone's responsibilities (Dale 1996).

Emotional support

Throughout the collaborative learning parents are given emotional support to:

- build confidence in their skills to help their child
- aid their well-being so that their own adjustment is promoted
- enjoy home therapy and not become stressed by the programme.

Piggot et al. (2002) point out that time and understanding need to be given for some parents to 'work through their grief' in order to become fully collaborative. Parents may deny the diagnosis, believing physiotherapy is not indicated, so a sensitive process, within their individual time, promotes learning readiness. Using small interactive groups with subgroups allows new parents to learn from experienced parents and more positive attitudes are facilitated (Levitt and Goldschmied 1990). It depends on the depth of grief, anger, and disappointment as to when some parents are ready to change.

Therapy is not just 'a bag of tricks' to increase a child's motor function or independent daily skills. A therapist not only shows practical ideas but also needs to give time to listen to parents' worries. However, therapists are always balancing their time between the parents and the child. Listening and observing a child's facial expressions and body language tells the therapist about not only the appropriate pace of work with a child but also the child's emotional needs in general. When listening to a parent's or a child's anxieties, a therapist need not immediately reassure them. It is therapists' empathetic and attentive listening that serves them best. Therapists need to repeat back to both the parents and the child what they have heard them say and only later clarify what they can do to help.

Therapists become aware of a variety of underlying anxieties in individual parents. A parent may be experiencing a complex

mixture of emotions such as despair, anger, disappointment, frustration, or guilt. This varies not only from parent to parent but also in the same parent at different periods in their life with their child. Such feelings can be part of the grieving process related to the loss of the expected normal baby. There is hardly time for parents to work through this grief as they feel pressure to accept the very different child who is alive and may be making great demands on them physically and emotionally.

Therapists face a difficult situation in which their offer of help can make a parent feel more helpless and guilty. Some parents may then become more dependent on therapists and burden them with excessive demands. Others resent their dependency, becoming angry that they should need professionals to show them how to handle their child. This anger can also be directed at the very professionals who are doing their best for such parents. Therapists need to grow in maturity and become the 'patient ones' rather than the patients. To do this, therapists benefit from their own support groups and sensitive support from others in a team. This support is essential to maintain therapists' energy, understanding, and motivation (Levitt 1984: chapter 1, 1991b; Price et al. 1991).

When a parent is particularly stressed, taking excessive time and energy from a physiotherapist or other professional, therapists need to discuss this with the team or with a qualified psychotherapist, family therapist, or specialised counsellor. The therapist will gain guidance on how best to manage such a parent and if *and* how to refer such parents for professional help from psychotherapy or counselling.

The collaborative approach described changes the situation of a professional being the helper and the parent the helpless one to that of a more equal partnership. Therapists, therefore, are not placed in any position where their help is rejected, which may understandably upset them, possibly inviting anger. The parent learns to ask for help instead of just receiving it. Parents who find it difficult to accept help may be able to do so in a more collaborative situation with therapists and/or in interactive parent groups.

Parents need particular support when changing from different places, such as their child changing from the neonatal unit with many professionals to being alone with a child at home. Parents may worry about separating from their children when they need to start playgroup or pre-school, or to go from there to school. Parents may feel protective and need support to let their child grow up or deal with unfamiliar people and the environment. Therapists encourage parents to meet any new staff, share their knowledge of their child, and give the current home therapy principles, and enquire what expectations new staff will have of parents and family.

Odman et al. (2007) carefully studied parents' perceptions of the service quality of two training programmes for a range of severity in children with cerebral palsy. Most parents were 'influenced by high service quality rather more than by perceived functional improvements'. The researchers used a measure that is given in the appendix to their paper. This measure, the Patient Perspective on Care and Rehabilitation Process (POCR), was slightly adapted by the researchers and had seven dimensions of the needs of the parent or child. Our experience with the collaborative learning approach has shown agreement with many of the findings of Odman et al. (2007).

Parents vary

There are single parents, step-parents, foster parents, grandparents, teenage parents, parents with disabilities, parents with severe financial problems, same sex couples, and parents of different ethnic groups. Sometimes a nanny or carer or even an older sibling may be the person who will

need to learn and carry out the home programme with or without a parent. Each parent, together with another carer, may be more participant, especially if both parents need or choose to work. A father may be the primary parent after divorce or the mother's death. Single parents with health problems warrant extra attention.

Other adults

Teachers, other professionals, carers, nursery nurses, playgroup workers, and classroom assistants discuss with therapists what they want to know about any child whose development they are assisting. Therapists devise methods to suit individual adults involved with a child. They may also gain relevant information from any of these adults about various environments and cultures in which a child they know well is functioning and participating.

Family members assist with the therapy programme in the way that parents wish. In which case, time needs to be given for them to become familiar with these programmes to maximise the child's potential. This inclusive team approach particularly facilitates both parents' and their family's participation and helps them feel of value to their child with cerebral palsy. However, some family members may find working with their child stressful and prefer to give their personal strength to support the parents and child emotionally. They can also offer support with, say, baby-sitting and family social events, offer financial help, and give parents respite periods. They can also enlighten therapists about their cultural values. Family members need to choose what they can manage.

Family members also need support from therapists whether they participate or not in therapy programmes. The well-being of families positively affects the development of their child. Therapists need to listen respectfully to their views and concerns and promote their education about therapy and especially draw attention to the assets in their child as a whole person, as well as to the gains in their child's development.

Consideration must also be given to the fact that babies and young children with disabilities prefer being handled by one or two adults as they have to relate to an adult and adapt to different ways of being handled. No two adults are precisely the same in their touch, speed of 'hands-on' therapy, and manual guidance. This is particularly relevant to those babies and young children who experience many unexpected spasms, uncontrolled reflexes, and unreliable control of their posture and movements.

Family-centred services

King et al. (2004) carried out a review of the literature on family-centred services for children with cerebral palsy. The family-centred service of Rosenbaum et al. (1998) 'was emerging in 1998' following studies of parents' perceptions of their service. It was based on a similar philosophy to the collaborative learning approach (Levitt and Goldschmied 1990). Therapists often claim that they are family centred, but when describing their roles they discuss their work with parents or primarily with the mother or father. Parents are at the heart of a family-centred service and essential to it. It is helpful if therapists are in a team of professionals devoted to family-centred work. The therapists are assisted and supported by other members of their team, such as psychologists, social workers, and paediatricians, who work specifically with the families. A number of research studies on family-centred services by Rosenbaum et al. (1998), King et al. (1999), Larsson (2000), and Odman et al. (2007) give evidence of parents' and families' increased satisfaction with the quality of services, and that they experience lower stress levels and better mental health. Further discussion of

cerebral palsy and the family is given by Rosenbaum and Rosenbloom (2012: chapter 8).

The Measure of Processes of Care (MPOC) of parental perceptions of a service was developed by King et al. (1997). There are 56 items in the full version of the MPOC, and there has been a shorter 20 item version available since 1999 (Siebes et al. 2007). Therapists can measure their own processes of care for parents and families (Woodside et al. 2001). These measures include the following areas:

- enabling and partnership
- providing general information
- providing specific information about the child
- coordinated and comprehensive care
- respectful and supportive care.

Many therapists have developed their specific ideas in supporting families and this continues to grow in physiotherapy and occupational therapy. However, the collaborative learning approach differs from some models in that it emphasises that *learning processes* are involved not only in 'changing function of a disabled person's body but also in changing ideas, behaviour and attitudes' (Levitt and Goldschmied 1990). The person with disability and the family members and carers are changing as they embrace new ideas, new attitudes, and behaviour as well as learning alternative ways of managing problems in partnership with a professional.

Therapists also become learners as they deepen their understanding, gain new ideas, change any of their attitudes, and give up old assumptions. A person's willingness to change is facilitated by desires to learn, achieve more, and feel more satisfaction in daily life. The quality of rapport between a therapist and a child, as well as between a therapist and parents and family, may take time in different cases. Investment in time is worthwhile as it is fundamental during mutual learning experiences, which results in more satisfying progress.

Graham et al. (2009) comment that family-centred practice has challenged occupational therapists and describe occupational performance coaching for parents. 'Coaching' may appear to mean instruction by therapists, giving them a superior role. However, much of their work is similar to the collaborative learning style described in this chapter. Litchfield and MacDougall (2002) carried out a qualitative study of physiotherapists in a community-based family-centred approach, exploring their benefits and dilemmas. Among the dilemmas was the need for evidence-based physiotherapy versus more family involvement. However, this can be solved with continuing education in professional meetings, conferences, and consulting the literature. This is how physiotherapists are able to share evidence-based methods with parents. Therapists can combine having a centre as a base where they have case discussions about their community visits.

Family cultures

Family-centred care needs to be culturally competent in order to be sensitive to different cultural values of families. Therapists can be culturally aware but not culturally competent. Cultural differences are not right or wrong regarding the ways families adapt, cope, and develop their own strengths in living with a child with a disability. With such families it is more important to listen non-judgementally and to avoid direct questions that may offend. A genuine interest in a child and family is needed and appreciated by them. It may be necessary to have an English interpreter with positive attitudes to disability.

We are aware that families in our own culture do not all bring up their children in exactly the same way. In our multicultural societies, therapists are faced with more diverse cultural differences in the families

they work with. Diverse cultural backgrounds can provide challenges for the professional in terms of communication. A qualitative study with British Bangladeshi mothers by Kingsley and Wickenden (2014) revealed that mothers wanted their child to develop independence. They also valued safety and emotional care. Shah (1997) gives principles for supporting Asian families.

Functional techniques and their safety and appropriateness need clarification. A therapist can learn from a Muslim family that a mother cannot be in a pool with her child during a swimming session unless the pool has a 'women only' time as this would be prohibitive for her. Special bath chairs and other equipment may not be appropriate for some parenting customs, and a special chair may not be relevant to floor sitting used socially in a particular culture. Typical motor and other developmental patterns of children differ in different cultures (see Chapter 5).

Therapists need to have a general practical knowledge of different cultural groups with whom they are involved. This can include likely health beliefs, religious practices, and social customs. However, the collaborative learning approach offers therapists a direct working knowledge of the customs of individual parents and families (Levitt 1999). This approach for individuals avoids stereotyping a child, parent, or family as being the same as all families in the cultural group. This stereotyping is less likely to happen when therapists are willing to learn from the individual older children, parents, and family. A qualitative research study of physiotherapists' perceptions in cross-cultural interactions by Lee et al. (2006) found that some participants did not recognise that they stereotyped 'clients' perceptions of pain, the desire for passive treatments, dependency on family members and male dominance in specific cultures'. This small study shows implications for the quality of physiotherapy.

Research on home and school visits

Novak et al. (2009) in their research show the effectiveness of home programmes for a number of therapeutic activities as well as for parent satisfaction. Piggot et al. (2002, 2003) also recommend home visits for therapy, emphasising emotional and behaviour values for the child and parents. The study by Goldstein et al. (2004) recommends home visits for learning routine tasks in a natural environment and to develop participation in home, school, and community. The effectiveness of equipment is best assessed in these environments. Therapists also need to observe and study children in playgrounds so that they can assist children to use regular or adapted play equipment (Levitt 1974; Goldstein et al. 2004). Difficulties can then be overcome together with a child, parent, and school staff. During home visits, therapists report that parents often inform therapists about their child's participation in various environments. In addition, family cultures and habits of the family are shared with therapists during home visits.

Some parents may wish to be seen in centres as they prefer their privacy at home and can use the collaborative learning approach when there is a positive relationship with their therapist. There can be useful meetings with other parents and the children can play and relate to other children. Besides visits to a centre, home and community settings can still be chosen by parents.

Collaborative learning approach

Children and their parents are offered:

- opportunities to discover what they want to achieve
- opportunities to clarify what is needed for these achievements
- opportunities to recognise what they already know and can do

- opportunities to find out what they still need to learn and do
- participation in the selection and use of methods
- participation in the evaluation of progress.

Genuine participation in all these aspects by the child and parents helps them feel more committed to the programme of work. It gives them some sense of control, which decreases many of their anxieties and builds their confidence. They become more able and more willing to absorb ideas, information, and practical suggestions from therapists.

Older children and their parents are accustomed to being asked 'What are your problems?' or 'What are your concerns?', as well as being given questionnaires with leading questions about their child's impairments and atypical function. In qualitative research on mothers learning from paediatric therapists (Harrison et al. 2007) a mother stated that 'The worst feeling you can have is having the therapist holding a paper and asking questions like as though in school…'. This may either decrease their confidence, because to them it emphasises the impairments, sadness, and inadequacies, or indicate a lack of empathy in a therapist. Before a relationship has been established, it is best to avoid using direct questions as this may feel like an uncomfortable confrontation.

A hopeful introduction about what could be learned and achieved is preferable. The type of language used by therapists needs to be more positive. For example, a therapist might say 'Tell me what you would like to do better in your daily life', 'Tell me what your child can do, when he does well and with whom', 'I would like to hear about your child's interests/activities at home'. More details of language used is given below.

The collaborative learning approach also considers the perspectives of therapists. There can be consensus and also different views between parents and therapists. Different views are managed by negotiation for an option both find acceptable. There can be a mutual understanding that there are different paths to the same common goal, which is carefully stated in the words of the parents. Early in the growing quality of the relationship, a professional can concede to follow the parents' choice until the relationship is strong (see also section 'Involvement in the selection and use of methods').

This collaborative learning approach takes account of all these aspects. A pilot study by Ahl et al. (2005) found that parents' expectations were of a functional training approach in daily life settings. When such a programme was used, parents' perceptions of the rehabilitation process were enhanced. The collaborative learning approach focuses on the parents' and child's choice of daily life functions (Levitt and Goldschmied 1990). Jansen et al. (2003) in their review of studies on parental experience with physiotherapy quote a number of studies that support aspects of this approach that find positive responses in parents.

Opportunities to discover what the parents and child want to achieve

Many parents are quick to say what their expectations from therapy are. Others want time to discuss this with their families. Some parents are unaccustomed to asserting what they want as they have anxieties and 'learned helplessness' (Seligman 1992). They may also not wish to upset their specialised therapist as they wrongly or rightly sense this might be so if they choose what therapy might focus on for *their* lives. Mothers who had a good relationship with their therapists did not always 'address their concerns for fear of offending their therapist' (Harrison et al. 2007). Therapists can continue to discover various ways to find

what parents and child want to achieve. For example, a therapist gains their trust by inviting them to talk about a typical day in their lives by saying which daily activities they would like to improve further and which daily activities are most stressful or time-consuming. Stressful activities may be priorities for a parent, or just where improvement of skills are desired. Parents may select an activity such as a child's feeding, washing, dressing, toileting, or playing, or a child going from place to place at home, school, or in other environments. Therapists prompt the parents and child to think about these activities as they are familiar to them. Therapists explain that if they know about their daily activities then they can plan a more relevant therapy programme with the parents and child. Therapists also tell the parents and child that they can then clarify what they can offer from their profession to meet the parents' and child's wishes.

If children cannot communicate what they would like to achieve or do better, then they are observed to see what interests them. Children may enjoy bath time, mealtimes, or special times for play with their parents. In a more specific situation, if possible in their familiar environment, babies, children, or severely multiply disabled individuals at an early stage of development have facial expressions of pleasure and body language that can easily be observed. An individual may use eye pointing or limb gesture showing what they would like to do. Eye pointing can be taught if speech is absent. Cards of pictures of an activity may be useful for children who are able to link them in their experience. Some children use their pathological symptoms to show pleasure or displeasure, such as extensor thrusts or increasing involuntary motions. When children's understanding has been established by professionals then 'Yes/No' answers with head motion can be taught.

It is essential to start with the priorities of the child and parents rather than set aims or goals for them. Even if we set goals and then ask for their agreement, *we* are really setting the goals. This does not enable them to discover their own aims, formulate their own expectations, and so improve their ability to share their ideas and feel more confident. Once a parent or child states their wishes, the therapist repeats what they have said with a check such as 'Have I got that right?' This places the parents and child in a more independent position. It is important to acknowledge when a child's wants differ from the parents' wants. Mothers' wants sometimes differ from those of fathers. These can be negotiated and may first focus on a child's or adolescent's wants.

We do recognise that professionals with clinical wisdom and experience do know what is needed for parents or patients, but do not really know what is needed for particular parents or patients at specific times. This leads to frustration on the part of both therapists and their recipients. Physiotherapists may say or think 'they [parents] do not really understand our aims' (Levitt 1986, 1991b). This is despite technical explanations clearly given by a therapist. It is the connection or marrying of a therapist's 'goals' with an individual's 'goals' that matters to facilitate mutual understanding.

Opportunities to clarify what is needed for these achievements, to recognise what parents and children already know and can do, and to find out what they still need to learn and do

These opportunities are given in the following ways.

1. The parents themselves carry out the daily task on their own. This is the task they have selected, but they first need to learn what that task involves using their own experience of it. As a parent

enacts the task, he or she is prompted to observe which *main* movements and postures are being used. They notice where they look, what they may hear, and other sensations relevant to a task. Comments from parents are encouraged so that a therapist learns something about their knowledge of, say, their own body movements and balance. The therapist then only adds to the parents' knowledge according to their stage of understanding and when this is relevant to their own child's function.

2. Therapists themselves may demonstrate the parents' chosen daily task, drawing attention to the general aspects of balance, movement, and some sensations. This is termed 'modelling' by some professionals. Some parents may prefer this before they carry out the task themselves.

In both points above, attention is drawn to the fact that observation is being made of adult actions. However, the child may then be observed to have achieved some of these, such as looking, listening, head control, hand-to-mouth movement, grasp, or other components normally retained from infancy and the early years. Any 'normal' components already achieved by their child boost both the parents' and child's confidence. Parents begin to feel that their child can achieve.

A mother or father can then apply these educational experiences by actually doing the task together with the child. This can also be used to learn what is needed to achieve a task. However, it especially demonstrates what a child and parents can do already and what they still need to learn to do. The therapist first underlines what they can do before saying what is still needed for successful achievement of their task. In this way parents can feel they are managing some skills, which builds their confidence to learn more unfamiliar skills that develop a task or modify impairments.

Direct questions about a child's functioning are also avoided so that parents do not receive an impression that their child should be doing something or is doing it atypically. Rather say '*Tell me* more about what your child can do and how they like to do it' and '*Tell me* when your child does it really well and what they do with whom'.

The same procedure is used with a child who is invited to try and carry out the chosen activity as best he or she can. Children experience what they can do – which they often may not yet have recognised as perhaps adults have always manually (though lovingly) supported them or not given them time to try. The therapist emphasises what the child can do, no matter how small, in simple words such as 'You can keep your head up' or 'You started to pull your sleeve down', according to the task. Even if not all words are understood, the parents appreciate what is being said as their child is reassured by the therapist's tone of voice and approving facial expression.

Therapists need to continue their studies on task analyses in different types and classifications of severity in cerebral palsy so that they draw attention to the most successful components of functions (tasks) in each child. Each parent will have their own pace of learning this task analysis for their child.

Although the therapist is also observing obvious impairments such as hypertonus, weakness, involuntary motion, or deformities, these are not yet stated in these words. Therapists' comments on impairments refer to 'what needs to be learned', such as a child 'still needs to stretch an elbow more' or 'still needs to learn how to sit more steadily' or 'how to stand up really tall'. This is a more motivating style.

Once child and parents show what they can do, the therapist validates their achievement and shares their pleasure. The therapist might say something like 'That is good, and it could be even better if we try the following suggestions'.

The therapist can then demonstrate additional positioning, modification of the physical environment, appropriate manual support, handling, or physical guidance to reveal more of the child's abilities.

As parents and child have had their capacities acknowledged by a therapist, they are more willing to listen to what this therapist adds to the programme.

Task or functional analyses. Task analyses, such as for a child learning a daily task or motor function, are outlined in Chapter 3. Analyses of the components of a child's function are given in Chapter 9, which outlines details of developmental functions, some of which may be more detailed for therapists than for some parents.

The therapist's specialised assessment. Once the motor and sensory components of a task have been observed by therapists within a whole task, they decide how much more needs to be assessed. Therapists can then carry out more detailed assessments of the components or limitations of the whole task/activity, daily function, and impairments of body functions, such as muscle work, joint ranges and tone, atypical postures, and other sensorimotor details. However, the advantage of first seeing all these separate aspects within a whole task reveals many ideas which challenge the accuracy of *only* using separate examinations of impairments or motor components (motor abilities, prerequisites) to plan therapy programmes.

The tasks/activities/daily functions have been chosen by the parent or child and are thus being performed by motivated persons. The results of such an assessment tend to be more positive. There is interaction among all aspects of a task, so ability in one component activates any residual ability in another component. Tests of reflexes may be abnormal if carried out in isolation, but if observed within the context of parent–child interactions during daily activities, the assessment shows a more positive result. For example, a grasp reflex may become immediately modified as a baby places her hand on her mother's breast during feeding; an asymmetrical tonic neck reaction or a Moro reaction is modified or overcome as a child puts both her arms around her father's neck or holds her head up in eye-to-eye contact during social and specific daily activities (Levitt 1986). Personal relationships are enhanced within such situations.

Involvement in the selection and use of methods

There is no sharp division between the assessments just described and methods. As mentioned above, a therapist's assessment methods of positioning, physical guidance, and amount of manual support reveal more of a child's abilities and function. These methods then serve as treatment methods and are extended to include equipment, orthoses, furniture, footwear, and playthings. It depends on the severity of the cerebral palsy together with the views of the parents, child, or older person as to the content of the therapy programme.

As with a child, parents are first observed practising their own methods of training their child, and if necessary can then be guided physically or verbally by the therapist as they carry this out. This allows them to improve their method. Details are added according to what each parent can absorb and manage. Once their own style of parenting and handling is used, some parents welcome additional methods from therapists. Options can then be explored. Each parent also has their own pace of learning and some need many more repetitions of a method than others. Videos of methods with the child can be taken home for reviewing what parents have learned with their therapist and to show to their family. One parent may make notes or list activities

Figure 2.1. There is pleasurable interaction between this father and his child as the child's postural control with hand function is being developed. Father chose to use his feet to assist his child in symmetrical weight bearing on hips and weight shifting from side to side or forwards and backwards during play.

in their own words, while the other carries out the activities with the therapist. The parent's record also reveals what has been understood. Clarification by the therapist can gently be given for increased learning.

As parents and child develop their confidence, they will share more of their own ideas with their therapist (Fig. 2.1). Therapists always welcome the child's and parents' ideas as they are showing an eagerness to take some responsibility in the programme and not become totally dependent on the therapist. The therapist considers their suggestions, and, if inappropriate, modifies them or shelves them for a later stage in a child's development. With any validation of the ideas of parents or child they become more able to cope with times when some of their ideas are incorrect. As parents have been learning and gaining information about their child's condition within a positive relationship, there can be negotiation on which methods are suitable. Clearly therapists need to become more flexible so that they can be open to what parents and child offer. This means that they cannot stick rigidly to any system of therapy. The therapist also needs to learn what is realistic in the parents', carers', and child's daily life. This includes cultural considerations, time constraints, and a child's general health as well as the physical environment.

Harrison et al. (2007), using qualitative research with mothers, found that their specific learning styles included 'observation of therapist with their child, practical methods guided by the therapist, asking questions, discussing their child's development, and reading materials provided by their therapist'. Videos, drawings, and especially parents' own notes are useful. Therefore each parent or carer needs to be invited to say which learning methods they valued.

It is helpful to clarify who will carry out particular methods. It is necessary to record the person at home or in school currently carrying out specific methods with a child. If possible, the frequency and duration of a session for people using methods are recorded according to what can be realistically managed by a child, parents, and others, including the therapist, who are involved in a child's development. This realistic record tends to be flexible or an approximate guide – unless it forms part of a clinical research project.

We avoid overwhelming a parent with a 'mountain of knowledge and tasks'. This may exhaust them and disrupt family life, creating additional feelings of inadequacy (Ross and Thomson 1993). With the many demands on parents to provide for their child, they may use a family member or other carer. However, expectations for them to take on the additional role of 'therapist' can be too much for some (MacKean et al. 2005). The collaborative learning approach, if appropriately carried out, enables parents to choose what is realistic for them, other family members, and carers. Mothers have used therapy methods in the context of their family lives rather than in a set therapy session. This allowed them to manage their other commitments and avoid stress.

In the authors' experience, parents have phases in their lives when they can and cannot manage as much. During difficult periods for parents, a home programme can be largely replaced by the therapist giving a bout of more sessions with a child, encouraging another family member or friend to temporarily assist more if deterioration of the child's condition occurs or is expected.

Special therapy techniques. Once a parent has some confidence in methods for the familiar, everyday tasks in childcare, they can add selected physiotherapy or occupational therapy treatment techniques. Some parents are intimidated by unusual techniques whereas others overdo them. They believe or want to believe that these strange techniques are 'magical treatments', and overdo them at the expense of developing their natural parenting abilities and positive relationships with their child. It is these relationships that are fundamental to real progress. Exercises such as ranges of motion, stretching, specific balance training, and strengthening exercises may be carried out in a didactic style that parents may have observed in a physiotherapist treating their child or perhaps treating some other person with another medical condition. von Wendt et al. (1984) found positive interactions by well-supported parents using selected physiotherapy methods. Jansen et al. (2003) reviewed 18 studies from 1981 to 1999 of parental experience with physical therapy that included positive parenting experiences and family satisfaction in many of the studies, all of which used specialised measures for the studies.

Therapy within play activities. Any negative behaviour in parents or child need not happen if therapists first set the scene as described above and find methods within play activities. For example, a child's postural mechanisms and movements are developed on the parent's lap, when being carried, and when being handled during all daily activities and play (Figs 2.2–2.4). A child's spine and limbs can be stretched and moved within positioning for daily tasks as well as in water and during musical rhythms and action songs. When a mother

Figure 2.2. Therapist showing tilt reaction facilitation on a doll so that this mother can interact with her child on her lap playing a 'see-saw' game. The position of the adult's hands on the child's hips rather than on the trunk is important.

Figure 2.3. A child developing postural control on her father's shoulders in playful activity.

Figure 2.4. Stimulating head control in parent–child interaction.

Figure 2.5. Learning early balance on one foot during dressing and undressing, washing, or drying with body closeness between mother and child.

also assists a child to enjoy his or her body parts which are being kissed, tickled, and touched by her as well as moved to her song, she also develops a more positive view of her child's body. This pleasure in both mother and child contributes to their developing relationship in a creative way. It is important to develop parenting abilities at the same time as promoting a child's function, and methods can be found to do this (Figs 2.1–2.5). Parents usually bring their own playful ideas with a child once their confidence is cultivated. This also avoids an increased dependency and excessive demands on a therapist for 'magical treatments'. Parents need to recognise that their handling of their children is as important as special treatment sessions. Mothers value the playful ideas used with their child by a therapist clearly showing their child's enjoyment of therapy (Harrison et al. 2007). See Chapter 10 for the development of play activities by occupational therapists and physiotherapists. Chapter 9 includes playful ideas as part of developmental functions.

Other sources of 'best methods'. These may be from perhaps another parent or helpful family member. Therapists can discuss whether this suits a child, as children do differ in developmental levels, severity, and in likes and dislikes. Therapists using an eclectic functional approach can combine methods with other suggestions to suit a child. The internet has created easier access to written information; however, much of this is not peer reviewed and can be confusing for the parents or child. This is confounded by the media's delight in promoting some types of therapies. Therapists' own clinical reasoning and experience will enable them to consider new approaches objectively, with emotional detachment, which is very hard for the parents of a child with cerebral palsy. The role of the therapist in interpreting information for the child and parents is an important feature of clinical practice. There is further discussion about this in the section on 'Alternative and complementary treatments'.

Involvement in the evaluation of progress

Throughout the therapy sessions, it is reassuring for all to know how well they are progressing. Parents and child are asked to report on any new achievements based on the original assessments. They may have

gained more of the steps in a sequence of actions in a daily activity or more postural control, more postural alignment, or more hand use. They may report more participation in family relationships and outings.

The collaborative learning approach in this chapter can offer detailed records of the priorities of parents and of a child, what parents and child can already do, what they still need to learn and do, their selection of methods, and their evaluation of progress.

Goal attainment scaling has become a desirable measure for individual parents and their child. It matches the collaborative learning approach, and is discussed in Chapter 8.

Professionals also use their own variety of outcome measures that can measure change over time. Improvements from a child's baseline abilities can be recorded with graphs, in written records, and, with permission, on video. These special measures and clinical observations as well as the results of consultants' special tests need to be explained to parents and, when understanding is available, to a child.

Following evaluation of progress or joint discussions with parents, carers, or any family member involved, there may be a need to modify therapy or new methods may need to be added for future progress. Equipment is checked together with parents and child to confirm comfort, correct size, and function. The relevance of equipment to a child's home and lifestyle as well as acceptance of their aesthetic aspects is a continuing assessment with parents and child.

Behavioural progress

It is essential to comment on the progress of child and parents in their development of confidence, motivation, communication skills, and personal relationships. It is after all not only functional gains that are important, but how much more viable life becomes for parents and child as a result. More qualitative research studies are being undertaken by psychologists, psychotherapists, and therapists to evaluate these aspects (see discussions of qualitative research in Chapters 1, 4, and 8, including the 'Review of a therapist's observations' in Chapter 8). Observations of videos made at home by both professionals and parents reveal progress to those experienced in parent–child interactions during feeding and other activities of daily life.

Parent satisfaction

Parents' satisfaction with the service they are receiving, rather than specifically with therapy, is measured by the Measures of Processes of Care (MPOC) (King et al. 1997). Odman et al. (2007) used the POCR and Ahl et al. (2005) used goal achievements, the Gross Motor Function Measure, the Paediatric Evaluation of Disability Inventory, the MPOC, and parent questionnaires in their research with parents and carers (see Chapter 8 for a description of these measures). Parents' and carers' questionnaires are also used (Goldsmith 2000). Kruijsen-Terpstra et al. (2014) reviewed both qualitative and quantitative studies of the experiences of parents with physical and occupational therapy for their children under 5 years. They found that the importance of the broader context of the child in a family should be acknowledged, and that there is realisation of the impact of the demands of daily life and the need for support and resource for parents. They draw attention to the attitudes in the community and culture that parents experience.

Parent–child interaction

When familiar daily activities are used in the programme, a therapist is able to see a parent and child functioning together. As Winnicott (1964) points out, 'There is no such thing as a baby, only a baby with someone else'. During these daily activities,

there is normally mutual pleasure between mother or father and child. However, a child with disabilities gives unusual communications as clues for a parent to know how to parent such a child. If a child has a floppy head, a visual problem, or hypertonus, this not only is a worry from a functional viewpoint but also interferes with a child's response to a parent. Such children cannot always initiate communication with their head and eyes, hands, or body to indicate their wants. Without head or trunk control, a child cannot turn away from his parents to show when he has had too much stimulation and may become irritable. Parents may find their child hypersensitive to touch, difficult to cuddle, or exhibiting unexpected startles of distress. It is easy for parents already unsure of their parenting abilities to feel rejected and anxious. It can make the bonding and attachment difficult for some parents. The natural expertise of a therapist may make parents feel more inadequate. There are, of course, other parents who are especially responsive to their child and who discover many subtle cues of communication from their child. They can clarify for a therapist what their child's body communications and sounds mean.

It is essential that during the joint assessments of feeding, dressing, bathing, playing, and other tasks the therapist points out that:

- a child's unusual body actions, hypersensitivity, or increase in stiffness may be due to the cerebral palsy and not to poor parenting
- a child's fears, apathy, hyperactivity, or poor concentration may be due to the cerebral palsy and not to poor parenting.

Enabling a parent to position a child well, to handle them, and to cuddle and play with them modifies the child's neurological symptoms, improves motor function and daily care, and even prevents some deformities; it also enhances their communication and the quality of their relationship. It is not just correct handling but a positive reciprocal interaction between parents and child that is being promoted (Figs 2.1–2.7 for parent–child interaction; see also Fig 10.2).

Figure 2.6. Physiotherapist enabling a mother and her key worker to learn how to activate early standing with close body contact as support.

Helping a child to learn motor control (body function) and motor function (activity)

This is discussed further in Chapter 3. The therapist makes sure that a parent and carer are enabled to develop these behaviours to reinforce a child's learning. Everyone involved with the child needs to:

- Give a child time to choose an activity or toy he or she likes and build in any desirable postures and actions.
- Wait for a child's initiation for a motor action and follow their lead.
- Wait for a child's response to the parent's initiation of an activity.
- Adjust a task so that a child can experience some success. Make it fun.
- Find ways to alert and maintain a child's concentration within their attention span.

(a) (b)

Figure 2.7. (a) Child with athetoid quadriplegia in supine. (b) Parent and child interact, enabling the child to master his symptoms.

- Show appreciation for a child's small and large achievements. Keep teaching a child even if gains are slow or minimal; eventually a child learns and achieves at his or her own pace.
- Grade sensory input so that a child is not overstimulated.
- Make appropriate demands on a child so he or she needs to make some effort to achieve a task without excessive increase in hypertonus, involuntary motion, tremors, or startles and spasms.
- Give time for the gradual development of parent–child relationships and enable parents to be patient with themselves as they are learning to interact with a child who is not developing typically. Many parents have *their own ways of managing* that therapists must acknowledge, especially when cultural differences also exist.
- Learn from family members what their cultural and customary practices are in child rearing. They may have their own individual modifications and views (Levitt 1999).

Observation of parent and child interaction

There are psychologists and psychotherapists who are specialised in observing parent and baby interactions and the building of optimal relationships for a child's positive development (Stern 1985). There is increasing research effort on interactive styles of mothers with children with disabilities, some of which shows such mothers as being more directive as their children use fewer interactive turns with a parent (Hanzlik 1990). When a physiotherapist or occupational therapist assesses a child together with his or her parents, the therapist can draw on the studies of psychologists or work closely with such a specialist on the team.

The therapist, therefore, observes not only the movements and postures which form the daily activities but also those that speak of the relationship between parents and child and between child and therapist. Therapists informally notice the body language of how a mother and child look at each other, touch, and move together. Therapists also notice how their bodies mould towards or away from each other. A child may initiate taking turns or need encouragement to do so in movement, eye contact, or sounds and speech. The upright posture not only develops postural control but also better communication and alertness. The way a parent supports and especially removes manual support demonstrates his or her anxiety and ability to trust a child to function alone.

The parents' willingness to follow their child's lead and wait for their child's slow achievement can be very difficult for them. The therapist's support and confidence in the parents' developing skills in parenting are essential.

The therapist needs to include such interactions in the therapy methods and may have to avoid methods that decrease positive interplay between parents and child. The therapist also models how to play, feed, dress, enable a child to move, and enjoy these and other activities. However, care is always taken to make parents feel as competent as possible at their stage of learning. Information is regularly given on the neurological symptoms, which can be modified to enhance non-verbal and verbal communication. Speech and language therapists can offer much in these areas. They also have the skill of enabling any adult interacting with a child to use an appropriate level of language (Winstock 2005; see also Chapter 10).

In this collaborative learning approach, a child is learning to make a choice by indicating his or her specific functional wishes at home and also his or her interests. Respect and serious consideration of these aspects by therapists and parents facilitate more positive parent–child interaction and avoid a number of difficulties with a child's lack of cooperation (see section 'Therapy within play activities'; see also the use of play in Chapters 3, 9, and 10).

Social needs

Parents and family can have a variety of other worries, some of which are of greater priority than adherence to therapy. Unless these priorities are appreciated, attention to physiotherapy and occupational therapy may be difficult for parents to manage (Fox 1975). There are family strengths that support parents and child. Nevertheless, it is important that other team members provide information on schools, playgroups, parent support groups, special organisations, respite childcare, counselling, and how to obtain housing and important financial advice for parents who want this. MacKean et al. (2005) found that many parents do not want the burden of making all the decisions themselves. Parents wanted to be working with a trusted and knowledgeable professional who could help them sort through the complexities of important decisions they have to make on these and other matters. Sometimes decision-making is overwhelming for parents. These worries, as well as coping with periods of crisis, need to be referred to psychologists, social workers, doctors, or specialised nurses. Should social services not be available, therapists may need to have available a database of local organisations and agencies in the community.

Parents' health

Parents can become both physically and emotionally exhausted with caring for their child with cerebral palsy as well as caring for the rest of the family. Their child frequently has sleep problems, or may need special feeds or medication at night, all of which impinge on parents' health. They also have to cope with disturbance of sleep routines in the child's siblings due to the child with sleep problems. Besides the suggestions given above, physiotherapists are well trained to advise parents on where to learn relaxation methods and to care for their backs and for their general physical health. Improved physical health helps mental health and vice versa. Mindfulness is an approach that enables peace of mind and self-care (Wax 2013; Rezak 2015). In Britain there are manual handling courses for therapists and nurses, which give practical ideas that can be selected and taught to parents and carers. See also Chapter 13 for information on equipment.

Teamwork with parents

The example of the collaborative learning approach can be carried out best with the therapist, sometimes together with another team member, as the key person or primary interventionist. This has the advantage of developing an ongoing relationship between therapist and child along with the child's parents and other members of the family. Parents find that visits from one professional are more desirable than from a stream of experts. They remain reassured that various experts are in support of their own primary interventionist. One person can coordinate the habilitation programme and avoid contradictory advice from different sources. This is particularly helpful in community work.

The key person, who may not be a therapist but of another discipline, will be designated by a team of professionals who will be supportive with their assessments and selection of ideas to suit the aims of parents and child. The key person will learn from the team when specialised assessments and advice are necessary and when any specialised 'hands-on' sessions are indicated. This applies to any other key worker designated by a team, who is also compatible with parents and child. A keyworker will judge the frequency of home visits so that dependency is not generated by them (McConachie 1986).

This type of teamwork is called the *transdisciplinary* model. There can also be an *interdisciplinary* model in which collaboration with parents can take place between each professional such as physiotherapist, occupational therapist, speech therapist, and teacher. Each professional will integrate the ideas of the others into her sessions with child and parents. When professionals work as a multidisciplinary team, such integration is rarely attempted as each professional carries out his or her own assessments and therapy or teaching sessions in the area of his or her discipline.

There is such a wide variety of professionals who can offer their expertise. But first each professional needs to understand what the parents' and family's needs are, how well they are coping on their own, and where the professional's expertise can truly be family centred. A support team may consist of medical consultants in paediatrics, neurology, ophthalmology, orthopaedics, audiology, and psychiatry who can inform psychologists, physiotherapists, occupational therapists, speech and language therapists, teachers, nurses, and social workers. Excellent progress has nevertheless been made by children with a much smaller and well-integrated community or centre's team including their parents and other family members, provided the whole child is considered. Liaison can be made with relevant specialists and agencies by a key worker or primary interventionist as well as by the team, depending on the needs of the child and family.

Effective teamwork does not consist of separate assessments and isolated specialised treatments of specific disabilities by each team member as if they equal the 'whole' child. Although specialised work is important, attention must be given to the interplay that exists between all functional areas of a child. Assets in one function may be used to develop another different and inadequate ability. For example, speech may reinforce movement, motor activities stimulate speech, and words and movement assist the training of perception and perceptual motor programmes, which in turn develop understanding and language. Interplay between apparently different developmental aspects is outlined in a book on therapy for parents and carers of children with multiple disabilities (Levitt 1994).

An integrated approach

In both the transdisciplinary model and the interdisciplinary model, or combinations of both, professionals need to carefully

learn the following in order to share this with individual children and all those involved with their care. Therefore, this may be either through one or two key workers or directly by each professional as part of their own programme.

1. Which postures and movements, including patterns of locomotion, to encourage so that a child develops them through practice in all environments?
2. Which undesirable motor and other behaviours to discourage?
3. Which positions make it easier for a child to see, hear, move, and communicate?
4. How to prevent and correct deformities?
5. Which sensory, perceptual, and cognitive experiences to encourage?
6. Which aids, special furniture, equipment, or orthoses to use to facilitate a child's function?
7. How to lift and carry a child so that there is participation in overcoming neuromotor difficulties and how this is done to protect the backs of the adults?
8. Which toys, playthings, and recreational activities are specially recommended?
9. Which augmentative or alternative methods of communication to use in a child who needs them?
10. All these aspects are managed in both anticipatory guidance and ongoing guidance based on a therapist's knowledge and experience.

All specialised information for the individual child is interwoven by a team of collaborative adults so that a whole programme is shared with parents and child. In Chapter 12, such collaboration is outlined when a child is in a peer group.

Teamwork is facilitated in many ways. For example:

- Staff conferences in small or large meetings.
- Staff meetings may or may not include parents, depending on the agenda and parents' availability.
- Informal discussions with team members, including parents.
- Visits to one another's workplace.
- Combined sessions with different therapists, with teachers, with health visitors, or with social workers.
- Assessment by a number of professionals together with parents can be arranged using a one-way window so that the key person and child are alone together in a room. A parent may be in the room or watching with other professionals to learn about their child's actions and behaviour. Parents can then talk easily as they are not in front of their child and their comments add to everyone's insight. It is important to know whether a child's behaviour with professionals is typical or different from that at home.

Siblings

Although a therapist is busy with a child, they need to acknowledge the feelings of the child's siblings as well. Their normal rivalries are difficult to handle, especially when their brother or sister with disabilities receives so much extra attention. It is wise not to shoulder them with responsibilities for any treatment of their sibling. Although they may respond to their mother's need 'for an extra pair of hands', this should not be overdone. Brothers and sisters may respond to play activities that are therapeutic for the child with disabilities. They may invent their own games together (Levitt 1994) (Fig. 2.8).

Simeonsson and McHale (1981) found many individual reactions in siblings that may be positive in many respects, especially if they are not overburdened and are given their own lives to lead as well. Craft et al. (1990) discuss an education programme for siblings of children with disabilities.

Figure 2.8. Therapeutic actions within play between siblings.

Review of practical points

As the collaborative learning approach may be new to some therapists or if a therapist feels it is not going well, reflection on some of the following points can be helpful.

- Acknowledgment of parents' assets has been adequate. Quality of relationship is promoted.
- Clarify whether parents' wishes are the same or have changed.
- Clarify if other parental worries are more pressing than working on what they need to do for their desired achievements. Refer to other professionals or organisations skilled in handling specific parental concerns or crises.
- Check whether physiotherapy and occupational therapy information or methods are currently overwhelming for parents or carers, so needing repetition or modification. Pace of learning differs in individual people.
- Make sure that emphasis has been on the therapeutic input contained in everyday tasks that are familiar to parents and families.
- Discuss whether the therapy programmes given make parents feel they have too much to do or do not have additional help at home to manage any programme.

Alternative and complementary treatments

Parents may wish to mention an interest in or need to obtain alternative and complementary treatments, and therapists need to respect their needs and inform themselves about what is to be carried out on the people for whom they are responsible. It is important to make clear that such treatments are no more able to cure cerebral palsy than traditional methods in Western medicine and therapies. However, parents of children with cerebral palsy and older people with cerebral palsy report improvements and a sense of well-being following such treatments. Therapists need to continue to hear what is being done for those people for whom they are responsible. They should show understanding about the need of parents and other individuals to 'do all they can' to help their child. The therapists' compassionate interest encourages parents and others to share what they need to explore so that discussion can take place. The theories underlying complementary medicine are very different from those underlying Western clinical medicine. There is always an extensive history and far-reaching information on the 'whole' person, including the individual's preferences for colours, odours, weather, and seasons, as well as the person's fears and dislikes.

Physiotherapists or occupational therapists need to observe any undesirable effects on an individual with cerebral palsy following alternative treatments and give an opinion on what they observe. They should draw on their knowledge and experience to say what they consider may be inadvisable for the child and the parents.

There are no research studies giving any evidence on the effects of alternative treatments in the field of cerebral palsy (Novak et al. 2013). Nevertheless, some positive effects due to relaxation associated with

many treatments as well as a patient's strong beliefs do provide additional support for parents and some individuals with cerebral palsy. Some complementary therapies are briefly outlined for information (Hurvitz et al. 2003).

Acupuncture. This is conventionally used for pain, though other benefits are also claimed. The technique involves partial insertion of a fine needle into the skin or the use of pressure (acupressure) using fingertips.

Homeopathy. A minute dose of a well-diluted preparation (similar to that which causes the condition) is given to the patient. The patient's body is believed to heal itself by responding to this increase in the condition. The homeopath advises how long the healing process will take. Homeopathy is definitely not recommended by the National Institute for Health and Care Excellence guidelines (NICE 2012).

Herbalism. Medicinal properties of herbs are claimed and used, often being gentle in action. The dosage is dependent on the age of the patient. Like homeopathy, it aims to 'restore the healthy balance of the body and use its self-healing powers'. Herbal remedies are used for common health problems in all children such as cold, cough, catarrh, or sore throat as well as sleeplessness.

Cranial osteopathy. A qualified practitioner gently massages or moves the bones and skin of a child's skull. It is believed that this affects the brain function and improves relaxation throughout the body, although this does not cure the cerebral palsy. There is no evidence for this treatment (Wyatt et al. 2011).

Reflexology. The soles of a person's feet are massaged, which is found to be relaxing and appears to increase circulation in relatively immobile children. Pain and spasm are said to decrease in the limbs and body. It is claimed that areas of the sole relate to organs in the body so that reflexology improves their function. Therefore, constipation, congestion, and dispersal of toxins in the body can also be treated.

Aromatherapy. Aromatic oils from plants and flowers and other substances are used and believed to have a variety of healing effects in conjunction with body and limb massage. Massage increases relaxation and improves circulation as well as helping to draw a child's attention to different body parts in a gentle and pleasant way.

Massage without aromatic oils is used in baby massage, which creates relaxation in both mother and child and helps mother–child bonding. The sensations of touch and smell are developed in a pleasant way for a young child.

Shiatsu massage does not use oils but massages certain 'meridians' beneath the surface of the skin, which is believed to contribute in the healing of a number of ailments.

Hyperbaric oxygen therapy. This treatment involves a child breathing pure oxygen in a special helmet while in a pressure chamber containing compressed air typically at a pressure of 1.75 times atmospheric pressure. The treatment is for a period of 1 hour either daily or between 5 and 12 sessions a week. Many risks have been reported, particularly for hearing and vision, as well as damage to the lungs, which cannot be dismissed. Although research studies have been carried out, they are not known by those using anecdotal viewpoints (Collet et al. 2001; Hardy et al. 2002). Rosenbaum and Rosenbloom (2012) report research firmly asserting that hyperbaric oxygen therapy does not work.

Contraindications

Qualified practitioners must be used. A parent should not carry out any of the procedures from a lay person's guide. A therapist

needs to have information from the practitioner as to what procedures will be used.

Any alternative treatment should not replace the drugs essential for controlling epilepsy. If this is attempted then there needs to be discussion with a child's medical consultant so that any drug is not suddenly stopped and parents are educated about the epilepsy.

Massage needs to be gentle and carried out by a qualified practitioner. A child may be hyperactive if the soles of his or her feet are touched or the palms of his or her hands receive pressure. Hypertonic muscles, especially those with spasticity, may be hyperactive or hypersensitive to touch and pressure. Massage is preferably applied to the antagonists as mothers in various cultures feel they want to do this.

Parents and child may spend a great deal of energy and time as well as expense in visiting practitioners of alternative and complementary medicine. We understand that some treatment regimes create demanding schedules that dominate parents' lives. This can result in fatigue or exhaustion and can lead to neglect of the needs of siblings and perhaps relationships between partners and the wider family. As with any therapy programme, parents need to avoid overwhelming themselves with too much to do.

When some parents wish to explore alternative therapies outside their service, they are entitled to do what they feel is best for their child. This can cause conflict in professional responsibilities as to which treatment is being effective and who is responsible for injury or deterioration. Parents who explore other ideas are given a channel of communication should they wish to return.

Summary

A collaborative learning approach involves a therapist in a joint venture with a child and his or her parents, or directly with older individuals with cerebral palsy. It can be used with other family members, carers, and with colleagues in a team. It is a radical departure from the traditional model in which a therapist takes full responsibility for assessments, treatment plans, use of methods, and evaluation, or takes responsibility for a few of these aspects. Instead, all aspects are shared with parents and a child who can understand this. Their culture and values can also be directly learned from them.

This collaborative approach has similarities to family-centred approaches and thus welcomes the increase in family-centred teams. The difference, however, may be that there is inadequate emphasis on an approach being a *learning approach* that includes learning not only to change a child or older person's motor function and daily life activities but also to change attitudes, feelings, as well as behaviour by all involved in the process of therapy. Collaborative learning in small interactive groups enables professionals and parents to change.

Emotional aspects are outlined in relation to parent–child interactions (Fig. 2.9), as well as therapist–child and therapist–parent interactions. The education and other needs of parents and their priorities are given attention as well as care for their health. Therapists also deserve support in their own groups and teams. The collaborative learning model enables a therapist to develop both professionally and personally and to learn to knit together ideas from counselling, communication skills, and the study of human relationships.

> Therapists and doctors often feel that they must advise parents and disabled people 'to be realistic'. This is not necessary if the child and his parents are directly involved with their assessments and selection and use of therapy methods and equipment. In this process of rehabilitation they come to see for themselves the discrepancy between what

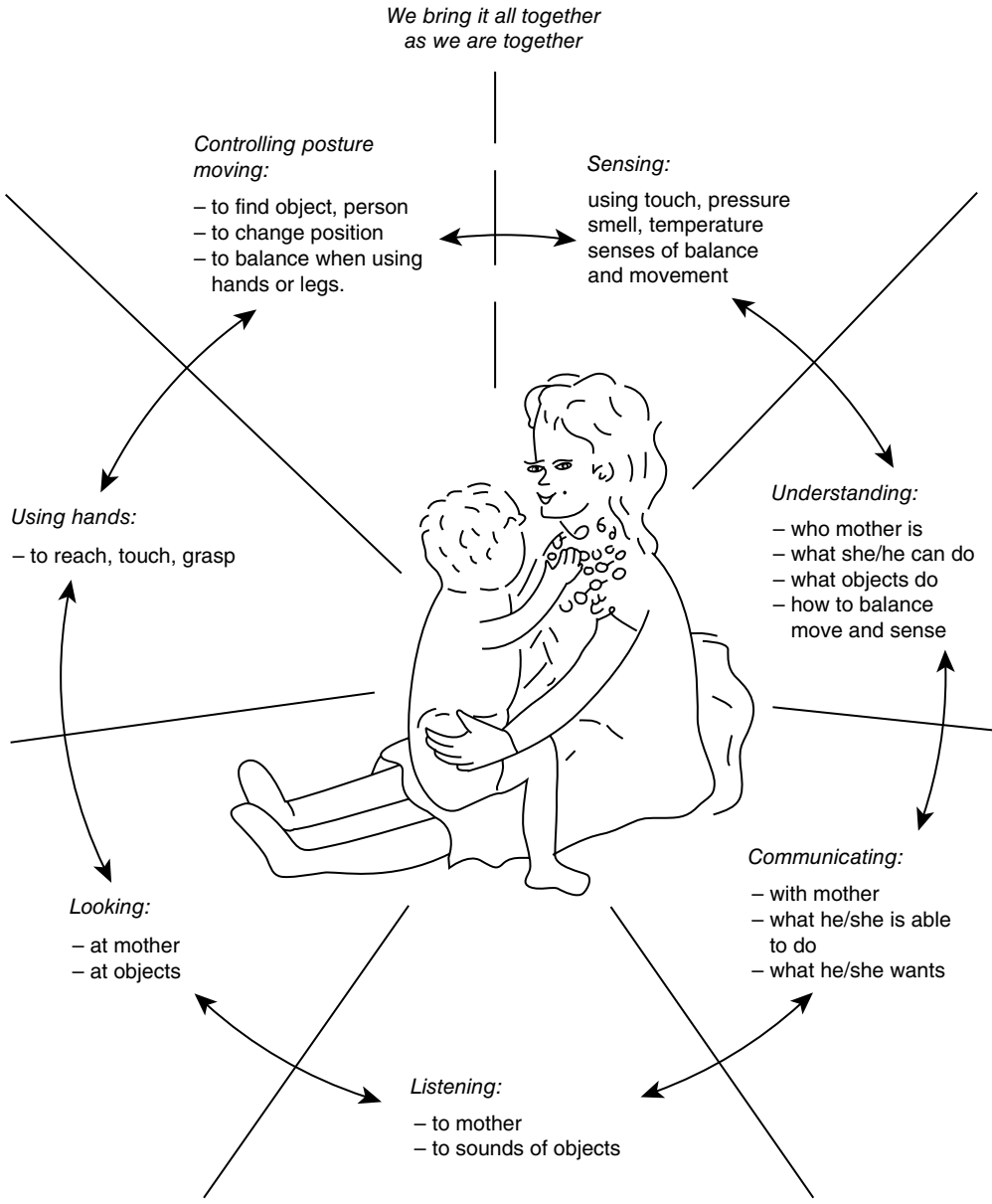

Figure 2.9. Collaborative learning in an integrated approach. (Reproduced from Levitt 1994.)

> their aims are and what their child is able to achieve. The therapist is there to support them and counter despair. (Levitt and Goldschmied 1990)

Parents who participate in physical therapy for their children with disabilities develop 'a more realistic view of their child's potential in terms of daily functioning' (Jansen et al. 2003).

Brazelton (1976) suggested that: 'the success of any intervention programme should be measured not only by the child's development but by increased family comfort, decrease in the divorce

rate, lower incidence of behaviour problems in siblings ….'

The qualitative research by Allard et al. (2014) with a broad range of neurodisability conditions found that 'health outcomes highlighted most frequently by children, young people and parents were: communication, mobility, pain, self-care, temperament, interpersonal relationships and interactions, community and social life, emotional well-being, and gaining independence.' In addition, parents revealed that they particularly valued sleep, toileting, and safety.

3

Learning motor function

Physiotherapists have been treating impairment of motor control separately, drawing on one or more neurological and orthopaedic approaches. Studies and clinical experience have shown that activation of muscles and decreasing stiffness of muscles, soft tissues, and joints improve the motor apparatus but do not necessarily promote everyday motor functions (Goldkamp 1984; Gordon 1987; Mulder and Hulstijn 1988; Mulder and Hochstenbach 2002). Achievement of motor control in a clinic (or research laboratory) does not necessarily carry over into daily life. Carry over depends on motor learning.

In Chapter 2, a collaborative learning model shows how therapy programmes relevant to the daily lives of parents and people with cerebral palsy can be jointly created involving therapist, child, and parents in a learning process (Levitt and Goldschmied 1990). This approach translates technical knowledge into what has meaning for them in our culture (Levitt 1991a, 1994) and in other cultures (Levitt 1991b, 1999). This chapter focuses more on children's learning.

What are the goals of a child that involve learning?

- A child with cerebral palsy *learns* activities such as sitting, standing, changing postures, using hands, playing with toys, and the various forms of locomotion.
- A child *learns how* to use equipment such as walking aids, wheelchairs, adapted tricycles, switch-operated toys, and digital assistive technology.
- A child *learns to* achieve activities such as self-care, play, hobbies, and sports.
- All these learning experiences enable a child to participate in daily life.

Sometimes an adult first explains in reassuring ways what a child is going to do and how to do it, keeping attention on these aspects. However, the collaborative learning approach first discovers a child's own goals, that is, what a child wants to achieve and what a child already knows and can do. There is then no need for explanations, but rather to observe how that child goes about trying to achieve a desired goal. A child's strategies may not be efficient, and thus need the therapist's intervention.

Treatment of Cerebral Palsy and Motor Delay, Sixth Edition. Sophie Levitt and Anne Addison.
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Learning methods

Many experienced paediatric physiotherapists and occupational therapists intuitively select training methods that suit an individual's learning style. This art and common sense of therapists can be supported by the knowledge and research presented by experts in the behavioural sciences. It is of much value to learn from such experts so that a therapist comes to understand more deeply and analytically what they are already doing so that they can be more precise in the way they work. This also allows therapists to further develop their practice. Carr and Shepherd (2003), Shumway-Cook and Woollacott (2017), and Mandich et al. (2008) quote research that supports practice. Bar-Haim et al. (2010) carried out a randomised controlled trial to research 'the effectiveness of motor learning coaching in children with cerebral palsy'. Children in the Gross Motor Function Classification System (GMFCS) levels II and III and aged 5½–12 years were given 3 months of either motor learning or neurodevelopmental treatment (NDT). Outcome measures were the 66-item Gross Motor Function Measure (GMFM-66) and parent questionnaires. Both motor learning and NDT gave improvement but only the motor learning group retained all of the gain over the next 6 months. Children in level II who received NDT lost much of the gain. (See Chapter 1 for GMFCS levels which are not relevant for children under 2 years (Gorter et al. 2009).)

Learning methods are also developed through interaction of paediatric physiotherapists with occupational therapists, teachers, and other professionals. Child psychologists experienced in child development and disabilities give therapists many ideas about learning. These ideas need to be adapted for learning motor function and activities of daily life. Community therapists interested in learning in different environments have found home, playgroup, school, and community visits enlightening and have adapted their programmes.

Key learning suggestions

There are tasks a child wants to or needs to achieve. Children are offered tasks that they can just manage to achieve (the 'just right challenge').

- When training a function, gradually give less manual support, less guidance, and less supervision. Use orthoses or equipment for one part of the body so that another can function, and decrease use when a child's abilities develop (Fig. 3.1).
- Positioning for function is used with equipment, special furniture, or handling by a therapist.
- Therapists understand and feel that mistakes are learning tools, so they do not show disapproval or disappointment when a child does not manage a task. They also wait calmly when individual children want to 'try again and again' and find their own way of achieving a task.

Figure 3.1. Child in standing frame with upper support released.

- Therapists offer information for achievement of tasks or for improving them, but while doing so avoid conveying assumptions of inadequacy by a child or disapproval of a child's own atypical efforts. Otherwise a child can be discouraged and feel a failure. This can increase what might be a 'normal' anxiety about an unfamiliar task.
- The therapist gives information for initial or better performance through 'hands-on' procedures, or other methods given in this chapter and Chapter 9. There are methods to manage fears of falling in procedures given in Chapter 9.
- Therapists share each child's success and pleasure of achievement with smiles, looking approvingly at their actions, and especially commenting on what was *specifically* achieved ('How well you stood up tall', 'You reached for that toy really well). However, overenthusiasm on children's achievement may well make children feel that only success pleases adults and earns approval. Children's mental and emotional energy is then wasted on fear of failing to please adults helping them. We therapists need to reflect on how our responses to the 'failure' or achievement by a child will be sensitive to a child's need to be accepted and valued as a person.
- Learning depends on active movement and/or postural control initiated by a child as much as possible.
- Children need many repetitions of therapy methods for learning.
- Special treatment sessions are important to minimise impairments but need to be used simultaneously within functional therapy sessions whenever possible.
- These tasks need to be interesting and enjoyable for children as well as challenging at their levels. The selected task includes developmental levels of understanding, perception, and motor function.

All these suggestions facilitate and depend on the positive relationship of a therapist with a child. In the security of this relationship, there is trust that assists a child to cope with the tasks. The trust is by a therapist for each child's developmental potential and trust by each child for a therapist's emotional support and discovery of their successes.

A behaviour

This is a term used by psychologists and teachers to convey any action of children that can be observed. When behaviours are troublesome for therapists and parents – in that the child refuses to cooperate or dislikes handling or having splints applied – these are discussed with team members. A clear description of what an individual child does, when he or she does it, and people's response to the behaviour is discussed so that a constructive approach can be worked out.

The behaviours that are more directly the concern of therapists are minimising impairments and promoting motor functions and activities of daily living. A description of what a child does with the criteria for success of an activity is called a *behavioural objective* or 'setting a goal' with a child and carer for therapy or training. For example, 'Sitting on a potty for one minute independently without extending backward or falling to the right' (Bower and McLellan 1992). This gives the activity, how it is done, and for how long. However, we need to make sure a child is motivated to learn an activity that is needed as well as an activity each child wants to achieve. We also need to go further than setting a goal and clarify the carer's or therapist's response to a child's efforts and achievement as is done with other behaviours. The adult's response will affect a child's learning of any function or daily task. It is essential to have careful planning of a therapy session, appropriate cues to guide children, and to make sure

that they understand what is expected of them. This promotes their collaborative behaviour.

Emotions and learning

There may be feelings of discomfort or distress in a child when a change in that child's familiar motor behaviour is expected by a therapist. The responses of children when confronted by new tasks may be fear, frustration, and anxiety. These emotions in such situations have been interpreted as fear of the unfamiliar and self-protection against failure or from past experiences of failure. This is understandable caution and hesitation about change. On the other hand, many therapists know that, by using specific play activities, most children may be motivated to try new motor skills and derive pleasure in positive achievement. However, there are children who even find a new toy or novel play activity too unfamiliar and hesitate to act. This is especially so when a child prefers not to use a part of their body for play that previously resulted in failure and frustration. Children have also experienced medical language focused on their difficulties during the making of a diagnosis, during use of measures of impairment or dysfunction, and within treatments that aim to overcome their problems. Statements and words such as 'he or she can't do this', 'that's wrong', 'you're not trying', and 'stop that movement' are some examples.

Children who have no or minimal speech, especially any words to express feelings, when asked to carry out a task, may cry or scream, show anger, or withdraw. Those children who do not have speech or gestures often use their extensor spasms, involuntary movements, and total flexor posturing to show that they are upset. These strong feelings of unease are also shown for all the situations above.

The significant tasks *for adults* to manage when they are involved with a child are the following.

1. Their own protective impulses. They need to balance their wish to challenge a child to develop with a desire to protect that child against possible failure and fears.
2. Their own examination about failure. Children learn from the mistakes they make so that they can improve their function. So-called failure can be a spur to better function. Failure may also not be true failure if the task is too far beyond a child's developmental stage or too easy so he or she is not interested.
3. Their own body language and words, so that adults learn to reframe their language in a more positive style. Examples are given in Chapter 2.

Development of a child's attention and learning

The cerebral palsies may create apathy, hyperactivity, and fleeting attention in children. Besides the brain damage that causes these difficult behaviours, they may be due to some drugs, fatigue, and emotional stress of a child. Parents may find their child's demand for non-stop attention with play activities and restlessness very difficult. Their child cannot maintain concentration and play on his or her own. Parents are enabled to understand that therapy tasks need concentration for learning and therapy is not necessarily only a set of procedures during which a child 'receives treatment'. Therapy with learning tasks of interest to a child will, therefore, improve not only the motor tasks but also a child's attention span. The child's general behaviour may improve with successful experience of achievement through active learning of tasks.

When children focus their attention on a motor task, they are more likely to learn it. The therapist clarifies for them where they need to concentrate. In the first stage, children focus attention on the purpose for moving. This is an *intention* to move or the *action goal*. This may be a daily living

activity of, say, eating, washing, or dressing. The intention to move can be part of an interaction with a parent or another family member. It may be exploring an object or getting to a place where they want to be.

Once focused on a goal, the children use what are called *goal-directed movements*. Their attention is kept on the task while learning which motor actions are used to achieve this goal. Therapists need to avoid *goal confusion* by their emphasis on the *best motor pattern* rather than first maintaining attention on the goal (Gentile 1987). Once some understanding of what to do is shown by children, attention then shifts more to how to do it. In 1991, van der Weel et al. carried out a study of children with cerebral palsy that demonstrated how goal-directed movements of pronation and supination in order to bang a drum obtained better action than pronation and supination as an exercise. Since then, much occupational therapy research has focused on goal-directed 'top-down' interventions that are in keeping with the ICF; these suggest that achieving task (occupation) focused goals is best supported through the use of the task/occupation itself (Cameron et al. 2017).

Practical ideas to promote attention and learning

1. The suggestions for a child's choice of an activity and those in section 'Emotions and learning' all promote attention and learning.
2. In developmental gross motor functions, task analyses for the use of small steps so that achievement is possible at each step appeals to individual children. Successful achievement maintains attention (see section 'Task analysis').
3. Impairments are known, so their influences are managed. For example, children with limited attention due to cognitive impairment can be aroused in supported standing by standing frames.
4. Difficult and new motor tasks need to be interspersed with easier ones. Rest periods may need to be interspersed.
5. Ensure that the therapy session does not have too many activities and that priorities are chosen.
6. The time of day must be considered. A child may be better in the morning or some time after a meal or rest. Clearly, concentration of children is not enhanced if they are taken away for therapy from their favourite lesson in school or from a special hobby or play activity.
7. The length of a therapy session must relate to the child's attention span and pace of learning.
8. Avoid distractions of too many people moving around, too much noise, or non-stop television or radio during sessions. Later, *following achievement*, train the motor function in the presence of distractions by grading the degree of distractions in the child's natural environment.
9. Encourage children to look at what they are doing with an object, toy, or walking aid, and not at the therapist. This enables them to focus on what they are doing so that they learn to manage on their own.
10. Children's attention is best appreciated in terms of the developmental stages of attention, so that too much is not expected. Infants attend to more of their internal activities and to stimulation very close to them. Around the age of 6–12 months, their attention can be focused on stimuli of sight and sound further away from them. Fleeting attention in infants becomes longer in duration until they focus rigidly on one thing at a time. Later they will allow an adult to shift their attention and become more flexible in the use of their attention (Cooper et al. 1978).

11. Enjoyable activities also focus a child's attention on pleasurable body actions. Use of swings, slides, pedal karts, tricycles, and rockers, actions with musical rhythms, as well as the creative ideas devised by any therapist assist learning motor function.
12. Activities such as swimming, horse riding, sledging, and abseiling with appropriate assistance include pleasurable experiences of balance and movement in social contexts. The associated development of fitness and health provides positive feelings and develops attention spans.

A child's own strategies for a chosen goal

These may be the following (Figs 3.2a,b and 3.3):

- an approximation of the whole task
- an initiation of the task without completion
- a child's individual way of completing the task.

The therapist can then enable a child to develop or modify the task if approximation of a task is at a *lower developmental stage* of performance, *uses symptoms* of cerebral palsy, *increases deformity*, or shows *disuse* of any body part or muscle groups. Once a task is initiated by a child, the therapist assists completion.

When atypical ways of performing a task are seen, careful consideration is needed as these patterns do not always cause deformities or disuse and may be a variation of performance, much like typical variations of motor function are acceptable in individuals without physical disabilities. When a child uses immature, pathological, or biomechanically compensatory patterns that do cause deformity, block further development, or demand excessive energy, they are replaced by a therapist guiding and encouraging alternative patterns. However,

(a)

(b)

Figure 3.2. (a, b) Child finding her own strategy of getting into a car. Part (b) is more desirable as she herself corrects spastic adduction of her legs.

Figure 3.3. A child with diplegia using her own strategy in dressing. Other varieties of motor patterns are used in daily functions to prevent deformities.

the 'undesirable' motor patterns may be the only ones possible for a child to achieve independence in a particular skill. For example, there may be creeping on elbows with stiff straight legs ('mermaid crawl') or hopping forwards with bent legs and extended arms ('bunny hopping'), which enables exploration of the environment. It is unnecessary to stop a child's independent style of exploration. It is important to plan a number of other motor activities using a variety of motor patterns in the day that counteract or minimise a child's choice of stereotyped patterns. Muscle and joint deformities may result from them. Splinting, mobility equipment, and treatments may also be added. Accepting atypical motor patterns for independence in a skill depends on the age of a child, as younger children may have more potential for variety that offers different lengths and strengths of muscles and different joint ranges. A classification of severity of the physical condition, the degree of intellectual impairment, and the degree of visual disability lead to some compromise on the use of atypical motor patterns for selected motor tasks.

Task analysis

A task is broken down into smaller and smaller achievable steps so success is possible. The children's actions are at their own individual developmental levels. Children are enabled to be aware of their own achievements no matter how minimal. Children can experience initial success and overcome a feeling of 'I'll never do this!' Task analysis is also encouraging for parents and family. There is also a hopeful future that additional components and perhaps the full function will develop.

Task analyses include the following:

- Sequences of actions such as getting up from the floor through various postures, getting in and out of bed, and for self-care tasks. There is a sequence of actions in using walking aids, wheelchairs and transfers, or play equipment.
- The activation of postural mechanisms at a particular developmental stage together with patterns of voluntary movements (synergies) within a task.
- The motor action and its related sensory, perceptual, and cognitive areas. This involves observation of where a child looks and what he hears, tastes, and touches during the motor function or activity of daily life. The child is becoming aware of sensations of a function. However, sensations alone are inadequate. There needs to be development of understanding for learning.

When analysing a motor function for an individual, consider the ways a therapist can augment the residual or established abilities of sensations, perceptions, and level of a child's cognition. A child's intrinsic motivation as well as a response to a therapist's motivation play an important part within learning the task. The physiotherapist also contributes to the motor components of a task by considering how the following body functions affect the quality of motor function:

- ranges of joint motion
- muscle lengths and strength
- postural alignments including asymmetries
- deformities, both fixed and unfixed
- involuntary movements, spasms, or reflex reactions.

These aspects are discussed in Chapters 8, 9, and 11, which cover assessment and methods.

There are different viewpoints on the analyses of tasks, not only among physiotherapists and occupational therapists but also among professionals. It is therefore necessary for members of a team to share their views on a child they all know. Interdisciplinary studies, research, and experience add to better task analyses

involving sensory, perceptual, cognitive, emotional, and motor interactions. Tasks in different environments need adaptations that influence task analyses.

Cues for learning

Cues for learning need to be clearly given in therapy. Each child will respond to different cues according to their stages of development:

- there is a child's desire, motivation (what is wanted)
- a plan (how will a child do it) (*feedforward*)
- the action (execution of the plan)
- the appraisal (did the plan work and was it followed (*feedback*)).

Cues may need to be given for the starting position, during the action, and for the final result of the action. Cues about the child's function are also *feedback*; they not only are given by a therapist but are intrinsic to the child's own experience in actively achieving any task. A child needs to detect or be informed of any errors in performance as well as the success (Schmidt and Lee 2014).

Therapists may use sensory input at the beginning, during, and end and depend on a child's cognition so that adjustments can be made or guided.

Verbal guidance with positive language is a cue to help a child learn motor control and function. Feedback by a therapist needs to be skilfully given. Winstein and Schmidt's research (1990) shows that too frequent feedback makes a learner too dependent on an instructor and dependency can be demotivating.

An approach that may be adapted for different individuals is as follows.

1. *Set the scene such that children can actively manage* what they can on their own. This means modifying the environment by having non-slip mats, place mats, appropriate toys, sturdy furniture, and equipment according to the child's size and providing adequate light and colour to encourage achievement. Placing toys or objects in different areas activates and provides success in the training of activities.
2. *A therapist's hands can physically guide* a child through a whole task to demonstrate what is to be done and how to do it. The therapist must then immediately remove his or her hands at any time that a child takes over this action from the therapist. This may be at the beginning, middle, or in finishing the task.
3. *A therapist gives minimal support* to a child's body, shoulders, or hips so that a task can be actively attempted and practised by a child. They may use equipment to support a child, allowing active movement of the body or limbs to begin or be fully controlled (Fig. 3.4).
4. *Appropriate manual assistance or resistance* to each child's movements or stabilisation of their head, body, hips, and shoulders allows sensation of what to do and how to do it. Joint compression may also alert the child's sensory understanding of postural stabilisation. Once correct postural alignment is manually given by a therapist, the child is encouraged to actively hold the posture. Starting positions are first assisted so that a child's own action is more effective and purposeful. The therapist's appropriate manual resistance also conveys to a child which body part to move and in which direction to move it.
5. *The problem presented by too much neuromuscular handling* is that sensory input is largely provided by a therapist handling the positioning and movements of a child while the child is concentrated on a goal that he or she wants to achieve. It is perhaps not always clear in every case that such excessive sensory input can be processed, and then understood. When present, motor

(a) (b)

Figure 3.4. (a, b) Physical guidance for learning arm and hand functions.

planning created by a child enables skill to emerge and be learned.

6. *Motor learning* also involves a child's concentration on the goal and goal-directed movements and postures underlying what he or she wants to achieve. This may not be given enough attention when too much 'handling' is given. When children have severe conditions or multiple impairments, specific handling by therapists receives more emphasis. However, there needs to be careful observations of any active participation by a child that will be practised for learning.
7. *Visual feedback* can inform a child of what to do and how to keep doing that. Encourage looking at the body and the actions taking place. Mirrors may help, though the reversed image may sometimes cause difficulties. A child's observation of another child with cerebral palsy can be helpful. Observation of a therapist or a parent/carer carrying out a task that needs to be learned may also help. Observing others directly or on video can only be used for children who are able to imitate others. Thus, severe visual impairment or severe learning impairments may make this impossible. Videos of themselves may be used by some children if they are not upset by seeing that they perform actions differently from others. A child's best motor performance might be videoed for feedback. However, this is a capacity that changes when the daily environment is challenging and occasionally when a child might not be disposed to function at the best capacity.

8. *Feedback with sounds, visual displays, or vibration* can inform a child on the results of their actions. These biofeedback techniques may also be arranged to augment the most desirable motor patterns of posture and movement. However, like therapy 'exercises', they do not transfer to daily living if feedback on isolated actions is given (Mulder 1985). Babies and children with severe intellectual disability who cannot understand *cause and effect* are not able to use feedback. They have to be enabled to learn that their movement created a sound or switched on a light.

Verbal guidance

Verbal guidance consists of the therapist, and later the child, naming the steps of a task while it is being carried out. It is only possible when a child understands words. For example, when showing a child how to stand up from a chair verbalise the function by saying 'Keep your feet flat, go forward over your feet, and stand up'. Words are used with physical guidance. If active participation by the child happens give feedback with praise, 'You stood up well', or if a component can only be achieved 'You kept your feet nice and flat'.

Feedback for the achievement of a component within a task is as important as the completion of the whole task. However, a child needs to learn the component as being *within the whole task* by a therapist's physical guidance for the components that still need to be learnt. Unless well understood 'in the context' of a task, components can be less motivating.

It is usually best if minimal verbal guidance is used with young children. Sometimes an operative word like 'Step, step, step' or 'Push, push, push' can be helpful.

Comments on the results of a child's efforts may not always be necessary if there is clear recognition by that child of achievements.

Remember. Care needs to be taken that physical guidance and words do not themselves distract a child. A child with visual impairment or multiple disabilities may become attracted to a therapist's touch or speech rather than keeping their attention on the task to be learned. One needs to avoid a child becoming passive and dependent on physical guidance or a *facilitation method*. It is wise for therapists to remove their hands from the child as soon as possible.

Rewards

Children can gain intrinsic reward in their own achievement of a task. This is especially satisfying if children have chosen the particular task themselves. However, there are those who have such profound impairments that they are hampered from making a choice or, if enabled to show what they want to do, cannot physically carry this out. Despite such difficulties, if a child does achieve something, then they warrant additional rewards which are extrinsic. Many teachers recommend giving a child with profound intellectual disability a reward *immediately after* they have completed a task or even *the intention* to try to do it. Smiles and words of approval and of information may not be understood. Very basic rewards, which do not depend on language or social development, are suggested. There are many possibilities and each child is observed to discover what they prize most as satisfaction. This may be food, juice, music, or lights. A variety of tactile stimuli such as stroking, patting, cuddling, blowing on the child's face, and vibration may please them particularly. The goals for a child must be tangible so that there is awareness of being rewarded within the range of an individual's abilities. It is important to observe when a child has had too much of

the same reward and becomes bored with it. This applies to all children who enjoy the incentives of a variety of toys and play during daily tasks. We continually use our imagination to find satisfying rewards for children.

Apparent rewards of 'well done', 'good boy/girl', a hug, and other social praise should not be used indiscriminately; for example, when a child is not doing anything constructive, such as they are slumped in a chair or carrying out involuntary movements or mannerisms. This does not help learning and confuses a child as to what adults expect from them. Of course, hugs and showing pleasure in knowing a child as a person are always worthwhile.

Natural rewards of enthusiasm and delight, together with clear information on what a child has struggled to achieve or tried to initiate, are recommended. When basic rewards need to be used, these are decreased as a child with profound learning disabilities learns and retains the achievement of a motor task (Levitt 1982).

Older children and young children who can appreciate it may be given a progress chart with ticks for abilities gained, or collect stars or tokens for achievement. They are also rewarded when their friends, classmates, and their family members approve their hard work and specific achievements.

Practice and experience

In Chapter 2, the collaborative learning outlines ways of sharing the practice of a motor task with others assisting a child's development. Practice of a motor task incorporated into activities used by teachers, playgroup workers, and family members is planned with them. A motor function is also practised on its own. The stages of learning are as follows.

1. A consistent way in which postural control, postural alignment, and movements are first practised so that some ability can be initiated and developed.
2. In the therapy session, a child may have tried out various different motor patterns to accomplish a specific goal and improved on them with a therapist's suggestions. When a child's strategies were unsuccessful, alternative patterns are given by a therapist. The successful patterns discovered by a child will be practised so that they are consolidated. They may be unusual or atypical but may not deform or increase symptoms of cerebral palsy.
3. Once consistency of practice has led to abilities, these are immediately used in a variety of situations. A child is encouraged to use their motor function to explore inside and outside environments at home and school. They are provided with the opportunity to roll, crawl, or walk on different surfaces indoors and outdoors. Surfaces may be stationary at first, but moving for later motor control. This may happen when a child is supported to access the community including places for their education as well as those that provide specific motor experiences. During these visits, time and patience need to be given so that the child can use their movements and balance as they acquire sensory, perceptual, and cognitive experiences. Various play experiences with sand, water, snow, and many other materials are at first presented so that the child uses his or her motor abilities or emerging abilities in play. Control of posture, movements, and the use of hands develop further during their own spontaneous exploration.
4. It is best to develop and practise a task in a child's familiar environment. This offers them well-known clues for learning motor function. Home visits or school visits are carried out by different disciplines that are available to do so.

5. The training of the motor components of a task needs to happen at home either following or preceding their use in the whole motor task or daily living activity. In this way, training motor components is not reserved for a clinical session in one venue and use of these components in their meaningful context in another venue.

A word of caution: A child should not be made to feel that unless he or she is achieving a motor skill they will not be loved. All children need to feel loved and appreciated for the person they are, whether they are working hard or not and whether they are successfully achieving or not. There are many ways of building this attitude into relationships with a child.

Summary

Learning motor function needs to be integrated with the purpose or meaning of such motor function to a child. Consideration needs to be given to the emotional aspects of learning a motor function, as well as the ways of helping a child learn the function either on its own or within a daily activity. Consider the following:

- Developing a child's active attention.
- Discovering a child's own goals and strategies and following this lead.
- Analysing the task for learning for each child.
- Giving cues for learning performance for what a child wants to do, is going to do, how they perform, and the results of what they do.
- A child's own actions and the results of them provide the child with sensory information as well as understanding for learning a task.
- Verbal instructions are usually minimal but are useful in working with children who understand them.
- There is intrinsic reward in achieving the task itself. However, external rewards may also be incentives for individuals with severe multiple disabilities.
- Practice is necessary to develop motor function. It needs first to be consistent and then within a variety of situations. A variety of movement experiences and familiar environments helps to stimulate as well as reinforce motor learning.

4

Adolescents and adults

The aims of therapy stated in Chapter 1 remain lifelong aims. It is particularly recommended that the collaborative learning model outlined in Chapter 2 is used directly with an adolescent or adult with cerebral palsy. The priorities of their goals depend on individual choices and are more focused in the context of social, educational, and employment situations.

Adolescents differ from adults in regards to the most appropriate approaches and interventions, which will be discussed below. However, there are similarities of management and therapy between adolescents and adults.

The collaborative learning model can provide for the fundamental emotional needs for both adolescents and adults. Examples are as follows.

A sense of control, opportunities for individual choice and opportunity to use more of an individual's solution-solving skills. Collaboration promotes new strategies and an individual's innovation especially as their educational progress increases understanding.

Sensitive listening to individuals and demonstrating action on what they discuss is essential in the collaborative approach.

Confidentiality. When therapists work with adolescents and adults in a collaborative way, this involves building the quality of their relationship. Therefore opportunities arise for conversations about their anxieties, concerns, or problems. What emerges needs to be kept in confidence to maintain their trust. Counselling sessions with a qualified professional are recommended if desired by an individual. A therapist may be asked to be an advocate for an individual.

Use of the International Classification of Functioning, Disability and Health (ICF) Framework (WHO 2001). Body Function and Structure includes pain, stiffness, weakness, deformities, fitness, and respiratory problems. Activities include motor functions and self-care. Participation includes use of activities in their daily lives with family and more so with friends, with people in the community, and at work. Environment and Personal Factors need consideration.

Treatment of Cerebral Palsy and Motor Delay, Sixth Edition. Sophie Levitt and Anne Addison.
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Choice. Adolescents and adults choose which activities they will practice, and which motor skills need improving for participation in daily life. They are given responsibility to state when, how often, and where activities can be carried out. Plans and methods are jointly discussed to say when time can be found to practise an activity or exercise. Being collaborative and specific about therapy programmes avoids feelings of doubt that time for therapy is unrealistic and irrelevant in an older person's daily life.

Quality of life and health-related quality of life for well-being need to be distinguished (Dickinson et al. 2007; Livingston et al. 2007, 2011).

Learning capacity. Research on the growth and development of brain structures and neural pathways (Paus et al. 1999; Sowell et al. 2002) suggests that potential for learning continues to mature.

Studies of function in adolescents and adults

A number of studies of health and function have found a deterioration in adolescents and adults with cerebral palsy (Bottos et al. 2001; Bottos and Gericke 2003). However, many recent studies are more optimistic. McCormick et al. (2007), using the Gross Motor Function Classification System (GMFCS; Palisano et al. 1997), found that 91% of 33 children who were walking without aids (GMFCS levels I and II) at around age 12 years were still walking without aids at about age 22. They also found that 96% of 48 children who were using a wheelchair as their primary or only mode of mobility (GMFCS levels IV and V) at the age 12 years were still wheelchair users at about age 22.

Day et al. (2007) made a retrospective study of walking in 7550 adolescents and 5721 young adults. Their graphs show that children with cerebral palsy with mean age 10 years, who walked well alone (GMFCS levels I and II), had a high likelihood (77–89%) of still doing so over the next 15 years. They also found that 54% of children who walked well but needed some assistance in climbing stairs (GMFCS level II) stayed the same until age 25. Those who changed were equally likely (23%) either to decline in walking or to improve in stair climbing. Children who walked only with support or unsteadily (GMFCS level III) but did not use a wheelchair had only a small chance (11%) of losing walking (ambulation), whereas those who used a wheelchair were more likely (34%) to lose walking.

In adults with mean age 25 years, the graphs of Day et al. (2007) also show that 71–84% of those who walked well alone (GMFCS levels I and II) were still doing so over the next 15 years. The graphs also show that, of adults in GMFCS level III who did not use a wheelchair, 15% achieved stair climbing by age 40 whereas 11% lost walking by that age.

Strauss et al. (2004), in a study of 904 adults aged 60 years, found that 60% were still walking alone or with support. By age 75, 40–50% of those survivors who had walked well alone at age 60 could still walk but with a decline in skill. They also frequently lost the ability to dress themselves completely. Nevertheless, other skills of speech, self-feeding, and ordering meals in public were well preserved. These research workers note that their subjects were more severely disabled than people with cerebral palsy as a whole.

Andersson and Mattsson (2001) found 79% of 77 adults with spastic diplegia had achieved walking ability with or without aids but, of these, 51% claimed that their walking ability had decreased in recent years and 9% said that they had stopped walking. The reasons reported by these adults for deterioration of walking included a decrease in muscle strength and in balance, and a worsening in their condition. The experience of adults is that either therapy services are focused on

children or they are tired of physiotherapy. They found that a specific strengthening programme showed positive results. MacPhail and Kramer (1995) also demonstrated improvement in function and walking following strength training. Butler and Darrah (2001) found that neurodevelopmental physiotherapy did not achieve long-term walking.

All these studies generally give a mostly encouraging picture, compared to past views. Prognoses for walking in older people have improved where services and physiotherapy methods together with psychological and social factors have developed for adolescents and adults. Walking may become more difficult for those who develop contractures, joint problems, and a decrease in strength, as well as in the presence of fatigue. Prognosis for walking in children is discussed in the section on 'Development of standing and walking' in Chapter 9.

Activity goals

The goals for activities are the assumption of sitting, rising to standing, standing and walking, hand use, and self-care. This book offers assessments and many practical suggestions for learning these activities independently, with assistance or with specialist equipment. Where 'a child' is given in the text, this can often be an older person with modifications for body size and weight.

Carers may also find an individual's participation useful, especially if abilities in sitting, standing, and stepping and transfers are maintained or trained. Carers may well be able to make less effort and save time. The need for two carers for people with more severe cerebral palsy may not always be necessary. A manual handling assessment together with therapist and individuals is necessary to confirm this. There are electric lifters into standers and other hoists and equipment that can be selected (see Chapter 13).

It is always important to explore the views of both carer and the individual to assess what is realistic in different situations and to assess what potential for assisted or independent function is present.

Individuals with severe motor difficulties may actively participate in their care by 'bridging' hips for dressing, rolling over, using minimal arm and hand actions, or grasping a support. Use of hands when lying in bed is naturally useful if an individual can pull up blankets or use hand grasps to get into and out of bed or to switch off an alarm clock.

Any use of a person's partial ability in a daily self-care task is emotionally helpful. Participation by an individual with disabilities, no matter how minimal, avoids passivity and a feeling of helplessness.

Motor developmental assumptions

Some professionals consider that, in older children, adolescents, and adults, only training in sitting, standing, and stepping functions is worthwhile because the individual no longer needs the child developmental sequences observed in prone or supine lying. Depending on the energy of an individual, this may be appropriate. However, the analysis of tasks needed by the older person involves the selected functional abilities observed in early child development, but they should nevertheless be age appropriate and relevant to the task desired by individuals and carers.

For all people, the ability to turn in bed, get out of and into bed, and get up to sitting or standing from lying assists activity engagement and should be enabled through compensatory approaches (including equipment) if not possible. All assisted or independent transfers involve selected elements of head control, reach and grasp, support on arms, half-roll or full roll-over, push up from lying to sitting with legs over the edge of the bed, lying change to supported upright kneeling, and then up to supported standing.

It is especially valuable to have the ability to use early postures in a transitional phase in any sequences of rising from lying to sitting or standing. An older person can draw on the early childhood series of rising observed in prone or supine developmental stages in this book. Such early childhood patterns are the easier motor patterns and therefore may be more useful for an adolescent or adult with disabilities. Naturally there will be adaptations for postural stability, postural adjustment, and changing of positions so that the developmental sequences are modified according to an individual's condition in specific environments. Generally, creeping, crawling, knee stepping, and floor sitting with and without equipment are not age appropriate.

Issues of concern for adolescents and adults

Pain. This can be due to many factors. There are changes in biomechanics causing joint and muscle pain. Excessive range of athetoid motion and dystonia can cause spondylosis of the neck or arthritic changes in joints. There may be associated secondary effects of overuse in efforts to keep dealing with daily life (Pimm 1992). Inability to change postures increases joint and muscle pains and skin pressure pains.

Pain may not receive adequate medical attention or may not be reported by the individual owing to inexperience or due to communication difficulties of cerebral palsy. This also applies to many other health problems in cerebral palsy.

Increased musculoskeletal and neuromuscular deformities due to biomechanical changes, increased stiffness, weakness, and disuse may occur as more time is being spent in sedentary academic or social activities. There is an increase in weight and height, which makes more demand on the neuromotor and musculoskeletal systems, leading to a compensatory biomechanical response that can result in deformities, pain, and fatigue. Deformities are discussed in Chapters 12 and 13.

New environments of schools, homes, and in the community offer new problems not easily overcome using familiar strategies. More help is needed due to a person's increased size. Adolescents and adults need to be educated in letting people know what assistance is appropriate for them. Therapists' communication skills need to be fine-tuned so they can let teachers, instructors, youth leaders, and others know what the physical needs of older persons might be. Unless others are informed of what assistance is necessary, persons with cerebral palsy remain at home and cannot join in community activities, as ageing parents are unlikely to have the capacity to help them do so.

Discrimination in society. Teachers and social workers and people with disabilities themselves do assist in dealing with discrimination in society. Therapists are involved in pressing for access, environmental adjustments, and other physical needs of individuals. The United Kingdom Equality Act (2010) states that all individuals regardless of any presenting disability must have access to both an appropriate education and social opportunities within the community.

Services. These may vary and a link-person is really helpful in knowing what is needed and how to obtain health, educational, and leisure opportunities. A link-person is particularly needed during a child's transition to adolescent and adult services. Transition by adolescents to adulthood is particularly challenging. Appropriate management is particularly important; though therapy needs may not be ongoing except for assessments. Assessments include state, size, and comfort of equipment, postural

management, and suitable footwear with or without orthoses. Scolioses and other spinal postures need monitoring to avoid deterioration. Therapists need to assist with treatment of pain and respiratory problems as well as with additional difficulties of family and carers. Teams for adolescents and adults with cerebral palsy are strongly recommended by many professionals, families, and the individuals themselves (Bax 2001).

Adolescents

The more specific needs of adolescents are the following.

Adolescent distancing from parents and preparation for adulthood are particularly difficult when physical independence is not fully achieved due to disabilities. Respect and personal value are especially needed by an adolescent facing the consequences of long-term disability and experiencing the biological changes of puberty at the same time. The collaboration gives them support and develops autonomy of individuals. They need to express independent views and achieve responsibility as far as possible. Parents and siblings also need support and encouragement so that their many years of help can be gradually withdrawn. Such anticipated withdrawal needs to be discussed in late childhood, around the age of 10–11 years, to begin to prepare adolescents and their parents and families for future changes.

The therapist focuses on their short-term goals and offers methods that will demonstrate success (see section 'Goal attainment scaling' in Chapter 8). The adolescent's responsibility and related success are helpful to parents so that they can feel able to withdraw their help. Successful independent achievements by adolescents promote their confidence and self-esteem. If possible, differing views of parents and siblings are not given priority over those of the adolescent, but much tact will be needed.

More severely affected individuals, who cannot make decisions or have communication problems, need parents, family members, or carers to act as proxy. Augmentative and alternative aids are helpful for those who can use them. Eye gaze or head nodding for 'yes or no' may be present for some communication.

Adolescents can show their distancing from parents by carrying out enjoyable activities in peer groups. An adult facilitator of peer group exercises, discussions, games, or other educational activities is often particularly useful. The therapist either works with groups or suggests individual functional positioning so that communication and social interactions are assisted. Self-help groups, especially for adolescents, are appreciated and help to foster some independent decision-making, which some have not experienced for many years.

An adolescent's rebelliousness and non-cooperation are provoked by a professional's or family's authoritarian communication. Negative or patronising comments must be replaced by a calm, firm manner and a sense of humour. Therapists overcome any sense of intimidation by adolescents through negotiation, concessions, and offering constructive professional knowledge without threats.

Explanations are given to educate an individual about why motor activities are necessary to minimise the effect of growth spurts, disuse, increasing weight, and immobility. Deterioration of motor functions may decrease confidence in physiotherapy. Young people need explanations such as shorter spastic muscles are bulkier and tighter as growth spurts lead to bones growing faster than muscles, causing deformities. They need to know that deterioration is not due to poor physiotherapy or primarily to their lack of practice. Information is given that muscles need to

Figure 4.1. An individual applying her own orthosis.

be lengthened and strengthened rather than use of unwitting habits of prolonged sitting in one posture for study or leisure.

Physiotherapy treatment for aches and pains needs to be offered and responsibilities for attending treatment appointments are given to those who need them. If possible, adolescents should be shown how to apply orthoses and given responsibility for doing so (Fig. 4.1). If hand function or balance does not allow independence, then the individual instructs someone in such applications. If speech is poor, then handout sheets can be prepared by the therapist with an individual. Computers enable many individuals to communicate care needs and exercises to carers. These are examples of developing autonomy in adolescents growing to be adults.

A qualitative research study with parents and young people by Allard et al. (2014) confirms some of the clinical experiences discussed in this chapter. They found there were important issues of communication, mobility, pain, self-care (including toileting), behaviour, temperament, independence, and participation in families, social life, and the community. Young people particularly valued well-being, which parents strongly supported. Parents were also concerned about safety. The study used individuals with neurodisabilities, including cerebral palsy, in different socioeconomic groups and cultures in various parts of England.

Adults

Adults with cerebral palsy are living longer than in the past (see Strauss et al. 2008 among others). A workshop in 2009 on cerebral palsy and ageing had a number of papers that are particularly helpful for therapists; see, for example, Haak et al. (2009) on general ageing in cerebral palsy and Tosi et al. (2009) on neuromuscular and musculoskeletal problems. They point out that much more research is needed for ageing in cerebral palsy. O'Brien et al. (2009) have written a chapter on ageing in cerebral palsy, and adult functioning is discussed by Rosenbaum and Rosenbloom (2012: chapter 15).

Pain. More aches and musculoskeletal pain may be experienced, which affect health-related quality of life (Opheim et al. 2011). Hodgkinson et al. (2001) found hip pain to be the main concern of non-walking adults with cerebral palsy. Hip and knee pain and osteoarthritis may be present. Atypical shoulder girdle postures, especially if pulling in a downward direction, may cause nerve traction. New health problems related to ageing, such as urinary or bowel problems, can cause severe discomfort.

Fatigue. Many are functioning and moving at their peak of performance with little rest. Locomotion is at a high physiological cost for both health and neuromotor problems. The older person is unaccustomed to working out strategies to conserve their energy. For example, the effort to speak need not accompany movement, which makes greater energy demands. Distances may be better managed with wheelchairs rather than walking so that energy is conserved for any social or other activity desired by the person. Jahnsen et al. (2003) found that adults reported significantly more physical, but not more mental, fatigue than the general population in Norway. They suggest that it is the challenges of work and daily life rather than motor impairment that create fatigue. Early loss of walking can be

attributed to the fatigue and high energy cost of having to make efforts to walk (Bottos and Gericke 2003).

Early and minor deterioration. This is often not detected by the person and increasing compensatory motor patterns are therefore used to 'keep going'. These motor patterns can cause increased deformities, stiffness, and pain, which add to the person's fatigue. Speech and swallowing problems also increase in some and they may need regular monitoring by a speech and language therapist and medical practitioner. Swallowing problems (dysphagia) are reported mainly in people with athetosis (dyskinesia/dystonia).

Urinary problems appear because either their locomotion has deteriorated and they cannot reach toilet facilities in time or there are bladder problems needing medical attention. Retention of urine is known to occur if adductor tightness has increased, and so initiation of urination is prevented. Urinary problems may also be due to ageing.

There are many older people who continue to be independent, have cognition and are in good health, and do not wish to have therapy. They do, however, need monitoring of there are atypical postures, pain, and health problems to enable them to maintain their best level of function. Some individuals may still want to re-learn or learn to walk with or without appropriate walkers. Designs of walkers and equipment have developed since the adult with cerebral palsy was much younger. This re-learning or learning may well be possible in the home and in some other environments. An individual may feel more independent, participate more in transfers, and manage to exercise with a walker rather than remain seated most of the time.

Healthy lifestyle

The health-related quality of life (HRQOL) and quality of life (QOL) for adolescents and especially ageing persons with cerebral palsy is improved in the following situations.

1. An understanding general practitioner who makes community resources available when an individual has pain, ordinary health problems, or mental health or relationship difficulties. Blaming the cerebral palsy condition is not addressing HRQOL or QOL needs of a person.
2. Communication difficulties can result in a person not conveying their needs well enough and thus not receiving health care as any other citizen would. When a person is using special communication aids and methods (including non-verbal movements and gestures), then the advocate for that person needs to educate health and social care professionals and anyone involved about the individual's preferred means of communication.
3. Adolescents and adults need to have had health education since late childhood, which is even more important in adolescence and adulthood. Growth spurts in adolescence demand more increased nutrition and energy needs. Those who have chewing and swallowing difficulties need urgent referrals to experts for safety reasons.
4. Research suggests that individuals with cerebral palsy have poorer physical fitness than the general population owing to sedentary behaviour and need different episodes of physical activity (Verschuren et al. 2014). Attention to nutrition, weight control, keeping fit, and positive mental attitudes or stress management improves lifestyles. The strength training studies with references above contribute much to physical and mental health. Exercising on stationary bicycles, rowing machines, or treadmills as well as sports are useful for keeping fit (Fig. 4.2) (see section 'Therapeutic activities'). The person with disabilities needs supervision by a therapist in case

Figure 4.2. Keeping fit with bowling and other motor activities. A hinged ankle–foot orthosis is worn on his right leg, allowing ankle motion.

deformities are threatened by the efforts of individuals. Pimm (1992) has drawn attention to physiological burnout in adults who try to maintain their motor levels in the presence of deterioration of strength and energy. Darrah et al. (1999) positively evaluated a community fitness programme for adolescents and Taylor et al. (2004a) found benefits from progressive strength training for adults in a community gymnasium. Dodd et al. (2002) in a systematic review and in their subsequent research (Dodd et al. 2003) demonstrated increased strength, which improved activity in adults and young people. A more recent systematic review by Reedman et al. (2017) has demonstrated that both therapeutic and behaviour change interventions have the potential to increase participation in leisure-based physical activity for young people and adolescents with cerebral palsy. Swimming as well as exercise is recommended by therapists for aerobic capacity and fitness, which may prevent fatigue. Even though evidence from randomised controlled trials has suggested that the increased aerobic activity obtained directly after interventions is short lived and not maintained at follow-up (Verschuren et al. 2007; Van Wely et al. 2014), engagement in these activities with friends or family may nonetheless increase participation and lead to gains in HRQOL outcomes (Maher et al. 2016).

Respiratory problems may arise in later years due to immobility, scolioses, and lack of ordinary health care. Offer medical care, exercises, and respiratory physiotherapy.

Counselling or peer group discussions as well as health education in groups are valuable for different individuals. Others may prefer health workers or therapists in one-to-one sessions. This preference may be relevant when sexual and bodily functions are to be discussed.

Develop appropriate community mobility

In order to access social clubs, meet friends, or participate in education and work, it is essential that appropriate wheelchairs and

transport are considered. Powered wheelchairs and correct seating have improved considerably through seating clinics and technological advances. Occupational therapists often provide assessments and, together with a physiotherapist, an individual is enabled to learn the correct choice and use of a wheelchair. In severe conditions, the therapist assesses which part of the body an individual can reliably control or learn to control for using joysticks or switches to access powered mobility.

Using a wheelchair does not automatically deter a person with cerebral palsy from learning to walk with a walker, with the help of friends, carer, or independently. The energy and motivation of individuals are crucial and realistically they may often wish to walk only within the home or in school rather than in the community. The distance, roughness or smoothness of the ground, and weather determine the decision to walk outdoors. Once again, discussions with the individual and comments by family members and friends contribute to planning. The physiotherapist considers the individual's weight-bearing abilities, stepping, and adequate hand function for walkers (see section 'Development of standing and walking' in Chapter 9, and Chapters 10 and 13).

Training of self-care and cosmetic appearance

This is discussed in Chapter 10 on function in daily life. Therapists also need to respect a person's own strategies, especially when deformities are unlikely to result from such strategies (Fig. 4.3).

Age-appropriate activities such as hairdressing, haircuts, cosmetics, clothes, and the interests of any typical adolescent and adult are important parts of the programme. An interest in one's appearance has motivated some adolescents to practise good posture and keep-fit exercises.

Figure 4.3. An individual using his own strategies for independence in fastening sleeve buttons. No resultant deformities.

Sadness about appearance due to cerebral palsy is not uncommon. Counselling or mindfulness training (Wax 2013; Rezak 2015) can be helpful. Therapists and family need to emphasise all assets of a person with disabilities. Skills with a hobby such as bird watching, photography, playing games consoles, or other interests of the person as well as emphasis and development of an individual's social assets increase self-confidence.

Knowledge about the condition

Assist individuals to learn all they want to know about their specific condition. This is implicit in the collaborative learning model. If parents have already received this information over the years, they may have conveyed this to their child or adolescent. However, this needs additional education

from a professional who explains aspects in a different style for adolescents and adults. In addition, adolescents who are feeling anxious or depressed may not have absorbed medical information. They are more 'grown-up' and need direct education for themselves and answers to their own questions.

Sex education is very important and there are organisations and groups that offer information in this area.

Therapeutic activities

There are an increasing number of activities for people with all levels of disabilities. They not only keep an individual fit but also maintain motor abilities and opportunities for treating deformities. Swimming is particularly enjoyable and useful for maintaining ranges of motion as it includes stretches. There are a number of clubs promoting horse-riding for people with disabilities, which helps individuals in maintaining balance, abduction, and use of hand grasp (see section 'Adjuncts to therapy' in Chapter 5). Sailing, angling, skiing, and abseiling are some of the many activities which are beneficial. In the UK, there are adventure holidays and imaginative activities designed for people with disabilities. Social skills and friendships develop in the clubs, which often have both the able-bodied and people with disabilities. All recreational, sports, and other activities can to be shared with friends in visits to gyms and leisure centres.

Measures

Goal attainment scaling (GAS) is an individual practical measure for planning and assessments (see Chapter 8 for GAS and other measures).

Reports by the individuals themselves are important. Older individuals report well on the decrease in falls, increase in any daily function, distance walked, wheelchair control, and bed mobility and transfers.

In their research, Shumway-Cook and Woollacott (2017) use a number of measures for adults with motor problems that can be selected by clinicians for adolescents and adults.

Summary

The collaborative learning approach is used directly with adolescents or adults. Many adolescent needs are different from those of children and adults but some are similar. Concerns of adolescents and adults are discussed. The choices of adolescents and adults result in the following main roles for therapists.

Roles of the physiotherapist and occupational therapist

- To train and maintain the ability to carry out functional activities in case they have been lost by disuse.
- To prevent and decrease pain, deformities, and fatigue wherever possible.
- To learn a healthy lifestyle, including physical fitness.
- To develop or maintain appropriate community mobility.
- To assess equipment including alternative and augmentative aids.
- To consider environmental restrictions and use collaborative solutions for home, school, work place, and community.
- To develop responsibility from early adolescence to adulthood.
- To enable individuals to learn about their current condition, procedures, likely prognoses, and ongoing research.

5

Outline of treatment approaches

History

There have been many systems of treatment for cerebral palsy (Levitt 1962, 1976, 1987; Scrutton 1984; McKinlay 1989). Various motor learning approaches have added to the neurophysiological and orthopaedic systems (Shumway-Cook and Woollacott 2017). This chapter presents the essence of each system after Levitt's many personal observations, discussions, practical work, and reading of the work of the originators. Ideas and methods from previous systems continue to be used by clinicians but different terminologies and more sophisticated applications are used, and are mentioned in this chapter. Mantovani and Scrutton (2014) present a longer historical perspective on the medical aspects and treatments of cerebral palsy.

In Chapter 6, evidence-based practice is presented as this developed some time after the original work of the past.

Muscle education and braces

W.M. Phelps, an orthopaedic surgeon in Baltimore, USA, was one of the pioneers in the treatment of cerebral palsy who encouraged physiotherapists, occupational therapists, and speech therapists to form themselves into cerebral palsy habilitation teams (Phelps 1949, 1952; Slominski 1984). The main points in his treatment approach were as follows.

Specific diagnostic classification. Each child's type of cerebral palsy was a basis for specific treatment methods. Phelps diagnosed five types and many subclassifications.

Fifteen modalities were described and specific combinations of them were used for the specific type of cerebral palsy.

The modalities (methods) are well known by physiotherapists, and most of them are still used today. These are: massage and passive, active, and resisted movements. Damiano (2007) refers to Phelps when she confirms the value of resisted motion for strengthening, which is based on her research (Damiano et al. 1995a,b, 2002a).

Additional modalities used in treatments were as follows.

- *Conditioned motion* was recommended for babies, young children, and children with cognitive impairment. This was the

Treatment of Cerebral Palsy and Motor Delay, Sixth Edition. Sophie Levitt and Anne Addison.
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use of the same song or jingle for the same movement so that children were 'conditioned to move' to the song. Today familiar songs are used for enjoyment of exercises for individuals and in group work.

- *Confused motion* or synergistic motion. This involves resistance to a muscle group in order to contract an inactive muscle group in the same synergy. For example, the activating of the hip–knee flexion–dorsiflexion synergy to stimulate inactive dorsiflexors with or without giving resistance to hip flexors. Damiano (2007) recognised the difficulties of poor isolation of muscle control (selective motor control) in some children with spasticity. Therapists now assess and train selective motion of a particular muscle group as part of motor development. However, mass movement synergies may be the only way severely affected children in Gross Motor Function Classification System (GMFCS) levels IV and V can activate specific muscles to manage deformity. (See Chapter 8 for selective motor control assessments.)
- *Combined motion* was training motion of more than one joint, such as a shoulder and elbow flexion as a component for upper limb function. Today more variety is emphasised, such as shoulder flexion with elbow extension combined with use of hands.
- *Relaxation techniques* used were those of conscious 'letting go' of the body and its parts as well as tensing and relaxing parts of the body (Levitt 1962). These methods were mainly used for children diagnosed as athetoid. Use of active tense-and-relax aimed to minimise grimacing and other involuntary motion. However, there was poor carryover of relaxation for these symptoms, so these methods were abandoned. Today relaxation methods may be used for stress or anxiety.
- *Movement from relaxation* is conscious control of movements once relaxation has been achieved. It was mainly used for children to control involuntary movements but this was not functional. People with dyskinesia can find their own functional strategies.
- *Rest*. Periods of rest are suggested for children with all types of cerebral palsy.
- *Reciprocation*. Reciprocal movement was trained in supine lying, crawling, knee-walking, and walking with and without walking aids/parallel bars.
- *Balance*. This was trained in sitting, kneeling, and standing with and without braces (calipers).
- *Reach, reach and grasp, and release* was used for training of hand function.
- *Skills of daily living* such as feeding, dressing, washing, and toileting. Many aids were devised by the occupational therapists; some remain but in much better designs.

The sequence of training reciprocal movement and balance was based on body mechanics, without reference to motor development. However, the small part of hand function development lacked detail and the full sequence.

Braces or calipers. These appliances were designed and developed by Phelps. He prescribed special braces to correct deformity, to obtain the upright position, and to control athetosis. The bracing was extensive and worn for many years. The children were taught supported standing and stepping in long leg braces with pelvic bands and back supports or sometimes a spinal brace. As children progressed, the back supports were removed, then the pelvic band, and finally they used below-knee braces. The full-length brace had locking joints at the hip and knee, so control could be taught with them, locked or unlocked. Currently, better designed, lighter orthoses have been developed.

Muscle education. Children with spasticity were given muscle education based on whether muscles are spastic, weak, normal, or *zero cerebral, i.e. being unable to act*. Muscles antagonistic to spastic muscles were activated to correct muscle imbalance. This is sometimes used today. Children diagnosed as athetoid were trained to control simple joint motion without muscle education. Children diagnosed as ataxic were given strengthening exercises for weak muscles.

Later others, including Rood (1962) and Tardieu et al. (1982), also developed ideas on muscle education. Plum and Molhave (1956) advocated strengthening spastic muscles as well as their antagonists. However, they exercised the spastic muscles in their outer ranges as the muscles are usually shortened, whereas the antagonists are exercised in their middle and inner ranges.

Tardieu et al. (1982) and Dietz (1992) have shown specific changes in muscle length (*hypoextensibility*) of spastic muscles and also changes in the muscle structures which are mentioned in Chapter 1. Research by Tardieu et al. (1988) suggests prolonged passive stretch for 5–7 hours to obtain a change in length, and this is accepted today. Prolonged stretch was carried out in braces by Phelps, but these have now been replaced by modern orthoses. An upright standing frame was used for stretch, for weight bearing, and to prevent hip dislocation. Today improved designs of standing frames are used for weight-bearing prevention or management of hip joint problems (see Chapters 9 and 13).

Progressive pattern movements

Temple Fay, a neurosurgeon in Philadelphia, USA, recommended that children be taught motion according to its development in evolution (Fay 1954a,b). He regarded ontogenetic development (in humans) as a recapitulation of phylogenetic development (in the evolution of the species). In general, he suggested building motion from reptilian rolling to amphibian creeping, through mammalian reciprocal motion 'on all fours' to the primate erect walking. As these early movements of progression were carried out with a simple nervous system, they can similarly be carried out in the human in the absence of a normal cerebral cortex to activate dysfunctional parts of the body. Fay also described 'unlocking reflexes' that reduce hypertonus. Based on these ideas, he developed *progressive pattern movements*.

The Doman–Delacato system or the Institute for the Achievement of Human Potential (IAHP) (Doman et al. 1960), which followed the basic tenets postulated by Fay, also recommended periods of inhalation of carbon dioxide, restriction of fluid intake, development of the use of the dominant eye, hand, and foot, and other methods. Children were also hung upside down and whirled around to stimulate the vestibular apparatus. They were also asked to hang and 'walk' their hands along a horizontal ladder.

The progressive pattern movements called 'patterning therapy' were first practised passively at least five times daily. There was a rigid and inaccurate view of development that expected demanding daily regimes of treatment, amounting to 8–10 hours a day, 7 days a week in many cases.

Parents could not manage this without obtaining a number of volunteers. There was a high rate of inappropriate parental expectations with reports of excessive guilt or stress as success or failure depended on the parents working intensively. In the 1960s, the American Academy of Paediatrics, the American Academy of Neurology, and the American Academy of Physical Medicine and Rehabilitation independently stated that this approach

has no value. Liptak (2005) found that there was no scientific evidence and the theories were outdated and oversimplified. Miller (2007) reported that patterning therapy had almost disappeared in the USA.

The British Institute for Brain Injured Children (now called bibic) originally acted in conjunction with the IAHP, but now continues to function on its own in the UK.

Proprioceptive neuromuscular facilitations (PNF)

Herman Kabat, a neurophysiologist and psychiatrist in the USA, discussed various neurophysiological mechanisms that could be used in therapy. With physical therapists Margaret Knott and Dorothy Voss, he developed a system of movement facilitation techniques for the decrease of hypertonus, for strengthening, coordination, and improving joint range (Kabat et al. 1959; Knott and Voss 1968; Voss et al. 1985). The main features are the use of the following.

Movement patterns (called movement synergies) based on patterns observed within functional activities such as dressing, walking, playing tennis, golf, or football. These patterns are spiral (rotational) and diagonal with a synergy or *chain* of muscle groups. Isolated muscle education was not used as a movement pattern could activate a muscle group within a chain of muscles. The movement patterns are not 'mass movements' seen after brain damage, but are functionally derived patterns. They consist of the following simultaneously activated components in hips, knees, and feet or in shoulders, elbows, wrists, and hands:

1. flexion or extension
2. abduction or adduction
3. internal or external rotation.

Sensory (afferent) stimuli are skilfully applied to facilitate movement. Stimuli used are touch and pressure, traction and compression, stretch, and the proprioceptive effect of muscles contracting against resistance. Visual and verbal stimuli are included. All these stimuli provide clues for the direction of movement and are gradually reduced as the individual achieves the movement independently.

Resistance to motion is used to facilitate the action of the muscles that form the components of the movement patterns.

Special techniques

1. *Irradiation* is the predictable overflow of action from one muscle group to another within a synergy or movement pattern or by *reinforcement* of action of one part of the body stimulating action in another part of the body.
2. *Rhythmic* stabilizations that use stimuli alternating from the agonist to its antagonist in isometric muscle work.
3. *Stimulation of reflexes*, such as the mass flexion or extension, which are now no longer used.
4. *Repeated contractions* of one pattern using any joint as a pivot.
5. *Reversals* from one pattern to its antagonist and other reversals based on the physiological principle of successive induction.
6. *Relaxation* techniques such as contract–relax and hold–relax. Ice treatments are used for relaxation of hypertonus.
7. *Timing* in using various techniques to train coordination or timing-for-emphasis to improve an element of movement synergy.

There are various combinations of techniques depending on the individual's physical condition. The use of stretch or traction and the optimal resistance needs care on unstable joints and the level of muscle contraction.

Functional work or mat work involves the use of various methods mentioned above in

training, crawling, walking, and various balance positions of sitting, kneeling, and standing. As PNF is largely practised with adults with motor difficulties, this was adapted for children with cerebral palsy within developmental motor functions (Levitt 1969, 1970a). PNF was also criticised for focusing more on treating movement pattern in isolation from a whole function. Using PNF within developmental functions provided a better approach. Some examples are given in this book using movements against resistance so that simultaneous postural adjustment mechanisms for trunk, pelvis, and shoulder girdles are activated. Resistance is also given directly for postural stability, changing postures, and for walking. In addition, the PNF patterns and resistance were combined with ideas from the Bobaths on positioning of other body parts to minimise stimulation of spasticity (Levitt 1969). However, the Bobaths disagreed as they were against the use of manual resistance. Today, resisted postures and movements have been accepted for strengthening. Adler et al. (2008), using PNF with adults, have added principles of motor control and motor learning from the work of Mulder and Hochstenbach (2002). They also added functional activities and different positions. As individuals achieve the movements and stability, there is now 'hands-off' by the therapist, so that patients can then detect any of their mistakes in their motor patterns. These mistakes give 'feedback', allowing the individuals to learn and correct themselves as much as they are able to do.

Neuromotor development

Eirene Collis, a therapist and pioneer in cerebral palsy in the UK, stressed neuromotor development as a basis for assessment and treatment (Collis 1947; Collis et al. 1956). Her main points were as follows.

The mental capacity of the child would determine the results.

Early treatment was advocated before atypical patterns could be established.

Management. The word 'treatment' was considered misleading in that besides the physiotherapy session there should be 'management' of the child throughout the day. The feeding, dressing, toileting, and other activities of the day should be planned.

Strict developmental sequence. The children were not permitted to use motor functions beyond their level of development. If the child was, say, learning to roll, that child was not allowed to crawl, or if learning crawling was not allowed to walk. At all times the child was given a 'picture of normal movement' and, as posture and tone are interwoven, Collis placed the child in 'normal postures' in order to stimulate 'normal tone'. Once postural security was obtained, achievements could be trained in strict developmental sequences.

The cerebral palsy therapist. Collis disliked the separation of treatment into physiotherapy, occupational therapy, and speech therapy. She established the idea of the *cerebral palsy therapist*.

The developmental sequences are now much more sophisticated and less strict. The idea of a cerebral palsy therapist has some appeal in the concept of a developmental therapist or primary interventionist. Collis assumed that the worries of mothers would be helped by the treatment and by their willingness to help their child. There is deeper understanding of parents' predicaments and variety of emotions today.

Neurodevelopmental treatment (NDT) (Bobath approach)

Karl Bobath, a neuropsychiatrist, and Berta Bobath, a physiotherapist, based assessment and treatment on the premise that the

fundamental difficulty in cerebral palsy is lack of inhibition of reflex patterns of posture and movement (Bobath 1971, 1980; Bobath and Bobath 1975). The Bobaths associated these abnormal patterns with abnormal tone due to overaction of tonic reflex activity. These tonic reflexes, such as the tonic labyrinthine reflex, symmetrical tonic neck reflexes, and asymmetrical tonic neck reflexes, had to be inhibited in order to counteract 'the abnormal patterns of released postural reflex activity, and at the same time facilitate normal reactions by special techniques of handling'. In time, the focus on reflexes was decreased (Bobath and Bobath 1984), but the Bobath system continues to focus on abnormal patterns and abnormal tone. Kong (1987) used very early intervention based on the Bobath approach, but there was no evidence to show that it was the intervention that obtained results and not the fact that the babies might have become normal anyway. The keystone of the approach still seems to be abnormal tone. Bobath-trained physiotherapists spent time on reducing abnormal tone so that the child was 'prepared' for movement (Mayston 1992). Preparation involves stretching, handling, and positioning by the therapist to improve quality of tone and therefore movement.

Palmer et al. (1988) found neurodevelopmental treatment (NDT) less effective than a global developmental programme. The NDT review by Butler and Darrah (2001) for the American Academy for Cerebral Palsy and Developmental Medicine (AACPDM) stated that the 'preponderance of results did not confer any advantage to NDT over the alternatives to which it was compared'. Brown and Burns (2001) considered 147 articles, of which only 17 studies met scientific criteria. These studies found insufficient evidence for NDT and the results were largely inconclusive. In a study of early treatment, Blauw-Hospers and Hadders-Algra (2005) found that specific or general developmental programmes had a positive effect whereas NDT was not beneficial. Twelve papers were of high methodology (levels I and II).

Today, practice of the Bobath approach or NDT is different in different countries, in different parts of a country, and in different centres. Physiotherapists have had to make modifications based on their clinical experiences and on the critical comments of others. As there is increasing scientific understanding of the brain and nervous system, the theories and concept of the Bobath system have been challenged by a number of therapists and other workers (Levitt 1977; Gordon 1987; Horak 1992; Damiano 2004).

Howle (2002) suggests that contemporary theories developed by other approaches are now used for NDT. She quotes Berta Bobath, who maintained that the concept (or philosophy) had not changed through the years but the techniques had been developed and refined. A series of several photographs in Howle's book show a skilful Bobath treatment with handling not only with hands but also with the therapist's body and legs to position and treat a girl with cerebral palsy with a mild and moderate condition. These are familiar Bobath methods despite the 'new theories'.

Mayston, a former Director of the original Bobath Centre in London, UK, states that 'little or no evidence is available to show that therapy offered by the "named approaches" is effective or that one approach is more beneficial than another' (Mayston 2004, 2012). Mayston has provided new thinking and self-questioning by physiotherapists wedded to this system. She also says that 'Bobath therapists' should and have become more eclectic (Mayston 2004, 2008). This is reassuring as Bobath and Bobath (1984), referring to earlier editions of this book, firmly stated that 'Eclectic treatment, using a mixture of treatment techniques derived from various

schools of thought which see the child's problems from different viewpoints, cannot result in a cohesive treatment programme'. Mayston (2004) also points out that conductive education (CE) (which is a learning approach) places more emphasis on the child's initiation, participation, and practice, 'which is different to the Bobath approach'. This is also different from any motor learning approach. The dramatic changes in theories underlying NDT make it no longer clear what this approach consists of in theory. In practice there are some additions of methods, from other therapists who have never been dedicated to this approach, which makes it difficult to know how different NDT is from other therapy programmes.

Features of the approach that can usually be observed are as follows.

Preparation for movement patterns specifically selected to treat abnormal tone associated with abnormal movement patterns and abnormal posture. Key components such as extension, rotation, and symmetry often form the basis for motor control and receive treatment methods.

Developmental sequences were more strictly followed in the past, but are now modified (Mayston 2004).

Sensorimotor experience. The reversal or 'break down' of the movement abnormalities is said to give the child the sensation of more normal tone and movements. This sensory experience, now called 'feedback', is provided by the therapist's handling and is believed to gain more normal motion. NDT therapists still quote that 'Learning to move is entirely dependent on sensory experience' (Bobath and Bobath 1984).

Key points of control are used by many therapists to change the patterns of spasticity so that a child *is prepared for movement* and correct posture. The *key points* are usually head and neck, shoulder, and pelvic girdles, as well as the use of distal key points to aim to 'normalise' abnormal tone.

All-day management by parents supplements treatment sessions. Parents and others are advised on daily management and trained to treat the children. Nancie Finnie (1997) wrote a book for parents on this all-day handling of the child in the home. This book has been updated by Eva Bower (2009).

Novak et al. (2013) considered that NDT should not be recommended. There are still no rigorous research studies to confirm the value of this approach. Mayston and Rosenbloom (2014) explain that comments by Novak et al. are irrelevant or inaccurate. For example, their traffic light system of evaluation is oversimplistic, all interventions given need further research to show 'what works for whom and at what stage of their life', and NDT/Bobath differs in different places. Of the 64 reviewed interventions, 20 are included in the NDT/Bobath approach, such as home programmes, parent training, anti-spastic medication, and orthoses.

Sensory stimulation for activation and inhibition

Margaret Rood, a physiotherapist and occupational therapist, based her approach on many neurophysiological theories and experiments (Rood 1962; Stockmeyer 1967). The main features of her approach were the following.

Afferent stimuli. Techniques of stimulation, such as stroking, brushing (tactile); icing, heating (temperature); pressure, gentle bone pounding, slow and quick muscle stretch, joint retraction and approximation, and muscle contractions are used to activate, facilitate, or 'inhibit' motor response.

Muscles are classified according to various physiological data, including whether they are for 'light work muscle action'

(movement) or 'heavy work muscle action' (stability). The appropriate stimuli for their actions are suggested.

Reflexes other than the above were used in therapy, for example tonic labyrinthine reflexes, tonic neck, vestibular reflexes, and withdrawal patterns.

Ontogenetic developmental sequence is outlined and strictly followed in the application of stimuli.

1. Total flexion or withdrawal pattern (in supine).
2. Roll over (flexion of arm and leg on the same side and roll over).
3. Pivot prone (prone with hyperextension of head, trunk, and legs).
4. Co-contraction neck (prone head over edge for co-contraction of vertebral muscles).
5. On elbows (prone and push backwards).
6. All fours (static, weight shift, and crawl).
7. Standing upright (static, weight shifts).
8. Walking (stance, push off, pick up, heel strike).

Vital functions. A developmental sequence of respiration, sucking, swallowing, phonation, chewing, and speech should be followed.

Carlsen (1975) showed improvement using methods from Rood (1962) compared with a functional occupational therapy approach. She had a small sample of 12 children.

Some sensory stimulation methods are sometimes used to draw attention to the part of a limb needing active control (Shumway-Cook and Woollacott 2017). Ice treatments may be used to reduce spastic hypertonus. The ontogenetic (developmental) sequence is a general outline of motor functions used as well as giving various types of muscle actions. Criticism of the approach is that stimulation may be overdone so care needs to be taken. Today developmental stages include Rood's items (other than item 1), but are more individual, less strict, and more sophisticated.

Reflex creeping and other reflex reactions

Vaclav Vojta, a neurologist working in Czechoslovakia and in Germany, developed his approach from the works of Temple Fay and Kabat (Vojta 1984, 1989; Von Aufschnaiter 1992). He used a list of postural reflexes as a measure of diagnosis and results that was not accepted by Norén and Franzén (1982). Reflex creeping and reflex rolling are present in newborns but persist in cerebral palsy. They can be used and adjusted by hands-on treatment for postural development and associated motion. The main features are as follows.

Reflex creeping. The creeping patterns involving head, trunk, and limbs are facilitated at various *trigger* points or *reflex zones*. The creeping involves active muscle response to the appropriate triggering from the zones with sensory stimuli. The muscle work used in the early creeping patterns or *creeping complex* has been carefully analysed. The therapist must be skilful in the facilitation of these patterns and not activate pathological patterns. There are nine zones for triggering reflex locomotion.

Reflex rolling or reflex turning is also used with special methods of triggering.

Sensory stimulation. Touch, pressure, stretch, and muscle action against resistance are used in many of the triggering mechanisms.

Resistance is recommended for action of muscles. Various specific techniques are used to apply the resistance so that either a tonic or a phasic muscle action is activated. The phasic action (through range) may be stimulated on, say, a movement of each limb creeping up (proximally) or downwards (distally). The tonic action, or

stabilising action, is obtained if a phasic movement through range is fully prevented by full resistance given by the therapist.

Rising reactions are also stimulated using resistance and all the methods above.

Vojta appeared to suggest that very early treatment could cure babies at risk, but he did recognise that there are limits to the results with more severely impaired children. His methods were criticised for creating crying and stress in children. The methods needed to be practised a number of times a day, which parents found stressful, especially as their child's crying during treatments was disturbing. A study by Kanda et al. (1984) on the Vojta approach is unreliable as very small numbers of children were used.

Katona (1989), like Vojta, suggests that, in infancy, early patterns can be observed that suggest infants at risk for cerebral palsy. Katona stimulates early movement patterns using methods different from those of Vojta. He considers these complex movements to be precursors for later posture and movement. Treatment is six times a day for 30 minutes, carried out by parents. Like Vojta, Katona claims this treatment 'cures' cerebral palsy in babies. However, we know that many babies do spontaneously outgrow a very early diagnosis of cerebral palsy.

Conductive education

Andras Petö in Budapest, Hungary, originated *conductive education* (CE). After Professor Petö's death, the work was continued by Dr M. Hari until her death (Cotton 1974, 1984; Hari and Tillemans 1984; Hari and Akos 1988; Russell and Cotton 1994; Tatlow 2005). Dorothy Seglow (1984), a physiotherapist, introduced mother–child groups based on CE.

The main feature of CE is the integration of therapy and education by having the following.

A conductor acting as teacher and therapist. The conductor is specially trained in the habilitation of motor-disabled children in a 4-year course. They may have assistants.

The group of children, about 15–20, work together. Groups are fundamental and motivating in this training system. The mother–toddler group for early intervention enables mothers to learn from each other using practical methods.

An all-day programme. A fixed timetable is planned to include getting out of bed in the morning, dressing, feeding, toileting, movement training, speech, reading, writing, and other schoolwork.

The movements. Sessions of movements take place mainly on and beside slatted plinths (table/beds) and with ladder-backed chairs. The movements are devised in such a way that they form the elements of a task or motor skill. The tasks are carefully analysed for each group of children. The tasks are the activities of daily living, motor skills including hand function, balance, and locomotion. The purpose of each movement is explained to the children. The movements are repeated, not only in the movement sessions of, say, the *hand class* or *plinth work*, but also in various contexts throughout the day. The children are shown in practice how their 'exercises' contribute to daily activities.

Rhythmic intention. The technique used for training the elements or movements is rhythmic intention. The conductor and the children state the intended motion: 'I touch my mouth with my hands'. This motion is then attempted together with their slow, rhythmic counts of one to five. Motion is also carried out to an operative word, such as 'Up, up, up' repeated in a rhythm slow enough for the children's active movement ability. Speech and active motion reinforce each other.

Individual sessions may be used for some children to help them to participate more adequately in the work of the group.

Learning principles are basic to the programme. Group dynamics with learning techniques are fundamental for training. Cognitive participation is stressed, as opposed to automatic reflex reactions. They assert that reactions or responses to handling by a therapist cannot create active learning by a child. There is emphasis on a child's initiation, active participation, and practice, and the promotion of self-worth.

There is also emphasis on analysing tasks in a 'task series' so that children will successfully achieve them. There is integration of cognitive, emotional, social, perceptual–motor, and communication in the learning programmes.

Bairstow et al. (1991, 1993) carried out studies on CE compared with a neurophysiological and developmental approach in a selected group necessary for CE. No difference was found between these two groups. However, the assessors were aware which children were in the intervention group and which were in the non-intervention (control) group. Reddihough et al. (1998) carried out a comparative study of traditional therapy and CE that showed little difference in outcomes, provided equal intensity of therapy sessions was used. This is not always so with traditional therapy. Johanna Darrah with three physiotherapists (Darrah et al. 2004) reported a thorough review of evidence for CE, approved by the AACPDM. Fifteen studies met the inclusion criteria. The studies included many aspects such as motor function, daily living activities, communication, various educational aspects, social skills, and parent satisfaction. Only four studies are rated I and II, and there were many difficulties in obtaining information about the subjects' specific activities and the heterogeneity in various studies. The result is that there is no conclusive evidence in support of or against CE as an intervention strategy. The focus of CE on daily life function and education may fit the needs of many families but cost, time, availability, and the effects on family dynamics need to be considered in view of the current lack of strong evidence. Further research is recommended.

Odman and Oberg (2005) have carried out studies on Move&Walk, an intensive Swedish CE programme with conductors educated in Hungary, compared with an intensive rehabilitation programme with an eclectic approach called Lemo with two physiotherapists and a special educational needs teacher. Children were aged 3–16 years. Both programmes emphasised parents' and assistants' (carers') participation. No major difference in function was shown between the two training programmes. Odman et al. (2007) explored parents' perceptions in Move&Walk and Lemo, finding that high-level service quality and achieved expectations influenced parents more than their perceived functional improvements of their children. No difference was present in their perceived functional outcomes. Most parents perceived high-level service quality. The parents in the Lemo approach perceived better service quality than those in the Move&Walk and were more involved in discussions about expectations and knowledge exchange.

Criticisms have been on quality of movements with the likelihood of deformities and contractures although the children gain independent motor functions. However, prevention and treatment of deformities can be integrated with many practical methods selected from CE, and also given in this book (see Chapters 9 and 12). Therapists such as Kay (2014) in a school using CE for a child with dyskinesia/dystonia in GMFCS level IV also needed to include additional therapeutic methods and communication aids required by individuals using this approach. The 88 item Gross Motor

Function Measure (GMFM-88) was used as an outcome measure, which showed positive results. The Scottish Centre for Children with Motor Impairments based at the Craighalbert Centre near Glasgow, UK, and its Director Professor P. Salter now use CE with other therapy techniques. CE is for more able children and Bobath (hybrid) for more severely affected children. Depending on individual needs, they use exercises with tricycles, rebound therapy, constraint-induced movement therapy, and therapeutic electrical stimulation. Parent opinion and engagement is considered essential.

Wright et al. (2005) explored eight responsive measures that could be used in research studies of CE. These measures were used in a school's full day during a year of the CE programme. They had problems with psychosocial measures, which were not responsive enough. Blank et al. (2008) found positive results on hand function and activities of daily life. Law et al. (2004) in Hong Kong used goal attainment scaling, showing progress in motor goals. Franki et al. (2012) found gross motor gains and social advantages in their review of studies. CE differs in different countries, being relevant to existing schools and health services. The New Zealand Report by Barry (2016) and that by the AACPDM (Darrah et al. 2004) both found that studies of CE had no conclusive evidence for or against the use of CE.

Sensory integration

The sensory integration (SI) approach was devised by Jean Ayres (1979) to 'take in, interpret, integrate and use spatial-temporal aspects of sensory-information from the body and the environment to plan and produce organised motor behaviour'. Occupational therapists may use this approach for children with sensory-based motor difficulties who may or may not have a neurodevelopmental diagnosis such as autism spectrum disorder, developmental coordination disorder, or central nervous system conditions, including cerebral palsy. In recent years there has been controversy regarding occupational therapists' use of the diagnostic term 'sensory processing disorder'. The UK Royal College of Occupational Therapists (RCOT) recommends that occupational therapists should not be diagnosing sensory processing disorder (COT 2015a). There continues to be much discussion around the efficacy of sensory approaches including Ayres' SI, as the evidence is inconclusive. The RCOT is clear that, although occupational therapists should consider the impact of an individual's sensory needs on their occupational performance, the focus of intervention should always be on promoting occupations (self-care, school, and work) rather than the remediation of underlying impairments.

Many children with cerebral palsy lack sensory experiences because of the paucity of their motor repertoire and research studies have identified possible sensory constraints experienced by these children and young people (Pavão and Rocha 2017). The guidelines on cerebral palsy produced by the National Institute for Health and Care Excellence (NICE 2017) explain that 'learning and movement difficulties may be exacerbated by difficulties with registering or processing sensory information, which can affect function and participation'. Stimulation of all the senses (tactile, proprioceptive, vestibular, visual, and auditory) is recognised and often used by therapists as part of their interventions for motor control, and motor learning with functional goals. NICE (2017) recommends that physiotherapists and occupational therapists should work on functional goals.

In their systematic review, Novak et al. (2013) suggested that SI should be 'discontinued from CP care' as it is based on outdated neurological theories.

Sensory input for children with low responses or with excessive responses to stimuli does not essentially need SI. Some children dislike sensory input and some seek it out. Much 'hands-on' physiotherapy is not welcomed by a number of children with dyskinesia. Any excessive stimulation needs to be avoided, as this can be disturbing to them, causing sudden spasms or muscle tension. Others with poor sensory responses may well want such experiences. For example, children with severe visual impairment or intellectual impairments tend to seek out sensations and may rock, suck their hands, or enjoy vibration and fans, music, and familiar human voices.

Context therapy

The focus of context therapy is on changing the task and the environment rather than changing children's impairments (Darrah et al. 2011). A research study was carried out to compare child-focused and context-focused therapy over a period of 6 months with a follow-up period of a further 3 months (Law et al. 2011). The results were that context therapy and child-focused therapy are equally effective. Frequency of intervention may be a critical component of successful intervention and various 'dose–response' relations of amount of treatment and functional changes need further evaluation. Carlberg's (2011) comment on this study asks whether the 'active ingredient' used for context therapy is the environmental change, the collaborative goal-setting, or the one therapist.

Strength training

Children develop functional strength within developmental functional training. There is also use of manual resistance within these functions that further increases strength in individuals able to manage this (Chapter 9). Predictors of independent walking by Begnoche et al. (2016) are functional strength, postural control, and reciprocal leg motion. They considered strength and postural control in sit-to-stand and stand-to-sit (Liao et al. 2007). Shortland (2009) discusses the value of strengthening based on research by him and others.

Progressive strength training (PST) is a resisted exercise programme typically having one to three sets of a number of exercises using maximum intensity of 8–12 repetitions. Lifting a weight 8–10 times through a person's available range two or three times a week for 6 weeks or more is carried out. The individual can exercise in a gymnasium or at home. Resistance includes weight machines, elasticized bands, cuff weights, dumbbells, and weighted vests (Dodd et al. 2002, 2003). Weight machines rather than dumbbells are safer for initial exercises. Specific muscles and ranges need to be targeted and progressed in difficulty at reassessment. Children under 10 years are not always suitable for this programme (Dodd et al. 2010: chapter 4). Scholtes et al. (2010) used a randomised controlled study, which found increased strength but no effects on mobility. Mockford and Caulton (2008) carried out a systemised review of PST in children and adolescents with cerebral palsy who were ambulant with mixed evidence that strength gained carried over to gait and other motor functions. Later Mockford (2017) reported a retrospective service evaluation of PST over 12 weeks which integrated into everyday mobility, with more able children gaining stair-climbing and less able children increasing walking time. Group sessions were also included that parents and children enjoyed. GMFCS levels of children and adolescents were I–III. Weights needed to be at least doubled in 12 weeks. Appropriate rest periods needed to be decided for individuals.

Verschuren et al. (2016) recommend exercise and physical activity for children,

adolescents, and adults. They also use weights in their exercises.

Targeted training

This option in physiotherapy for cerebral palsy has been developed by Butler and Major (1992) and Farmer et al. (1999). It is a biomechanical study for motor learning. In the training of sitting and standing balance, targeted training reduces the number of joints at which motor learning of control must occur. Specially designed equipment stabilises the joints below the targeted joint so that stability, weight shift, and tilt are sequenced from head to trunk and to pelvis in the upright posture. The equipment replaces a therapist's manual support for training postural control in sitting and standing. The equipment is more precise for assessments and training of segmental levels of spinal joint control and is, therefore, useful in detecting minimal and slow progress of postural control in severe cases. This would encourage parents and children who can then see such progress, which is not obvious to them because of the severity of the disability.

However, the equipment is expensive, as is any equipment in research and in very precise evaluation of progress in postural control. In Chapter 9, this book has offered and still offers 'hands-on' assessment and training of postural control in the typical developmental stages from head control progressing downwards, similarly to the research of Butler (1998) and Butler and Major (1992), and we continue to develop these aspects. Targeted training selects children who are potentially able to gain control of relevant joints, and results have shown sitting achievement in a shorter time. Intellectual ability is not necessary but epilepsy should not be present. Research has continued in targeted training with a much more precise measure for targeting upper, middle, lower thoracic, upper lumbar, lower lumbar, and full trunk control; this is called segmental assessment of trunk control (SATCo) (Butler et al. 2010; Curtis et al. 2015). They related SATCo to GMFM and Paediatric Evaluation of Disability Inventory (PEDI) mobility functions. Desloovere and Heyrman (2015) in their comment on the research draw attention to the fact that the subjects were in GMFCS levels IV and V (not sitting) and suggest using the SATCo measure for other levels of GMFCS.

Neuromuscular electrical stimulation or functional electrical stimulation

This is used for muscle re-education, strengthening, or as a biofeedback for training function such as gait pattern or wrist-with-hand function. The desirable action of a muscle within function is used to provide sensory feedback. Shumway-Cook and Woollacott (2017) and others have used electrical stimulation as biofeedback in adults, and its use with children has increased. Damiano et al. (2013) used functional electrical stimulation (FES) to gain ankle control in cases of foot drop in cerebral palsy. A literature review by Bosques et al. (2016) and studies by Pool et al. (2015) and Chiu and Ada (2014) all found positive results. This therapy option can obtain a local muscle contraction in children with poor selective muscle control in specific tasks. Neuromuscular electrical stimulation (NMES) has been combined with constraint-induced movement therapy in hemiplegia (Xu et al. 2012). Van der Linden (2008) used a randomised controlled trial of FES for 8 weeks to the dorsiflexors and quadriceps in children. The result was immediate benefits but not in the long term.

Earlier studies such as that of Kerr et al. (2006), who carried out a randomised placebo-controlled study on NMES with 60 children with different types of cerebral palsy, found no statistically significant difference for strength or function. Some children disliked the sensation of

stimulation or were too young to cooperate. More recent studies including cerebral palsy found that children tolerated FES well.

Lycra suits and splinting

Garments or orthoses made of Lycra (Spandex or elastane) are highly elastic and intended to give dynamic stabilisation by support of the trunk and proximal joints and allowing movement and flexibility. Sensory input is provided by Lycra splinting designed to fit an individual's whole or parts of the body. The pelvic or shoulder girdle is included. Additional features include the use of certain tensions and direction of pull, thickness of the Lycra, and the use of plastic boning to provide extra support. Like other types of orthotics, Lycra splints are provided for one of two reasons: to prevent or correct physical contractures and deformities or to improve functional abilities. Each child needs to be assessed for the aims of the intervention.

Nicholson et al. (2001) noted improvements, although these were not significant on the PEDI scores. The AACPDM report by Blackmore and three occupational therapists (Blackmore et al. 2006) studied evidence for soft splinting with Lycra or neoprene on upper limbs and found only one randomised controlled trial, which showed no evidence for grip and abdominal strength in children. Elliott et al. (2011) published the results of their randomised clinical trial (n = 16) carried out to measure the impact of the use of Lycra arm splints in conjunction with goal-directed training on self-identified goals (using Goal Attainment Scaling) as well as joint kinematics and range of motion. The results demonstrated that splint wear in combination with goal-directed training enabled 15 out of 16 participants to achieve their personal movement goals, while the use of training alone did not demonstrate the same level of improvement. In regard to the impact on movement, after 3 months, those in the treatment group were shown to have increased pronation/supination of the elbow extension and shoulder flexion ranges. No further randomised controlled trials have since been carried out to measure the effect of Lycra splints on upper limb function of children with cerebral palsy.

Research considering the impact of full body Lycra suits is also limited. While the systematic review of suit therapy by Martins et al. (2016) demonstrated improved gross motor function post treatment and at follow-up, there are numerous identified limitations (small samples, heterogeneous participants, and use of different versions of the GMFM) that lead the authors to recommend cautious interpretation of the findings. A further review published by Almeida et al. (2017) considered the use of specific suits (full body suit, dynamic elastomeric fabric orthoses (Lycra), TheraTogs, and the TheraSuit/AdeliSuit) and their associated protocols. The authors concluded that, because of the low quality of available evidence, therapists should be cautious about recommending the use of these suits. Therapists recommending their use should ensure that provision is accompanied by regular monitoring and review in relation to functional goals. There is no adequate evidence of postural control without the Lycra splinting following its use. Disadvantages range from difficulties in putting on Lycra garments, discomfort when hot, and toileting problems among other practicalities affecting compliance (see Fig. 9.197 of an arm splint used in hemiplegia).

Treadmill training

This is carried out with a body harness for body weight support or partial body weight support so a child is partially unweighted in order that stepping is promoted without the need for balance. Some therapists guide the lower extremities for the best pattern of stepping. Gradually the partial body weight

support is reduced. The work by Schindl et al. (2000) is often quoted by physiotherapists as support for treadmill training in children with cerebral palsy. Their study of 10 children, six non-ambulant and four slightly ambulant with help, had 3 months of training, three times a week in 25-minute sessions, in addition to usual physiotherapy. Unfortunately, this study is not scientific enough for clinical use as the children were few, differed greatly in age and in diagnoses, and were selected for cognitive and communication abilities and no contractures. Controls were absent and there were no follow-up measurements (see Chapters 6 and 8).

Cherng et al. (2007) and Dodd and Foley (2007) studied small numbers of children on the treadmill and, although they found some benefits, the evidence was not strong.

Mutlu et al. (2009) in a systematic review of seven studies found limited evidence for treadmill training despite positive reports in gross motor and functional walking and gait parameters. Numbers were too small to show the benefits of treadmill training for clinical settings. Novak et al. (2013) also found insufficient evidence for treadmill intervention.

In their comprehensive updated Cochrane review, Valentín-Gudiol et al. (2017) concluded that the 'review can provide no firm evidence for the clinical application of treadmill interventions'. Grecco et al. (2013) in a randomised controlled trial found that, once children were ambulant, treadmill training without partial support rather than overground training improved their walking.

Our own observations are that treadmill training is useful for keeping children fit and motivated to exercise, although the treadmill is an expensive item for parents to purchase. Treadmill walking practises walking without use of visual flow, spatial perception, change in direction, and may need supervision for safety. In clinical observations, once the child was not on the treadmill, there was no change in their atypical gait patterns nor in acquisition of walking.

Horse riding

There are two types of therapy on a horse: therapeutic riding (horseback riding therapy) and hippotherapy. Therapeutic riding is in a small group carried out by a specially trained instructor and may be together with a physiotherapist. Hippotherapy is one-to-one carried out by a physiotherapist giving a child various exercises on the horse. Tseng et al. (2013) in their systematic review found that hippotherapy improved postural control and symmetrical abduction of the hips. The reviews by Zadnikar and Kastrin (2011) and by Whalen and Case-Smith (2012) concluded that hippotherapy and therapeutic horse riding improved postural control and gross motor function, respectively. A review of 11 quantitative studies by Sterba (2007) of horse riding and hippotherapy suggests that both riding methods are individually efficacious. There is mobilisation of the pelvis and lumbar spine and hip abduction with improvement of sitting posture. However, the effect on impairments is inconclusive. Further research is needed for more severe children, who are able to carry out riding a walking horse with a rider behind them. Snider et al. (2007), in their review on horse riding, suggest that this is family oriented in a natural environment and there are favourable physical effects of symmetry in trunk and hips. (See Appendix 2 for the address of the Riding for the Disabled Association.)

Swimming and hydrotherapy

Exercises in water is hydrotherapy, which differs from swimming therapy. Both are recommended for health reasons, physical fitness, and participation with family and friends. Both can be carried out in groups

for social stimulation and peer encouragement. Both need to have a suitable and safe pool environment. Access to the pool such as hoists, chair lifts, ramps, and hand rails are needed for a variety of disabilities. Many children need to be able to grasp the ledge of the pool. Other safety aspects and manual handling by therapists and assistants need to be checked with the organisations involved with hydrotherapy and swimming therapy.

Hydrotherapy focuses on strengthening and passive range of motion and stretching. Movements in water eliminate problems of postural control and balance and reduce the risks of joint loading (Kelly and Darrah 2005). The buoyancy of water makes exercises in water more motivating to many children with significant movement limitations and is welcomed by any child postoperatively. Individual sessions are used for ensuring correct movements and adequate intensity of exercises.

Getz et al. (2006) in their literature review found 'a substantial lack of evidence-based research for aquatic interventions' (hydrotherapy) for neuromotor impairments in children. Special swimming techniques such as the Halliwick method continue to show achievement of swimming by children with cerebral palsy, giving them a complete sense of independence of movement and enjoyment of games in the pool. (See Appendix 2 for the address of the Halliwick Association of Swimming Therapy.)

Kinesio-taping

This is a developing technique used by Şimşek et al. (2011) and Kaya Kara et al. (2015) that activates cutaneous input, proprioception and sensory feedback. Tapes are polymer elastic, which can be stretched, and zinc oxide tape, which is non-elastic. Participants have the tapes for two sets, being changed every 3 days with a 24-hour break. The studies were carried out for 3 months. Both studies used taping for lower limbs and Kaya Kara et al. also used taping for upper limbs, including the scapula. Taping is not used if the results of tests show skin hypersensitivity. Two participants were excluded from their trials because of skin reactions. The outcome measures used were GMFM-88 by Şimşek et al., GMFM-66 by Kaya Kara et al., and the Functional Independence Measure for Children (WeeFIM) by both. Weatherhead et al. (2016) give a detailed report of various studies including the above. Kaya Kara et al. and Şimşek et al. had the largest numbers of participants.

Rebound therapy

Rebound therapy involves the use of the trampoline in physiotherapy to develop gross motor abilities and participate in a playful experience. It is usually a 20-minute session once a week for 6 weeks. Rebound therapy improves participation with friends and is based on activity and participation in the International Classification of Functioning, Disability and Health (WHO 2001). Duff et al. (2016) carried out a small-scale study using 20-minute sessions twice a week for 3 weeks for 39 children in GMFCS levels I and II. There were no improvements on the GMFM-66 scores, but the Canadian Occupational Performance Measure scores improved. Care was taken that the trampoline was on a padded floor and enclosed by padded walls. Rebound therapy is a complex intervention having several interacting components such as the amplitude of the bounce. The study identified many difficulties to be considered in the future.

Specialised medical treatments

Drugs to reduce spasticity, manage epilepsy, and aid in the medical management of general health problems, particularly inadequate nutrition and chest infections, are important for individual children and adults. The therapist will obtain information from the medical consultants

responsible and find out from them if there are any side effects. Drugs to reduce spasticity (Albright and Neville 2000) are usually baclofen (Lin 2004) as an oral medication or as intrathecal infusions into the spine (Albright and Neville 2000; Miller 2007). Localised injections of botulinum toxin A (BoNT-A or Botox) to reduce spasticity and allow muscle lengthening are also used and are discussed in more detail in Chapter 12. Treatment of spasticity with any drugs is planned together with therapists, parents, and carers, as therapists' programmes are essential for best results.

Pain in children can be due to deformities, poorly fitting equipment, and reflux in feeding. Assessment and treatment is important so that appropriate drugs and other management can be given in non-verbal as well as verbal children (Hicks et al. 2001; Boldingh et al. 2004; Hunt et al. 2004; Johanssen et al. 2010; see also http://pediatric-pain.ca). Performance during therapy cannot be at a child's optimum function unless they are pain free and comfortable. BoNT-A is also used to treat pain (Lundy et al. 2009).

Feeding problems, which cause pain, poor nutrition, and a decrease in energy for therapy, are discussed more fully in Chapter 10.

Selective dorsal rhizotomy (SDR) is carried out to reduce spasticity. Devised by Peacock and Staudt (1991) and used by Oppenheim et al. (1992), Steinbok et al. (1997), McLaughlin et al. (1998, 2002), and Tedroff et al. (2011). Josenby et al. (2012) and Ailon et al. (2015) carried out long-term follow-up, usually after 10 years.

The selective dorsal rootlets most responsible for spasticity at spinal levels across L2–S2 are divided. Patient selection includes children who are ready for walking or are ambulant, intelligent, and motivated; and another non-ambulant group whose spasticity prevents bathing, perineal care, and positioning for daily care and classroom activities. Intensive follow-up physiotherapy for 6–12 months is needed for the postoperative weakness and training new motor patterns. Children in GMFCS levels I–III show the most benefit following long-term follow-up but others in GMFCS levels IV and V were not worse off, having small non-significant gains (Josenby et al. 2012; Ailon et al. 2015). Tedroff et al. (2011) point out that persisting contractures are not due to spasticity only. There is a need for orthopaedic intervention, plasters, or orthoses following SDR as well as intensive physiotherapy for 6–12 months for weakness, stretching for range, and training new motor patterns (Giuliani 1992). Chris Smith and staff (personal communication 2016) have a programme of muscle strengthening, treadmill training, dynamic balance, NMES, and task training such as use of stairs and sit-to-stand from bench and floor. Participation in active leisure experiences such as cycling, table tennis, basketball throwing into basket nets, and frame football is emphasised.

Systems-based task-oriented approach

This approach is advocated by Shumway-Cook and Woollacott (2017) for the assessment and training of posture and movement in people with neurological disabilities and motor problems, mostly in the elderly population, and for stroke. Their theoretical studies in children are also given and evidence is available for training balance in children with cerebral palsy (Shumway-Cook et al. 2003; Woollacott et al. 2005). The main aspects of this approach are as follows.

1. Constraints on a motor task are hypothesised as:
   a. motor impairment and inefficient movement strategies
   b. cognitive difficulties
   c. sensory and perceptual difficulties.

2. The demands of a motor task include the person's interaction with relevant features of the environment in which the task is performed. For example, the task may demand motor, cognitive, and visual abilities to manage locomotion on rough, slippery surfaces, the moment when terrain changes, or whether the surface is moving, unstable, or stationary. Movement solutions need to be adaptable and efficient for changes in direction and at different speeds.
3. Motor learning strategies are used to train motor behaviour. The specific task or intended goal will have a number of possible 'goal-directed' movement strategies or a variety of potentially useful solutions. The same task performed in different environments demands different movement strategies. Therefore, motor tasks need to be learned and practised in a variety of environments and situations.
4. Augmented feedback is given to assist the achievement of the task.

Treatment mitigates impairment or disabilities, or the environment is structured for achievement of the task. In some situations environment structures are useful despite the person's impairments and disabilities. Therapists using task-oriented approaches are also influenced by dynamic systems theory on motor control proposed by Thelen (1992) among others. For example, she states that 'Development of a particular motor pattern depends on a combination of mechanical, neurological, cognitive and perceptual factors in addition to environmental contributions specific to both the task and the context of the infant's action.'

Shumway-Cook and Woollacott's motor control and motor learning approach has many similarities to the movement science-based model of Carr and Shepherd (1987), Gentile (1987), and Horak (1992), as well as with elements in conductive education and in learning motor function discussed in Chapters 3 and 4.

Shumway-Cook and Woollacott (2017) have also developed their own approach.

Mobility Opportunities Via Education (MOVE)

This is a mobility programme using learning methods. The approach originated in California, composed by a teacher in special education and a physiotherapist (Bidabe and Lollar 1990). Thomson (2005) has given a review of theories supporting MOVE. The motor tasks are broken down into components well known to cerebral palsy physiotherapists. It uses 'prompts' for guiding movement, which are decreased as the child achieves each component after repetition. Decreasing support and guidance, not termed 'prompts', with the repetition of function are also traditional in physiotherapy but are not as systematically structured as in this approach. The MOVE programme in the UK is an example of how assistance called 'prompts' is recorded when given and when decreased according to the child's achievement of a motor function. It is a programme structured for teachers and carers. Therapists will have a greater variety of methods of manual assistance to offer in training carers, parents, and others. Physiotherapists in the UK assess problems of deformity and prescribe equipment and procedures that may be needed to treat the impairments. What physiotherapists may find useful are the systematic teaching methods used to develop motor function. Results state that older children and adolescents have achieved sitting, standing, and walking, although this was not expected and not enthusiastically pursued in the past. Teachers are expected to give an hour's practice daily and integrate motor function within the teaching day. Practice continues

by the children on their own, if possible, or with a parent at home.

Developmental stages are arbitrarily changed with many neurological omissions in the belief that there is no time for the child to follow developmental stages of motor functions other than sitting, standing, and stepping. 'Treatment' is interpreted as being related to the impairments, so the MOVE programme is not called a therapy. This is presumably because MOVE has been criticised for not taking adequate account of the development of deformities. MOVE relates only to gaining function.

Alternative and complementary therapies. These are discussed in Chapter 2. As Chapter 2 discusses, parents, family members, and others involved with a child will usually value the views and comments of the therapists on procedures which claim to help their child. Therapists need to consider offering procedures which are rational, realistic, and as effective as possible in the light of current knowledge and research.

Constraint-induced movement therapy is discussed in 'Development of hand function' in Chapter 9. It is a motor learning system for hemiplegia (unilateral cerebral palsy).

Contemporary theories

Dynamical systems theory

The dynamical systems theory, or dynamical action theory, of motor development suggests that the acquisition of motor skills emerges from dynamic interaction of multiple subsystems. Multiple systems are spontaneously self-organising in the context of a task (Thelen 1992; Bartlett and Palisano 2000; Law et al. 2007). The number of subsystems to be considered varies with different authors.

Motor learning and motor control involve interaction between an individual, the task, and the environment (Shumway-Cook and Woollacott 2017). These headings help to clarify the different systems involved.

Subsystems within the individual child are neurological, biomechanical, musculoskeletal, sensory, perceptual, cognitive, and emotional. A child's own developmental levels of all these aspects influence whether he or she has the skills to do a task and is willing to attempt a task. For the latter, a child's temperament and motivation to do a task need to be included. Some add factors of a child's size and weight as well as cardiorespiratory and nutritional needs, which relate to the energy required for motor tasks.

Subsystems involved in the task (what the child is trying to do), which affect motor behaviour, include examples such as the position, shape, texture, and weight of an object for reach and grasp, or the height of a chair or table that a child uses for sitting and pulling to stand.

The environment. Subsystems such as postural control, voluntary movement, and vision are influenced by factors in the environment. Examples are surfaces on which motor function takes place, the effect of gravity, lighting, noise, and obstacles in the child's path, which include crowds of people. Dynamical systems theory points out that a particular system is rate limiting if it has not yet developed. The other developed systems need to await the development of the limiting system before a function can develop.

Motor learning approaches are included in Chapters 2–4.

Neuroplasticity

This theory considers the nervous system in a dynamic way. The nervous system is adaptable and changing when there are demands from the environment, from new

learning, from developmental processes, and from a variety of experiences. The following influence the changes in the structure and neurophysiology of a developing nervous system or damaged nervous systems in children, adolescents, and adults (Kidd et al. 1992):

- practice and repetition
- task-related voluntary actions for learning
- movements in the context or under conditions in which they are to be used
- active and purposeful sensorimotor experiences which are part of a person's daily life
- early treatment takes more advantage of neuroplasticity after brain damage in children, adolescents, and adults.

There are responses in the nervous system if movements are regularly practised, but synapses are cut and neural pathways disconnected if motor activity is absent. Any repetition of 'abnormal' motor patterns results in the nervous system adapting and establishing them. On the other hand, the nervous system can be influenced by the promotion of normal motor patterns with prevention of 'abnormal' patterns.

The neuronal group selection theory

This theory suggests that the structure and function of the nervous system depend on repeated behavioural experience, motor actions, and their sensory consequences. The nervous system is continually adapting to them (Sporns and Edelman 1993; Hadders-Algra 2000, 2001). Neuronal selection involves primary exploration of possible variations of movement, interactions, and the selection of the most efficient patterns for a useful repertoire. Ultimately, a large variety of mature motor patterns, specific for tasks, are achieved.

Each neuronal group of strongly interconnected neurones is arranged in neuronal maps. There are reciprocal connections between groups to integrate activities. This theory seems to relate more than others to the experience of moving that activates sensory receptors.

A child uses active self-generated movement to develop coordination, accurate movement, and functions that relate to a variety of tasks and environmental demands. Many functional synergies become available to accomplish a task in different environments, so no 'correct' synergy exists.

This theory suggests early intervention to provide a variety of postures and movements to increase sensorimotor experiences and active functions.

Implications for therapy in cerebral palsy

The main conclusions of dynamical systems seem to be that 'we should be aware that many factors are involved in the development of motor control'. This is an excellent notion. In fact, many thoughtful clinicians, particularly those working in interdisciplinary teams, have long been aware of this. Different expert professionals have shared ideas and methods with physiotherapists on many aspects such as vision, communication, perception, biomechanics, deformities, and psychological aspects. In addition, attention to the human and physical environment of a child has been observed and managed by community therapists, often together with social workers and health visitors in the UK and elsewhere. There is recognition that the child's interactions with the human environment of family, friends, therapists, and teachers influence motor learning, motor control, and motor development.

Therefore, one welcomes these theories, which appear to support familiar views that all aspects of the whole child, their family, teachers, and others involved with the child provide information for therapy and management.

Shumway-Cook and Woollacott (2017) review many more theories on motor control, motor development, motor learning, and learning processes. They also adapt ideas for their approach and find limitations in many of the current theories.

What guidance do we receive for practical physiotherapy from all the theories outlined?

- All constraints to function should be assessed and eliminated or minimised. If one alters a constraint or trains a missing element, the whole function will improve. However, it is rare that only one constraint is present in cerebral palsy.
- Comprehensive assessments (motor, sensory, perceptual–motor, cognitive, and social and emotional) continue to be essential but need to be integrated with motor function.
- The whole child is in the process of development and therapy is more effective if given at a child's levels of development. Therapy is particularly effective if given when a child is attempting a more advanced motor function, which is when an individual's motor behaviour is unstable. This is in the developmental transition phases.
- Provide experiences of a variety of movements and postures, as much as is possible, and give many opportunities for exploration and discovery learning according to an individual's abilities. Self-generated active motor patterns are more important than excessive passive guided movement and overuse of 'hands-on' facilitation.
- If a subsystem is absent, such as postural control, give postural support to a child so the other subsystems can be activated. Adapt the furniture, toys, and feeding and other utensils so the child can use what subsystems he or she has.
- Early treatment and postural management offer useful motor patterns so the brain, nervous system, and musculoskeletal system can adapt or learn and so grow and develop more effectively.
- Modify environments so that a child can function in them. Functional motor patterns need to be practised not only in the clinic but especially in a child's school, playground, home, and other environments that may or may not have been modified.
- A child may not be developmentally able to function in all environments. Basic motor control and learning need development so that this can be possible in, say, moving surfaces and slippery, rough, and other physically challenging environments.
- Functional activities should have meaning for a child and such functions motivate a child more than only the treatment of specific constraints (specific muscle tightness, weakness, stiff joints, and other impairments).
- Use appropriate equipment, walkers, and, where indicated, give manual support or guidance so that a child can achieve function in any environment and there is a feeling of success. Equipment needs to be used to assist children's learning and not as substitutes for motor functions that they lack.
- A child's emotional and social relationships in different environments need attention or need awareness, as they also greatly affect a child's motor development.

In the past, therapists have already attempted to give attention to all or most of these factors using information and practical ideas from other professionals to integrate into their work. These principles are stated in the eclectic approach in all editions of this book. As the writing on some of the theories can be obscure and lead to different interpretations, practical methods by therapists have understandably not yet developed and there are very few

publications of the models tested in clinical practice. Selected hypotheses are taken by clinicians from current theories to support methods which are specific to particular systems favoured by them. These methods still differ from system to system, although boundaries are not as sharp as in the past. This is not surprising as there are limitations in the theories, and therapists select and interpret ideas that support their practice.

Examples of limitations are:

- A child with impairments cannot self-*organise* in a normal way. If left to do so, atypical motor patterns result in, say, gaits or contracture, which may later cause pain and discomfort. Atypical motor patterns are useful in some cases but others may be or become inefficient.
- A baby with poverty of movement has a limited repertoire with which to gain or receive sensory and other experiences. There are few, if any, primary movement systems for dynamic development of neuronal groups given in the neuronal group theories.
- Dynamical systems theory considers that all systems are equally important. There is no acceptance of a central motor programme but only interaction of systems. Yet, with damage to the central nervous system, there are devastating disturbances to many, if not all, systems such as motor, sensory, perceptual, cognitive, and emotional.
- Dynamical systems theory does not identify which of the constraints are most important and how they interact in different circumstances. Is it the stiff shortening muscles, connective tissues, joint and bone adaptations? Is it perception, adequate experiences, lack of learning abilities (cognition, attention, problem-solving, memory)? Research by Thelen and others was carried out on a treadmill, and not in a child's natural environment, in their experiments to develop the theory.
- If self-generated active motion is very important in motor learning and motor control, then this challenges the long periods in different postural equipment and in orthoses. Severe conditions with almost no movement and with other multiple impairments may warrant so much equipment for most of the time.

It is important to recognise that the contemporary theories may be from research on typical infants, adolescents, or adults with or without brain damage or on subjects with adequate cognition. Therefore, not all theories will apply to the heterogeneous population who have cerebral palsy. We use our interpretations of theories as hypotheses to plan therapy programmes. We still need to test these hypotheses in research on cerebral palsy.

Campbell (2006) states that 'we remain at the mercy of theoretical knowledge rather than hard evidence'. She points out that few publications have resulted to test the theoretical models presented in clinical practice. Fortunately there is now increasing evidence-based therapy.

6

Evidence-based practice

Research and clinical studies

Whenever available, research, clinical studies, and experiences of expert therapists and those of other disciplines are quoted throughout this book. Good practice depends on all of these – none of them is adequate on its own. In evidence-based practice we need to 'integrate the best external evidence with individual clinical expertise and patients' choice, it cannot result in slavish, "cookbook" approaches to individual patient care' (Sackett et al. 1996).

After all, physiotherapists or occupational therapists want to know that their intervention or treatment produces benefit to a child and that child's family. Throughout the history of management of cerebral palsy, practitioners have kept records of their patients. Clinicians need to reflect on their own practice with careful observation and good records. In this way, clinicians may be able to formulate questions for research or clinical studies to confirm their findings.

Research and academic therapists communicate current scientific studies by presentation and publication so that an up-to-date rationale for practice is developed. In a therapist's experience and knowledge, there are insights enabling them to be critical of published research. Ideally, there needs to be a dialogue between researchers and clinicians so that research is not isolated from practice. When there is an absence of evidence of effectiveness, this is not evidence of ineffective treatment. Hence, further research is needed so that better evidence for effective practice can be gained.

Research on treatment approaches

All the various treatment systems claim good results. It is difficult to decide which system is superior, whether on theoretical grounds or on the basis of a scientific study. Clinical experience of many therapists, as well as our own, has not confirmed the superiority of any one approach.

As therapists 'want to know what is the best thing to do for children', there has been a focus on which therapy approach is superior. Perhaps this is not a worthy aim to pursue on theoretical grounds or research studies.

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Theoretical grounds

Every therapist wishes to understand 'why we do what we do' and, unfortunately, may accept a therapy system because it offers a ready explanation. However, there is no all-encompassing theory that fully explains all the atypical motor behaviour presented by people with the different cerebral palsies. In addition, theories may not adequately explain the effects of various treatment systems or, in some cases, of specific procedures. Theories also do not fully clarify mechanisms underlying motor behaviour from infancy to adulthood. Each therapy approach is based on the scientific evidence available at the time, and the neurofacilitation systems are based on a number of controversial neurophysiological hypotheses. There are currently newer theories on motor learning and motor control. However, controversies exist, so current neuroscience and behavioural psychology do not favour a single model for motor behaviour. Therapists continue to work with an underlying theoretical framework with some scientific evidence but also with assumptions about motor control, motor development, or motor learning. Increasing scientific understanding of brain function and motor behaviour will contribute to therapy and its knowledge base. Therapists will need to judge the relevance of such studies and advances and apply them to clinical work. It is still unwise to be dogmatic about a theoretical framework or about procedures which arise from that. Therapy techniques cannot fully rest on different and more current theories underlying motor control or motor learning. We still have to learn to live with these doubts.

Although therapists should continue to ask themselves why they are using a particular method, this enquiry should focus more on the careful observations of motor behaviour and any changes in behaviour after treatment procedures. Increasing clinical studies and research, together with clinical experience, will offer scientific evidence underpinning treatment procedures. Therapists need to draw on those studies that are relevant to their particular patients/clients.

Contemporary theories are discussed in Chapter 5.

Research studies

These are fraught with many problems and to date no study to compare the value of different treatment systems has convincingly dealt with all the problems. First, the results of treatment are influenced by the methods dictated not only by the concept of an approach but by the severity of motor function and impairments, age, and sex of an individual. Second, results are influenced by possible associated impairments and disabilities of vision, hearing, communication, perception, and cognition as well as by the presence of epilepsy and poor health. A child's personality and 'drive' as well as his or her home background contribute to the results of therapy. One must also recognise that the therapist's enthusiasm, personality, and abilities to make positive professional relationships as well as his or her technical skill may have a strong effect on the results of treatment with any method.

There are other problems. The results of a scientific study would have to be obtained over a long period of time as progress is slow. At least a 6-month follow-up is now generally recommended. Crothers pointed out many years ago that one would really need a follow-up to adulthood to establish the ultimate effects of treatment methods in childhood (Crothers and Paine 1959).

Reviews of research studies

The research studies that have been carried out on therapy approaches have been reviewed by Parette and Hourcade (1984)

for the period 1952–1982, by Tirosh and Rabino (1989) for the period 1973–1988, by Siebes et al. (2002) from 1990 to 2001, and by Anttila et al. (2008) from 1990 to 2007. They all found in their reviews that the research designs were not rigorous enough and they discuss the problems facing researchers. Franki et al. (2012) present a systematic review of the evidence for most of the physiotherapy approaches outlined in Chapter 5. The review was based on the International Classification of Functioning, Disability and Health framework (WHO 2001).

Research on specific procedures

Studies and reviews of particular interventions appear throughout this book. A sufficiently large series of single-case studies, carefully designed, and with sensitive and specific measures, can offer useful results for therapy and further research (Siebes et al 2002). Such studies have increased and are useful for evaluation of procedures such as strength training, constraint-induced movement therapy in hemiplegia, methods for postural control with arm reach, use of below-knee plaster casts (inhibitory casts), ankle–foot orthoses, and other procedures.

Other research

A series of research studies in cerebral palsy have been carried out by E. Bower and D.L. McLellan, investigating the effect of intensive physiotherapy with specific measurable goals. All the studies use the Gross Motor Function Measure (GMFM; Russell et al. 1989, 2002). The first pilot study (Bower and McLellan 1992) used a controlled series of single-case studies with only seven children. The trend was that increased intensity for 3 weeks with goal setting generally improved the rate of progress compared with routine physiotherapy. The intensive treatment was carried out by the researcher.

In a subsequent randomised controlled study of 44 children (Bower et al. 1996), the subjects were assigned to four different groups of 11, with careful checks being made that each group was similar. Intensive physiotherapy was given for 2 weeks to two of the groups, one with general aims and the other with specific goals for physiotherapy. The other two groups received routine physiotherapy for 2 weeks, again one with general aims and the other with specific goals. The study showed that intensive therapy together with specific goals can accelerate the acquisition of motor function. There was no follow-up to see whether these gains were subsequently maintained.

A further study of 56 children (Bower et al. 2001) used four groups as before. However, the period of routine or intensive therapy lasted 6 months and, unlike the 1996 study, there was a period of 6 months of routine therapy (about half an hour a week) with aims (baseline observation period) before the treatment period and a similar (follow-up) period afterwards. In the baseline period, there was some progress, which accelerated with intensive therapy (average 3.5 hours a week). The mean total score on the GMFM improved by 5.9 percentage points on intensive therapy, whereas it improved by only 3.1 percentage points on routine therapy. There was no difference as to whether aims or goals were used in the intensive or routine treatment period. The follow-up 6 months later showed that the average child did not maintain the lead gained during the intensive therapy. However, despite this obvious difference, Bower reports that the lead during the treatment period was not statistically significant.

Studies of rhizotomy by Steinbok et al. (1997) and McLaughlin et al. (1998) provide data on rates of progress on the GMFM during intensive physiotherapy alone. These show a range of average gains of 4.2–5.2 percentage points over a period of 9–12 months.

This is less than the gain of 5.9 points from conservative 6-month intensive therapy found by Bower et al. (2001).

Clinical experience with evidence-based practice

Today, what evidence of the evaluation of therapy is available to the clinician?

1. *Professional experience*. We still use findings from long experience of our own and of acknowledged experts in the field. Careful observations, reflections, and clinical reasoning from practical experience and from related existing studies remain important.
2. *Measures of outcome*. Current practice continues to develop objective evaluations of outcomes (results) of motor training or treatment that are not biased by a school of thought or therapy system. There are still methods of assessment and reassessment that are often self-validating in terms of the theories of an approach. Because the theories or concepts are controversial, such evaluation measures of progress are not objective enough. However, objective measures themselves may not be sensitive or specific enough to pick up the outcomes. Therefore, measures need to be developed to be more specific and to reduce the risk of subjectivity of any measures. Measures for evaluation of clinical therapy outcomes are discussed in Chapter 8.
3. *Research studies*. These are an increasingly valuable source of evidence for therapy. They offer quantitative or qualitative evidence for the value and effectiveness of physiotherapy and occupational therapy.

Quantitative research aims to measure the effects of a particular intervention and presents the results as numerical data. Such research uses experimental designs to test hypotheses, as discussed below.

Qualitative research aims to identify and describe the common experiences and relationships of all those involved in treatments, including the therapists (Whalley Hammell et al. 2000; Patton 2015). It is exploratory by design and is often called 'client centred' because it is concerned with the meaning that treatments and outcomes have for the individuals with cerebral palsy. Research also involves their parents or family, when the term 'family centred' is appropriate. The collection of data uses methods such as specialised focus groups, semistructured interviews, or open-ended questionnaires. Studies can show how therapy or specific therapy methods affect the individual's perception of changes in their bodies, especially for pain, and thus affects their health-related quality of life (HRQOL). Quality of life (QOL), however, is individuals' own judgement, thoughts, feelings, and values and is quite different from HRQOL. Measures of HRQOL are objective, whereas measures for QOL are essentially subjective (Rosenbaum et al. 2007b).

The different research styles of quantitative and qualitative studies provide different kinds of useful information and are complementary. They are each scientific in that their different methods are rigorous, systematic, and disciplined. Most of the research in cerebral palsy therapy has been quantitative, whereas qualitative research is growing in the whole field of rehabilitation. Some issues such as QOL and empathy can be studied by quantitative methods using scales derived from counselling, psychology, and psychotherapy. It is also possible to combine interviews of a sample of people and present some of the findings quantitatively (Ross and Thomson 1993; Rosenbaum et al. 1998; Odman et al. 2007). There are also surveys on, say, attitudes which give numbers of the particular responses. This is not really qualitative research.

In order for the paediatric therapist to develop the skills of critical appraisal and

so appreciate research studies and consider their clinical relevance, the following discussions can be helpful.

Systematic reviews

The best evidence comes from papers that systematically review all the research studies that have been published on a particular question. In a systematic review, the research design used in each study is assessed using a scale (or hierarchy) often called the 'levels of evidence' (see the next section). Unfortunately, systematic reviews of research in cerebral palsy frequently conclude that there have been too few high-quality studies for reliable conclusions to be drawn – so 'further research is needed'.

Nevertheless, there are more and more reviews being published, particularly under the auspices of the American Academy for Cerebral Palsy and Developmental Medicine (AACPDM). The Physiotherapy Evidence Database (PEDro; www.pedro.org.au) currently lists more than 150 systematic reviews related to cerebral palsy. It includes reviews from the Cochrane Library and the AACPDM.

The guidelines produced by the National Institute for Health and Care Excellence (NICE) in the UK are based on its review of all the relevant evidence.

Another way of considering the results of a number of studies is a *meta-analysis*, in which data from a number of similar studies are combined and so the resulting larger sample size is more likely to give statistically significant results. In cerebral palsy, there are now more than 15 meta-analyses listed on PEDro.

Levels of evidence

These are scales used to assess research designs derived from the original work of Sackett et al. (1996, 2001). Most of the scales have five levels, with level I being the highest, although levels are sometimes further subdivided.

> In descending order, the designs are decreasingly able to demonstrate that the intervention – and not something else – was responsible for the observed outcome. Level I evidence is the most definitive for establishing causality, with greatest reduction in bias. Level IV can only hint at causality; Level V only suggests the possibility. (AACPDM 2008)

For research into cerebral palsy, the most commonly used classification scheme is that adopted by the AACPDM (2008) in its *Methodology to Develop Systematic Reviews of Treatment Interventions* (see the AACPDM website: www.aacpdm.org). An example of its use is in the botulinum toxin A systematic review (Lannin et al. 2006). Another scheme for levels of evidence was created by the Scottish Intercollegiate Guidelines Network (SIGN; www.sign.ac.uk), which has eight levels and is highly detailed. It is important to remember that the level of evidence is only one way to appraise a study for evidence-based clinical work. More details are needed for clinical evidence and these are discussed in section 'The appraisal of research studies for therapy'.

The AACPDM levels of evidence are shown in Table 6.1.

Definitions

Case–control study A retrospective study that compares subjects who received the intervention (the 'cases') with subjects who did not receive the intervention but are otherwise similar (the 'controls').

Case series A case series can be retrospective or prospective and usually involves a smaller number of patients than more powerful case–control studies or randomised controlled trials.

Cohort A group of subjects with a common defining characteristic.

Confidence interval The narrower the confidence interval, the greater the degree of certainty in the result.

Table 6.1 American Academy for Cerebral Palsy and Developmental Medicine levels of evidence

Level	Intervention (group) studies
I	Systematic reviews of RCTs Large RCTs (with narrow confidence intervals – high probability of certainty) (more than 100 subjects)
II	Smaller RCTs (with wider confidence intervals) (fewer than 100 subjects) Systematic reviews of cohort studies 'Outcomes research' (very large ecological studies)
III	Cohort studies (must have concurrent control group) Systematic reviews of case–control studies
IV	Case series Cohort study without concurrent control group (e.g. with historical control group) Case–control study
V	Expert opinion Case study or report Bench research Expert opinion based on theory or physiological research Common sense/anecdotes

RCT, randomised controlled trial.

Control group A comparison group that does not receive the intervention but is as similar as possible to the group being studied.

Randomised controlled trial Subjects are randomly assigned either to the treated group or to the control group.

The PEDro lists numerous *randomised controlled trials* and grades the quality of research design by using a checklist of 10 items, all of which should be present in the best design. The number of items present gives a mark out of 10. For cerebral palsy research, scores higher than 8/10 are very rare and many studies have much lower scores. Some studies which score high on this scale for significant treatment effects do not necessarily provide evidence that the treatment is clinically practical. This is where the therapist's own clinical experience and professional judgement are necessary to assess the relevance to their situation.

The appraisal of research studies for therapy

Clinical therapists need to consider some fundamental issues when deciding whether a research study is relevant and worth applying for the child or children they are treating. Consultations with research workers as well as participation in journal clubs and discussion groups can facilitate critical appraisals of research.

The points below can be helpful in appraising a research study, which could be either quantitative or qualitative.

1. *The questions asked*. A research study seeks information about specific questions. These need to be clearly stated, so that practitioners can decide whether they are questions to which they too would welcome some answers or more information to improve their practice. Research questions may be on:
   a. the impairment
   b. the motor function (task) or its components
   c. the participation in society as a result of therapy
   d. the organisation which affects therapy results.

   Questions that *assume* a particular theory or therapy system are controversial. This is especially true if the researcher is clearly wedded to that system.
2. *The sample of children studied*. The characteristics of the children studied (subjects) must be stated, such as age, sex, diagnosis, severity of condition,

and any associated disabilities that affect motor function. In some studies, culture, family, and socioeconomic background need stating, as they are relevant. Clinicians can then judge whether the sample of children in the study is similar to the individual(s) they are treating.

The sample size is very important. The larger the number of children in the sample, the higher the probability of obtaining statistically significant results. Furthermore, if there are only three or four subjects studied, then the results cannot be generalised to the population of interest to the clinician.

3. *The intervention methods*. These methods need to be identified, as different therapists use different methods. For example, individual neurodevelopmental treatment (Bobath) trained physiotherapists frequently use different methods for the same aims of this approach. Eclectic physiotherapists may well use different methods for an eclectic approach.

There is increasing research into which specific method or strategy from a system or from an eclectic approach is responsible for results. This is important when a therapist uses a 'named' system which is a box of methods based on a concept. This is the question facing both researchers and clinicians that identifies which methods to use in an eclectic approach. We need the type of study that focuses on one well-defined treatment method aimed at a specific problem, such as plaster casts for a dynamically short spastic muscle group, to evaluate a method.

The length of *time* of intervention needs to be reasonable. Some research shows that 'reasonable' in the eyes of a therapist may be a burden for a child or for his or her parent or anyone else who is involved in enabling the study to continue.

Some studies need to confirm ongoing cooperation in all the children and their parents. For example, Chappell and Williams (2002) have studied non-adherence to home physiotherapy in paediatrics. The reasons for lack of 'compliance' are a subject for both qualitative and quantitative research. Qualitative research may lead to quantitative research to complement understanding of an issue. On the other hand, as an example, quantitative research can lead to qualitative research (McBurney et al. 2003).

Cooperative children *practise* methods at home or elsewhere. We need to take account of this variable, as practice influences results. Other activities such as occupational therapy or therapeutic horse riding can also affect physiotherapy results.

Furthermore, *the length of a session* (an hour or half hour) and the *frequency of sessions* per week must be stated, as longer or more sessions may perhaps account for the results.

4. The setting or environment may be relevant for a child or older person's competent performance (Tieman et al. 2004). Children may perform better at home during play, with their peer group, with a special friend, or particular family member. For example, a study comparing motor function in a special adventure playground with function in a physiotherapy department found differences in motor performance (Levitt 1975). The setting of the research may need to be obvious or stated.

Specific points in quantitative research

1. *Evaluation tools*. The measurement tools must be appropriate and measure what the research claims to evaluate. These measures of outcome have to be stated

and be accepted as standardised and applicable to the clinician's interests. For example, measures used by doctors or psychologists do not necessarily have the details that interest physiotherapists (see Chapter 8).

One needs to consider whether the measures are suitable for particular questions. It may be more appropriate to use qualitative evaluation methods which are quite different from the 'numbers' used in quantitative research. These are outlined below.

2. *Research designs*. The effect of a specific intervention or treatment should be evaluated by comparing it with the effect of routine intervention. The subjects receiving this routine intervention are called *the controls or control group*. Routine intervention can be either their usual therapy or only parent-handling at home. Others compare physiotherapy or a specific intervention with passive range of movement as a control.

   The comparison in a research design can be with the same subject in single-case studies where the subject is compared with himself so that he is his own control. A single-case study can compare the subject with a different group of subjects (the control group). A series of single-case studies can be used, provided the numbers of subjects are large enough to give statistically significant results (Kazdin 2010).

   a. The simplest acceptable single-case design (the ABA design) starts with a baseline period (A) in which the subject receives everyday therapy or no therapy. This reveals the variations and the role of *maturation* in the behaviour (motor or other) of the individual child. This is followed by a period (B) in which the treatment to be evaluated is given and should be followed by another period of A. This second A period shows whether the progress, or lack of progress, measured in B continues once the specific treatment is no longer given. The results of treatment may not be maintained once a specific therapy is stopped (Bower and McLellan 1992).

   b. The simplest control group design consists of two groups: a treated group and a control group. If subjects are assigned at random to one of the groups, then it is an RCT. This randomisation aims to produce two groups that are as similar as possible but the researchers should demonstrate that chance differences are not biasing the results (see 3a).

      If the study is an RCT, then it should be in the PEDro database (unless it is very recent) and should have been given a score as to its quality.

3. *Sources of bias and error*. There are various reasons why the research may not be comparing what it is supposed to.

   a. The subjects in the control group may differ too much from those in the treated group. As well as random assignment, there may also be an attempt to match subjects in different groups. The research always needs to show that the groups are sufficiently similar. People with cerebral palsies are a very heterogeneous population and, consequently, matching subjects is difficult. The common characteristics which are considered are age, diagnosis, severity of condition, intelligence, and the presence of additional impairments. Moreover, the study should not be influenced by other variables such as social, emotional, cultural, economic, and other unknowns. Variables such as occupational therapy and other activities should be similar in both groups in a physiotherapy study. An example of unmatched severity can be detected in the research of Kanda et al. (1984), who showed that early

Vojta treatment under 6 months obtained better results than the same treatment after 9 months, but the younger group was less severe than the older group.

b. The therapists carrying out the treatment should be independent of the research because therapists are expected to be highly motivated, to be helpful, and see results of their work. It is wise to have a number of therapists carrying out a procedure to be tested, in case the research is really a test of one therapist's skill. All therapists should be of professionally acknowledged skill.
c. The assessors measuring the effects should not know (be 'blind' to) which child has received which treatment; otherwise they may unwittingly bias their measurements.
d. Ideally, the subjects (children and their parents/carers) and the treating therapists should be 'blind' to what treatment is taking place. In practice, it is pretty obvious that a different procedure is being used.

4. *Analysis of results*. Graphs need to be clear when giving results to the clinician. They are useful for ABA research designs, as they can show trends during each of these three periods. For example, an upward trend in the first A period may be markedly increased in period B. The trend in the second A period shows whether any gains made during period B are *maintained*, once the bout of intervention has stopped.

Research studies differ from routine clinical measures and assessments in that statistical methods are used. Statistics are needed because people are variable and cerebral palsy is a heterogeneous condition. These statistics should be explained and not be so obscure that the clinician cannot decide on the value of the study.

Results are given as differences between the groups of children studied. These differences or changes in outcome may be positive, non-existent, or even negative. However, the change may be a fluke or due to unknown factors which give a chance result, and the purpose of statistical analysis is to show whether the change is genuinely due to the intervention. This is what the phrase 'statistically significant' means. This is stated as a *p*-value. A *p*-value less than 0.05 is taken to show that the results are statistically significant.

Remember, a statistically significant result is no guarantee that the research is worthwhile unless all the elements of the research are satisfactory. Clinicians and research workers are more knowledgeable about those elements than are statisticians. But even if the change is statistically significant, it could be quite small and may not be 'humanly significant'. Is it worth people making the effort in time, energy, and money? Is it great enough to warrant a change to clinical practice? Changes in specific impairments or elements of function may only give minor gains in an activity (function). Quality of life can matter more than a large, statistically significant increase in, say, active ranges of movement.

Studies which use large numbers of children are more likely to give statistically significant results, as they can average out the variability. However, if a study is focused on one well-defined treatment procedure aimed at a specific impairment and if the effect is quite a marked change post treatment, then a small number of children is acceptable. Even a control group is not absolutely necessary. Clinicians know the usual history of such cases in the short term.

Statistical significance cannot be calculated for only one or two cases.

In addition, one cannot generalise from one or two cases to all children with the same condition. Certainly a marked improvement in a clinical case encourages the therapist to try out the treatment with other similar children. There are difficulties in recruiting enough children at a local level to participate in a statistically significant study, in which case a multicentred trial would be a good way forwards.

Specific points in qualitative research

In considering the value of qualitative studies, Greenhalgh and Taylor (1997) have made some helpful suggestions. The paper by Greenhalgh and Taylor is 'How to read a paper: papers that go beyond numbers (qualitative research)', which may seem 'unscientific' to some workers accustomed to quantitative studies. As already mentioned above, there can be equal quality checks to ensure rigour and trustworthiness in this research approach.

In an appraisal of a qualitative research paper, one considers the following:

- Was a qualitative research appropriate for the clearly formulated question?
- Consideration of the methods used and that a number of methods needed to be included.
- The results need to appear credible and also important.
- The conclusions drawn have to be justified.
- Consideration of whether the results can apply in other settings, that is, generalised.

Examples of qualitative research methods (Greenhalgh and Taylor 1997)

Documents Study of documentary accounts of events, such as meetings.

Passive observation Systematic watching of behaviour and talk in naturally occurring settings.

Participant observation Observation in which the researcher also occupies a role or part in the setting, in addition to observing.

In-depth interviews Face-to-face conversation with the purpose of exploring issues or topics in detail. Does not use preset questions, but is shaped by a defined set of topics.

Focus groups Method of group interview which explicitly includes and uses the group interaction to generate data.

The additional aspects which need to be checked in a qualitative study are the following:

- Was confidentiality and anonymity assured in sensitive information?
- The subjects need to be able to communicate verbally. The children and parents need to be interviewed in some studies.
- The researcher needs to have checked with the subjects that their quoted statements in the transcripts of interviews about the issues are accurate.
- The quality control is also having the researcher's findings shown to other independent researchers to check any bias in the researcher's perspective.
- There are a growing number of assessments in qualitative research.

The use of qualitative research in health is devised or carried out by social scientists or medical sociologists.

The clinical practitioner needs to consult colleagues who are research therapists for further discussion.

The useful references on research methods are Hicks (2009), Whalley Hammell et al. (2000), and Greenhalgh (2014).

7

Synthesis of treatment approaches

The eclectic viewpoint in therapy

In Chapter 5 there is a discussion on the lack of scientific evidence for theories and treatment methods in cerebral palsy. Based on studies of many therapy systems, over many years, it has always been difficult to confine oneself to any particular system as each includes valuable contributions. Therefore, an eclectic approach has been and still is recommended (Levitt 1962, 1970b, 1974, 1976) and continuously developed, in the light of new ideas, in all editions of this book since 1977.

The eclectic viewpoint had become increasingly accepted from 1984 to 1996. Mayston (2004), a well-known proponent of the Bobath approach and former director of the Bobath Centre, London, UK, stated that 'little or no evidence is available to show that therapy offered by the "named approaches" is effective or that one approach is more beneficial than another' (Mayston 2004, 2008, 2012).

Damiano (2004) discourages following any specific therapy system, pointing out that there are increasing numbers of research studies supporting specific treatment procedures that are not dependent on any system and its philosophy. Fortunately, research evidence continues to accumulate for specific methods for an eclectic approach. There is still more research needed on methods found clinically useful by observant and highly experienced physiotherapists and occupational therapists. We still await research studies providing evidence for methods for specific children, at different ages and developmental stages, with different severities with or without comorbidities. We need more research on how often, how much, and for whom methods should be used.

In the UK, studies by Bower et al. (1996, 2001) mention that most UK physiotherapists use an eclectic approach, and also find that this best meets families' needs.

Different varieties of eclectic practice

It would be difficult to evaluate an 'eclectic approach' as there are different varieties of practice. The diversity of the cerebral palsies, individuals' different ages and their variety of experience, and different families create individual eclectic programmes. Selection from different therapy approaches

Treatment of Cerebral Palsy and Motor Delay, Sixth Edition. Sophie Levitt and Anne Addison.
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varies according to the knowledge, skill, and experience of particular therapists, which is fortunately developing. Some therapists use neurodevelopmental or neurofacilitation methods but without understanding up-to-date motor learning models. Others combine one complete system with another system, although one needs assessments for thoughtful selection from each. Combining two therapy approaches can even be largely contradictory in concept and methods for an individual child. Furthermore, two systems enthusiastically used for a child may well demand too many therapy sessions without regard for many other aspects of a quality of life for that child and family.

In developing an eclectic approach to create a synthesis, it has been necessary to try to understand the different rationales underlying the methods in various therapy systems. The aim was to attempt to analyse and clarify this complicated field, over many years, in order to bring together isolated but valuable pockets of knowledge (Levitt 1977). At first, the systems appear different and even contradictory to one another. However, this is not really the case. Although there are differences, there are also areas of common ground. The following discoveries emerged in the comparative study of the theory and practice of various treatment approaches – neurophysiological, developmental, orthopaedic, and motor learning.

1. Different rationales are given by different systems for the same or similar methods. The common ground is the method, but the reasons offered differ.
2. In some instances, the rationale and methods are not really different, but either the rationale or the methods are only couched in different terminologies. The common ground can be both the method and the reason for it.
3. In other instances, the rationales are the same, only couched in different terminologies, but the methods suggested differ from system to system. The common ground is the rationale but methods differ. Currently, there are new theories (see Chapter 5), yet methods are not always quite different, and even old, habitual methods continue to be used and are said to be directly related to these theories. This either supports or leads to questioning of the methods used.
4. There are still differences in methods and rationale, which need understanding so that contradictory methods are avoided in an individual child at a specific level of development.
5. Although methods may even differ, they are sometimes given the same name.

During these studies, it has also been difficult to know which methods and ideas in any particular system are the ones that are responsible for the results achieved. In any system, there are methods and ideas which are superfluous. It is not correct that 'everything in a system depends on everything else' (Levitt 1977).

Methods and ideas have been selected rather more according to minimising the impairments and promoting functional solutions than according to the changing neurophysiological and different motor learning theories. Today the International Classification of Functioning, Disability and Health (WHO 2001) provides a common terminology based on much that relates to therapists' previous clinical experiences.

Synthesis of treatment systems

A synthesis of therapy and management approaches is based on consideration of postural mechanisms, voluntary motion, and perceptual–motor function intrinsic to function. It is particularly activity (motor function and activities of daily life) that must draw on learning/teaching methods.

Any synthesis for activity development cannot be divorced from the emotional and social concerns of children, their parents, and families. Synthesis also selects those methods that can enhance children's functional experiences in their daily life in home, school, playground, and community.

Despite different terminologies and methods, the following aspects of activities are fundamental to treatment and management of motor disorders in cerebral palsy:

- the postural mechanisms
- voluntary motion
- perceptual–motor function.

The postural mechanisms

The postural mechanisms are neurological mechanisms that maintain posture and equilibrium and are included in locomotion. Sensory information from visual, proprioceptive, vestibular, and tactile input are involved with the postural mechanisms. The importance of particular sensory systems varies during typical postural development. Young children until about age 3 years find vision more important than proprioception for postural control, whereas adults depend more on the proprioceptive input for postural control (Lee and Aronson 1974). Fully developed postural mechanisms, other than tilt reactions, are exhibited by adults who are blindfolded. Tilt reactions need vestibular and visual perception.

Postural mechanisms have been described by various neurological workers (Martin 1965, 1967; Belenkii et al. 1967; Foley 1977, 1983; Marsden et al. 1981; Visser and Bloem 2005; Hadders-Algra and Carlberg 2008; Shumway-Cook and Woollacott 2017; among others). Paediatric physiotherapists need to focus on postural mechanisms of stability and related postural adjustment, righting (rising) to change postures, saving and protective responses to balance loss, as well as tilt reactions in both active and reactive methods. It is important to remember that, if physiotherapists stimulate each of the postural mechanisms separately, this does not necessarily lead to their use within daily functions. Therefore postural mechanisms are activated within the context of developmental functions desired by an individual with cerebral palsy.

Purdon Martin's presentation (Martin 1967; Foley 1977) drew on many neurological studies at the time and used their own observations or studies. Purdon Martin's clear functional scheme originally provided a practical observational framework for clarifying many terminologies and methods in different treatment approaches (Levitt 1977). In later editions of this book there have been slight modifications related to children with cerebral palsies and in view of new research.

Whatever the terminologies and different viewpoints, there are methods to stimulate or train postural mechanisms within most treatment approaches. However, particular approaches have emphasised some, but not all, of these postural mechanisms. Some assessments for therapy such as the Chailey Levels of Ability (Pountney et al. 2004) and the Gross Motor Function Measure (Russell et al. 1989) omit examination of the tilt and the saving/protective postural mechanisms as their therapy emphasises other aspects.

Children with cerebral palsy with severe visual impairments, severe intellectual problems, or with perceptual–motor difficulties are among those individuals who cannot function safely and fully independently without all the postural mechanisms (Chapter 9). It is important to draw on all treatment approaches to find methods for postural mechanisms so that we make sure that none of an individual's potential postural mechanisms are omitted. There need to be methods for a child's active initiation as well as for automatic or reactive aspects

of postural control. Hadders-Algra et al. (1996) have shown that increased experience improves postural control in the developing nervous system of typical babies. Training postural control in cerebral palsy provides positive results in sitting (Hadders-Algra and Carlberg 2008: chapter 4) as well as in standing (Shumway-Cook et al. 2003; Shumway-Cook and Woollacott 2017). Those therapy approaches that have given attention to all the problems of postural mechanisms have not necessarily suggested methods to cover the needs of all children, adolescents, and adults. Therefore, methods need to be selected from different approaches and from eclectic clinicians so that dormant motor controls of postural mechanisms can be activated in an individual as much as is possible. Suggestions are given in Chapters 9, 10, and 12. The postural mechanisms are given mainly in the terminology of the functional scheme of Martin (1967), including other terminologies when known. They are illustrated in the practical chapters.

In outline they consist of the following six postural mechanisms.

The antigravity mechanism or the mechanism that helps to support the weight of the body against gravity. This provides a pillar of the limb for support against gravity. This firm pillar becomes more flexible with development of the postural mechanisms discussed above.

This is also known as the supporting reaction in infants, leg straightening reflex, or positive stützreaktion (supportive response), and is similar to infantile co-contraction.

The postural stabilisation of parts of the body, including head on trunk, trunk on pelvis, stabilisation of the shoulder girdles and pelvic girdles, and the muscular activity of the lower jaw, tongue, and pharynx. Postural stabilisation of the body as a whole takes place in a variety of positions. In upright sitting and standing, there is vertical alignment of body parts and symmetry of both sides of the body. In typical individuals, stability is achieved in many other postures. Although quiet stability results, there are subtle adjustments called 'postural sway'.

Terminologies also used for this are *stability*, *heavy work*, and *tonic activity*.

Counterpoising mechanisms or postural adjustments are closely associated with postural stabilisation. They are adjustments of the trunk and other parts of the body so that a movement can be made while the person maintains a posture or equilibrium. Movements are those of the limbs, head, or trunk, which require these postural adjustments for equilibrium. Weight shift precedes limb movements and is minimal before any movement is started. Counterpoising or counterbalancing is an 'anticipatory' postural adjustment discussed below with voluntary motion. This is by proprioception and sometimes tactile as adults without labyrinthine function respond adequately.

Terminologies also used are *balance during motion, load shift, weight shifts*, and various *balance exercises* and *movement superimposed on co-contraction*. In crawling, knee-stepping, and walking, *reciprocal leg motion* depends on weight shift and postural adjustment.

Righting or rising reactions make it possible for the person to rise from lying to standing, or from sitting to standing, or for many other changes of position. It is not only rising into position but also returning to the original position. The rising involves a sequence of automatic 'righting reactions' or of intentional motor actions. The rising depends on turning over from supine to prone and later direct head and trunk raising from supine. Intentional rising by a

child develops the ability to focus on different ways that might be used to get up or change from one posture to another.

Terminologies used are *assumption of posture*, *moving into position*, and *movement patterns*. The last is confusing as there are a number of movement patterns used within voluntary movements that are different from these more automatic changes of posture. The rising or righting reactions above depend on tactile and proprioceptive input but other terminologies of 'righting reflexes' use vestibular or labyrinthine input. They are *righting* reflexes that have been studied in relation to being tilted down. When a baby is suspended and passively tipped downwards (forwards, backwards, or sideways), this elicits *head adjustment to the upright and with further tilting adjustments of the trunk*. In this book the terms of righting/rising are integrated responses that are functionally more important for rising to standing and changing positions (Martin 1967). Others consider righting reactions to be part of 'equilibrium reactions' stimulated on stationary or tilting surfaces (Bobath 1980; Aubert 2008).

Tilt reactions occur when a person is tilted well off the horizontal plane and adjusts the trunk so that balance is preserved. This is seen on a therapy roll or on a rocker or tilting board. Tilt adjustments are anteroposterior, lateral, or diagonal to each side with equal responses.

Reactions to falling or saving from falling include various responses in the limbs which try to prevent the person from falling over. These responses are stimulated if the perturbation of a child is so great that tilt reactions cannot preserve balance. Saving/protective reactions may be excessive if a child has no tilt responses. Usually, children do not, on their own, stop falling over completely. For example, the arms may be thrown out to save the person from falling forwards, sideways, backwards, and in more complicated patterns. Once a person has fallen, the saving response may result in propping on arms or hands. Should the person be falling over from the standing position, he or she may stagger, hop, or quickly place a foot out to stop the fall.

When a less vigorous push is given to the front of the body, threatening a fall, the person's reactions are ankle dorsiflexion or hip flexion. When a perturbation is particularly great, the person reacts with a forward leg placement to stop the fall (Shumway-Cook and Woollacott 2017). When the person is pushed from behind, he/she rises on the toes. The arms may also be thrown out to stop falling. In sitting, kneeling, and other positions, arms and legs also move in order to save a person from falling.

The terminology for these reactions is protective responses. Particular arm-saving reactions are also called parachute reactions, protective extension, arm balance responses, precipitation reaction, or head protective response.

Equilibrium reactions or balance reactions are also terms used which mean a combination of tilt and the limb reactions. These terms are confusing as all the six postural mechanisms above are involved with equilibrium or balance. Maintaining a stable posture alone or during movement is synonymous with maintaining balance (postural control and postural adjustment) even before equilibrium reactions develop. Also, limb-saving reactions need not be accompanied by tilt reactions, nor need tilt reactions be accompanied by limb-saving reactions. In children either limb-saving or tilt reactions may only be present and then each is augmented, when on its own. This is seen particularly in athetoid and ataxic conditions. Perhaps the use of 'equilibrium' has led to the

confusion that 'equilibrium reactions' result in postural stabilisation and adjustment during limb and other intentional movements.

Besides the main postural mechanisms above, there are also the following reactions.

Locomotive reactions, which serve to initiate, continue, and stop stepping as well as enable turning in walking and running. They are also known as the mechanisms for propulsion or progression and control slow or faster locomotion. For stepping, locomotive mechanisms are initiated by slight forward lean, and for stopping by a slight backward lean. They operate with other postural control mechanisms in adaptation for human gait.

Visual postural reactions. Vision is of importance for babies' and young children's development of postural control. Vision initiates and monitors both posture and movements. Vision compensates for poor postural mechanisms, especially the tilt, and is important during locomotion and when avoiding obstacles. Severe visual impairment delays the development of postural control, particularly tilt reactions (Sykanda and Levitt 1982).

All these postural mechanisms need to be stimulated *within developmental functions* and in different environments. Postural control in different tasks and in different environments involves adaptation or orientation (Shumway-Cook and Woollacott 2017). This is learned through experience using higher level integrative processes for adaptive and anticipatory mechanisms for postural control. It is helpful to be guided by motor developmental levels, for as children acquire functional motor control they are also acquiring these neurological mechanisms. However, the developmental sequences may vary in both typical children and those with cerebral palsy. This is discussed in the section on 'Developmental training'.

Trunk control

Saavedra (2015) heads her commentary 'Trunk control in cerebral palsy: are we ready to address the elephant in the room?' Her comments are on the study by Sæther et al. (2015), published in the same journal. Saavedra states that 'we do not yet know if treatment of trunk control in sitting can generalize to improvements during gait'. Sæther et al. use as evaluations the Trunk Impairment Scale within the base of support, described by Sæther et al. (2013), and the Trunk Control Measurement Scale outside the base of support (Heyrman et al. 2013). However, both Saavedra (2015) and Sæther et al. (2015) in their discussions state that the study is to be interpreted with caution. It included 26 children spread across Gross Motor Function Classification System (GMFCS) levels I–III. Children in level I were only unilateral, and in level II unilateral and bilateral. Level III had very few numbers. Saavedra also draws attention to the Segmental Assessment of Trunk Control (Butler et al. 2010).

Trunk control is another term for postural control focused on the trunk.

Voluntary motion

Voluntary motion, which is purposeful, conscious, willed motion, is sometimes confused with the active automatic movements that occur in the postural mechanisms such as rising or saving from falling. Although some of the automatic movement synergies are also seen in voluntary movement, stimulation of the automatic patterns only corrects some atypical movement synergies (patterns) but does not contribute much to the training of voluntary motion. Physiotherapists contribute techniques to strengthen and stretch muscles and increase joint ranges to minimise musculoskeletal problems, which interfere with voluntary arm and leg motion.

These physiotherapy methods can be drawn from many treatment approaches and, as in the past, may still be treated separately from the functional training. In such cases, these methods need to be immediately activated in functions. When children are able to carry out functions at their own developmental levels, it is preferable to include active stretching out and strengthening within function.

Voluntary motion of the arm and hand is important for many daily tasks. There is some difference of opinion about the use of atypical grasps, though there are specific atypical functional patterns that are acceptable. The section on 'Development of hand function' in Chapter 9 discusses fundamental fine motor development, including neurological anticipatory control in hands. Both musculoskeletal and neuromuscular methods for hand function are not enough for the development of voluntary motion, which is involved with sensory experience, perception, praxis (motor planning), and understanding (cognition). Voluntary motion in typical children develops many different coordinated upper limb patterns and there may be a great variety of patterns (synergies) in any one child for the same task. Therapy in cerebral palsy needs to offer a variety of motor patterns so a child can have a choice for a task and use what can be managed and also avoid those deformities that may hamper function.

In Chapter 9, various methods are suggested in play and daily care with more details on daily life given in Chapter 10. Additional information needs to be gained from other colleagues, such as speech and language therapy, psychology, and special education.

Voluntary motion and postural control

Voluntary motion is intertwined with the postural mechanisms. Postural mechanisms allow voluntary movement to take place and any voluntary motion itself further activates the relevant postural mechanisms. When a child makes a voluntary movement, he has to maintain his balance as he does so. If postural stability and postural adjustment are inadequate, the child may not be able to initiate or carry out the movement. Should a child manage to carry out an active movement on a background of unstable posture, the movement can be imprecise, clumsy, or uncoordinated. There are weak limb movements due to disuse as the unstable person is fearful of using them in case of falls. To stabilise oneself, the arms and hands are used as supports rather than for voluntary motion. Clinicians understandably want to train voluntary movements giving external support to an unstable child. This can happen if a child is firmly supported for most of the day in, say, special chairs and standing frames. Equipment needs to be viewed as tools to assist individuals to learn functions. Postural adjustments can be activated if support can be removed from one part of the trunk in equipment for training. Training can be used with manual support given under a child's axilla, followed by the upper then lower trunk, and finally pelvis for postural stability and postural adjustment to allow voluntary movement and to increase a variety of intentional hand and limb motions.

Since Martin's work (1967), there have been many research studies to show that postural adjustments for limb movements are anticipatory postural responses (Marsden et al. 1981; Cordo and Nashner 1982). Nashner et al. (1983) found that, in cerebral palsy, there is inability to activate postural muscles in anticipation of voluntary arm motion. They quote many studies, including their own, showing that an anticipatory postural response takes place before an intended voluntary movement is begun. This is a 'feedforward' mechanism among others which are

activated before voluntary initiation of movement. For example, von Hofsten (1992), in his many research studies of infants' visually directed reaching, had his infants fully supported as they did not have stability and anticipatory counterpoising under the age of 4 months. Amiel-Tison and Grenier (1986) manually stabilised an infant's head on his trunk to reveal pre-reaching arm movements that were not seen without postural control. von Hofsten's studies also showed that an infant's reaching became more successful as his postural control developed from 4 months of age. Anticipatory postural responses of their trunks were observed at the typical age of 9 months. There are also 'feedback' mechanisms to grade the size of the muscle responses of postural control, which develop with experience.

Postural control of the head and trunk helps eye–hand coordination in voluntary movement. Orofacial muscles function better with head control (Winstock 2005). Delayed postural mechanisms are observed in children with severe visual impairment and need development (Chapter 9).

Perceptual–motor function

Perceptual problems are linked with understanding concepts such as above, below, under, and so on. The therapy systems explored in this book not only mention the role of the physiotherapist and occupational therapist, but also emphasise the contributions of speech and language therapists, psychologists, and teachers to support the development of children's perceptual–motor function. As therapists we understand that the development of motor skills can be viewed as part of an interactive developmental process alongside perceptual, social, and cognitive abilities. Perception and cognition guide movement while movement also influences perception and cognition.

Children with cerebral palsy who have less opportunity to move and explore the world will naturally experience less sensory and perceptual stimulation and may subsequently perceive and process information about their environment differently from their typically developing peers. A number of motor learning theories have been utilised by therapists over the years, from which several motor learning principles have evolved. As a result, physiotherapists and occupational therapists continue to use activities that provide intrinsic feedback from the sensory systems as a result of movement, as well as those that provide extrinsic feedback through direction and instruction. However, as detailed elsewhere in this book, contemporary occupational therapy practice has moved away from sensory-based motor approaches towards a top-down motor learning approach that focuses on promoting function and occupational engagement.

Principles for a synthesis of therapy and management

The common ground between the different approaches forms some of the basic principles of treatment. This is followed by additions from experience and from recent research studies. These common denominators will be discussed so that therapists can understand where they exist and where differences are apparent or real.

General principles of management that are currently accepted by most practitioners:

- team work (in various styles) (see Chapters 1, 2, 10, and 12)
- early treatment (see Chapters 1 and 2)
- repetition or practice of functional activities (see Chapters 2–4, 9, and 10)
- education, support, and encouragement of the child, adolescent, and adult as well as parents, family, and carers (see Chapters 1–4)

- use of activities in the home, school, playground, or community (see Chapters 1, 8, 10, and 13).

Specific principles of treatment. The common aims detected in the various systems of treatment with common factors and differences are as follows:

- developmental training
- treatment of impairments, tone, and weakness
- training of a variety of movement patterns, including lack of selected motor control
- use of afferent stimuli–sensory input, handling, and guidance
- management of deformity.

Developmental training

Viewpoints differ as to whether to train a total motor function such as rolling, sitting, crawling, standing, and walking, as measured in various motor scales, or whether to break each function down into elements or components for treatment. Most physiotherapists prefer to train elements or *bricks* that build up the motor function as well as train the total function. However, views differ as to what these elements are. Some talk of different types of muscle tone, different muscle work, and different biomechanical ideas. In addition, various *basic motor patterns* are recommended as fundamental abilities that underlie many motor functions on the developmental scales. For example, Bobath and Bobath (1975) suggested head and trunk control, symmetry, extensor activity, rotation, arm support, and equilibrium reactions; Rood (1962) suggested muscle work in the main stages on an *ontogenetic developmental sequence;* Vojta (1989) suggested normal muscle work within the basic creeping complex and reflex rolling from which stabilisation and rising are facilitated. Cotton (Russell and Cotton 1994: appendix A) recommended symmetry, grasp, elbow extension, and hip mobility as fundamental in cerebral palsy. Green et al. (1995) emphasise load bearing on different body parts.

Motor learning approaches also use methods based on task analyses of a motor skill into elements for learning. It is possible to contain all these viewpoints as one or a few may be relevant according to the individual assessment of a child. The assessment will of course not be bound by any specific therapy approach.

- Training postural mechanisms and locomotive reactions described above, as well as specific voluntary motion, includes attention to symmetry *and normal asymmetry*, grasp, head and trunk control, both flexion and extension, rotation, and other components (abilities) according to the assessment of individuals. It is important to look at the postural mechanism in each *part* of the body (i.e. head, shoulder girdles, trunk and pelvic girdles), which reveals weight-bearing patterns on all body parts. These neurological postural mechanisms are directly involved with aspects of biomechanics.
- Postural mechanisms of one part of the body may be more advanced than another part; for example, the head may be better than pelvis and vice versa; shoulder girdle may be better than pelvis and vice versa. One side of the body may be more advanced than the other. Methods are selected from any approach for these problems.
- Muscle work for activation and strengthening is included in training of postural control and voluntary movement within developmental motor functions and management of deformities. Therapists also carry out exercises for muscle strengthening separately or use progressive strength training, but some studies show that there may not be an automatic transfer to developmental

motor functions including gait. Postoperative therapy includes strengthening of specific muscles.

Development assumptions

The developmental training of the past trained first head control and only then rolling; next was sitting, then crawling, and, only after all these, were standing and walking. This view of one developmental ladder may have arisen because these motor skills *appear* more or less in this sequence. However, in typical children, all these skills are developing simultaneously but are not fully achieved until different milestones (*motor ages*; development levels) are reached. At birth, the supported child is able to take weight on his feet and momentarily hold his head upright. These are the elements of standing, but it will take many months before the full achievement of standing alone. The same occurs for crawling, for rolling, and for sitting. The therapist works on developmental levels of these elements to build up motor elements for each motor function in, say, 'stages for crawl', 'stages for sitting', and 'stages for standing and walking' in the relevant developmental channels. It is now traditional to use prone, supine, sitting, and standing as parallel motor developmental channels rather than one developmental ladder. This is more relevant to therapy. Parallel channels are also more task specific biomechanically for muscle groups and joint ranges (see Chapter 9).

The use of parallel developmental channels by some therapists has also generated unproven assumptions. There are many examples such as: back extensors must first be trained in prone lying before upright standing; legs must first be strengthened in lying before walking; reciprocal leg movements must first be trained in reciprocal kicking, creeping, or crawling before stepping in walking; rolling is necessary for the rotation component of sitting and reaching across or behind the body or for the gait pattern. There are assumptions such as that load bearing and load shift in lying will transfer to sitting and standing, and if sitting is not being achieved then treatment 'goes back to lying' (Pountney et al. 2004). Yet, the influence of gravity, the muscle work, and joint positions are not the same in lying on a surface and being in upright positions. Body morphology changes and affects motor patterns. It is also of interest that Thelen (1992) mentions her research in which reciprocal kicking, though similar in pattern to stepping, continued after infantile stepping disappeared. Thelen also notes that an infant's legs can be strong but walking could not develop if other factors, including postural control, were absent. In this book, since 1977, the developmental sequence in standing position from manually supported infantile stepping, weight bearing to independent standing and walking is supported by research (Forssberg 1985).

The examples of the above developmental assumptions are usually clinical observations that appear to correlate motor components in different positions. But *correlation is not causation*. Therapists need more research to confirm the beliefs of what are the prerequisites of motor function. In individual cases, we also need to avoid *confusion of sequence with consequence*.

Therefore, postural mechanisms need to be activated in all the positions in which they underlie the sequence of specific developmental functions. Methods for strengthening, stretching short muscles, decreasing spastic hypertonus, and mobilising joints in lying may show results, but will not necessarily transfer to functions in other channels of development against gravity. Methods for these aspects also need to be used in all parallel channels of development.

An accepted view by most therapists is that there needs to be recognition of other

factors such as vision, sometimes hearing, as well as perception and motivation. Motivation is intrinsic to a child or extrinsic by the guidance of therapists and parents. The complexity is that these physical and psychological aspects may be at different levels of development from that of motor control. Comprehensive assessment by an integrated team assists individual therapy.

Biomechanics and motor development

Biomechanics involves the shape, size, and weight of the body and includes the lengths and strengths of muscles and the degrees of joint ranges throughout the body. All this changes as a child develops. There are typical developmental stages against gravity which include biomechanics in a child whose size and weight is changing. For example, it is easier for the child to acquire postural stability of the head in a motor function at, say, the 3-month normal developmental level than at, say, the more demanding functions at the 6- and 9-month levels. Control of the head in supported sitting (3 months) is easier than head and trunk control in unsupported sitting (7–9 months). Tilt reactions are easier in lying (6–9 months) than in sitting (9–12 months). Rising onto all fours (6–9 months) is easier than rising onto two feet (18 months).

These and other motor functions depend on the postural mechanisms, as well as on other aspects of biomechanics such as muscle lengths and strengths (forces). For example, at the 9–12-month developmental level, the postural mechanism of rising from sitting to standing and return to sitting involves length and strength of muscles. In another example, at the 4- to 6-month level, a baby in prone with postural stabilisation of the posture, propped up on the hands, strengthens and shortens hip and trunk extensors while stretching out hip and trunk flexors.

Aubert's (2008) 'progressions of development' are based on a number of studies and her own observations of typical child development, which draws attention to the biomechanics. The biomechanics also depends on the size and shape of a person and, consequently, is not always the same as in a baby, toddler, or older child. Nevertheless, there are a number of similar biomechanical features in early typical motor behaviour that are characteristic of older children with cerebral palsy. Examples are as follows:

- Flexion of arms and especially of legs for weight bearing is present before extension. As stability develops, the centre of gravity is being raised with extension. Nevertheless, flexion returns at times of instability in both children and adults.
- Forward lean in sitting and standing with use of arm props before upright independent posture.
- Bases of support are first wider before smaller bases develop for stability.
- Younger children first hold onto supports in development of sitting, standing, and walking, as well as when rising up against gravity from, say, kneeling or sitting to standing, before later independence without supports.
- Gait components in toddlers are similar to many used in older children with cerebral palsy to balance during walking (see the discussion on a typical toddler's gait in section 'Development of standing and walking' in Chapter 9).
- Use of the long lever of a limb in movement improves when stability develops in the trunk, shoulder girdle, or pelvic girdle, which then act as points of fixation.
- None of these patterns are due to hypertonus. Of course, hypertonus and especially weakness play a part in deformities. When hypertonus and weakness

increase with age, there are changes in muscle lengths, creating secondary deformities and making biomechanics more complicated (see Chapter 12).

Individual variations

Individual assessment findings frequently suggest motor training at different developmental levels in each channel of development. A child can be ahead in one developmental channel rather than in another. In typical babies, those who spend time predominantly in supine or in prone or in a sitting position have motor abilities in a preferred position that are developmentally ahead of abilities in the other positions. This takes place as normal individual variations in Western cultures.

This is also observed in typical babies in different cultures. Solomons and Solomons (1975) found that infants in Yucatan, Mexico, had a fine pincer grasp earlier than North American infants. The Mexican infants preferred different positions and sequences and were slower in walking than North American infants. In some cultures, parents rarely put a child down on the cold tiled floors or on rough unhygienic ground, so crawling and rolling were not used. Studies by Hopkins and Westra (1989) among others in cross-cultural studies show that mothers' expectations, parental training, and especially opportunity create preferences which increase or 'delay' particular developmental functions in children in different environments. Physiotherapists, together with parents, in any environment, can also be an influence on developmental functions through training and practice as motor development is a learning experience and not only maturational. Even biological maturation is unique to each child. Therefore, in Chapter 9 on therapy procedures, there are also ranges of the developmental stages to take account of individual variations.

Variations within each channel also need to be recognised. The functional severity and age of each person determine how much of a repertoire of motor items can be achieved in each channel. It is unlikely that all items will be possible due to the abnormal nervous system or abnormal musculoskeletal system.

Developmental sequences

There are different views on developmental sequences with some therapists being meticulous in following sequences, although most therapists regard them as guidelines with a variety of views on modifications according to a child. The following summarises some ideas.

Some advantages and disadvantages of modifications of developmental sequences

- Fears or strong dislike by a child when placed in any posture lead to initial use of another posture and developmental channel. Prone can be disliked by children with breathing problems, gastrostomies, or severe visual impairment. Children, whether typical or with disabilities, who become bottom shufflers dislike prone sequences. Children with severe upper limb involvement or hemiplegia often cannot use arm support and crawling in prone. If head and shoulder control from the 0- to 6-month levels cannot be activated in children who dislike prone, then train such control in a prone standing frame supporting the trunk, pelvis, and feet. The child's head is forwards with chin in and weight taken through forearms on a table. A child may also accept training of head and shoulder control in well-supported sitting, leaning well forwards onto the forearms or hands on a table of relevant height. Training of head, arm, and leg control may not be acceptable in the four-point

(crawl) position but might be practised in four-point standing on hands and feet with hands on a low box. If unstable, the individual is supported at trunk or pelvis.

- Supine development normally has actions of head, arm, and later leg against gravity that a child finds difficult to do. Head, arm, and hand functions and leg actions may be easier in side lying than in supine. The examples are bringing hands to midline, to touch body, grasp feet, and play with toys. There are arm and hand functions that are easier with gravity assisting when in prone on a wedge or in crawl position with body supported.
- All techniques for arm and hand functions ideally need to be trained in many different positions. Supportive equipment is used when a child cannot maintain particular positions for hand function, perceptual–motor experiences, and use of vision and hearing with and without hand function.
- Rising from either prone or supine may have to be a choice for some individuals so that they can manage the rising sequences. The disadvantage is that use of active rising in both prone and supine developmental channels offers more variety for increasing ranges of joints and muscles. A person also learns more strategies of turning in bed, getting out of bed, or getting up from the floor.
- Development of standing and stepping seems to require training in the standing position. As in typical babies at ages between 1 and 6 months, this can be activated early with appropriate trunk support. In cerebral palsy, well-designed fully supporting walkers are used, but the person is standing and stepping in these early patterns. This is a disadvantage if postural control is not being trained. The advantage is that a standing position provides the necessary visual, proprioceptive, and spatial experiences. Vertical head stability may initially be stimulated in standing, but it is important to simultaneously emphasise development of head and trunk control in the upright sitting as well as in the standing position. Sitting provides a wider and more stable base than standing for promoting independent head and trunk control.

Pre-walking skills of rolling, crawling, and creeping have not been shown to need establishment before training standing and walking in adult neurology (Shumway-Cook and Woollacott 2017). This is similarly so in some children, provided these earlier skills continue to be established as far as possible. A disadvantage of focusing on standing and walking or on sitting, standing, and walking (Mobility Opportunities Via Education (MOVE) programme; Thomson 2005) is that there may be omission or inadequate training of rising from lying to standing and managing bed mobility, components of which develop in the supine and prone developmental channels. This is likely to result in an individual remaining dependent on others to be 'stood up' for walking with and without walkers, and dependency in getting out of bed or for turning in bed. The advantage for a child, particularly one with severe visual impairment, is that mobility along the floor through rolling, creeping, crawling or bottom shuffling avoids deprivation of important spatial and other basic perceptual–motor experiences.

Summary

Parallel developmental sequences activate fundamental postural mechanisms and voluntary motion within developmental motor functions. They may be sequential or modified according to culture and individual conditions. Developmental assumptions and the biomechanics in development

are discussed so that methods can be appropriately selected. In the practical chapters, ideas are selected from various approaches to train the motor activities according to each child.

Treatment of atypical tone

Treatment of spasticity

The term spasticity or hypertonia is used in different ways by clinicians and researchers (Sanger et al. 2003; Lin 2004). It is a general term covering a number of motor problems that are not directly caused by spasticity. Katz and Rymer (1989) point out that spastic hypertonia is only one component and that other features may be more disabling. Weakness, fatigue, and loss of dexterity are among the other problems. Therapy plans need to identify which problem is being treated (see Chapter 8). There are atypical postures, excessive co-contraction, muscle imbalance, atypical activation patterns, and muscle sequencing. Spasticity also involves changes in the viscoelastic properties of muscle and other tissues that contribute to atypical gaits, increased resistance to passive stretch in limbs, limited joint ranges, and deformities (Dietz and Berger 1995).

Spasticity is given particular prominence, for diagnosis, in orthopaedic approaches and for the use of botulinum toxin A injections. Physiotherapists may take their lead from such workers. However, spasticity is not of great significance for functional development (Levitt 1977; Lin 2011). Too little attention is given to the absence of functional aspects.

Young and Wiegner (1987) state that 'spasticity may be partially responsible for joint contractures, it does not produce most of the functional disability…'. Giuliani (1992) in her many assessments of the results of dorsal rhizotomy to remove spasticity states that '…assumptions that spasticity is the underlying cause of disordered movement and that reducing or eliminating the spasticity will improve movement are unfounded….Reducing spasticity may increase range of motion, but may unmask underlying weakness rather than underlying control.'

Dietz (1992) points out that various drugs can reduce stretch reflexes but this effect does not result in a significant improvement of function. McLellan (1977) reduced velocity-dependent stretch reflexes (spasticity) with oral baclofen, but co-contraction of quadriceps and hamstring muscles remained. Co-contraction can be used in function, as it compensates for lack of postural control, so the person can be propped up against gravity. Sometimes a moderate amount of co-contraction will assist transfers of individuals with severe conditions. Co-contraction is also used by able-bodied people coping with unstable or slippery surfaces. Research studies by Shortland et al. (2002), Gough et al. (2005), and Ross and Engsberg (2007) have shown that weakness is much more important than spasticity in causing functional disability. Kim and Park (2011) studied 81 children in all GMFCS levels and found that 'spasticity' had a significant negative effect on functional outcome, whereas strength had a significant positive effect on functional outcome, and gross motor function (activity) had the largest effect on functional outcome. They concluded that 'activity-based rather than impairment-based intervention is more important for reducing activity limitation in children with cerebral palsy'.

There are situations when spasticity, now called 'spastic hypertonus', is relevant to function. This is when spasticity together with weakness and viscoelastic muscle changes results in musculoskeletal problems. These problems are discussed in more detail in Chapter 12 on the management of deformity.

The eclectic view on treatment of spasticity is held by McLellan (1984) and Dietz (1992). Lin (2000, 2004) also points out

that there are various mechanisms causing spasticity that affect medical decisions.

Methods from different therapy systems are now used to lengthen and strengthen short spastic muscles and shorten and strengthen excessively lengthened muscles, rather than a general aim to 'treat spasticity'. These are discussed in Chapter 12.

If a child is being helped to move with a greater variety of motor patterns and as actively as far as is possible, this will *include* minimising the stiffness as well as short muscle lengths of spasticity, while providing activation or strengthening of muscles.

Hypotonicity

Hypotonicity is also not necessarily correlated with strength of voluntary motion but seems more associated with the postural mechanisms (Foley 1977, 1983). Improvement of the postural control seems to coincide with improvement of the hypotonic muscles. 'Floppy babies' improve as the postural mechanisms are regularly activated. Proprioceptive neuromuscular techniques of joint compression through limbs, while weight bearing with correct alignment, assist postural control using stabilising muscle work.

Fluctuating tone

Fluctuating tone or severe sudden spasms and involuntary motion seem to 'throw the child off balance', but may not prevent the development of the postural reactions. Dyskinesia has disrupting spasms or tone fluctuations and disability in function. Nevertheless, in some children, voluntary motion can be trained, despite some disturbance by the involuntary movements. Improvement of postural control seems to *decrease* the disrupting effect and sometimes the degree of involuntary motion. Excessive arm-saving actions are due to poor postural stability, so they appear to decrease when postural stabilisation is improved.

Summary

The therapist should not collect techniques for atypical tone *as such* but rather:

- *Emphasise training the developmental motor functions, which increases the variety of active motor patterns.*
- Concentrate on threatening and established deformities to which atypical tone may contribute, together with other factors (see Chapters 9 and 12).

Training of movement patterns

Movement patterns or synergies are made up of muscle groups or chains of muscles. Some therapy systems assess and treat individual muscle groups, which is associated with orthopaedics. Research by Damiano et al. (1995a) demonstrated an improvement in crouch posture (flexion of hip and knees) following strengthening of quadriceps. Although individual muscle groups may be treated *in isolation*, this is not possible with children who have more severe cerebral palsy or have lack of selective motor control. The children in their study were older and more mildly affected and were walking.

At early levels of development and in impairment, children cannot easily carry out discrete or isolated movements. They lack selective motor control. Such children and adults can only use mass movements or stereotyped synergies of muscle action. Tedroff et al. (2006) found 'abnormal' synergies and recruitment patterns in mild and moderate conditions in cerebral palsy. The 'immature stepping pattern' with trunk fully supported is used for very early training of walking. The activation of muscles within this infantile pattern is used to avoid immobility. Children themselves have used these early patterns when they have no other means of functioning.

More mature or different motor strategies need to be trained to achieve developmental functional stages. For example, a

child uses stereotyped flexion of shoulder, elbow, and hand. Treatment methods aim to vary these patterns by, say, training shoulder flexion with elbow and hand extension in reaching tasks. In the leg, the stereotyped movement of flexion at hip, flexion at knee, and ankle dorsiflexion needs to be modified to carry out active dorsiflexion with knee and hip extension. This fractionation of stereotyped synergies is more mature.

Both specific muscle education and the fractionation of movement for selective motor control may not always transfer to a motor function. This is related to the variety of muscle actions in functions and the different muscle lengths involved.

Muscles are activated as prime movers, synergists, or fixators when they contract during motion. Muscles have to shorten and contract (concentric work or isotonic), keep the same length and contract (isometric work), or lengthen and contract (eccentric work) in different motor functions.

For example, during dressing in supine, bridging hips is used. Bridging hips is concentric action of hip extensors while the 'hold' which follows is isometric muscle work. This also applies to head raise and then head holding in prone.

Summary

- Motor learning, discussed in Chapters 2, 3, and 4, emphasises a person's use of movement patterns adapted to a task.
- However, separate movements are devised for impairments such as muscle tightness, stiff joints, weakness, and lack of selective motor control.
- When possible, take the lead from a child's initiation of motion to solve motor difficulties in daily life. Modify stereotypical motor patterns by developing more mature patterns as far as possible. The severity of brain damage may not allow for a repertoire of typical motor patterns.

Use of afferent stimuli

There are differences between neurofacilitation methods and learning models such as conductive education and the approach of Carr and Shepherd (1987, 2003) and the MOVE programme (Thomson 2005). The neurofacilitation treatment systems use 'hands-on' afferent stimuli of touch, temperature (cutaneous) or pressure, stretch, resisted motion, joint compression or retraction (proprioceptive stimuli), as well as visual and auditory stimuli. 'Handling' by therapists obtains automatic active muscle activity. In learning methods, the adult's hands are used much less for handling, guiding, or minimally supporting a child. *Fixation* or manual holding of a part of the child's body is used, but not in the same way as in neurofacilitation systems. The handling methods help a child sense a movement or posture that cannot be achieved. In time, this sensorimotor experience is said to help a child acquire the motion or posture independently. Equipment for improved postures in lying, sitting, and standing and orthoses are believed to give a sensory experience which a child can later achieve. However, this is passive correction and the prolonged stretch helps to obtain muscle and soft tissue length. Active participation by the individual augments the result. Motor learning takes more than sensorimotor experience and particularly emphasises active movement and postural control for achieving function. Although muscular activity is present in automatic neuromuscular techniques, what is not active is a child's own initiation of the function. Independent actions enable learning and understanding as well as opportunity to develop strategies for function.

During training, there are times when a child should have his attention on the afferent stimuli used by the therapist, as they are often cues to direction or to parts of his

body and convey what movement is required. In addition, afferent stimuli need not be used when a child can learn to respond actively to 'pull', 'push', 'stretch up', 'try to sit alone', and so on.

The Petö approach (conductive education) is particularly careful to use the child's concentration on control of motion (Russell and Cotton 1994). However, this approach does not carry out every aspect of motion with concentration. The active efforts may focus on, say, voluntary arm motion while automatic head and trunk postural stability and postural adjustment are simultaneously activated. Voluntary movements that are selected do not aggravate spasticity as these active motor activities are not too far ahead of the child, so that he is *pushed* to make excessive efforts to achieve a movement.

Gordon et al. (2005) and others have drawn attention to research that shows that movements can be achieved without afferent input. However, von Hofsten and Rosblad (1988) demonstrated that sensory input is essential for fine coordination. There is a central motor programme in a child's central nervous system that can be used without afferent stimuli. Afferent stimuli are, however, needed to modify the child's actions and achieve accuracy of motor control. 'Hands-on' sensory stimuli are therefore not always necessary. Vision and cognition with language may assist a child's acquisition of motor function.

Summary

- It is advisable to show a child how and where to move by the therapist's afferent stimuli for movements and postures. However, as soon as possible and even in the same therapy session, check whether the child can carry out the motor activity independently, even though it will be partial or unreliable.
- A child may be able to concentrate on and practise the motor function without being handled or touched by the therapist. Depending on the severity of the condition, appropriate support by equipment or furniture may initially be needed.
- When children are so severely impaired that there is little activity possible on their own, manual support and afferent stimuli or handling may be the only way to begin motor activity.

Interaction between body parts

There are methods that different clinicians use that activate one part of the body to facilitate action in another part of the body; for example, arm elevation simultaneously activates head elevation and back extension, and creeping techniques triggered at the legs facilitate activity in the whole child. Stimulation of one part of a synergic movement pattern activates the other muscle groups within the same synergy. These facilitation techniques involve *overflow* of activity from one area of the body to another. Feldenkrais (1980) has made an intensive study of such interactions in the normal body acting as a whole.

In a person with cerebral palsy, it is, however, possible to activate undesirable actions in other parts of the body; for example, grasping may increase flexion in the elbows and shoulders in a child already round-shouldered and flexed, use of the arms may increase atypical postures in the legs, and grasping with one hand may be associated with clenching of the other hand. Physiotherapy techniques, which use resisted motion, must be used in such a way that the rest of the body does not deform (Levitt 1966). Vojta's techniques use resistance to a creeping complex but the whole body is moving in a corrective pattern. Also, much rotation within motor patterns in people with spastic hypertonus prevents undesirable associated motor activity in other parts of the body.

There are interactions between body parts in all the postural mechanisms. A scoliosis can correct during tilt reactions, an inactive arm is activated in a saving reaction, and the 'constraint-induced methods' include activation of an inactive body part when the more able body parts are constrained.

Summary

- Any action in one part of the body should be accompanied by careful observation of the whole child and not only of the part being activated. Physiotherapists can learn more about normal interactions of body parts in their own experience in 'Feldenkrais classes' (Feldenkrais 1980).
- There are a number of different methods that use or constrain one body part in order to activate another less able body part.

Management of deformity

Every therapy approach aims to prevent, minimise, or correct deformities and contractures. There are many methods to counteract deformity as well as various viewpoints as to the genesis of deformity. Chapter 12 is devoted to this aspect.

8

Assessment for therapy and management

Approach to assessment

The framework for all assessments is outlined to synthesise various approaches.

The framework consists of the following assessments:

1. The task(s) individuals and their families want to achieve, can already do, and what they find challenging. Their choice may be a daily activity in self-care, play, social interaction, or a recreational/leisure activity.
2. The motor functions for the individual's chosen task, for example sitting, standing, using a form of locomotion, and using hands. The individual's developmental level of motor functions is identified.
3. The component abilities of each motor function needed for the chosen task. These include specific postural mechanisms, relevant voluntary movements, and perceptual motor abilities that may be present but atypical or are absent. They have their own developmental levels.
4. The impairments that may be preventing achievement or affecting performance such as limited range of motion (ROM), weakness, postural malalignments, or limited repertoire of movements for the task. The impairments are primary and secondary. Impairments also include pain, fatigue, poor nutrition, respiratory problems, and general health in individuals.
5. The constraints on motor functions and their components by other impairments of vision, hearing, perception, understanding, and communication.
6. The abilities or residual abilities of vision, hearing, perception, cognition, and communication, which enhance the learning of motor skills and daily tasks.

This chapter addresses the specific assessments and objective measures used by physiotherapists and occupational therapists that grow out of the collaborative learning models in Chapters 2, 3, and 4.

Assessments of motor functions, of their components and impairments, and of self-care often take place in structured idealised clinical settings in hospital units and special centres. The individual's capacity is assessed. Whenever possible, these daily motor functions, self-care, or daily tasks

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are best observed in individuals' natural environments most relevant to the tasks chosen by them and with the specific people involved with them. Therefore, depending on a therapist's workplace, appropriate organisation is made to include the important observations of individuals in their own environments. The therapist is then enabled to complement the clinical examinations. Capacity in the clinical setting needs to be compared with participation in daily life and within an individual's environments, when, say, ground is uneven or slippery, furniture is inappropriate, or there are no stable objects or bars to grasp. Personal factors of individuals such as health, social background, and culture also play a part. Capacity is what an individual *can do* and performance is what that individual *does do*.

- Recommended special equipment needs to be assessed as useful in different environments.
- Attitudes and behaviours of people in the individual's environments may be facilitating or be barriers to an individual's motor function and daily activities.
- A child's motivation and behaviour may vary in different environments.

Occupational therapists in different places have expertise in environmental assessments and share their information with centre-based physiotherapists. Joint visits by physiotherapists and occupational therapists to an individual's environment are desirable whenever possible. Community paediatric physiotherapists and occupational therapists are well placed to obtain the broad perspective of a child's motor function and daily living activities in home, school, and community settings.

Purpose of assessment and outcomes

1. *To respond to the reason for referral*, which may be for additional medical information, for educational placements, for parental needs, or for social or legal considerations. Some adolescents or adults with cerebral palsy refer themselves and state their reasons. People paying for therapy will want assessments indicating the need for physiotherapy and reassessments of outcomes.
   Therefore, the type of assessment varies according to the referral. Physiotherapy and occupational therapy assessments need to relate to what information is wanted and how it will be used.
2. *To add to medical and other diagnostic* information as specific assessments before *and* during therapy involve long periods of time and close contact with a child and their family. Information may be revealed to a therapist when not obvious in shorter consultations with different medical consultants. A therapist will also detect any unusual deterioration that needs referral to a neurologist in case a progressive neurological condition rather than cerebral palsy is becoming obvious. Deterioration in function due to neuromuscular, deformity, health, or behavioural problems may be detected so that referral can be made to other professionals.
3. *To participate in screening and follow-up* of children 'at risk' of developing cerebral palsy and to decide whether specialised therapy or monitoring is indicated.
4. *To plan a specific physiotherapy and occupational therapy programme based on the child's and parents' needs*. There are programmes of selected treatment methods focused on function and the component abilities as well as for impairments constraining function. Therapy includes a management programme with information and practical ideas for all involved with a child, adolescent, or older person.
5. *To evaluate progress (outcomes)* in reassessments that may lead to continuation, modification, changes, or periodical stopping of specific therapy methods

and sometimes of specific therapy sessions. The evaluation also changes practical suggestions for others involved with an individual.

6. *To share assessments and evaluations* with child, parents, and family, and others involved with a child and especially to receive their reports and views.
7. *To contribute to research into the effectiveness of therapy* by using standardised measures within a research study. Clinical assessments and measures discussed in this chapter also detect questions for research.

Review of a therapist's observations

Observations are made during joint assessments with a child and parents or with an adolescent or older person. There will also be other joint assessments with another professional and with carers. They are continued during specialised 'hands-on' assessment and evaluation as well as during ongoing therapy and management. Observations need to be as unobtrusive as possible and must precede 'hands-on' examinations and measurements to gain rapport with a child.

1. *Behaviour*. Observe whether a child is alert, apathetic, irritable, or fearful in a session or during particular activities. Individuals may become fatigued easily, make undue effort, or show discomfort or fear. There may be fear of falling, of augmenting musculoskeletal pain, or space perception problems. Find out what motivates any actions. The individual can have intrinsic motivation. Is it a particular situation, a person, special plaything, or hobby? Behaviours are detailed in Chapters 2, 3, 4, 10, and 11.
2. *Communication*. Observe how the child and parents interact (see Chapter 2). Find out whether a child initiates or responds with gestures, sounds, hand or finger pointing, eye pointing, or uses words and speech.
3. *Attention span*. What catches a child's attention? How does a parent assist them to maintain attention and what distracts them? Distractibility or inattention can be due to brain damage and/or environmental overstimulation.
4. *Understanding*. Observe if a child follows suggestions to move or promptings to act. What does he or she appear to understand? (See section 'Motor function in communication' in Chapter 10.) Liaison with speech and language therapy and psychology colleagues will ensure a good knowledge of a child's understanding.
5. *Position*. Notice which position children choose to be in and if they can get into that position on their own or require help. Observe if a parent can place his or her child in a position and if the child participates in any way. The child's limbs, trunk, and head may move more easily in some positions than in others. Involuntary movements may be decreased in some positions. Is the parent/carer able to lift an individual?
6. *Postural control and alignment*. Observe how much parental support is given and check a child's own ability in postural control in all positions. Parental support may be excessive or reasonable. Check whether a child bears more weight on one side of their body, or on one hand or foot. A child may tend to collapse to one side, twist to one side, or tilt and turn their head to one side. Observe any fears of falling in a child due to poor balance experience. Observe whether parental anxiety about falling increases a child's fears.
7. *Use of limbs and hands*. Observe limb patterns in changing or going into a position as well as using them in a position. There may be excessive flexion, extension, or rotation in one part of the range. Observe whether one or both hands are used, and the type of grasp and release. Inaccuracy of reach and

hand actions also indicates a possible visual or perceptual problem. Observe any involuntary movements, tremors, or spasms that interfere with hand use.

8. *Sensory aspects*. Observe children's use of vision, hearing, touch, smell, and temperature in relevant tasks. Are they enjoying particular sensations? Notice their emotions on being moved or having their position changed. Some children may show an increase in tension and apprehension on being touched and handled. Are their hands persistently fisted so sensation cannot be experienced?
9. *Form of locomotion*. On entering the room, observe how a child is carried or if a wheelchair or walking aid is used. During the session, create interest that motivates children to roll, creep, crawl, bottom shuffle, or walk to where a playful activity is to be carried out. A child may have unusual ways of getting about, such as dragging themselves along on their stomach, on their back, *bunny hopping* on both knees, *running headlong*, or using an unusual gait.
10. *Deformities*. Observe any recurring positions of the whole child as well as of parts of their body in all postures and in the movements they use in motor functions and daily living activities.

Impairment and function

The observations above are predominantly functional. The observation of impairments that constrain function will vary with age and any changes in diagnostic classifications (see Chapter 1).

There is a functional view of the impairments as subtypes of cerebral palsy. For example, unilateral cerebral palsy (hemiplegia) tends to be less disabling in motor function than bilateral cerebral palsy (diplegia), and diplegia less than bilateral cerebral palsy (quadriplegia). Dyskinesia tends to be more severe than unilateral cerebral palsy (hemiplegia), diplegia, and ataxia (Østensjø et al. 2004). However, other research studies with a large number of participants identify subtypes of spastic quadriplegia and of dyskinesia that present in milder levels of functional disability, and a few of hemiplegia in more severe levels. Spastic diplegia can be present at any functional level (Gross Motor Function Classification System (GMFCS) levels I–V) (Beckung et al. 2007; Voorman et al. 2007).

Chapter 9 gives more details of impairments linked with developmental functions if they are constraining function.

Teamwork and the influence of other disabilities

The therapist will need a comprehensive assessment from a team (see Chapter 1; Thylefors et al. 2000). Each therapist will learn from each other and from other professionals what modifications to make for specific visual, hearing, and sensory impairments. They will adjust their communication with a child in relation to any speech and language difficulties and find out what communication systems are being used, for example signing or Makaton, low-tech communication strategies, or high-tech communication aids. If a child has perceptual problems relating to body scheme, space, distance, and timing, then adaptations need to be recommended by specialists in the team.

Medical consultants inform therapists about an individual's health such as nutrition problems, fatigue, pain, and epilepsy and other medical diagnoses that affect energy, motivation, and attention span. The health problems of parents are also relevant to therapists' home programmes for the child.

The team not only contributes assessments of both impairments and difficulties in functions but can make significant contributions for participation in daily life.

Physiotherapists and occupational therapists continue to learn how to promote participation with all children regardless of their underlying physical abilities. Training, use of equipment, special furniture, walking aids, and electronic devices are assessed for individuals to promote participation.

General points for assessments

- Assessments need to be playful, interesting, and non-threatening.
- Assess a young child, as much as possible, on a parent's lap.
- Observe a child among the familiar toys as well as with selected toys to activate interest as well as reveal dormant abilities.
- Keep sessions within the bounds of an individual's concentration.
- Have an unhurried atmosphere.
- Have easy, successful actions of a child interspersed with difficult tasks.
- Avoid undressing a child, especially an adolescent, until they are happy about this.
- Time is needed for a child who is unhappy about a new environment, new professional, or new experience of being assessed in a different style.
- An individual needs time to attempt new abilities in the assessment.
- Consider a person's state of health and energy.

Assessments can take a number of sessions, depending on each child's severity, mood, level of energy, and cooperation. It is usual to create a final plan of therapy and management after a number of assessments, especially if a therapist meticulously checks their assessment findings with the variations in daily behaviour of a child. It is surprising that daily variations are rarely checked by some therapists as it is well known that a child has good and bad days, which impacts on their presenting functional ability. Assessments need to relate directly to therapy methods and evaluations so that parents appreciate the relevance of specific professional assessments. It is wise to select some home therapy on the first visit, so parents feel 'something is given' for them to do that will help their child.

Assessment and measurements

Clinical assessment includes both careful observations and measurements. There continues to be growing importance of measurements for evidence-based practice. However, in cerebral palsy there are still observations of unique abilities and difficulties discovered in careful clinical assessments of an individual. These are significant for therapy and for a child's own strategies. The observations for clinical assessment cannot always be easily measured using current measurement tools.

It is also recommended that a therapist's assessments are not limited to existing measures. Although measures are important, they should not reduce a therapist's own innovative observations. In addition, current measures are based on values that may change in the light of research. For example, measures were focused on spasticity for many years and functional measures thought to be dependent on them (Bobath and Bobath 1984; Haas and Crow 1995; among others). In some references in Haas and Crow's review (1995), in Levitt (1977, Physical Ability Chart), and in Carr and Shepherd (2003), spasticity was not given great significance and functional assessments and measures were valued much more.

As in previous editions, Chapter 9 continues to present clinical assessments in all positions of developmental functions. Impairments are integrated so that quality of function may be gained as far as possible. Therefore treatment and management suggestions (sometimes called 'tactics' or 'strategies') are immediately related.

A developmental framework is used to show how the components of motor functions are typically developed and how an atypical performance may appear typical at an earlier age. For example, asymmetry is typical in a number of early actions and postures, and so weight bearing on one side of the body in lying is expected at the 0- to 3-month developmental stage. A person's stepping in a walker giving full trunk support is similar to the manually supported stepping of a typical baby at the developmental level of around 6 months. The typical gait of a toddler uses components such as co-contractions, wide base, flat foot contact, and more double leg support, which are also seen in older children with cerebral palsy. A developmental framework also shows a therapist the degree of motor difficulty or delay which has an effect on other areas of child development.

The examination of the individual in developmental channels of prone, supine, sitting, standing and walking, and hand function also shows any influence of impairments on functional ability. Deformities are assessed within these developmental functions and also discussed in Chapter 12.

Clinical progress is assessed when supports by equipment, walkers, and orthoses are decreased or eliminated. Walkers can change from wheel walkers to elbow crutches, quadripods, or sticks. Assessments of a decrease of supports by special furniture, wheelchair sitting, hand splints, and other aids reveal positive outcomes.

Current measures used in cerebral palsy

The traditional therapy measures in physiotherapy and occupational therapy had already been considered in the past for impairments and difficulties of gross and fine motor functions as well as for self-care tasks in an individual's environments. These measures are now linked with the terminology of the International Classification of Functioning, Disability and Health (ICF) (WHO 2001): Body Structure and Body Function (impairments), with Activities of daily motor functions and self-care skills (limitations), and with Participation in daily life (restrictions). The teamwork with other professionals, families, and others involved in the life of the young or older person with cerebral palsy adds information to a therapist's assessments. Parents and family contribute their observations as well as those of the Environmental and Personal factors which are outlined by the ICF. Therapists then ensure a holistic assessment of all aspects of the life of a child, adolescent, and adult with cerebral palsy.

Measurements of impairments

When assessments of impairments are made, a therapist assumes which of the impairments appear to primarily constrain function. This assumption is studied by Østensjø et al. (2003, 2004) and discussed in relation to the ICF (WHO 2001). 'Motor function is strongly related to accomplishment of essential tasks in daily life' (Østensjø et al. 2004). This study also found that the measure of difficulty with selective motor control links more with overall motor function than with spasticity and ROM. Voorman et al. (2007) support the view that selective motor control and strength are most important for gross motor function. However, in a past study by Bartlett and Palisano (2002), spasticity, topographical distribution, and ROM were listed by paediatric physiotherapists as the most important impairments that contributed to change in motor function. Selective motor control was not listed and weakness was not given emphasis.

Selective motor control

Immature motor control does not activate the appropriate muscles but muscles and joint movements not needed for the specific action. This lack of selective motor control

has also been called confused motion (Phelps), mass movement patterns, or stereotyped movement patterns. The muscles in stereotyped patterns are so closely linked that an isolated movement is not possible. A number of these synergies are described in legs or arms and hands and can be difficulties for people with cerebral palsy. These patterns reflect a lack of fractionation in lesions of the central nervous system (Shumway-Cook and Woollacott 2017).

Measurement of the selective motor control by Voorman et al. (2007) is to ask a child to extend the knee and dorsiflex the ankle in sitting without feet supported.

For example, scoring for selective ankle dorsiflexion is:

Score 0 No selective dorsiflexion, only synergy of hip–knee flexion with ankle flexion.

Score 1 Diminished selective movement. Selective dorsiflexion in the first part of the movement range. Later in the range there is no selective movement.

Score 2 Full selective movement, knee extension with ankle dorsiflexion.

The scores for both legs together vary from total scores of 0, 1, or 2 for poor; total scores of 3, 4, or 5 for moderate; and total scores of 6, 7, or 8 for good selective motor control.

Fowler et al. (2009) use the Selective Control Assessment of Lower Extremity (SCALE) to measure voluntary motor control. Smits et al. (2010) test and train selective motor control in sitting with extended knee together with dorsiflexion of the foot. Selective motor control is part of orthopaedic assessments as it relates to gait analyses (Chapter 12).

Weakness

Strength is the ability to generate force to either move a body part or stabilise a body part and resist movement. There was no correlation of true spasticity with function in GMFCS levels I–III (Palisano et al. 1997). Research by Ross and Engsberg (2002, 2007) showed no relationship between strength and spasticity, or between spasticity, motor function, and gait. They used KinCom, an instrumented dynamometer, to measure spasticity and strength in the same subjects. They pointed out that their research did not include children in more severe classifications.

Research studies find that *weakness rather than spasticity* is particularly significant for functional disability in cerebral palsy (Damiano and Abel 1998; Damiano et al. 2002a,b; Ross and Engsberg 2002, 2007; Shortland et al. 2002; McNee et al. 2004). Weakness and motor function need assessment for physiotherapy exercises and functional activities.

Strength may be measured isometrically (no change in muscle length), isotonically (shortening of muscle length), or isokinetically (concentric and eccentric work during a specific velocity of movement). Endurance is measured by the number of repetitions of a motor function. Cardiovascular measures of fitness relate to energy consumption and endurance. A child can be 'weak' when not fit (Miller 2007). Parker et al. (1993) found that aerobic power and anaerobic power of the legs, but not of the arms, were correlated with the total score and with the scores for the standing and walking, and running and jumping subsections of the Gross Motor Function Measure (GMFM).

The isotonic (concentric) and isometric (eccentric) muscle actions are measured clinically and the isokinetic measure is tested with instrumented systems. The hand-held dynamometer quantifies isometric strength or the force required to break the active position held by a person against resistance given by the examiner. The procedure and reliability of the hand-held dynamometer are confirmed by various authors (Taylor et al. 2004a; Crompton et al. 2007; Willemse et al. 2013; Dallmeijer et al. 2017).

Taylor et al. (2004a) measure 'dynamic muscle strength using a one-repetition maximum'. They record how much weight a person can move just once with control using the full active range of available motion and then back to the starting position. The measure requires a machine with weights on a stack. Alternatively free weights such as dumb-bells or recorded weights of sacks of sand can be used. A person's best effort within three or four goes is recorded. The person must rest for around 90–120 seconds between efforts to avoid fatigue affecting the amount of weight that can be lifted (Taylor et al. 2004a). If weights are not available the above procedure with the dynamometer is used. High levels of retest reliability and responsiveness are given by Taylor et al. (2004b) but they say 'change is difficult to document' in some individuals.

Children under 4 years do not cooperate with these measures or traditional muscle tests because they cannot understand the procedure, nor do they tend to have the ability to isolate muscles for testing because of lack of selective muscle control. Furthermore, excessive co-contraction and impaired selective motor control in any person may interfere with the ability to produce agonist force (Damiano et al. 2002a).

Wiley and Damiano (1998) have strength tests for typical children and in cerebral palsy. Their subjects are frequently older and less severely affected and can be classified in GMFCS levels I, II, or III (Palisano et al. 1997). Manual muscle tests are very difficult in adults and children in severe levels (IV or V). These individuals often have cognitive impairments that prevent them following test procedures.

Clinical assessment of strength. Therapists also prefer observations of muscle actions within motor functions, whether this is a holding action for postural stability or a moving action in voluntary motion or in rising (righting) and saving reactions. This is for children who are not ready to manage other measures. Long and Toscano (2002) also use observation of muscles in antigravity positions and assumption of positions, symmetry, and any compensatory patterns rather than muscle testing in very young children. It has been found that muscle tests on the couch can differ from muscle actions in function, which include the actions in synergies and the postural mechanisms. For example, shoulder girdle muscles may work well in crawl position but not in a muscle test on the couch. Back extensors may be well activated in prone but not in sitting or standing. Extension of the elbow is greater when a child reaches out for a desired object than when tested with the conventional 'stretch your elbow' in muscle tests. Static and dynamic measures of lower extremity ROM in the clinical examination are inconsistent with instrumental measures of gait (McMulkin et al. 2000).

Functional assessments such as Five Times Sit to Stand (FTSS) and return to sitting assess functional strength (Wang et al. 2012; Kumban et al. 2013). Sit-to-stand includes both concentric and eccentric muscle actions. Rising onto toes and standing on toes assess both concentric and isometric muscle action of plantar flexors. Rising from lying to sitting, crawl to sitting, and crawl to standing reveals strength of arms in weight bearing. Voorman et al. (2007) within their research used a test of strength of legs by having children squat and stretch up eight times. Support for balance is allowed. The categories are:

- good strength for eight or more times
- moderate strength for fewer than eight or performed as part of the motion eight times
- poor strength if not able to squat and stretch out at all.

This test apparently also includes endurance as well as strength in ranges of flexion

and extension of limbs. ROM was measured with goniometry in supine and in other tests. However, their test is scoring for impairment within function. This should motivate therapists to develop better scoring for evidence-based muscle actions in functional assessments in the future.

Endurance

The Early Activity Scale for Endurance (EASE) is a measure devised by McCoy et al. (2012) for children aged from 18 months to 5 years. It measures how long a child can sustain physical activity for play, sports, and doing exercises for fitness and mobility. Compare EASE with the 6 metre walk test. Impairment will relate to daily life participation.

Spasticity

Slow passive ROM demonstrates the muscle length or extensibility of the muscles. The slow passive ROMs are measured by goniometry and limitations of range show stiffness of spastic muscles, mobility of joints, and tightness of soft tissues. The measurements of length limitations in slow ROM are not the same as measurements of range limitation in velocity-dependent spasticity or reflex response to quick stretch. Passive joint range may be full in very young children with spasticity but active movement can be *hypoextensible*, that is, limited in range. Clinical reasoning is available to select treatment options.

Clinical measurements of spasticity. The frequently used Ashworth Scale and Modified Ashworth Scale (MAS) have the examiner rate the amount of tone felt as a limb is passively stretched. On a scale from zero to five, there is an estimate of how soon in the motion and how much during the motion the resistance to stretch is felt (Bohannon and Smith 1987). It is also used in measurements for botulinum toxin A (BoNT-A) treatment of spasticity (see section 'Botulinum toxin A' in Chapter 12). However, it should not be the only measure.

There are questions about the objectivity of the MAS (Pandyan et al. 1999; Miller 2007). Damiano et al. (2002b) investigated the precision of the Ashworth scale by using isokinetic dynamometer measures of passive stretch together with electromyography (EMG), which shows muscle activity in response to the quick passive stretch. They show that slow passive stretch without muscle activation on the EMG is *stiffness due to muscle transformations and tight soft tissues*. This 'intrinsic' muscle stiffness has a higher correlation with the original Ashworth test rather than the magnitude of resistance to quick passive stretch. The children in the study by Damiano et al. (2002b) were in less severe classifications (GMFCS levels I–III), with most at levels II and III (Palisano et al. 1997). Ashworth scales are weakly correlated with function measures. Damiano et al. (2002b) hypothesise that, in future studies, measures with instrumented isokinetic dynamometers used with cases of severe cerebral palsy may demonstrate an influence of spasticity on function.

Scholtes et al. (2006) reviewed 13 clinical instruments to measure spasticity, having identified validity criteria from 119 references. They report on a number of 'Ashworth-like scales', the Tardieu scale, a Modified Tardieu Scale (MTS), the New York University tone scale, and other lesser known scales. They found most instruments to assess spasticity did not comply with the physiological definition of spasticity as a velocity-dependent response to passive stretch. This definition was used only in the Tardieu measures. Tardieu tests measure increased muscle tone at three different velocities of stretch and the joint angle at which the 'catch' or increased tone appears. However,

the original Tardieu scales are time-consuming in order to carry out a comprehensive assessment and the speed of the velocities are not standardised. This is questioned, particularly the time-consuming aspect, for use with children. From their detailed studies, Scholtes et al. (2006) advise that clinicians make a comparison of 'the maximal ROM at a very slow passive stretch before and after treatment of spasticity and the joint angle of the catch at a fast velocity passive stretch before and after treatment'.

Boyd and Graham (1999) proposed a measurement of passive range by modifying the Tardieu scale and calling it an MTS. They used goniometry to measure R1, the joint angle of the 'catch' after fast stretch, and R2, the maximum joint angle after slow stretch. It is suggested that if there is a large difference between R1 and R2, then there is a greater dynamic component, whereas a smaller difference would indicate that muscle contracture is greater than spasticity. As these measurements were essentially devised to plan BoNT-A treatment, they found that BoNT-A was useful for the dynamic component.

Fosang et al. (2003) investigated the reliability of clinical measures of passive ranges of motion (PROMs), MAS, and an MTS. They did not use the MTS by Boyd and Graham (1999) as its reliability had not been assessed. They found that PROM and MTS measures can be reliable, provided the examiners were sufficiently trained with enough time for practice. Large changes as a result of intervention are needed to overcome error margins in test–retest and interrater results. Because of poor reliability the MAS, if used, should only be carried out by single raters for the same participant (subject/client).

Table 8.1 is an improved Swedish modification of the Ashworth scale used in a careful research study by Østensjø et al. (2004).

Factors for reliable clinical assessments are as follows.

1. Standardise the posture for testing, the position of the other limbs, and midline head position.
2. Standardise the initial length from which the muscle group is stretched.
3. Use the same maximal force for slow ROM (difficult to assess by researchers).
4. Check that the child/adult is relaxed, avoiding sensory stimulation by those present.
5. Consider any fatigue of a child or older person.
6. The time of day, temperature, and any pain may influence results.

Table 8.1 Modified Ashworth scale

Score	Description
0	Hypotonic: less than normal tone, floppy
1	Normal: no increase in muscle tone
2	Mild: slight increase in tone, 'catch' in limb movement, or minimal resistance to movement through less than half of the range
3	Moderate: more marked increase in tone through most of the range of motion but affected part is easily moved
4	Severe: considerable increase in tone, passive movement difficult
5	Extreme: affected part rigid in flexion or extension

Source: Modified by Hedberg et al., see Østensjø et al. (2004).

Examination of deformity and ranges of motion

The therapist should obtain information on the following.

- *Structure of joints* in children over 3 years – especially subdislocation or dislocation of the hips, varus or valgus of the neck of the femur, spinal vertebrae, knees, and feet. The structure of all joints in the body is also important, especially as a child becomes older, adolescent, and adult. X-rays are used for joints causing concern.
- *Inequality in the length of legs* but not so much in the arms, as far as function is concerned. Measure limb length from anterior iliac spine to medial malleolus.
- *Joint range*. There needs to be a flexible musculoskeletal system as far as possible for motor functional training. PROM carried out slowly detects fixed or unfixed deformity. Limited range of deformity is due not only to joint problems but also to length of stiff muscles and to tightness of soft tissues (tendons, ligaments, connective tissue). Fixed deformity is a contracture that cannot be overcome in a PROM and is present during sleep. Dynamic or unfixed deformity can be manually moved through full range and disappears during sleep. (Different workers define deformity and contractures differently.) The current Cerebral Palsy Integrated Pathway (CPIP-UK) was developed by a specialist group of orthopaedic surgeons and physiotherapists to standardise passive joint ranges in cerebral palsy (see section 'Passive range').
- *Strength of short and overlengthened muscles* is assessed as they contribute to deformity.

See section 'Deformities and gait' in Chapter 12, in which different topographical types of spastic cerebral palsies are discussed.

Passive range

Examples of passive joint range are shown in Figs 8.1 and 8.2.

Practical points include the following.

- *Passive joint range* to demonstrate joint flexibility, muscle length (extensibility, shortening), muscle and soft tissue tightness (spasticity, rigidity).
- Test *slowly* for muscle and soft tissue tightness and with fast speed for true physiological spasticity. *Active joint* range for range and ability to move. Strength and the opposing degree of tightness affect active range.

(a)

(b)

Figure 8.1. (a, b) Example of range of motion. Examining and explaining dorsiflexion to a person. Hip and knee flexion (90°). Hold calcaneus in neutral, supinate the forefoot to avoid movement of the intertarsal joints. Passively dorsiflex the foot towards the vertical. Extend the knee or hip and knee, passively dorsiflex the foot towards the vertical. See CPIP-UK for photographs of measure with goniometry.

Figure 8.2. Example of range of motion. Examining hamstring length while relaxing a child. The popliteal angle is between the shank and the vertical line from the femur. See CPIP-UK for photographs of measure with goniometry. Norm 30–40° from the straight knee at 0°.

Different positions may affect ROM in some cases. Check in supine, prone, and side lying. Observe postures in sitting and standing as well to see the effect of limited joint ranges. Standing or walking is typically between internal and external rotation.

- Note any pain, especially in the hip ranges. Avoid associated pelvic and spinal positions during tests. Keep pelvis level (stop anteroposterior tilt, lateral tilt) during the leg assessments. Keep head in midline.

The CPIP-UK (available from Association of Paediatric Chartered Physiotherapists (apcp.csp.org.uk)) is a neuromuscular assessment using goniometry measures of passive joint ranges. Goniometers measure ranges, provided a standard procedure is used (see section 'Factors for reliable clinical assessments' under 'Spasticity'). The CPIP-UK demonstrates accuracy using photographs of a single experienced examiner with an assistant, using standard procedures with care taken with proximal and distal segments for measures, standard force, and the appropriate application of the goniometer. Goldsmith et al. (1992) offer a measure for windswept position in the legs. Electrogoniometers are also used but are not easily available. The Spinal Alignment and Range of Motion Measure (SAROMM) (Bartlett and Purdie 2005) measures deviations in symmetry of spinal alignment (4 items) and ROMs and muscle extensibility in legs and arms (11 items). It is reliable for ages 3–18 years. GMFCS levels are significantly associated with SAROMM (Eliasson et al. 2006). Rapson and Marsden (2016) have developed a battery of measures of leg ROM, muscle tone, and strength indicators in non-ambulant children with cerebral palsy. They used a footboard, digital inclinometers, a Myotonometer, ultrasound, and tape measurements for interrater, intrarater reliable clinical measures of leg function in typical children aged 1–4 years. Their battery of tests needs further development for children with cerebral palsy to improve those tests that have not given reliability in clinical trials.

Active range

Preoperative and postoperative physiotherapy may require localised assessment to confirm that muscle groups that have been given the opportunity to act by the operation are in fact doing so. Active ranges and strength can be clinically observed in function, as given under section 'Clinical assessment of strength'. Postural mechanisms include testing for strength of the trunk and pelvic musculature pre- and postoperatively as well as for postural control and balance.

Examples of atypically persistent postures, movements, and functions

Head flexion, extension, rotation are observed during head raise in prone, supine, sitting, standing developmental channels. Observe whether the head is held asymmetrically with too much extension or flexion.

Shoulder elevation, abduction, rotation, flexion, and extension movements are observed during the functional examination of, say, creeping, reaching out, and other arm movements involved in daily functions, play, or music and movement. Shoulders may be held in atypical postures.

Elbow flexion and extension observed during a child's reach to parts of his body or toys. Forearm pronation or supination affects flexion and extension, and can be seen in isolation during daily actions or play. Elbows may be held in atypical postures.

Wrist and hand will be observed during hand function developmental activities. Fingers may not function independently of persistent atypical wrist postures.

Hip flexion and extension will be observed during all functions. Also ask the child in supine to bend their hip and knee to their chest and touch their foot; to sit or stand and bend to touch the ground; to sit on very low stools; to squat and come up to standing and sit/squat down again. There may be persistent posture of the hip(s).

Knee flexion and extension seen in sit-to-stand, as well as observing the child sitting using active extension to kick your hand or a dangling toy, and their knee extension in standing *tall*. There may be persistent flexion or hyperextension postures of knees.

Foot movements need to be tested separately, especially if there are atypical postures of feet. Playfully tip the child backwards onto the heels and forwards to toe standing for dorsi- and plantarflexion of feet. Observe persistent postures in sitting, standing, and lying.

If the child cannot achieve a full active range, check that it is not due to:

1. a decrease in the passive ROM of the joint
2. weakness in associated stabilisers or synergists
3. interference of excessive extensor activity, dysfunction of selective motor control, or lack of understanding of instruction by a young child or older person with cognitive or body image problems.

Functional measures

The grading of motor scales is in tune with the way both typical children and those with cerebral palsy develop. Atypical function may be typical at an earlier age in typical development, for example asymmetry, fully supported stepping, and gait pattern of a toddler.

Gross Motor Function Measure (GMFM-88 and GMFM-66) (Russell et al. 1989, 2002). This is a criterion-referenced measure that is used to assess changes before and after interventions in cerebral palsy. It is designed for children from 5 months to 16 years. The motor functions measured are in the typical age range from birth to 5 years. The GMFM has 88 (or 66) test items arranged in five dimensions: lying and rolling; sitting; crawling and kneeling; standing and walking; running and jumping. Each dimension is scored separately as a percentage and then a total percentage score is calculated. It covers individuals who are developmentally delayed. The therapist can use items as targets/goals for therapy from the dimensions that have the lowest scores or where change is expected from intervention. The GMFM measures achievement of motor function but not the quality of motor functions. Atypical patterns of motor functions are difficult to grade and record owing to their individuality. This can be recorded in videos and sequential photographs or still photographs. It still depends on a therapist's experience as to what atypical motor

patterns are observed and which are given significance.

Generally, the GMFM score for an individual increases more in earlier ages than in later years. However, there may be various patterns with spurts of progress and periods of plateau or even decrease. During these periods, the *quality of motor function* can be improving, especially if motor function is increasingly used in daily life.

The GMFM-66 was developed using Rasch analysis, which eliminated 22 items to create an interval-level measure (Avery et al. 2003). It is not suitable for children who can only manage abilities such as lying, assisted rolling, minimal head control, and supported sitting. Other individuals who are more able can be assessed with the GMFM-66.

The Challenge Module was developed as an extension to the GMFM to measure advanced motor skills in children aged 5–15 years in GMFCS levels I and II who are able to walk and run independently (Wright et al. 2018). Two abbreviated versions of the GMFM – GMFM-66-IS (item set) and GMFM-66-B&C (basal and ceiling) – have been developed (Avery et al. 2013).

Ontario Motor Growth Curves (Rosenbaum et al. 2002). The motor growth curves (also called motor development curves) present a graph of GMFM-66 scores (on the vertical axis) by age (across the horizontal axis) for each of the five GMFCS levels. These smooth curves were meant to show how the *average* GMFM-66 score for children in each level increases with age before reaching a plateau. More recently, the Ontario group (Hanna et al. 2008) has subjected the data from Rosenbaum et al. (2002) to a new analysis, producing percentile curves for age 2–12 years. Except for level I, the shapes of the median (50%) curves are quite different from the somewhat simplified curves fitted in 2002. The new curves give clear evidence that the average GMFM-66 scores for levels IV and V reach a peak around 7 years and then decline.

The Ontario group (Hanna et al. 2009) has since extended their data to cover ages 16 months to 21 years. For levels I and II there is no evidence of a decline (the curves reach a plateau), whereas for levels III–V there is evidence that the average GMFM-66 scores reach a peak at around 7 or 8 years and then decline.

It is important to recognise that an *individual child's* score is likely to follow a much more erratic progress. This can be seen in the original graphs (Rosenbaum et al. 2002: fig. 2), where the points for individuals are widely scattered about the 'average' curves. For some children (in all GMFCS levels) the score continues to increase after age 8 years, whereas for some others the score may fall in the early teens. It is unclear how many children have scores that follow an 'average' pattern.

It is not apparent that the percentiles are useful in clinical practice, since Hanna et al. (2008) found that the percentile ranking of any individual child (in any GMFCS level) can rise or fall by 10 points or more over a year. Moreover, Hanna et al. (2009) state that 'children in Levels III–V are not "destined" to lose function in adolescence'.

The original motor growth curves (Rosenbaum et al. 2002) were claimed to predict a child's progress from 2 to 15 years of age and this has led professionals to use these curves to give parents a prognosis for gross motor function in the long term. However, as each curve is an *average of many scattered points, it cannot give a firm prediction for an individual*. Unfortunately, there are physiotherapists who consider that the motor growth curves provide 'realistic expectations for clinicians to share with families' when planning long-term intervention.

The specific prediction parents often ask for is 'Will my child walk and when?'

A professional can discuss long-term prognosis in broad terms according to the child's *current* GMFCS level (see Chapter 1), while acknowledging that this may change in future. There is much more detail in the section 'Prognosis for walking' in 'Development of standing and walking' in Chapter 9.

Gross Motor Performance Measure (GMPM) (Boyce et al. 1995). This is a companion to the GMFM. It measures changes in quality of movement or performance of 20 items. Five components of weight shift, alignment, coordination, dissociated movement, and stability are addressed. There are other components which are not considered and only 20 items of the 88 items in the GMFM have been included. However, Wright et al. (2014) have developed the Quality Function Measure for the standing and walking, and running and jumping dimensions. This is only meant to be used for GMFCS levels I and II. Atypical performances of motor functions are difficult to grade because of their individuality. This can be recorded in videos and sequential photographs. It still depends on therapists' experience to judge some individuals' quality of motor function and decide which aspects are given significance. However, work on assessing quality is still in progress.

Specific functional items

Sitting Assessment for Children with Neuromotor Dysfunction (SACND) is an assessment test of sitting on a bench, at rest, listening to a story or watching a video for 5 minutes for children aged 2–10 years. There is also a reach section. Reaching is up, down, and sideways with the preferred hand for an object on a board (Reid 1997; Knox 2002). Assessment is of postural alignment during quiet sitting, proximal stability (shoulder girdle), and dynamic balance (postural adjustment during arm movements). Details of measurement are given in the SACND manual (Reid 1997).

Paediatric Reach Test (PRT) by Bartlett and Birmingham (2003) is a dynamic balance test of voluntary, horizontal, reaching forwards, and as well as to each side in sitting and standing in children aged 5–15 years. The starting position is on a seat without back or side supports with feet flat on the floor. The distance that the individual can reach is measured by a tape measure to a wall near the person. The wall is not to be touched by the individual. Using the standing position measures are of the distance an individual can reach forwards and to each side while maintaining standing on a fixed base of support, that is, without losing balance or taking a step. Young children need reminding to keep their feet fixed. The difference between starting position and reach position is noted and the three positions (left, right, and forwards) give a composite measure of dynamic balance. There is high retest reliability in children and young people with cerebral palsy.

Gillette Functional Assessment Questionnaire (FAQ) asks parents to assess the level of their child's walking ability on a 10 functional-level scale (Novacheck et al. 2000). It has good reliability and validity of testing non-ambulatory and ambulatory children in communities and on different terrains.

Clinical tests also select items or specific dimensions (sections) in the GMFM. These may guide therapy and choice of equipment. However, such a selection does not fully measure a person's function. In addition, one does not learn the interaction between dimensions. There may be a gain in one dimension and a loss in another after therapy. It is valuable to test the levels and changes in all dimensions to increase understanding of what is happening in the lying, sitting, standing, and walking dimensions. However, in milder classifications

(GMFCS levels I and II, possibly III), using one or two dimensions has been accepted in specific research studies. Timed stairs test (outlined below) is based on two items in the GMFM.

The Berg Balance Scale, used for adults, has been evaluated for children with cerebral palsy by Kembhavi et al. (2002), Franjoine et al. (2003), and Yi et al. (2012). It is called the paediatric balance scale, taking 14 items from Berg balance scale.

Randall et al. (2014) compares the PRT with the Early Clinical Assessment of Balance (ECAB). A research study found that the ECAB was more precise and preferred by clinicians. It can be used for ages 2–7 years (eighth birthday) and is relevant to all children with cerebral palsy regardless of their GMFCS level. Interrater and test–retest reliability have both been demonstrated and it also correlates with the GMFM-66-B&C. There are sections for anticipatory and reactive postural control in floor sitting, on a bench, transfer to standing, and in standing (static and dynamic).

Timed sit-to-stand test is a measure of the time a person takes to move from sitting to standing independently three times. Taylor et al. (2004a) used this test after a 10-week training period of children. Kumban et al. (2013) strongly suggest the need for this test to be done five times (FTSST) for reliability and validity.

Timed up and go (TUG) is used with high reliability and validity. Dhote et al. (2012) used a modification of the child walking to touch a star. The TUG involves a child walking 3 metres from getting up from a stable stool, then coming back to sit on the stool. The height of the stool should be adjusted so that the child's feet are flat on the floor.

Timed stairs test. This is taken from two items of the GMFM. Using a stopwatch to time walking up and down three steps of standard size (17.5 cm) as fast as possible. Rails can be used if needed.

Six-minute walk test. This is a measure of walking endurance of how far an individual is able to walk in 6 minutes on a flat standardized course (Andersson et al. 2006). Two tests are used so that the first is considered as practice.

One-minute walk test (McDowell et al. 2005) is more appropriate for severely involved children. Pirpiris et al. (2003) compare two assessments of walking speed.

Chrysagis et al. (2014) have examined the validity and clinical utility of a number of functional assessments and found that the 1-minute walk test, 10-metre walk test, and lateral step-up test 'are simple to administer, quick, low cost, and user-friendly'.

Wheelchair skills test (Kirby et al. 2002) uses four areas: basic skills; wheelchair manoeuvring and daily skills; obstacle negotiating skills; and advanced wheelchair skills. Scoring is: 0, unable to complete safely; 1, partial completion; 2, safe and successful completion. There is good to excellent reliability and construct validity (MacPhee et al. 2004). See also Knox (2018).

Chailey Levels of Ability (Pountney et al. 2004). This is an assessment of atypical postures in lying, sitting, and standing with biomechanical details, so that appropriate positioning equipment can be selected. The biomechanical details are based on those observed in an infant from birth until walking. The assessment is tailored for older children in GMFCS levels III–V. Such children are taller and heavier than a baby and have a different shape. The scoring is unusual in that the absence of a small detail of an ability can dramatically lower the overall score. Debuse and Brace (2011) in their critical review of assessments did not recommend using the Chailey Levels of Ability.

Measures of upper extremity and hand function

Individuals' functional use of their arms and hands (activity) depends on their maintaining upright sitting or standing using postural adjustments (dynamic balance/counterpoising). However, most upper limb assessments do not also explicitly assess these postural mechanisms. The strength and ROM of arms and hands are involved in holding on, pulling/pushing, getting up, using most walking aids, as well as for the manipulation of objects in self-care or play. Hand use for gestures and/or signs supports communication. Measures of arm and hand function are included in the gross motor assessments described above as they are interwoven with dynamic balance. There have been several systematic reviews of upper limb assessments for children with cerebral palsy such as Gilmore et al. (2010) and Elvrum et al. (2016). Elvrum et al. evaluate measures of hand function, emphasising manual capacity and performance.

Quality of Upper Extremity Skills Test (QUEST) (DeMatteo et al. 1993). Elvrum et al. (2016) suggest that we should no longer use this outcome measure. In addition QUEST has limited to moderate evidence for test–retest, and intrarater and interrater reliability. Thorley et al. (2012a,b) found inadequate measurement properties for QUEST.

Assisting Hand Assessment (AHA) (Krumlinde-Sundholm et al. 2007) is an assessment of how effectively children with unilateral cerebral palsy can use their affected hand during bimanual tasks. It is the only assessment to measure bimanual performance using naturalistic play that is standardised and has sufficient psychometric properties (Holmefur et al. 2007, 2009). The AHA was designed for ages 18 months to 12 years. It has been extended for adolescents to age 18 by including a new test activity, the Ad-AHA board game, which has been proven to be valid for clinical practice to elicit bimanual performance in adolescents with unilateral cerebral palsy (Louwers et al. 2016). In addition, a version of the assessment (the Mini-AHA) for babies and young children who have signs of unilateral cerebral palsy between the ages of 8 and 18 months has been developed and shown to have content and internal scale validity (Greaves et al. 2013). Eight months is the developmental level when postural control enables children to use two hands independently (Case-Smith 2006) and when their cognitive skills have developed to allow advanced bimanual hand use (Kimmerle et al. 2010). The AHA for 8–18 months has content and internal scale validity. Assessment scoring is the same for all the test kits and assessors need to complete individual training courses for each in order to demonstrate their own reliability.

Melbourne Assessment of Unilateral Upper Limb Function (MA) was originally developed by Randall et al. (2001). It was updated with a revised second edition (MA2) for children aged 2.5 to 15 years (Randall et al. 2012). Early research had identified the MA as a reliable measure of biomechanical changes in upper limb function and quality of movement. Later Rasch analysis resulted in division of the assessment into four subscales, which means that the reliability and validity of the original assessment as demonstrated through research does not yet apply to the MA2. Although the ability of this new criterion-referenced assessment of an individual's assets and difficulties with movement qualities (ROM, accuracy, fluency, dexterity) of each upper limb is clear, its sensitivity to detecting small changes in ability has not yet been proven (Elvrum et al. 2016). As the MA2 also does not provide information on the use of both hands

together, additional outcome measures which specifically address bimanual function, and performance also need to be used when assessing people with bilateral cerebral palsy.

Shriners Hospital for Children Upper Extremity Evaluation (SHUEE) is a video-based evaluation tool validated for use in children aged 3–18 with (unilateral) hemiplegic cerebral palsy (Davids et al. 2006). It is designed to assess spontaneous functional movement alongside dynamic alignment of the affected upper limb while the child performs functional tasks. Completion of the SHUEE requires the clinician to measure both passive and active ranges of movement in the upper limbs, to assess tone, and to consider performance in regards to the family's goals. The second part of the assessment comprises scores taken from video recordings of the child in which function, dynamic arm posture, and grasp and release are analysed and evaluated. However, while Davids et al.'s study has demonstrated evidence of validity and reliability, the scores can only be used to measure change over time and do not provide comparisons within more general populations.

Measures of daily activity and participation

Both children and their caregivers have identified activities of daily living (ADL) as important goals for interventions (Allard et al. 2014). Structured assessments in the clinic reveal a person's capacity. Measures of participation are therefore needed to identify their performance when there are potential barriers and facilitators in real-life situations and across environments. Law et al. (2012) have developed an Assessment of Preschool Children's Participation (APCP) for children aged 2–6 years.

The ICF combines 'Activities and Participation', which has been the experience of therapists. Activity measures may not identify whether it is the pattern or biomechanical elements that are impacting on function or whether the task is carried out atypically. Other measures may be needed to do so. While it is best to observe a child's functional tasks in a relevant setting, this is not always possible for all daily activities such as toileting, bathing, or getting dressed. In such cases, parental questionnaires or patient reported outcome measures (Wallen and Stewart 2015) can provide further information. James et al. (2014) have carried out a systematic review of eight ADL measures for children and adolescents with cerebral palsy.

Pediatric Evaluation of Disability Inventory (PEDI) (Haley et al. 1992) was originally designed to measure adaptive functioning in children from 6 months to 7.5 years. A child's level of independence was considered for tasks within three domains – self-care, mobility, and social functions – but with more than 200 items it is time consuming to administer, which is impractical in some settings (Haley et al. 2010). Although the original version is still available for purchase, this assessment has since been superseded by the Pediatric Evaluation of Disability Inventory – Computer Adaptive Test (PEDI-CAT), which is intended for use with children and young people aged 0–21 years (Haley et al. 2011). Designed as a computer-based parental report measure, the parent/carer is required to rate the child's performance in four areas (daily activities, social/cognitive, responsibility, and mobility) that are aligned to the ICF activity and participation domain using a four-point Likert scale as 'unable', 'hard', 'a little hard', or 'easy'. In three of these four categories, the 'activity' domain is addressed and parents or carers can identify the most appropriate rating by

considering the child's usual performance, which may or may not include the use of supports such as a walking aid or communication device. Participation is considered within the 'responsibility' domain, where a five-point rating scale is used to ascertain the amount of responsibility a child takes for a task; this ranges from parents/carers taking all responsibility, to shared responsibility, to the child taking all the responsibility. A recently published study (Shore et al. 2017), which used a convenience cross-sectional sample of 101 school-aged children with cerebral palsy, finds this assessment a valid outcome measurement of daily life functional abilities in children and is able to differentiate across fine and gross motor functional levels. In practice, it is the authors' experience that the identification of a child's percentile rank as being within a group (i.e. below 5, 5–25, etc.) means that sensitivity to change over time is minimal if the assessment is repeated. In addition, the items (questions) are selected by the software program as the PEDI-CAT is intended to be used to provide an overall description of functional activity performance rather than to document a child's level of difficulty for specific tasks; it is not possible for the clinician to select questions to ask specifically about tasks they consider important for an individual and they may therefore need to complete an additional functional measure or take a full functional history.

Functional Independence Measure for Children (WeeFIM) (Msall et al. 1994; Ottenbacher et al. 2000) was adapted from the adult Functional Independence Measure (FIM) and is designed for children with developmental disabilities including cerebral palsy from age 6 months to 7 years. It includes six areas (self-care, sphincter control, transfers, locomotion, communication, and social cognition) and uses a seven-level scale from complete independence to complete dependence. The WeeFIM can be used by any professional discipline and should only take about 20 minutes. The WeeFIM's validity and reliability for children with cerebral palsy has been confirmed by Tur et al. (2009), although they point out that there may be a 'floor effect' with the youngest children. The FIM was used for adolescents and adults with cerebral palsy (Donkervoort et al. 2007).

Functional Mobility Scale (FMS) detects change in independence and need for mobility aids based on a clinician's interpretation of the child and parent report. Mobility in home, school, and community environments is considered (Harvey et al. 2007).

Assessment of Motor and Process Skills (AMPS) (Fisher and Jones 2010) is an observational scale used to measure an individual's performance from a list of more than 125 activities of daily living that range from simple self-care tasks to more complicated domestic tasks. The occupational therapist and the person select two or three meaningful activities that are observed in a task-relevant environment. The person's performance is rated in 16 motor and 20 process skills on a four-point scale. These scores are then analysed with special software. The assessment and the software can only be used by occupational therapists who have completed an expensive course lasting 5 full days plus 10 AMPS assessments after the course. In spite of these limitations, James et al. (2014) in their systematic review conclude that the AMPS is the best tool to evaluate ADL task performance in children and adolescents with cerebral palsy but further work is required to strengthen its reliability in this population. While the validation sample is extremely large and included individuals with a wide range of diagnoses including cerebral palsy, less than 10% of

this sample was below 16 years of age (Fisher and Jones 2010) and thus further validation of use with children and young people is warranted.

ABILHAND-Kids (Arnould et al. 2004) is a parent-reported questionnaire developed to measure the manual ability of children with cerebral palsy aged between 5 and 16 years. For this assessment, manual ability is defined as the performance of daily activities that require the use of the upper limbs and includes functional assessment items such as taking off a T-shirt and washing the upper body. Ability is scored by a parent rating of each individual task as 'impossible', 'difficult', or 'easy' for their child to carry out with or without assistance. It does not provide information on whether the child completes the assessment with one or two hands and component fine motor skills are not considered. Strong evidence for validity and reliability has been demonstrated (James et al. 2014) and reported by Elvrum et al. (2016). Several reviews suggest that ABILHAND-Kids is the most psychometrically robust measure of upper limb activity limitation as it has been developed using Rasch analysis (Preston et al. 2017). This assessment may not be sensitive enough for use with children with more severe difficulties, as very few of the children in the study by Arnould et al. (2004) had severe difficulties.

Kirkpatrick et al. (2016), in their research on 'home-based parent-delivered therapy' for unilateral cerebral palsy, used ABILHAND-Kids, MA2, and AHA.

Children's Hand-use Experience Questionnaire (CHEQ) (Skold et al. 2011) was developed specifically to assess the ability of children with unilateral upper limb motor difficulties. It contains 29 items that require the use of both hands and can be used to provide information on how the child views their own performance (Ryll et al. 2017). James et al. (2014) suggested further validation to determine its suitability as an outcome measure for this population and a more recent study has indicated good validity and test–retest reliability (Amer et al. 2015).

Children's Assessment of Participation and Enjoyment (CAPE) and Preferences for Activities of Children (PAC) (King et al. 2007) are two companion self-report measures of children's participation in leisure activities. The CAPE documents what a child or youth participates in, the intensity of participation with scores for who the child participates with, and where and how much they enjoy it. It is a 55-item questionnaire that provides an overall participation score as well as scores reflecting participation in five types of activities (recreational, active physical, social, skill-based, and self-improvement activities). The PAC provides a means to measure preference for activities and is designed to be used alongside the CAPE. Both tools are designed for young people between the ages of 6 and 21 (with and without disabilities). The CAPE has been well validated with a large group of children in Canada (Imms 2008) and the Netherlands (Bult et al. 2010). Sakzewski et al. (2007), in their systematic review of participation measures for 5- to 13-year-old children with cerebral palsy, stated that the CAPE was one of their preferred measures.

Canadian Occupational Performance Measure (COPM) (Law et al. 2005) measures performance in the areas of self-care, productivity, and leisure. A semistructured interview is used to enable the individual to identify areas of difficulty in occupational performance and problem areas are rated on a scale of importance from 1 to 10. The individual then chooses up to five identified problem areas and scores their current level of performance and satisfaction with that performance, again on a scale from 1 to 10. Once the intervention has been

carried out, the COPM is completed again with the individual reviewing their performance and satisfaction on the same tasks. The initial and reassessment scores are compared to evaluate any change (Law et al. 2005). A recent study by Schiariti et al. (2017) has identified the COPM as a clinically feasible, psychometrically robust measure that aligns with the ICF core sets for children and youth with cerebral palsy.

Systematic reviews of outcome measures

Harvey et al. (2008) have reviewed the following measures of activity limitation: GMFM, Activities Scale for Kids (ASK), Child Health Questionnaire (CHQ), Gillette FAQ, WeeFIM, PEDI, Pediatric Outcomes Data Collection Instrument (PODCI), and the FMS. They pointed out that the GMFM is a measure in the clinical setting ('what the child can do'), whereas parent and child measures, such as the ASK, give performance in their own environment ('what the child does do'). The review showed that GMFM and ASK are the most robust measures and that the other tools require further validation. Therapists rarely use the PODCI, which is preferred by orthopaedic surgeons, or the CHQ, which is more useful for doctors.

Debuse and Brace (2011) critically review GMFM-88 and -66, WeeFIM, Gillette FAQ, PEDI, and PODCI. They prefer GMFM for younger children and PEDI for older children. They note that the PEDI-CAT was still being developed.

The reviews of measures of participation by Sakziewski et al. (2007), of upper limb function by Gilmore et al. (2010), of ADL by James et al. (2014), and of hand function by Elvrum et al. (2016) have been mentioned above.

Goal Attainment Scaling

Goal Attainment Scaling (GAS) (King et al. 1999; Cusick et al. 2006; Steenbeek et al. 2008, 2010) is an individualised outcome measure that captures small and meaningful changes. Goals are negotiated with a child, adolescent, or adult where possible and with parent or carer. This is followed by sharing ideas about their functional tasks such as an aspect of self-care, play with a toy, or managing transfers. When assistance is needed for severe problems this is clearly recorded as how much, where given, and for how long within the duration of the activity. Goals for problems such as pain/discomfort that prevent sitting/standing function can be planned, Individuals, their parents/carers, and professionals appraise outcomes after an agreed time interval. Steenbeek et al. (2008) and King et al. (1999) recommend training.

GAS consists of the five-point scale constructed prior to intervention to establish therapy objectives. On this scale, '0' represents the expected level of function that the individual will achieve following intervention; scores of −2 or −1 and +1 or +2 are used to indicate that changes in function are less or more than expected, respectively. Within the available literature, there are some suggestions that GAS is more sensitive to change than standardised functional measures (Cusick et al. 2006; Steenbeek et al. 2010) but the fact that therapists are required to develop the scale on an individual basis has raised questions about content reliability and bias. Despite this, GAS has been used in a number of intervention studies to measure the effectiveness of BoNT-A on functional outcomes for children including Lowe et al. (2006), Hoare et al. (2013), and Löwing et al. (2016). In 2010 a further study by Steenbeek et al. was carried out to determine the interrater reliability of GAS during routine therapy practice with children with cerebral palsy. Despite acknowledged limitations in regards to possible bias the results suggest that interrater reliability scores were in fact good to excellent and that scale

construction by the child's own therapist as opposed to an independent rater actually had a positive effect.

GAS has been used together with COPM (Østensjø et al. 2008; Øien et al. 2010). Some of the measures given in the section 'Specific functional items' may be useful if they match individuals' chosen goals.

Although the *T* score is used by some therapists, it is best to describe the levels of achievement on goals. Steenbeek et al. (2007), experienced researchers on GAS, state: 'it would probably be best to abandon the *T* score, 38 years after its introduction.'

Quality of life and health-related quality of life measures

Quality of life (QOL) is different from health-related quality of life (HRQOL) (Rosenbaum et al. 2007b; Ronen and Rosenbaum 2013). QOL is how individuals feel about their own life from their own personal assessment and valuation. HRQOL considers the physical impairments of cerebral palsy such as pain or mobility that interfere with individuals' well-being. HRQOL is objectively measured whereas QOL is self-assessed.

QOL measures for children and young people with cerebral palsy are increasingly used by the multidisciplinary team to address potential difficulties across all areas and provide appropriate support when required (Mueller-Godeffroy et al. 2016). Although it is accepted that self-report should be the primary means of ascertaining QOL, for some children and young people this is not possible if they have cognitive impairments. It is therefore important that reliable discussions or questionnaires for proxy report are also available.

Lifestyle Assessment Questionnaire – Cerebral Palsy (LAQ-CP) (Mackie et al. 1998), which Kerr et al. (2007) have used to compare gross motor function with restriction of participation. They found that better physical function correlated with a better well-being or HRQOL.

Pediatric Quality of Life Inventory (PedsQL™) (Varni et al. 2006). The PedsQL has two versions of two parallel forms, a self-report form for children aged 8–12 years and one for young people aged 13–18 years and parent proxy versions for both age ranges. While the initial studies into the psychometric properties of PedsQL showed good validity and reliability, both PedsQL and the LAQ-CP have since been designed by instruments with more robust statistical processes to ascertain clinical utility. Maher et al. (2008) have used PedsQL for adolescents.

DISABKIDS (DCGM-37) has been developed as a core measure of QOL that includes complementary condition-specific modules, including one for use with children with cerebral palsy (Simeoni et al. 2007). It consists of 37 items on six scales (independence, physical limitation, emotion, social inclusion, social exclusion, and treatment) and a total score. Items are reported on a five-point Likert frequency scale and transformed to a linear scale with higher scores indicating a better QOL. A study by Mueller-Godeffroy et al. (2016) demonstrated that both the DCGM-37 and the cerebral palsy module provide a valid and reliable means of measuring QOL. There were no floor effects and only very small ceiling effects in all the scales.

KIDSCREEN, which has both self-report and proxy versions, was developed in 13 different European countries to ensure cross-cultural applicability. Content was generated from a literature review, a Delphi exercise, and focus groups with children and parents (Ravens-Sieberer et al. 2014) and resulted in three versions with 52, 27, and 10 items, respectively. All three versions were then psychometrically tested using a European sample of 22 827 children (Berra et al. 2007) and have been shown to

be a reliable, valid, and conceptually appropriate measure of QOL. The KIDSCREEN is a screening, monitoring, and evaluation tool and can be used in many different settings. It has been utilised in numerous studies including the SPARCLE project, which carried out a longitudinal analysis on the self-reported QOL of 818 adolescents with cerebral palsy (Colver et al. 2015). These studies have demonstrated that reduced QOL includes mood, autonomy, and social support. Colver et al. (2015) suggest that promotion of good QOL is essential so that an overemphasis on remediation of impairments needs to be avoided. More recently a computer version, Kids-CAT, has been developed and is being implemented in a longitudinal study in 1200 school children and 300 chronically ill children to assess its feasibility, reliability, validity, and responsiveness to change. Early results of a feasibility study have demonstrated that the Kids-CAT promises to be a reliable and valid measurement tool for children with chronic illnesses (Barthel et al. 2016) and can be easily implemented in clinical settings (Barthel et al. 2017). However, people with cerebral palsy are not 'chronically ill'.

Norm-referenced measures of stages of child development

These measures compare a child with typically developing children. These measures and many other developmental assessments detect developmental delay and give a broad picture of a child or older person's stages of development but not quality of movement for cerebral palsy. Therefore, these developmental measures cannot show the details of progress either in function or in minimised impairment due to therapy. However, they do offer a means of describing a child's developmental delays in a profile across cognitive, linguistic, and motor domains.

Bayley Scales of Infant Development (third edition (Bayley-III); Bayley 2005) is a measure of developmental levels of mental and motor skills from 1 to 42 months. It is frequently used to assess development of children at risk of developmental delay, despite the fact that it appears to underestimate delay (Milne et al. 2015). A meta-analysis (dos Santos et al. 2013) also concluded that the Bayley-III only has limited predictive value for later development of children born very preterm or with very low birth weight. Consequently, this assessment should not be used with such children, who are at greater risk of cerebral palsy.

Peabody Developmental Motor Scales (second edition; PDMS-2) (Folio and Fewell 2000) measures both gross and fine motor skills for children up to 6 years of age and includes a separate fine motor skill section that is divided into two scales (grasping and visual–motor integration). There are both unimanual and bimanual tasks in these subscales, with the former scored by how they are performed with the child's preferred hand and the latter according to task completion. Even though subsequent studies have shown the reliability of the fine motor skill section for children with bilateral cerebral palsy, the test itself has not been validated for such children (Elvrum et al. 2016).

Griffiths Scales. The revised version was published in 2006 following standardisation on a group of 1026 children from the UK (Johnson and Marlow 2006; Luiz et al. 2006). An overall development norm-referenced test for infants and young children, the Griffiths Scales comprise the Baby Scales for children from birth through 23 months and the Extended Scales for children from 24 months up to 8 years. While Griffiths scores at 2 and 3 years of age have been shown to correlate with intellectual ability at 5 years as

measured on standardised cognitive assessments, the scale's test–retest reliability is particularly poor for the first year, and information regarding interscorer reliability and validity has not been evidenced (Milne et al. 2015).

The Denver Developmental Screening Test 2nd Edition (DDST-II) (Frankenburg et al. 1992) measures fine and gross motor skills, personal social intellectual skills, and language in young children. Like a growth chart, the Denver allows a child's developmental trajectory to be monitored and mapped on a chart from 2 weeks of age until 6 years of age. Although DDST-II is reported to have excellent sensitivity (low false negative rate) (83%), its low specificity (high false positive rate) has been questioned (Glascoe 2002).

Neonatal assessments

Therapists working with children with cerebral palsy are aware of the role of their colleagues working in neonatal units to ensure smooth transition of care following discharge home. The Department of Health (2009) in the UK has produced a *Toolkit for High-Quality Neonatal Services*, which indicates that specialist physiotherapy, occupational therapy, and speech and language therapy should be available to all units. Physiotherapists and occupational therapists working in neonatal care are frequently involved in early assessment of risk or identification of cerebral palsy.

Bosanquet et al. (2013) have systematically reviewed tests to predict cerebral palsy in infants and young children. They include neurological assessments such as the Lacey Assessment of Preterm Infants (Lacey et al. 2004). The Hammersmith Infant Neurologic Examination (Dubowitz et al. 1999) detects infants at high risk and is useful for follow-up. Other tests, as well as the therapist's role, are discussed in the Neonatal Special Edition of the *APCP Journal* (vol. 6, no. 1, May 2015).

Prechtl's Assessment of General Movements (GMA) (Einspieler and Prechtl 2005). Note that to learn how to carry out the GMA in a standardised way and to demonstrate reliability, therapists must complete a training course run by the General Movements Trust (http://general-movements-trust.info).

This assessment has been developed from an increased understanding that the quality of spontaneous movements in very young infants is more indicative of possible brain lesions than traditional testing of reflexes and responses. The assessment is a standardised procedure that involves the infant being videoed in a supine position.

The assessment specifically considers two types of general movements: 'writhing movements', which are elliptical and characterised by 'small-to-moderate amplitude and by slow-to-moderate speed' (Einspieler and Prechtl 2005), and 'fidgety movements' of the neck, trunk, and limbs, which are much smaller in amplitude, are of moderate speed and variable acceleration, and are continuous while the infant is awake except for when they are fussing and crying (Prechtl et al. 1997). In the first 2 months post term, observation of the infant's movement periods shows whether the writhing movements are 'normal', 'poor repertoire', 'chaotic', or 'cramped synchronized'. Although poor repertoire movements do not have a high predictive value for cerebral palsy (Prechtl et al. 1997), chaotic movements often develop into cramped-synchronized movements and the presence of cramped-synchronized movements are highly predictive of cerebral palsy (Ferrari et al. 2002). At 6–9 weeks post term, movements gradually change, with fidgety movements emerging. These fidgety movements are categorised as 'normal', 'abnormal', or 'absent'. Although the predictive value of abnormal fidgety

movements is low (Einspieler and Prechtl 2005), the absence of fidgety movements is highly predictive for both cerebral palsy (Einspieler et al. 2002) and other neurological deficits (Einspieler et al. 2016). Research shows that specific patterns of writhing or fidgety movements are indicators of cerebral palsy topography. For example, the presence of cramped-synchronized general movements and the absence of fidgety movements together predict spastic cerebral palsy, while poor repertoire general movements, circular arm movements, and finger spreading predict dyskinetic cerebral palsy (Einspieler et al. 2002).

Both the validity and interrater reliability of the GMA have been repeatedly demonstrated (Morgan et al. 2016b), with several studies suggesting that the predictive validity is superior to neuroimaging. Bosanquet et al. (2013) identified six studies (with a total of 1358 participants) evaluating the GMA for diagnostic accuracy. The review provides evidence that the GMA can accurately predict the development of cerebral palsy, and that it is the most sensitive assessment currently available to predict spastic cerebral palsy in high-risk infants. Combining the GMA with magnetic resonance imaging results has been shown to be 100% predictive of an outcome of cerebral palsy in a cohort of preterm infants (Hadders-Algra 2004; Spittle et al. 2008).

Other examples of measures of infants' motor function are as follows.

- *Test of Infant Motor Performance (TIMP)* (Campbell et al. 1995; Girolami 2015). This is a measure for preterm babies up to 4 months developed to identify delayed motor development and to assess the efficacy of physiotherapy and occupational therapy in clinical practice. It allows adjustments for prematurity. There are 42 items and the babies are presented with a variety of tasks and placed in different positions: prone, supine, side lying, and supported sitting and standing. The TIMP has been shown to be valid as an outcome measure in a number of clinical trials involving intervention in the neonatal intensive care unit (Valizadeh et al. 2017).
- *Alberta Infant Motor Scale (AIMS)* (Piper and Darrah 1994) is a measure of motor development from birth to 18 months and observes a child in supine, prone, sitting, and standing. It is devised for 'at risk' infants, detecting developmental delay. Research has demonstrated that the AIMS is not as sensitive as the TIMP and does not capture delayed functional motor performance before 6 months corrected age (Barbosa et al. 2003).

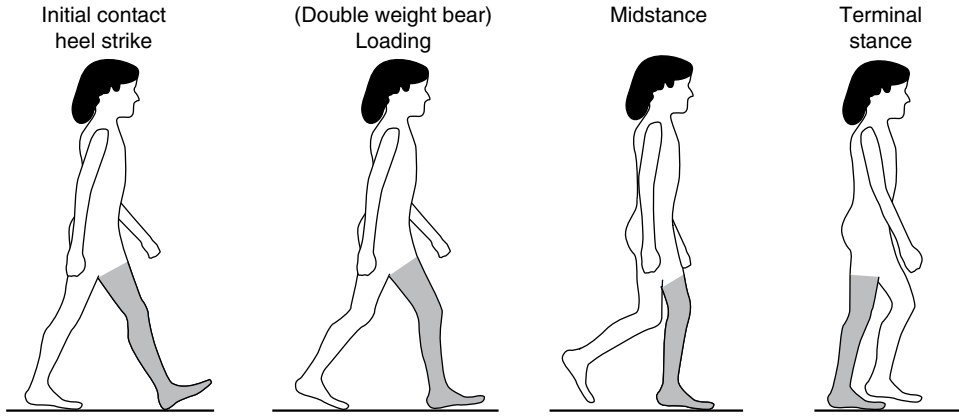
Methods of observation of gait

Gait laboratories assist observations but are expensive and not always easily available. Some children are less natural in such assessments and cannot cooperate below age 6 years (Mackey et al. 2003). Instrumented gait analyses have been developed for the use of orthoses and before and after orthopaedic surgery to evaluate spastic hypertonus, muscle contractions, force, and skeletal malalignments. Electromyography, recorded joint movements, and force plates are some of the tools used. These analyses are called 3DGA (three-dimensional gait analysis) and are recommended by surgeons for complex gait deviations (Gage et al. 2009). Dobson et al. (2007) published a critical review of gait classification.

Clinicians depend on a visual assessment to evaluate individuals' gait patterns (particularly in children) for therapy outcomes. There are a number of visual gait scales to assess a child before and after treatment with BoNT-A injections. These scales are

similar to the Physician Rating Scale (PRS) (Koman et al. 2001), which assesses crouch (hip, knee, ankle flexion), knee recurvatum (hyperextension), equinus foot, hind foot, speed of gait, and gait pattern. Video recording is used for assessment. Ubhi et al. (2000) have a slightly different scale from the PRS concerning details of the initial foot contact after the leg swing.

The sagittal plane for observation was validated (Mackey et al. 2003). Knee position mid-stance, initial foot contact, foot position in mid-stance, and timing of heel raise in preparation for leg swing are in



	initial contact strike loading	midstance to terminal stance
Head	Erect arrest forward/down shift	Erect
Trunk	Erect lateral shift to right	Erect lateral shift to right
Pelvis	Forward rotation right Lateral tilt up right	Level Lateral tilt up right
Hip	Flexion 30°	Extension
Knee	Full extension, semiflex on loading. 5°	Full extension
Ankle	90°	90°. Increase dorsiflexion 10° midstance
Arms	Right back swing, left forward swing.	Midway
Examples of atypical gaits	Toe contact, whole foot contact; swivel on toe while loading. Forward shift atypical, continues as *run* or backward lean. Unstable. Hip flexion – hyperextended knee. Hip flexion – knee flexion. Hip flex – lordosis – pelvic tilt. Pelvic retraction; atypical rotation.	On toe; pronation, equinovarus. Hip, knee flexion: overflexed ankle. Hyperextended knee. Excessive hip internal rotation/external rotation; adducted/abducted pelvic retraction. Excessive pelvic tilt up. Antero-posteriorly tilts excess. Unstable. Fleeting stance phase. No lateral shift.

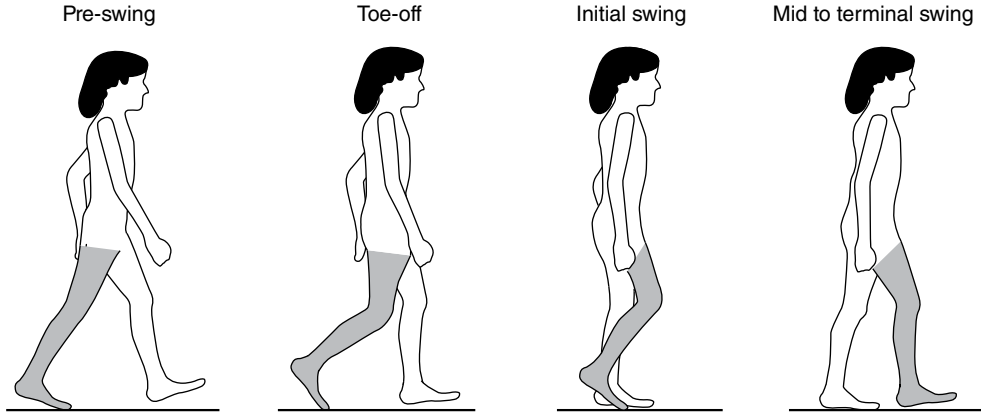
Note In all phases of gait kyphosis, lordosis, scolioses, atypical head position, atypical arm postures/swing may be present.

Figure 8.3. Right leg gait analysis (child over 2–3 years of age).

agreement in most gait analysis studies. There is also the Edinburgh Visual Gait Analysis (Read et al. 2003). Maathuis et al. (2005) commented on the PRS and Edinburgh Visual Gait Analysis in their study. They found excellent intraobserver reliability but poor interobserver reliability for children with cerebral palsy and recommended one observer for longitudinal assessments.

Desloovere et al. (2006) found in their studies on gait analysis that strength and selective motor function had a higher degree of correlation with gait analysis than ROM and spasticity.

A clinical gait analysis is given in Fig. 8.3 based on the above discussions and on clinical experience (Levitt 1984). An easier functional observation is detecting a contact phase from heel strike to foot flat in



	pre-swing toe-off	initial swing mid swing terminal swing
Head	Erect forward/downward shift	Erect forward/down shift
Trunk	Erect lateral shift to left	Erect lateral shift to left
Pelvis	Rotates back as contralateral left rotates forward Lateral tilt down right	Rotates from back to forward on right Lateral tilt down, right
Hip	Extension 10°	Flexion 20°
Knee	Extension becomes 30° flexion	Flexion 70° changing to extension
Ankle	Change to plantarflex 15° to push-off, to swing.	Plantarflex to neutral
Arms	Right forward, left back.	Right swing back, left forward
Examples of atypical gaits	Absent phase and *fall* on to left excessive lateral shift or forward minimal hip extension: hip rotates overflexion all joints: no plantar extension. Pelvic drop excessive on right. Equinovarus or valgus *push off*. Atypical hip adduction. Atypical posture and patterns as seen in *swing through*.	Failed ballistic swing giving short stride. Foot drag. Failed left stance giving quick limp onto right. Overflexed swing (high step). Atypical pelvic tilts and rotations. Circumduction.

Figure 8.3. (*Continued*)

mid-stance. Foot flat changes to heel lift at the end of mid-stance and toe-off at the end of stance and beginning of swing. In Fig 8.3, there are more details that need a slow motion video for observation, so that repeated viewing for all the details can take place. Footprints of a child have also been used to assess gait for step lengths, base, and amount of weight bearing on each foot. Cadence is the number of steps per minute and stride is the full gait cycle, which equals two steps. The basic cycle of one leg is a step.

Fast walking is likely to activate spastic hypertonus. However, fast walking is not common in the spastic type of cerebral palsy. In dyskinesia, individual children run headlong using momentum rather than being able to give time for weight shift and single leg balance.

In Chapter 12, gait analyses of individuals with spastic cerebral palsy are presented by orthopaedic surgeons in relation to surgical procedures.

Reactions and reflex responses

These are summarised in Table 8.2, so that a therapist recognises them as possible compensations by a child trying to function. They are *not* measures for the hierarchical reflex model, which were previously emphasised in some developmental therapy plans. Each of the reflex reactions in Table 8.2 need not be routinely examined by the therapist except as an academic exercise. The postural mechanisms and voluntary motion for motor control are assessed in more detail within the developmental functions in Chapter 9. Treating and developing these components within motor functions will simultaneously modify or eliminate infantile reactions or reflex responses.

The measures of function rather than reflexes are a much more relevant demonstration of change following therapy and management (see section 'Infantile reflexes' in Chapter 1).

Speed of performance

One of the problems in cerebral palsy is a delay in initiation and especially in completing a movement for a task (Shumway-Cook and Woollacott 2017). This is due to inadequate force generation (weakness), limited ROM, and poor anticipatory postural stabilisation. There may also be poor understanding and remembering of the movement required.

Independence of a child and older person with disabilities is not fully achieved if they cannot move fast enough for the particular needs in a specific task or environment. To help children fit into regular (mainstream) schools or later work situations as well as live as independently as possible in society, they need to be supported to function at reasonable speed. This could be slower than normal but not *very* slow. It is easy to assess when a child is very slow and therapy is adjusted accordingly. Other speeds have to be assessed if they are relevant to the child's life, and whether people are likely to wait for a person whose movements and walking are slow. Those without disabilities do learn to adjust their speed to that of the person with a disability, and if not then this needs to be suggested.

Assessment of speed of a task depends on the precision needed for it. For example, lifting a tiny object with a hand demands more coordination and so takes longer than lifting a larger object. Timing for assessment is best carried out unobtrusively to avoid increasing anxiety in some individuals. Assessment for powered wheelchairs will also be associated with the problems of speed as well as distance and terrain that need to be managed by a person with disability.

Table 8.2 Reflex reactions. A reflex conveys a stereotyped response to a stimulus. As responses vary in children, the term reflex reaction is used

Reflex reaction	Normal until	Stimulus	Response	Therapy
Sucking	3 months	Introduce a finger into mouth	Sucking action of lips and jaw	Train correct feeding
Rooting	3 months	Touch baby's cheek	Head turns towards stimulus	
Cardinal points	2 months	(1) Touch corner of mouth	(1) Bottom lip lowers on same side and tongue moves towards point of stimulation. When finger slides away, the head turns to follow	Desensitise face by child's own touch and other stimuli by therapist
		(2) Centre of upper lip is stimulated	(2) Lip elevates, tongue moves towards place stimulated. If finger slides along oronasal groove, then the head extends	
		(3) Centre of bottom lip is stroked	(3) Lip is lowered and tongue directed to site of stimulation. If finger moves towards chin, the mandible is lowered and head flexes	
Grasp	3 months	Press finger or other suitable object into palm from ulnar side	Fingers flex and grip object (head in midline during this test)	Weight bearing, stimuli over whole hand, hand opening in development of hand function
Hand opening	1 month	Stroke ulnar border of palm and little finger	Automatic opening of hand	
Foot grasp	9 months	Press sole of foot behind the toes	Grasping response of feet	Weight bearing in development of standing
Placing	Remains	Bring the anterior aspect of foot or hand against the edge of a table	Child lifts limb up to step onto table	Use in provoking early step
Primary walking (automatic walk: reflex stepping)	2 months	Hold baby upright and tip forwards, sole of foot presses against table	Initiates reciprocal flexion and extension of legs	Weight bearing in development of standing

(*Continued*)

Table 8.2 (Continued)

Reflex reaction	Normal until	Stimulus	Response	Therapy
Galant's trunk incurvation	2 months	Stroke back lateral to the spine	Flexion of trunk towards side of stimulus	Train trunk stability in development of sitting and standing
Automatic sitting	2 months	Pressure is placed on the thighs and the head is held in flexion. Supine position	Child pulls to sitting from supine	Train child's own rising in development of sitting
Moro	0–6 months	Baby supine and back of head is supported above table. Drop head backwards; also associated with loud noise	Abduction and extension of arms. Hands open. This phase is followed by adduction of the arms as if in an embrace	Train vertical head stability, use grasp, use prone position, use flexion position, shoulder fixation with grasp or hand support
Startle	Remains	Obtained by sudden loud noise or tapping the sternum	Elbow is flexed (not extended as in the Moro reflex) and the hand remains closed	Desensitise to noise by warning and experience
Landau	From 3 months to 2.5 years, strong at	Child held in ventral suspension, lift head	The head, spine, and legs extend Extend arms at shoulders	Used in therapy to activate extensor muscles
	10 months	When the head is depressed	The hip, knees, and elbows flex	
Flexor withdrawal	2 months	Supine; head mid-position, legs extended – stimulate sole of foot	Uncontrolled flexion response of stimulated leg (do not confuse with response to tickling)	
Extensor thrust	2 months	Supine; head, mid-position, one leg extended, opposite leg flexed – stimulate sole of flexed leg	Uncontrolled extension of stimulated leg (do not confuse with response to tickling)	Weight bearing, joint compression, knee splints, and calipers in development of standing
Crossed extension	2 months	Supine; head, mid-position; legs extended – stimulate medial surface of one leg by tapping	Opposite leg adducts, extends, internally rotates, and foot plantarflexes (typical scissor position)	
Asymmetrical tonic neck reaction	6 months, usually pathological	Patient supine; head in mid-position; arms and legs extended – turn head to one side	Extension of arm and leg on face side, or increase in extensor tone; flexion of arm and leg on skull side or increase in flexor tone	Use both arms together and train head in midline, use prone position, only encourage in severe older child

Symmetrical tonic neck (STNR) reflex	Rare and usually pathological	(1) Patient in quadruped position or over tester's knees – ventroflex the head (2) Position as above, dorsiflex the head	(1) Arms flex or flexor tone dominates; legs extended or extensor tone dominates (2) Arms extend or extensor tone dominates; legs flex or flexor tone dominates	See 'Prone development' (Chapter 9) Correct weight bearing on hands and knees with head control. This overcomes the STNR
Tonic labyrinthine supine	Pathological	Patient supine; head in mid-position; arms and legs extended. Test stimulus – is the position	Extensor tone dominates when arms and legs are passively flexed	See 'Supine development' and 'Development of sitting' (Chapter 9) Overcomes excessive extension
Tonic labyrinthine prone	3 months	Turn patient prone – head in mid-position. **Test stimulus – prone position**	Unable to dorsiflex head, retract shoulders, extend trunk, arms, legs	See 'Prone development' (Chapter 9) Overcomes excessive flexion
Positive supporting	3 months	Hold patient in standing position – press down on soles of feet	Increase of extension in legs Plantarflexion, genu recurvatum may occur	See 'Development of standing at 0–6 months' (Chapter 9) Excessive anti-gravity response
Negative supporting	3–5 months	Hold in weight-bearing position	Child 'sinks' astasia	See 'Development of standing at 0–6 months' (Chapter 9)
Neck righting	5 months	Supine, rotate head to one side, actively or passively	Body rotates as a whole in same direction as the head	See sections on rolling in 'Prone development' and 'Supine development' (Chapter 9) Stimulate body rotative reactions
Associated reactions	Pathological	Have patient squeeze an object (with a hemiplegic, squeeze with uninvolved hand)	Clench of other hand or increase of tone in other parts of the body Atypical overflow	See 'Development of hand function' (Chapter 9)

(*Continued*)

Table 8.2 (Continued)

Reflex reaction	Emerges at	Stimulus	Response	Therapy
Rising labyrinthine head righting Vestibular righting (decrease of head lag)	2–6 months	(1) Hold blindfolded patient in prone position, in space, as head drops (2) As above in supine position	Head rises to normal position, face vertical, mouth horizontal Head rises to normal position, face vertical, mouth horizontal	For all reactions, see all sections on developmental training in Chapter 9
	6 months	(3) Hold blindfolded patient in space – hold around pelvis, tilt to the side	Head rights itself to normal position, face vertical, mouth horizontal	
Optical	6 months	As above, no blindfold	As above	
Amphibian	4–6 months	Patient prone, head in mid-position, legs extended, lift pelvis on one side	Automatic flexion outwards of hip and knee on same side	
Body righting				
(a) Derotative	4–6 months	Supine – rotate head or one knee one side, passively	Active derotation at waist, i.e. segmental rotation of trunk between shoulders and pelvis	
(b) Rotative	6–10 months	Rotate hip and knee or arm or head actively	Active segmented rotation (hyperactive at 10 months, cannot lie supine)	
Lift reaction (*not* the pathological lift reaction (Tardieu))	5–6 months	Lift body through space	Head rises (lifts)	
Shoulder/pelvic girdle righting Postural fixation counterpoising (see the sections on developmental training in Chapter 9)	3–6 months	Fix distal part(s) of limb	Rise up on to limb	
Tilt reactions				
(a) Supine and prone	6 months	Patient on tiltboard. Arms and legs extended, tilt board to one side	Lateral curving of head and thorax, protective reaction in limbs accompany trunk reaction	

(b) Four-point kneeling	7–12 months	Patient in quadruped position, tilt towards one side	Lateral curving of head and thorax. Abduction–extension of arm and leg on raised side and protective reactions on lowered side may accompany this	
(c)		Tilt forwards and back (anteroposteriorly)	Forwards – head and back, flex Backwards – head and back, extend	See Chapter 9
(d) Sitting	9–12 months	Patient seated on chair – tilt patient to one side. Tilt forwards anteroposterior back	Head and thorax curve abduction–extension of arm and leg on raised side, other protective reactions may accompany this	
(e) Sitting		Tilt forwards Tilt back	Child extends head and back Child flexes head and trunk	
(f) Kneel–standing	18 months	Patient in kneel–standing position, pull or tilt patient to one side	As above	
(g) Standing	12–18 months	Patient in standing position. Tilt sideways. Tilt anteroposteriorly	Trunk as above	
Staggering reactions (see 'Saving from falling' below)	12–18 months	(1) Move to left or to right, side push or holding upper arm	Hopping, or step sideways to maintain equilibrium	
		(2) Move forwards	Hopping, or step forwards to maintain equilibrium	
		(3) Move backwards	Hopping, or step backwards to maintain equilibrium or dorsiflex feet going on to heels	See Chapter 9
Saving from falling	5–10 months	Prone – sudden tip downwards Sitting – sudden tip downwards Standing – sudden tip downwards	Immediate extension of arms with abduction and extension of fingers to save and then prop the child	
	6–9 months	Standing – sudden tip sideways – one arm		
	9–12 months	Standing – sudden tip backwards – both arms		

Note. Motor patterns of the responses may be atypical. This is *not* a chart for testing a child, but as background information for observation in function on which the therapist focuses.

Additional assessment required

Sensory examination. Historically loss of sensation in the cerebral palsies was considered to be rare, having first been described in hemiplegia (Tizard et al. 1954). However, although it is difficult to assess sensation in babies and young children with disabilities or older children with severe multiple impairments, more recent research has demonstrated that children with other distributions also experience differences in tactile sensation compared with children without cerebral palsy (Yekutiel et al. 1994; Odding et al. 2006; Sanger and Kukke 2007; Auld et al. 2012). Perceptual difficulties are much more common and various assessments are available and done by neurologists, psychologists, and specialised occupational therapists and teachers. Lack of body awareness and other perceptual problems may result from lack of *sensory experience*. Poor sensory awareness is common in people who are immobile or have poor mobility. Sensory unawareness can lead to pressure marks and pressure sores as well as from a person's inability to move out of any position.

Assessment of equipment includes the selection, the measurements, and the assessment of the child in or using selected equipment to promote activity and participation.

See Chapter 13 for assessment and examples of equipment. The general principles for assessment of equipment are also given.

Select equipment according to the following considerations.

1. *Assessment of the child's disabilities and abilities*, especially emerging 'unreliable' abilities to decide if equipment is necessary, and, if so, which items remain appropriate over time. The correct amount of compensation makes it possible for the child to carry out tasks otherwise impossible, but too much aid prevents their own active participation and development of emerging ability.
2. *Assessment of the child's deformities* or threatening deformities. Ranges of movement need to be adequate for equipment or allowing stretch within the child's current potential. Good alignment in any equipment and correction of atypical postures must be maintained during the use of the equipment. For example, standing may be correct in a standing frame, but become atypical in standing; sitting may be upright in a pushchair or wheelchair with postural supports but become unsymmetrical when the chair is pushed.
3. *Good design* of equipment takes account of adjustments for the child's growth, removal of supports with increasing ability, a variety of modifications for different children in a clinic/school, is as portable as possible, and looks as 'normal' as possible. Simple designs easily adjusted by busy parents and staff are desirable. Continue to check measurements of the child as he or she grows so that equipment is not too small. Continue to reassess equipment in relation to achievements gained in therapy and daily care. Once again, equipment must facilitate independence, not substitute for it.
4. Assess that equipment provides a variety of additional motor experiences in different positions. Equipment needs to give individuals appropriate support so that they can participate in communication, eating and drinking, social and educational activities, as well as have assistance for desirable mobility to increase participation.
5. Assess that equipment can be transported and stored and have manoeuvrability

so that it can be used in different environments in a person's life.
6. Monitor different items of equipment for a variety of postures throughout the day and night as part of the prevention and correction of deformities. Consideration of night-time postural management is detailed in Chapters 12 and 13, as part of the 24-hour postural care programme to minimise deformities.
7. Check for any pressure points on bony prominences during use of orthoses and equipment.

Assessment of a child's and family's needs

1. The ability of parents and carers to use equipment correctly needs ongoing supervision, education, and support by each child's therapists. Their acceptance of equipment in their home needs collaborative discussion and self-reported questionnaires by patients and their families (Goldsmith 2000). Encourage their views so that ideas on equipment can be developed for better practice.
2. There may be problems such as equipment being too cumbersome in a home or school; isolating the child from a family group too much; proving too fragile and requiring expense, time, and worry on the part of people caring for the child; and other considerations of a similar kind. Home and school visits are a great help in discovering these problems as some parents may not report these difficulties after 'all the efforts made' by staff to assess, provide, and check the equipment in a clinic.
3. Respect cultural views such as not using lying on the floor or use of crawling apparatus and preferred use of floor seats rather than special chairs in some social groups.

Note. Provision of equipment, designs, and new ideas change with research and general progress in helping children with disabilities and consideration of this may help the child at reassessment.

Assessment of techniques required

Assessment of an individual's, parents', or carer's abilities to manage techniques and their opinions are sought as these are significant (see Chapter 2). Selected techniques used in therapists' own sessions will be assessed during use. Assessment of techniques chosen *must* take place, as one cannot always predict the individual's response. For children who are able to use a method, there must be either an *active* response or active initiation. A change in a component of a function needs to be detected by the end of a session. If not, it should be discarded within the first or first few sessions, and another method found. Assessment of methods for deformities is discussed in Chapter 12.

Records

Records are made of the following:

- *Background information* of medical history, general health, drugs being used, assessment of the individual's other abilities and disabilities, general development, and family background. These are frequently taken from records of other professionals as parents may be unhappy about being 'asked the same questions by many different professionals'.
- *Developmental history*. Additional details for therapy not in other professional records.
- *Priorities of the individual, parents, teachers or carers*. For physiotherapists, other professional records are frequently

used for priorities of social, financial, and housing requirements other than motor function. Occupational therapists consider health and social care within their assessments. Priorities for education should be ascertained by the multidisciplinary team. In the UK, all needs are currently included within a child's Education, Health and Care Plan (EHCP).

- *Measures* recorded are chosen to provide both outcomes (evaluations) in clinic and performance in home, school, and community.
- *Goals* need to be recorded and clarified with individuals, family member, and carer. There are *short-term goals and long-term goals*. Some therapists have set goals for the end of a therapy session and achieve these immediate goals. However, although encouraging, and even used in studies to suggest the value of a therapy approach, this is not valid as results may not be maintained that day or later.
- *Videos* are accepted practice and need individual's and parents' agreement. The viewing of an individual's function needs to be the same each time they are assessed to enable accurate comparison. Record clinical progress when any supports, equipment, walkers, or orthoses are no longer needed.

Summary

- Assessment is essential for therapy plans relevant to individuals and their families.
- Assessment methods need to be selected in *direct* relationship to techniques and strategies of treatment. Such a practical approach is outlined in this book.
- Objective, valid, responsive, reproducible measures continue to be researched, and are increasing.
- The measures outlined in this chapter are selected according to the individual child's or older person's goals.
- The practical assessment which directly relates to training includes developmental functional assessments, examination of deformity (threatening or established), daily living activities, and assessment of equipment (Chapters 9, 10, 12, and 13).
- Additional assessments by other professions are needed. They are concerned with communication, perception, cognition, social behaviour, and health problems.
- The way in which you approach a child in assessment affects the information obtained.

Note. See Appendix 1 for the detailed clinical physical ability guide and illustrations of the clinical developmental levels.

9

Treatment procedures and management

Motor training

Motor training in this chapter includes 'hands-on' treatment procedures, called *physiotherapy suggestions*, and therapeutic activities by anyone daily involved with a person with cerebral palsy, called *management* or *treatment and management*. The therapist needs to select and supervise methods according to what is relevant to an individual's situation and abilities.

Aims and methods are for the following interrelated aspects.

1. The motor functions needed for the individual's chosen daily task. There are methods for specific delays in motor function and are stated in this chapter as *delays*. These are the functions that a person cannot do. However, there are functions that an individual can do. In this case some items given in *delays* are not observed in these individuals. Generally individuals achieve motor function at earlier developmental stages than their chronological age. This depends on their level of severity, opportunities, and experience.
2. The components (specific abilities/prerequisites) of the motor functions needed for the individual's chosen task. They are in their own earlier developmental levels. The absence of these components accounts for particular motor compensations. Examples are given under the headings 'Atypical performance'. Atypical performance reflects the solution of the damaged motor systems to achieve motor control. This compensation can be inefficient. Training enables more efficient and more functional patterns.
3. The impairments result in *atypical performance* at each developmental stage. There may be weakness, stiffness, limited joint ranges, hypotonia, involuntary motions, atypical movement synergies, and a limited repertoire of movements. A person can avoid using an impaired body part altogether.
4. Associated factors in motor function. Although this chapter concentrates on the motor difficulties, they are not isolated from other influences. The methods of motor training are interwoven with visual, hearing, tactile, proprioceptive, and perceptual–motor experiences. Severe visual impairment

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is particularly significant in influencing motor as well as all functions. Understanding (cognition) is needed for some functions such as walking or crawling safely and for following instructions for some techniques.

The direct training of developmental motor *functions can simultaneously minimise the constraints by impairments*. It is the *appropriate* selection of methods for direct training of active or active assisted motor function that can increase strength, improve joint ranges, decrease stiffness of hypertonus, modify hypotonus, and overcome residual infantile responses and some involuntary movements. As motor training increases a child's repertoire of movements and postures, there is less need to use atypical performances.

Therefore, emphasis on motor function with simultaneous improvement of motor patterns in this chapter does not separate treatments of impairments from training of function. They can be integrated in many individuals. However, this does not imply the cure of the cerebral palsy condition but rather an improvement of function as much as is possible for each individual. Functions are linked with participation in daily life and are essential to therapy programmes.

Chapter 12 on deformities suggests treatments of specific impairments that are not adequately modified by functional methods. This is particularly required for severe conditions when active function is very poor or absent. There are also treatments of secondary impairments that appear as children grow older.

Motor training in daily life activities

Although this chapter concentrates on motor and locomotion development for daily life, there are also motor functions within other daily activities such as feeding, dressing, washing, toileting, playing, and communication. They are explicitly discussed in Chapter 10 and with equipment in Chapter 13.

Learning motor function only in these whole daily life activities and contexts can be too complex for some individuals. Their motor function needs to receive specific concentration on the deficient motor apparatus. Specialised techniques initiate dormant motor control.

Similarly, perceptual problems, speech and language difficulties, specific hearing difficulties, and severe visual impairment need to have structured separate sessions of specialised treatment and teaching. However, as Neistadt (1994) points out, the specialised training of perceptual problems does not transfer to other contexts. Like motor training, they apparently need to be trained in different contexts as well.

Thus, therapy and management have the following main related procedures:

1. Methods that integrate motor function with communication, vision, hearing, sensation, perception, and understanding in the contexts of whole daily life activities.
2. Methods for motor functions that are relevant to an individual's home, school, and community. Parents, carers, and teachers are offered motor activities appropriate for classroom, playground, and physical education and sports. Generally an increase of activity is associated with more participation in daily life and a better health-related quality of life.

Developmental levels and techniques

The therapist will use the developmental channel most appropriate to the posture in which children might manage to carry out their chosen daily activity. This might be standing for transfers, sitting for eating and socialising, or lying for bed mobility and getting out of bed. The therapist's

assessment of the developmental stages of children's postural control and movements reveals their independence or their need for appropriate support.

The following are important points for developmental motor training.

1. Different positions for the chosen activity may be used by a parent or carer to assist their own management of an individual. This posture may not necessarily be developmentally challenging for a child or older person. For example, lying may be used for dressing a child, when this child is capable of supported or even unsupported sitting. A child may be able to help with dressing in a different posture. Lying may be used 'to save time' or as a habit from the period when a child was less able. A mother's intuitive handling of her typical baby includes accurate timing of when to give less support and when to expect more advanced skills. A child with very different motor behaviour demands more enabling of mother and father in handling methods. Furthermore, there needs to be recognition that learning to change any existing habits is not always easy. Parents need practice and encouragement. At appropriate times, a therapist explains, demonstrates, guides, and negotiates the value of another posture using methods based on an assessment of their child. At the same time, a therapist gives sensitive consideration for comfort and support of a parent or carer (Chapter 2).
2. Therapy plans become involved with *simultaneous* use of each developmental channel of prone, supine, sitting, standing, and walking as well as hand function. There is also crossing of channels when a child goes in and out of various postures. It is *most unwise* to first train stages in lying before stages in sitting and standing.
3. We cannot assume that obtaining a functional component *in one channel will transfer* to another channel, as muscle work, joint positions, and gravity are not the same. Each component needs practice within each channel. Postural mechanisms such as stabilisation on forearms or hands can later be used in sitting, standing, and when using walkers.
4. Managing gravity can be used to activate and strengthen particular muscle groups. For example, using side lying makes arm reach or leg movement easier along a surface. A child in supine can use gravity to allow abduction and external rotation from bent hips and knees during changing of nappies or dressing. An example against gravity in bed mobility is when a child uses rolling and rising onto arm(s).
5. Atypical postures are modified or changed by activating specific motor patterns. Any preference shown by an individual for particular motor patterns of, say, flexion will need methods to emphasise motor functions with extension in each developmental channel and vice versa. Such emphasis attempts alternatives to the individual's persisting motor patterns in cerebral palsy. In different developmental channels different muscles are strengthened. There is, therefore, prevention and minimising of deformities together with learning of a variety of movements.

General plan of the developmental programme

Initially therapy plans start with the developmental sequences in prone, supine, sitting, standing, and hand function as guidelines. Typical developmental components of functions and whole functions are developed in these sequences. As a therapist gets to know each child, modifications

may or may *not* be needed. With experience of a child's needs, together with careful observation of each individual, modifications become obvious. The developmental sequences are therefore flexible and not a dogmatic scheme.

Using the assessment findings of what individual children can and cannot do, plan a programme to:

- Establish motor functions already achieved, so giving individuals confidence that there is something they can do. Build on these motor functions in the next developmental levels.
- Attempt motor functions at the next developmental levels not just the current level of the child. This is to check any flickers of response to assess readiness of a child to try a more advanced motor item(s). Parents are encouraged to report when their child seems ready for a more advanced developmental motor function. These are also called 'transition stages' and are thought to be the times when intervention is *most effective* (Bodkin et al. 2003).
- Consider any developmental omissions/gaps as possible contributions to compensations, resulting in atypical performance. Omissions are not always important owing to individual variations.

Age of child and techniques

Select techniques according to a child's next developmental levels and *not* according to chronological age. Use a similar approach when treating deformity. For example, asymmetry or persistence of prone flexion is typical for a child developmentally delayed to levels 0–3 months. Select methods for the next 3–6 months. Commence *self-care training* at a child's developmental level of feeding, dressing, and washing for babies and for severely and profoundly affected older individuals (Gross Motor Function Classification System (GMFCS) levels IV and V). Use whatever sensations, understanding, or motor abilities that an individual may have, no matter how minimal. Communication with babies, children, and older persons with learning disabilities is given according to suggestions by relevant professionals and parents.

It is unfortunate that some workers still think physiotherapy should be cut down in older children so more time is given to education. In some individuals, motor abilities may only mature much later and unless stimulated will remain dormant. The therapist at or visiting the child's school can work out ideas with teachers and classroom assistants to include motor functions in school or playground. Extra effort also needs to be made by a therapist to maintain contact with a child in mainstream school and with an adolescent's parents.

Onset and techniques

Response to therapy sometimes seems much quicker if the onset is sudden on a previously normal nervous system. However, ultimately spontaneous recovery and motor development in acquired brain lesions may be as unpredictable. Children with either congenital or acquired lesions warrant appropriate therapeutic procedures given in this book so that the potential is given every chance to reveal itself. There are more behavioural problems in many children following a traumatic brain injury, which may interfere with therapy. Psychologists need to be consulted for advice concerning these problems. Expectations of better results in children who have 'already known typical movements' may be more of a frustration than a help. It is not so much the memory and past experience that matters but the amount of damage *and* the capacity of any particular damaged system to compensate for the difficulties.

Diagnosis and techniques

The techniques are not primarily devised for particular diagnostic types but for motor problems of developmental *delay* and *atypical performance*. Different diagnostic types of cerebral palsy may have similar functional levels and some similar patterns of atypical motor compensation described in this chapter. Other diagnostic conditions causing only motor delay may exhibit atypical performance also seen in cerebral palsy, such as rounded backs, hyperextended knees, or pronated feet. This is especially so if atypical performance is a compensation for delayed balance (postural mechanisms).

Application of techniques

These should be carried out by qualified paediatric physiotherapists and occupational therapists and shared with anyone caring for a person or, whenever possible, directly with individuals who are able to respond. Selection of methods depends on an individual's abilities, time, and changing family situations.

The repertoire of techniques in this book cannot possibly include all those available. First, not *all* individual difficulties and different situations could be included together with possible techniques. Second, describing some techniques without demonstration is not easy. Only those techniques which could be described have been included. Third, those techniques which have been frequently used have been selected. There are many more and experienced therapists also have their own methods. Techniques in this book are thus *suggestions* not *recipes*.

Lack of response to any technique given in this book indicates the need to try others in this book, in other publications, or preferably from clinical colleagues. Check that, if the person scarcely responds to any technique, it is not due to:

1. inaccurate assessment of the child's level of development
2. inadequate knowledge of the child's non-motor areas of function, such as vision, understanding, perception, and emotions that interfere with motor function
3. lack of skill of the therapist with the particular technique
4. a need to modify or change the goals of therapy

The section 'Helping a child to learn motor control' in Chapter 2 is relevant to getting a response.

Development of the child with severe visual impairment

Severe visual impairment has a significant impact on motor function, self-care, and participation in daily life. Motor delay will occur because of visual impairment in otherwise typical children. When cerebral palsy is also present, the delay will be increased. Intellectual disability may be present or only appear to be present as the child is limited by the multiple disabilities. The therapist should learn what influence the visual problems have on gross and fine motor development as they not only cause delay but also create unusual patterns and sequences. Unusual movements, stereotypical behaviour, or inappropriately called *blindisms* include hand flapping, waving, or flicking fingers near the face or near light sources, gazing at the light coming through windows or electric light, eye poking, rocking, and other bizarre patterns. Children who show such patterns need to be carefully observed to find what purpose or reward these behaviours have for them. Understanding the children helps parents and families as well as other professionals. Psychologists, paediatricians, or specialist teachers have to be consulted as these mannerisms and others can be prevented or

minimised if understood. Personal contact with individuals with severe visual impairment, showing them emotional warmth and encouragement to join in activity with familiar people, soon brings positive results. The Royal National Institute of Blind People (UK) and other voluntary societies have specialists and leaflets explaining how to manage these mannerisms so that individuals do not withdraw completely into their own world.

The methods for motor developmental training in this book can be adapted for children with severe visual impairment provided that the following factors are kept in mind.

Remember to call the child by name and say who you are before you begin intervention.

Hypotonia, motor development, and the postural mechanisms

As discussed throughout the book the postural mechanisms are undeveloped in children who are hypotonic. Postural mechanisms are given for each position in this chapter. Blind, severely visually impaired, as well as sighted babies with lack of movement are often hypotonic (Jan et al. 1977). Assessment and development of the postural mechanisms in the visually impaired baby and young child have been studied by Levitt (1984) and found to be delayed. As vision is an important factor in detecting the vertical in the child's world and in appreciating any tilt of this world, it is not surprising that the baby's postural control is absent or poor. Babies with severe visual impairment prefer to lie safely on the ground and avoid the challenges of gravity. The development of the postural mechanisms is the story of motor development against gravity and changes in gravity. Severe visual impairment, with or without cerebral palsy, will need careful assessment and training of postural mechanisms using auditory, tactile, and increased proprioceptive and vestibular stimuli.

Postures such as rounded backs in sitting and standing, hyperextended knees, and flat feet are common in young children (Fig. 9.1). The specific delays in postural stability, postural adjustment, forward tilt, and posterior saving reactions are often observed to accompany the presence of round backs and shoulders (Levitt 1984).

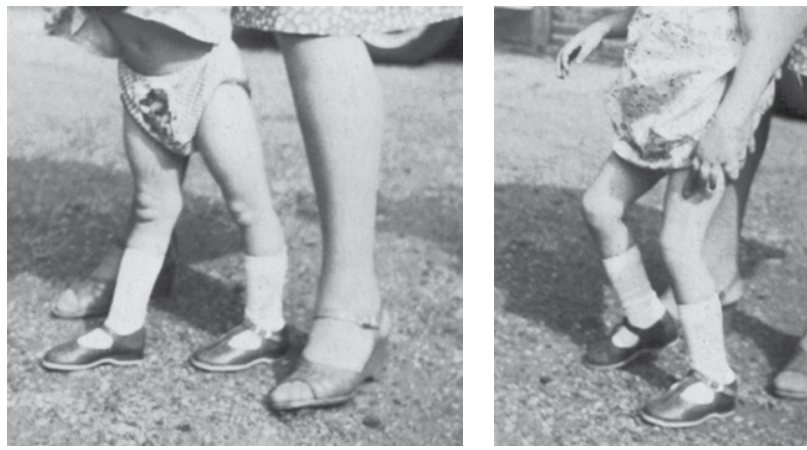


Figure 9.1. Hyperextended knees (a) being corrected (b) by training pelvic control (postural stability and counterpoising).

Vision stimulates and monitors the postural mechanisms. It is the exciting object or person that typical babies catch sight of that stimulates them to look up. This then develops head raising and postural stability of the head. It is also the effort to understand the visual stimuli that further activates exploratory movements and increasing postural control. Methods using a variety of sensory stimuli help to develop motor functions that cannot be isolated from a child's total development (Sykanda and Levitt 1982; Levitt 1984: chapter 14; Sonksen et al. 1984).

Specific visual problems

Dutton and Bax (2010) have published a book on impairment of vision in children with brain damage. Dutton (2015) and Dutton et al. (2014) discuss visual problems needing spectacles as well as visual impairment due to brain damage with many practical approaches. For example, hemianopia (lack of vision on one side) needs individuals to be trained to look to their visual side to check visual information, motion in new environments, and to learn to cross roads. Teaching eating and drinking needs turning dishes more to the visual side as well as placing cups on the visual side. A child needs an appropriate seat position in the classroom.

Lack of vision down below needs training to look down to be sure of the ground ahead and to touch the ground with a foot to recognise its height. Plain tablecloths, carpets, and blankets are needed when children have difficulty finding objects on patterned backgrounds.

Total child development and motor training

Mother–child relationships. The shock and stress felt by the mother who does not even receive the *primal gaze* from her blind baby (Goldschmied 1975), as well as the unusual reactions to her feeding and cooing, must be appreciated by any therapist attempting to help. All motor developmental training needs to be designed to build up mother's and father's confidence in parenting their child. Many playful gross motor activities help enormously in creating bonds with the child. Enjoyment demonstrates to the baby love and security, which is needed so much. The techniques in this book should all be adapted to take place on a parent's lap, close to their bodies and faces, so that their kisses, touch, stroking, talking, and singing to the baby assist bonding, development, and body image.

Clinging to the mother in an unknown or puzzling world should be accepted for children with these visual difficulties. The weaning of a child with visual disability to a therapist needs to be carefully done after parent–child bonding and confidence is established. Introducing more than one therapist or developmental worker may be disconcerting to the child and even the parents. Other disciplines advise that one therapist rather than each of them handle a young child with suggestions from the team. These children are particularly sensitive to touch and voice and need to be handled by only a few familiar people until confidence is established. Family participation in the motor programme is planned when a child welcomes handling by them. If mother is under stress, it is important not to overload her with exercises, but rather use movements and postures within the daily living activities. Social workers and other counsellors work closely with therapists to support the family.

Motor function and the child's daily life (Chapter 10) is usually the priority in the developmental motor training programme for a child with visual disability, not only from the parent's viewpoint but also from the child's viewpoint. The purpose of motor function needs to be emphasised when conveyed to each baby and child (Fig. 9.2).

Figure 9.2. Movements for dressing.

If not, they could be trained in motor patterns but never use them. They cannot *see* their purpose!

The assessments of the child's developmental stages in feeding and other self-care, play, or sensorimotor understanding and in exploration of the world is obtained in order to introduce the appropriate motor patterns. There are special stages and sequences for severe visual impairment available from developmental psychologists and developmental paediatricians (Sonksen 2016).

Use of compensatory stimuli for motor development. As vision is not available, it seems obvious to use auditory and tactile stimuli to facilitate motor development. However, it is vision that normally teaches the baby what makes sounds, where they come from in direction and in distance, how humans communicate, and the association of sounds with situations such as mealtimes, bath times, and so on. Therefore, first train a baby what sounds mean before they can really be motivated to move. Also use existing movements to confirm what sounds mean.

Auditory development is followed as observed in the typical child (Sharma and Cockerill 2014) but with special adaptations for the visual impairment (Sonksen 2016). First, the baby is trained to listen, then to turn to sound, and after that to reach for sound. A very young child will first localise the source of sound near his or her ears horizontally and then above and below the head. Each child is helped kinaesthetically to search for the sound *kept stationary* nearby. Developmentally this will be at ear level, horizontally, above, below, and later behind a child. Children will *only* achieve reach for sound when their conceptual development includes *the permanence of objects* and their sounds. It is at about these stages that reach and move towards a sound will only be worth using to stimulate roll over, creeping, crawling, or bottom shuffling. Until the permanence of objects is conceptualised, help the child locate sound and move towards it with handling. Reaching for an object making the sound is easier if a child's hand moves along a surface on which the object is placed. Practise in one position and then offer the sound in another part of the surface.

Similarly the appreciation of tactile stimuli, localising and searching for them, has to be developed. Linking tactile stimuli with sound stimuli is carried out. Encouraging a child to create sound independently is also included as they bang a mobile, rattle, tambourine, or a surface with hands or feet. The therapy programme is devised together with specialised teachers, psychologists, or developmental paediatricians. Mother's voice and her touch rather than the therapist's will be more successful in the early stages. Vibration, smell, taste, and air currents can be introduced and associated with real objects and situations linking sound, touch, proprioception, and vestibular stimuli. All these aspects are part of the child's conceptual development (Sonksen et al. 1984).

Body image development. Poor body image is related to poor motor experiences and not seeing body parts as static or moving. Use of tactile stimuli on a baby's body helps to develop the body image. However, it is a baby's parent's hands as well as a baby's own hands that are best to do the touching first. Hands of the baby are notoriously slow to move and explore because of many reasons, not least of which is the absence of *hand regard*. Help the baby bring their hands together in midline, *pat-a-cake* hand to hand, touch hand to mouth, to face, hand to body, and hand to feet (Fig. 9.3a). Later use as many other stimuli to their body such as rubbing with towels, soap, creams, and powder at bath time. Use vibrating toys, bells, and playthings placed for them to find on their tummy or limbs and invent similar ideas. The sections on stages of hand function development in this chapter and in Chapter 10 offer ideas for the sighted child in this book. For the child without sight, these stimuli offered in play activities need to be emphasised and also *presented more slowly* and stage by stage. We do not bombard a baby with too many stimuli at once. Confusion or fear could be aroused if stimuli are not sensitively given. Thus, carefully introduce different surfaces for the child to roll on, creep, crawl, and walk on with bare feet.

Always give a child time to experience tactile and auditory stimuli and allow a child to reach and find out about toys and objects as independently as possible. Create opportunities for movement so that children can feel their own body movements and how they actively produced them. If children cannot or do not move alone, parents can move them and change positions for them. Children enjoy feeling their parent move about if slung close to the adult's body in a baby pack. Body image depends on proprioceptive and vestibular function.

Proprioceptive and vestibular function. These aspects are also part of total child development. They are compensatory stimuli for visual impairment and also develop body image. All the postural reactions are dependent on these stimuli in a developmental context discussed in this book. Touch, pressure, and resistance can

(a) (b)

Figure 9.3. (a) Body image development. (b) Baby exploring mother's face and hair.

be correctly given to stimulate movement, giving clues as to direction and degree of muscle action. Opportunities are also given for a child to lift, push, and pull objects of different weights, which also increases proprioception and strength.

However, as with all therapy methods, give a child time and observe whether the child understands and is not confused by what is expected of them. Do not use therapy techniques with handling, pressures, or other stimuli from behind them as they may well lean back or use their extensor thrusts to reach the stimuli or the familiar voice behind them!

Visual development. Not all blind babies are totally blind. Even reaction to light only can be used and perhaps developed to the child's full, if limited, capacities. An assessment of the developmental *use* of residual vision is given by the developmental paediatrician and specialist teacher and relates to vision available for exploration and learning (Sonksen 2016). This guides the therapist in the motor plans for the individual child. The therapist needs to learn how large an object can be seen by the child, how far away, whether it can be seen if stationary or moving, and which visual fields are present. The therapist also needs to know whether there is equality of vision in each eye and the acuity, as well as any other special visual defects which may affect a child's motor development and use of therapy methods. The development of a child's visual potential is easily integrated with the methods for head control, hand function, and all balance and locomotor activities discussed in this book. The appropriate level of visual ability needs to be related to a child's motor programme. There are times when one may have to accept unusual head position and other patterns that make it possible for a child to use residual vision. There may then be muscle tension or aches to be treated with exercises and massage.

Language development. It is important to talk and clearly label the body parts used and the motor activity if this does not distract a child's attention on body image and motor training. A child may also not yet be able to understand words. Delay is *normal* for a child who cannot yet understand the meaning of sounds, words, and conversation as the child cannot see what they mean, cannot see gestures, and cannot link the stimuli from the external world. Psychologists and teachers work closely with therapists to plan the language and speech programme. This enables therapists to give general encouragement of language development and be advised on communication systems for a child and by a child with severe visual impairment.

Hand function development. The development of hand function is obviously the most important area for the child whose hands are their eyes on the world. The section on 'Development of hand function' in this chapter should be adapted to use compensatory tactile, auditory, and proprioceptive stimuli before motor actions can be expected to follow the typical rate of development. Do not force objects into children's hands but train searching for the nearby rattle or shiny toy to orientate the hand to take it. Develop a variety of searching actions or finger moulding and feeling actions. Children also have their own strategy of reaching and exploring a parent's hair, face, or beard, which also includes the parent's pleasurable sounds and promotes parent–child bonding (Fig. 9.3b). Later a child has a strategy of reaching along a table beyond a desirable object and then sliding the hand around to find it. Bilateral hand function will take more work than with a sighted child. Encourage both hands together in midline, holding and especially exploring both sides of a cup, bowl, ball, or toy and transfer of toys. Train losing the toy and finding it. Offer toys which involve a child having to take them apart, and

constructing them again. Also, find objects and toys that activate crude and fine voluntary grasp and release. Offer playthings that depend on hand and fingers pressing a switch to activate a sound, music, vibration, or a fan blowing air. Supervision by an adult is needed. All these actions not only promote motor development but also integrate it with concepts of cause and effect, object permanence, and other intellectual development of children. Remember that index finger pointing and associated index/first finger grasp is very much a visual conceptual skill and will be delayed. Therefore, offer toys and food to promote finger actions as mentioned in the section of this chapter on hand function and in the sections on play, feeding, and other self-care activities in Chapter 10.

Gross motor development. Prone development is not popular with the baby with visual problems as there is no interest there, sounds cannot be heard as easily, and a child may be far removed from family and especially mother. There are no visual lures to provoke the child to look up and progress to creeping and crawling. It is often noted that crawling is not used by blind children and that they prefer shuffling on their bottoms and then walking. It is, however, possible to train prone development on mother's lap or on a soft cushion with attractive noises, especially those of mother's or father's voice with their gentle stroking of their child's back. The advantages for a child having activities in prone are increased head and back muscle extensor strength. When a child pushes up on hands, this adds strengthening of shoulder girdles for arm and hand function. Balance on hands and knees leads to additional exploratory skills of crawling through space, feeling the ground, and gaining additional body image experiences. The round backs and shoulders often seen in children with visual impairment benefit from stronger back extensors. Activate upright sitting by gentle hand pressure on a child's back and encourage reaching up and turning back in sitting and reaching for desired sound-making toys and especially to play with father's or mother's face and hair.

Crawling is not of course essential for the acquisition of walking, as bottom shufflers demonstrate. However, creeping, crawling, rolling, or any mobility across space helps spatial learning and especially that *the floor is continuous*. This enables a child to be less afraid and be more motivated later for walking. Walkers with wheels all around the child should be avoided as they will not develop their own postural and locomotive abilities. Children often sit or lean onto these walkers, stepping their legs but not learning to take weight through their legs, which is needed for learning to walk. Baby bouncers and rocking chairs are also undesirable if used for a long period when someone is not present. A child can withdraw into a rocking or bouncing world that engenders disinterest in the environment. Baby bouncers may stimulate atypical leg actions, excessive 'on toes' postures increasing spastic muscle shortening and dyskinetic patterns. Short supervised sessions in any equipment often produce more desirable results, especially if parent–child interaction is happening.

Blind babies without other disabilities develop stationary postural control slightly later or within the ranges of sighted developmental levels (Fraiberg 1977). However, there is more of a delay of moving into, out of, or forward from these postures. Thus, this book on developmental levels should be used as a guideline and not as rigid rules for developmental ages nor as strict sequences for severe visual disability. The postural mechanisms are developed using the methods given on motor training of developmental functions below, but delays and modifications will be required according to a child's particular vision and hearing development and emotional situation such as fears.

As fears are common, the techniques should be adapted to build confidence and provide fun and a sense of adventure. Large balls, rolls, and swings should only be used *after* confidence has been established in relation to the levels of development of the postural mechanisms present or just commencing in the individual child. Changing postures will require extra care as visual lures usually promote these changes. All other motor developmental training from 0 to 5 years presented in this book is learned by a child to decrease the frequent clumsiness associated with visual impairment. Use walking while pushing along a wheeled toy. The bump into furniture by the toy alerts a child and helps learning that obstacles exist and how to avoid them and avoid tripping or further bumping into furniture. Keep furniture always in the same place. Use of stairs may be coming down on the bottom or using the banister with both hands on coming up or down the steps sideways. Some children also slide their heel down to feel the height of the step. Coordination exercises, balance tasks, music and movement, dance, games and physical education, and movements in water are of great value for children with visual disabilities. The older child will also be receiving mobility training from those employed for this work by the Royal National Institute of Blind People (UK). Teachers for severe visual impairment will integrate their work on this and other aspects with therapists, as there is a need to create a whole programme for each child and family.

DEVELOPMENTAL TRAINING

Prone development

The following main features need to be developed at the individual's developmental stages.

- *Postural stability of the head* (Fig. 9.4a–d) when lying prone (0–3 months), on forearms (3–5 months), on hands (4–6 months), on hands and knees (6–9 months), in half-kneeling hand support (9–11 months), or on hands and feet (12 months). Head held in alignment with spine (4 months), with chin well in (5–6 months).
- *Postural stability of the trunk*. At first a baby in prone is often in flexion with hips off the surface and then tips over into side lying with weight bearing

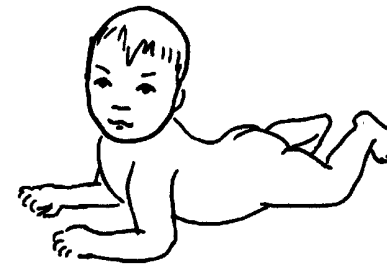


Figure 9.4. (a) Postural stability of head and shoulder girdle (on forearms).

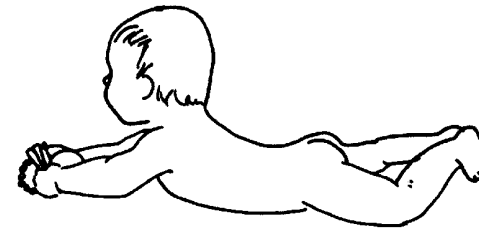


Figure 9.4. (b) Postural stability of head and shoulder girdle.

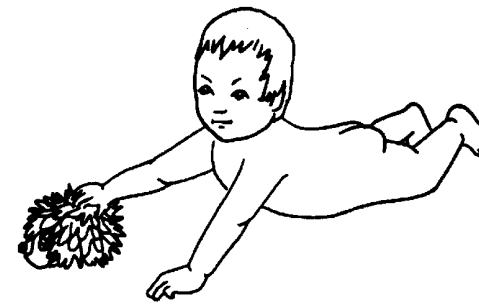


Figure 9.4. (c) Postural stability and postural adjustment (counterpoising) for arm reach.

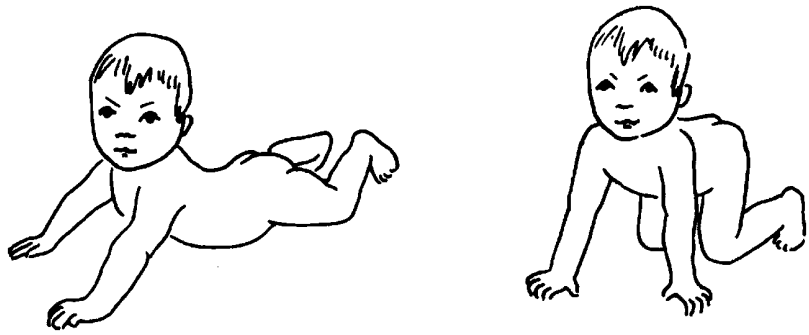


Figure 9.4. (d) Postural stability on hands and on hands and knees.

continuing forward on cheek or side of face and shoulders (0–3 months). Weight then shifts towards the legs. As head, shoulder, and trunk stability develops the child can control side lying and symmetrical prone lying (6–9 months). The back becomes straight and then slightly extended on forearms (3–5 months), becoming fully extended on hands (6–7 months). In 'pivot prone' (5–10 months) the extended trunk stabilises well and a child can pivot sideways. When a child is on forearms, they shift their weight backwards and forwards and to each side (3–5 months) and similarly when on hands (6–7 months). Weight shifts are later used if creeping along the floor. When on hands and knees, weight shifts continue with a straight back held against gravity and adjusting anteroposteriorly for rocking, then using this with lateral and diagonal shifts during crawling.

- *Postural stability of the shoulder girdle* (Fig. 9.4a–d). When taking weight on forearms (3–5 months), on hands with elbows semiflexed (4–6 months) and elbows straight (6–7 months), weight bearing on hands and knees (6–9 months), and in prone lying with arms held stretched forward along the ground to hold a toy (5–6 months) or later when holding an object in the air (6–7 months). There is 'pivot prone' (begins 5–6 months and established 8–10 months) with weight on the abdomen and pelvis with extended trunk and legs in the air as well as with arms held abducted–extended in the air to stabilise the shoulder girdle ('high guard' position). Shoulder girdle stability is promoted with trunk stability in extension. In other positions, stability develops further during half-kneeling or in upright kneeling, leaning on hands (9–12 months) and during grasping a support, within all prone developmental stages, especially around 9–12 months.
- *Postural stability of the pelvis* (Fig. 9.4d) on knees with hips at right angles (4 months), on elbows and knees (4–6 months), and on hands and knees (6–9 months). Stability of the pelvis and hips on the surface (6–9 months) enables on hands with straight elbows, stabilises in half-kneeling and upright kneeling with support (9–12 months) and without support (12–18 months).
- *Postural stability and postural adjustments for counterpoising limb movements are closely related.*
- *Counterpoising of the head* takes place in activities that include head partial raise and turn (0–3 months) and head movements while holding the head up against gravity (3–5 months). Free head movements are counterpoised in prone kneeling postures (6–12 months).
- *Counterpoising the arm movements* in prone, abdomen on the ground, creeping

actions (3–5 months), when weight bearing on one forearm while reaching with the other (5–7 months) or leaning on a hand reaching with the other (7 months) (Fig. 9.4c). Reach in all directions increases counterpoising abilities. All reaching is preceded by weight shifts in all positions in base and then away from moving arm, later towards a reach well out of base. Arms are counterpoised in crawling (9–11 months) and on hands and feet (12 months).

- *Counterpoising leg movements* takes place in prone lying during creeping actions (3–5 months), leg movement on knees with upper trunk and arms being supported (5–6 months), leg lift when on hands and knees (6–8 months). Weight shifts precede leg movement first within base laterally and in rocking forward and back, leading to counterpoising limbs for crawling. This is together with the counterpoising of arms in crawling (9–11 months) and in bear-walk (12 months). Stand with lean on hands on low table (modified bear-walk position), weight shift laterally develops to allow counterpoising of leg lifting and also prepares for cruising at low furniture. This overlaps into the development of cruising in standing at around the 9–12-month levels.
- *Rising from prone* (Fig. 9.5). Head (0–3 months), on to forearms (3 months), on to knees (4 months), on to forearms and knees (5–6 months), on to hands and knees (6–7 months), to half-kneeling hand support (9–12 months), prone to standing (12–18 months). Change to other postures from and to prone position, involving rolling, sitting, or squatting (6–10 months), and from 'bear-walk' posture to standing (9–12 months). There are hand supports and grasps that assist rising. Children assume many other positions with later motor development.
- *Tilt reactions in prone* (Fig. 9.6). Reactions seen on tilting the surface on which the child lies at about 6 months, on hands and knees at about 9–12 months, and in upright kneeling around 15–18 months.
- *Saving from falling reactions* (Fig. 9.7) in the arms at 5–7 months downward-and-forward 'parachute', followed by arm propping. Arm saving sideways and

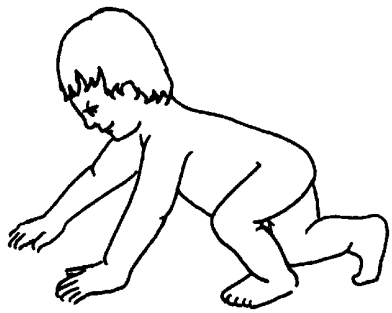


Figure 9.5. Rising from prone.

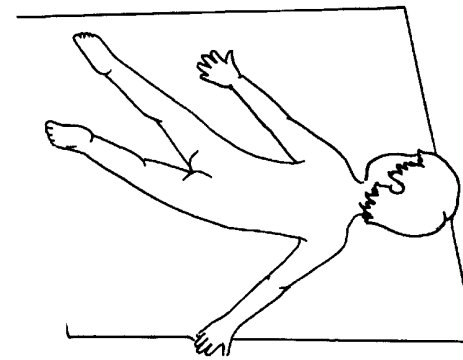


Figure 9.6. Tilt reaction in prone.

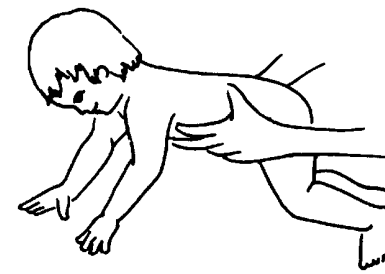


Figure 9.7. Saving reactions in the arms.

forward can also be seen when a child is on hands and knees, if the child is suddenly pushed sideways or if pushed forward from a heel-sitting position, or from supported upright kneeling. Leg reactions also occur on pushing the child over sideways, forward, or backward when they are on hands and knees. Arm and leg reactions accompany the tilt reaction, especially if the trunk reaction is particularly poor.

See the stages in prone development in Figs 9.8–9.22.

Figure 9.8. Flexion posture decreases. Head turn (*0–3 months*).

Figure 9.9. Head raise and hold (*0–3 months*).

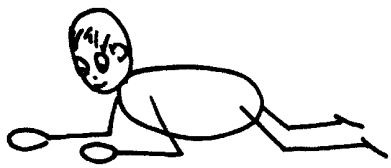


Figure 9.10. Head raise, weight on forearms (*0–3 months*).

Figure 9.11. On forearms and/or weight bearing on knees (*3–6 months*).

Figure 9.12. Stretch forward to reach; stretch legs. Lean on one forearm and reach with the other arm (*3–6 months*).

Figure 9.13. Roll from prone to supine (*3–6 months*).

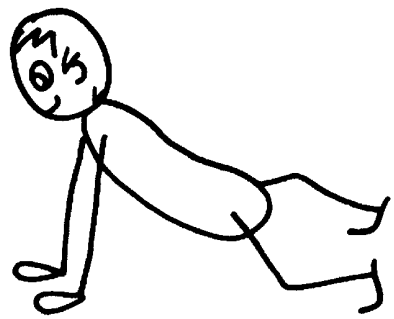


Figure 9.14. Weight bearing on hands (*6–9 months*).

Figure 9.15. Weight bearing on hands and knees (*6–9 months*).

Figure 9.16. Lean to one hand, reach with the other (*7 months*).

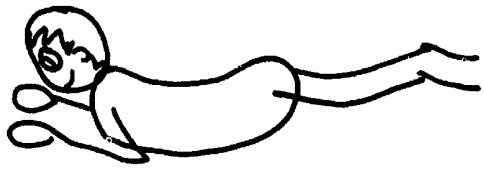


Figure 9.17. Extend head, shoulders, hips pivot in prone position (*8–10 months*).

Figure 9.18. Hands and knees, lift arm, leg, or both (*8 months*).

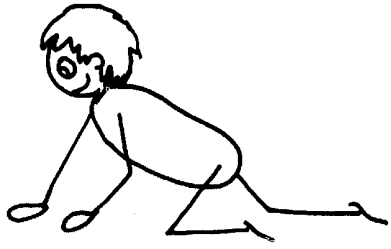


Figure 9.19. Crawling. Rise into crawl position (*9–11 months*).

Figure 9.20. Half-kneeling lean on hands (*11 months*).

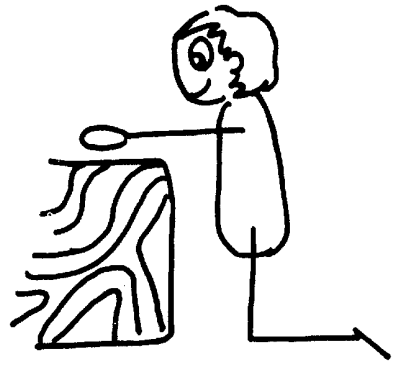


Figure 9.21. Kneeling supported (*11 months*).

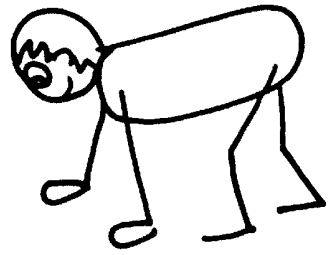


Figure 9.22. Bear-walk (elephant walk) on hands and feet (*12 months*).

Rolling and rising

As rolling development takes place from supine to prone, prone to supine, or a complete roll with side lying as an initial transition position, techniques are all outlined in section 'Supine development'.

In this section, strategies are presented for rising directly from prone onto arms, onto knees, onto hands and knees, and eventually into various sitting and standing postures in the prone developmental levels. The active and active-assisted sequences of rising strengthen muscles, stretch and increase ranges, and minimise the tightness of spastic hypertonic muscles.

0–3-month normal developmental level

Some common problems

Dislike of prone position. This may be due to early breathing difficulties, inability to turn the head and free the nose, inability to lift the head up, excessive flexion creating discomfort in prone, gastrostomy, severe visual impairment, or even lack of opportunity given to lie on the stomach. Later a dislike of prone may be due to a child's inability to use the hands in prone.

Delayed development of head control and on forearms posture. There may be no head raise or partial head lift and even no turn to free the nose and mouth. Head turn is initially associated with body turn and later head turns keeping the body still. Head control may be poor when on forearms.

Atypical performance (Fig. 9.23). Many of the motor patterns of a typical baby of 1–3 months may persist as atypical performance in older children. This includes flexion posture or persistence of asymmetry in lying. There is atypical asymmetrical head raise, rising on only one forearm, or asymmetrical stabilisation on elbows. There may be more flexion–adduction in one leg than the other as the hips lift off the surface into flexion. Only one leg may flex and abduct into a forward creeping pattern with hips flexed or flat on the surface. Children with bilateral or unilateral impairment can begin to creep by flexing the unaffected leg while the affected leg is less active in extension and internal rotation. This is seen especially when the child raises the head and turns to the less affected or unaffected side. Creeping pattern is limited without head control and use of arms.

There may be excessive flexion and adduction of both or either of the arms, with shoulder retraction and pelvis and

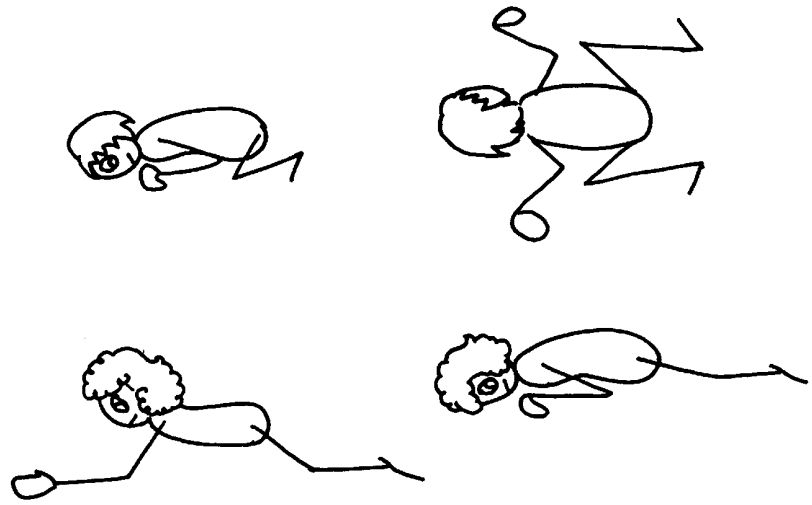


Figure 9.23. Some atypical postures in prone.

hips in posterior flexion rather than lying flat. There may be flexion of the trunk or legs, or all of them. The head may be overextended with chin poking in prone lying and when raised. Extensor thrusts may persist. The child's weight is taken onto their face, chest, knees, and sometimes on feet when flexion is less. On head turning weight may not shift to the opposite side and body weight does not shift towards the legs due to lack of head raise and flattening of the pelvis. Weight shifts are needed for creeping along a surface.

In hypotonia, particularly in very young children, there is flexion–abduction of arms and legs with flattened pelvis into the *frog position*. In hypertonia, independent head raising in individual children may be associated with overflexion of stiff arms and stiffness of legs in extension–adduction–internal rotation. This persists into the next level when abduction and external rotation is normally expected.

Treatment suggestions and management

Acceptance of prone position. Accustom children to prone by placing them slowly on their abdomens and on soft surfaces, such as sponge rubber, an inflatable mattress, over a large soft beach ball, or over your lap (adding a cushion if your knees are bony!). Check that a child's nose is over the edge. Rock and sway children to a song.

Gently roll a child from side lying towards prone either on the soft surface or suspended in a blanket. Roll a child back and forth slowly, keeping the nose free and observing whether there is acceptance of going towards prone. Try using the incentives for head raise and turn, given below, to make prone lying more acceptable.

In older children and adolescents. Prone is more acceptable in prone standers (*prone standing frames*) in which the angle of the forward incline can be adjusted according to the person's ability to initiate head raise and hold or turn the head. The rest of the body is well supported by the frame so that the individual can concentrate on active head control at this developmental stage.

Note. Some children continue to strongly refuse to go prone and should not be made to do so. They may be like those typical children who are *rollers* or *bottom shufflers* and a few others who do not use prone development in their motor development (Robson 1970). Cultural influences may also affect the use of prone.

Head control. Train the following aspects of head control:

- raising the head (righting)
- holding the head steady (postural stability)
- turning the head from side to side (postural adjustment for this movement).

Suggestions are as follows.

1. Place the child in prone with their arms elevated across a sponge rubber roll, a large therapy ball, a pile of pillows, or across your lap. Hold both a child's shoulders back and inwards towards the spine for stability with symmetry in enabling active head raise and hold. Rock a child forward and backwards over the edge of the roll/ball or your lap to activate raising the head. Vary the speed to a song. Achievement and maintaining head stability can motivate children to, say, look at a familiar face, bubbles in the air, or a mobile. For all individuals television, social contact, and your own ideas make this activity worth doing by the person. In prone lying on a table/couch or small wedge, a child may be assisted or encouraged to reach out, elevating both arms to someone's face or object of interest. Sit on a seat so that you are at the child's eye level. When using both arms symmetrically, the child keeps their head and body in the midline. It is easier if they reach downwards to a toy, with the help of gravity, or horizontally

along a ball's smooth surface. If a child can reach horizontally towards an object of interest, the head often raises as well. Stiff arms may first have to be grasped near the shoulder joints and turned outwards as they are extended forwards over the edge of your lap, along the couch or above the wedge.

The child's legs may be bent or stiffly extended, turned in and held together, before or only during head raise or turn. In such cases, turn upper legs out, keeping them apart *while* a child is initiating head control (Fig. 9.24). This helps learning postural control without excessive leg tension.

A table with a smooth surface placed against a stationary ball or roll also enables arm reach forward, enhancing head raise. Instead of your stretching the arms, active reach by a child may be possible with some assistance. Later encourage a child to push a heavy object down an inclined surface followed by a push along a horizontal surface. These activities stretch out bent arms and strengthen them together with the shoulder girdles, which enables other activities that you can offer the child.

2. If a child has preferred head turning to one side, then extend the shoulder girdle on the opposite side to activate head raise and turn to the other side (Fig. 9.25). Draw a child's attention to a familiar person or objects of interest on the opposite side. Head raise and turn are components for later rolling.
3. When training head control, continue to present mobiles, Christmas decorations, mirrors, moving toys on springs, or sounds from musical boxes or toys. Place objects below, in line, and above the child. First use visual and auditory stimuli in the centre and progress to having them at each side of the child and move them slowly from centre to the side and from side to side. This helps to develop visual and auditory attention and tracking together with training of head control. Later eye movements are learned without head movement.
4. Place wedges on a table or platform so that a child can see someone's face when looking up. A friendly person obtains eye-to-eye contact by sitting in the centre and opposite the child, and sings or speaks and then encourages eye movements from side to side to follow his or her face. Rhythmically tapping under the chin or at the forehead of a child gives momentum for head lifting, provided a child accepts having their face touched.
5. Keep the wedge on the floor or in a sandpit or in front of a trough of water where other children are playing so that social interaction can be facilitated. Adjust the angle of the incline on a wedge to enable better head control or use of the child's hands and arms.
6. Place a child in prone on an inflatable mattress, water bed, or trampoline and gently use a bounce to stimulate and enjoy active head control. Tip the child from side to side to activate head turn. These are some of the early components for learning to roll towards supine.
7. Swing a baby in prone over an adult's arms or a larger child on a horizontal tyre suspended from a tree. Help a child to go down a slide while lying prone on

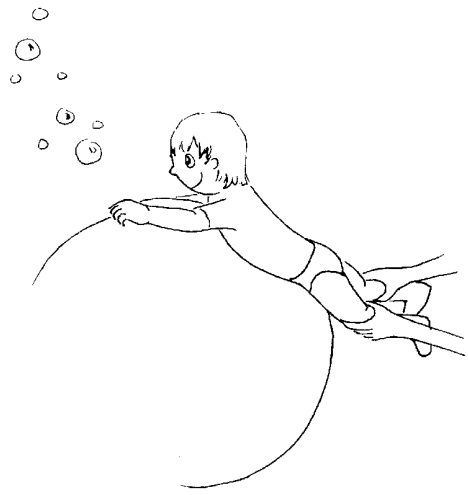


Figure 9.24. Activating head raising.

(a) (b)

Figure 9.25. (a, b) Activating head turning away from the preferred side.

a cushion with the head held up. Place a child on a wedge on wheels or on a trolley with a roll of towels between their body and upper arms.

8. Weight bearing on forearms will also activate a child's head control (Figs 9.26 and 9.27). Give adequate support with a small roll of towels between the child's chest and upper arms to prevent shoulder hunching or pulling their arms down against their body. Check that a child's forearms are well away from the body, with elbows at right angles and beneath the shoulders, and, if possible, hands open for stability. Encourage keeping the head and trunk centre, legs apart, straight, and, if possible, turned out from the hips.
9. Motivate a child to raise the head and look down with chin held in, at a book or a toy in order to avoid hyperextension of the head (Fig. 9.28). Help with gentle manual pressure down on a rounded back and on the pelvis for symmetrical weight bearing when a child is on forearms. A small roll under the chest and between the shoulders overcomes hyperextension of head and body and helps to bring forearms forward to counter retracted shoulders. Reverse a child's

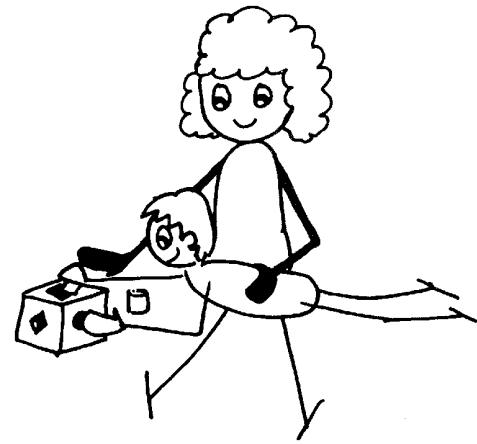


Figure 9.26. Weight bearing on forearms activating head control.

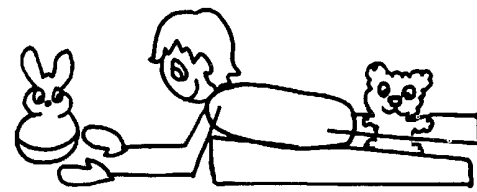


Figure 9.27. Head control and weight bearing on forearms (on elbows). Prone, on forearms over a low wedge, roll cushions. Keep legs apart and turned out in those children whose legs press together and/or twist inwards. Use a pommel, toy, small wedge, or cushion for the legs.

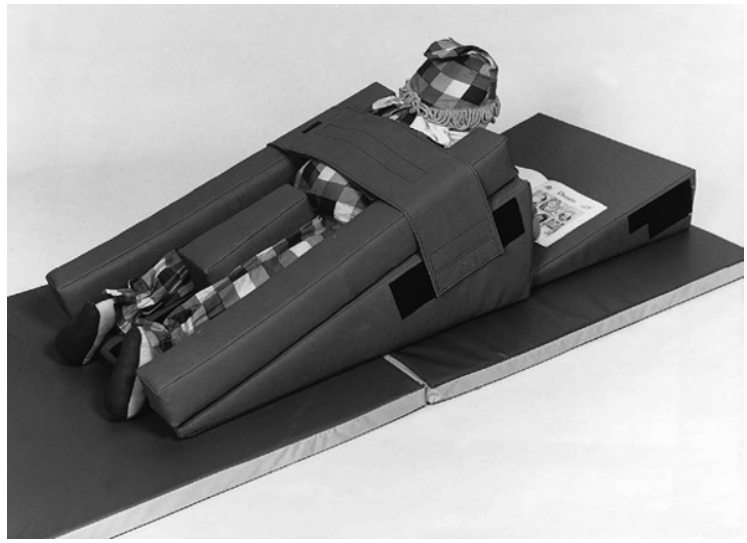


Figure 9.28. Wedge with lateral supports and an adjustable strap to prevent twisting of the trunk, sliding, or rolling off the wedge. Abduction block to separate adducted legs. (Courtesy of Jenx, Sheffield, UK.)

Figure 9.29. (a) Child needing head, shoulder, and trunk control.

Figure 9.29. (b) Use a wedge for weight bearing on knees. Straps may be needed to hold the child on the wedge. Also note the child attempting head raise and a forearm support with pelvis support.

position on the wedge so that they kneel over the edge with their body fully supported in order to decrease lordosis and elongate a rounded back or lateral spinal curve (Fig. 9.29). Lying across your lap with the child's legs over the edge, feet flat on the ground, also corrects spinal postures during head control and hands playing on a low table.

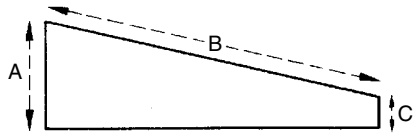


Figure 9.29. (c) Measurements for a wedge for prone lying, arms over edge 'A'. 'A' represents the measurement from the axilla to the wrist, 'B' represents the measurement from the axilla to 50 mm (2 inches) above the ankle, and 'C' represents the length to the top of the foot.

Equal weight on forearms. Weight bearing is often better on one side.

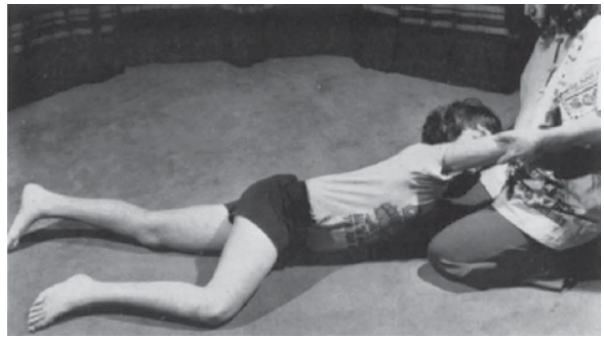
1. When the child is in prone lying over a roll, pillows, or wedge, assist the head carefully to be aligned with the spine. Train a *long neck with chin held in*. Use joint compression through upper arms or by pressure at the top of the shoulders for more muscle action (as shown in sitting; see Fig. 9.97).
2. Encourage weight bearing on the more unstable side by placing a toy near the other arm for visually directed reaching. Gently push and hold the child over the weaker weight-bearing forearm, during play. Press down on the shoulder with elbow directly beneath it. Use this motor pattern during feeding, other play activities, and functions in supported sitting and standing.
3. Hold a baby with the full weight through the forearms and gently shift the weight from side to side, or playfully lift a child up from side lying onto one forearm and then repeat onto the other side. Emphasise weight bearing more onto a unilateral (hemiplegic) side. An older child can do this if you hold their legs up in the air while they take weight onto their forearms. Shift weight from side to side, which may elicit stepping on forearms. Hold thighs to keep stiff legs apart, turned out with straight hips and knees.

Remember. Always try removing any supports given by your hands or equipment to check whether children can actively lift their heads or take weight on their forearms on their own momentarily or reliably.

Physiotherapy suggestions

1. *Atypical postures*. These are corrected within the treatment suggestions above. Physiotherapists select methods that parents or carers can manage and find relevant to their situation.
2. *Activate symmetrical head raising and holding upright*. Assist a child to move both arms into elevation, with abduction–external rotation behind the plane of a child's head. For a child who understands, use your manual resistance, asking for a push of the arms into elevation against your hands. Keep the child's elbows as straight as possible. This activates associated head raising. The child then tries to maintain arms in elevation against your manual resistance ('stay there', 'don't let me push your arms down'). Help them keep the chin in with long neck posture. The head holding is also activated by appropriate manual resistance carefully given between the ears at the lower occiput ('stay there').
3. *Facilitate head raise and turn* by lifting the child's elevated arm on one side back and behind the child's head as in the creeping pattern (Fig. 9.30a). An older child can have their arm on a cushion to actively practise holding the elevated arm stable and then practise active head turn.

Creeping patterns. It is difficult to describe these patterns without demonstration. Some aspects will be described as these techniques are particularly helpful to decrease flexion in prone, for muscle strengthening and lengthening, and for activating early creeping on the abdomen.



(a)

(b)

(c)

Figure 9.30. (a–c) Facilitating creeping patterns.

Babies or severely involved older children are most responsive and may use the automatic actions under their own control later.

The *face arm* is elevated into shoulder abduction–external rotation (Fig. 9.30b). The *occiput arm* is brought down into shoulder extension–adduction–internal rotation (Fig. 9.30c). The child may lie flat on the surface or over the edge of a roll, small pillow, or wedge.

1. Assisted active changing of the arms, so the opposite arm is elevated while the face arm moves down. These arm actions facilitate head raise and turn, back extension, and, when on a surface, leg creeping movements.
2. Use of stretch–rotation and appropriate manual resistance will activate the creeping movements of limbs with body–pelvic rotations.
3. The child may continue active creeping on their own and so acquire one form of locomotion beginning at this level of development.
4. Rising onto a forearm can be stimulated by having the elevated *face arm* held stationary by your hand. You stretch the *occiput arm*, giving manual resistance to the rebound creeping action response. If the child understands, ask them to pull their arm forward and above their head. An automatic rising reaction onto the forearm of the face arm occurs. As the child rises, they also raise and turn their head. Their sense of rising is an experience they can draw on later.
5. Using the action of the leg for creeping involves single leg flexion–abduction–external rotation, preferably with pelvic rotation backwards. The other leg is held

in extension–adduction–*external* rotation. Legs should be held at the thigh and knee using stretch–rotation and resistance according to the young child's reaction (see also Fig. 9.30a).

6. Active leg creeping may stimulate arm creeping actions. If the child understands, ask them to bend their hip and knee up and out against your hand on their thigh to have full pelvic rotation backwards. Offer them enough resistance to augment their movement so that an associated arm action to creep is gained.

   This creeping technique is useful for activation of more affected arms or the hemiplegic arm of babies or severely affected children. Movement and/or rising are initiated.

   There are many possibilities for automatic rising reactions and other stabilising and movement reactions with Vojta's creeping techniques in addition to the authors' own modifications. However, they are best demonstrated and supervision given by physiotherapists experienced in this approach.

Modified creeping over the mother's lap or down a slippery wedge/incline is enjoyed by children. Once automatic creeping is experienced by a child, they need to use it actively to reach an object or person.

Train active rising onto both forearms, or later hands, at the same time. Support a child's head by spanning their occiput between their ears. Ask them to raise their head up against your hands. This teaches them to initiate rising with head action.

Augment head holding and forearm support by asking a child to maintain head posture as you gently hold their head. Encourage the child to pull their chin inwards getting *a long neck*. Also give a manual nudge or push to the front, side, back of shoulders, as the child is told to 'stay there' or 'don't let me push you down' or simply 'hold it'.

Note. Use of resistance is particularly recommended for stabilising and strengthening the child with dyskinesia, ataxia, and hypotonia. In all types of cerebral palsies, manual resistance needs to be appropriately given so that there is no excessive overflow such as increase of involuntary movements or extensor or flexor spasms.

3–6-month normal developmental level

Common problems

Delay in acquisition of rising on knees or rising onto hands with extended trunk and flat pelvis. Weight bearing on knees, knees and forearms, and on one forearm; reaching for objects; inability to lie prone with both or one of the arms stretched out to reach overhead; unable to roll over to supine or unable to creep on abdomen, on elbows, or using a variety of creeping movements of both arms and legs.

Atypical performance. Asymmetric positions of limbs, clenching hands during the activities, beginning *mermaid crawl* (see 6–9 month level), asymmetric weight bearing.

Atypical rising patterns in prone such as atypical rolling patterns within rising. A child may use either excessive hyperextension of the head and trunk or flexing hips and knees under the abdomen on forearm support, then pushing up onto the hands or only rising onto the knees, leaving head, arms, hands, and trunk fixed in flexion. Some children cannot use the arms at all or a child manages to push up on semiflexed arms with hunched shoulders and then sits back on the heels with legs bent inwards (*W sitting*).

Although useful for a child who has struggled to achieve these rising patterns, more mature and less effortful patterns can be trained.

Treatment suggestions and management

Rolling from prone to supine. Begin with assisted and unassisted weight shift of body from side to side. Turn shoulder girdle then together with arm, or pelvis rotation, then together with leg to enable initiation of rolling from prone. Give children time for their own achievement of part or whole of rolling. Rolling down the incline of a wedge onto a mat may be helpful.

Rising onto knees, forearms, and knees. Encourage the child's rising onto knees instead of your lifting the child each time. Place one leg in creeping position and hold firmly or fix the foot against a heavy box, tip the child's *opposite* hip and pelvis up and back with a slight touch, and wait for active rise onto knees, first onto the one that is fixed. The other leg creeps forward onto its knee. Carry this out without giving the child a *tip-up* at their hip, *if they can manage alone* as shown in Fig. 9.31. Use the instruction 'Knee forward and get up!' Rising onto forearms and, later, hands is usually activated as well.

Weight bearing on knees, on forearms and knees (4–6 months), on hands and knees, on hands with abdomen on the ground, or on hands over a wedge (6–9 months) (Fig. 9.32). Place the child on knees, knees and forearms, hands and knees, or on hands with straight elbows with abdomen on the ground, according to what they can manage at their level of development.

1. If there is tightness of hips and knee flexors, use *on hands* support with back, hips (buttocks), and legs straight. Press both sides of the child's pelvis down and invite them to do this alone when they can.
2. Use your lap, wedges, rolls, pillows, suspension in a blanket, sponge rubber shapes, or big soft toys for support until the child can balance alone.

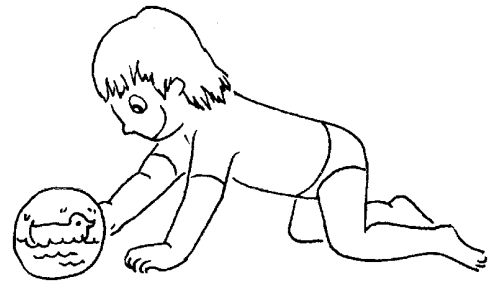


Figure 9.32. On hands and knees unsupported (*6–9 months*).

Figure 9.31. Rising onto knees and arms.

3. Use interesting toys, balls, sand, and water play in these positions.
4. Have hips at right angles when the child takes weight on their knees. Active use of the hands also increases greater weight bearing on knees for stability.
5. Press down on the child's lower back and buttocks to increase their weight bearing on their knees, and prevent sliding of the knees during play with their hands, or *shoot out into extension*, or sideways into *frog position*.
6. Use elbow splints to help weight bearing on hands with straight elbows so that shoulders develop stability during these weight-bearing activities.
7. Open the child's hands by pressing their weight through the heels of the hands; by gently bringing the thumbs out from their bases and not from their tips. Press palms flat with joint compression through the length of the arm. Keep elbows straight. Do this while a child watches television or suspended mobiles for interest so that they maintain the position for a period. Avoid distracting a child from their interest.

Unstable weight bearing through the arms. Use joint compression through the top of the shoulder or the upper arm with straight elbow to develop stability on hands in prone, in sitting, or in standing positions (Fig. 9.33a,b). A low table is used for training arm-propping support. Keep the arms in straight alignment with the line of pressure through shoulder or elbow. Have a child's weight through posterior 'heels' of the hands to avoid finger flexion. Arms are placed on a surface below the child, so the weight of their body adds to the joint compression; for example, a child may enjoy being held upside down for 'standing or *walking on hands*' with elbow splints, for similar effects. Use a variety of floor textures to increase tactile experience.

Motor control actions for daily activities. These can also be learned in four-point standing and in a prone stander with a table.

1. Weight bearing on one forearm, reach with the other. Weight bear and shift from forearm to forearm. Encourage reach with one arm on the floor, then above the head and in different positions to obtain objects.
2. With the child bearing weight on both forearms give them toys in each hand to grasp and play. Let them grasp the

Figure 9.33. (a) Unstable shoulder and pelvic girdles with excessive action of elbow and knee flexors to maintain balance (postural control).

Figure 9.33. (b) Training stability with weight shift of shoulder and pelvic girdles in four-point standing – a modification of the developmental sequence.

Figure 9.33. (c) Weight bearing on one arm while throwing a ball to hit skittles.

ends of a bicycle pump, concertina, plastic bottle, transparent cylinder with coloured water or marbles inside, grasp two balls or blocks to bang together, or push a ball from hand to hand. Toys should move or make a noise if touched, patted, pressed, or grasped. Remove any supporting wedge and hold the child on one of their forearms while they actively use the other arm in play. Whenever possible remove adult support altogether (see section 'Development of hand function').

3. Child in prone lying on forearms on a thick soft sponge, inflatable mattress, water bed, or trampoline, press the surface down on each side so that the child tips onto their elbow. Also help them shift weight back and forward. Use a song or rhythm to develop weight bearing and weight shift for the methods in point 4.
4. Place a child on a low platform or low wedge on wheels with the legs held in abduction with an abduction splint or a pommel. The child will move backwards or forwards by push or pull forearm actions. If they are on a bed and wish to get off, they could then move themselves backwards so that their legs come off the edge of the bed, their feet take the weight, and they can stand up leaning on elbows and progress to supporting themselves on their hands with their body against the bed (see Chapter 10 for uses of forearm support).

Note. Avoid creeping on forearms for a 'forearm drag' along the floor in those cases where there is a strong tendency to tightness of elbow flexors and shoulder

hunching, and motivate other forms of locomotion. Also practise a child's forearm weight bearing on one side while the other arm stretches out for toys. Try stretching both arms well forward to toys or to push a big ball away.

Arms stretched overhead and forwards: arm saving reactions; arm propping. This can be learned as follows.

1. Encourage a child to reach forward and overhead for toys or to push away a ball, a balloon, or a toy on wheels. Older children can walk their hands up a wall or wall bars as far as possible. Use a small bolster or wedge to help them stretch their arms out *and* up towards toys on a box or suspended above them. Arm elevation activates head hold and raise and hold.
2. Place a child over a beach ball or large roll with their arms over the top. Tip the ball forward and encourage them to reach for the ground in preparation for saving themselves from falling. Encourage them to prop themselves on their hands by first placing their hands on the ground and then gradually increasing their weight onto them, while you hold their body safely on the ball (Fig. 9.24). You can hold the body of a young child and tip them upside down near a surface, for example a table, and encourage them to put their arms out to save themselves and then to take weight on them. Provide different tactile surfaces for hand propping.
3. Place a child in prone on a large cushion with their arms stretched forward, and help them to go safely down a slide head first.
4. Place a child on a beach ball to develop weight bearing on one arm while throwing a ball to hit skittles (Fig. 9.33c).

Note. The therapist needs to check whether positions of arms and legs are as correct as possible during all the activities above so that a child learns them in the best possible posture. For example:

- shoulders and hips bent at right angles in weight-bearing positions
- knees pointed outwards without a *frog* position
- extended hips and knees as straight as possible, apart, and if able turned outwards
- shoulders and arms turned out rather than in excessive internal rotation
- hands open and palms down as much as possible if weight bearing.

It is important to recognise that *all the training* of weight bearing on elbows, one elbow, on hands may be done in *sitting* or *standing*, leaning forward or down onto a low table or box. This reinforces the prone development *or* if prone is occasionally not indicated for a particular child these activities can and need to be trained in these other positions (Fig. 9.33a,b).

Facilitate rising for assumption of a four-point position, which becomes more independent in the next developmental stage.

1. Fix one of the child's legs in creeping position manually (Fig. 9.34). Press down through the buttocks. Alternatively, hold the other leg above or below the knee and stretch it into extension–adduction–external rotation, which stimulates leg forward creep and rise onto the other knee. If the child understands, they should be instructed to *bend* a hip and knee. The child can then rise onto hands with or without chest support.
2. When a child is actively able to commence or even complete rising up onto knees and forearms, but is weak, manual resistance is used to reinforce their efforts. Apply manual resistance at the pelvis in a diagonal direction (Fig. 9.35)

for better muscle activation and avoidance of stimulating spastic hypertonus.

Augment holding of posture on hands and knees. This can be done as follows.

1. The child attempts to maintain this position against the therapist's slow or quick pushes. Later manual resistance to push the child out of position is used. Advise the child to 'stay there'. Push the child in the following ways:
   a. laterally at each hip or each shoulder
   b. forwards and backwards at hip or shoulders
   c. at opposite shoulder and hip
   d. at shoulder and hip on the same side.
2. Manual pressure *carefully* given to occiput with the child's chin held in. Manual resistance to the shoulders advising the child to 'stay there' assists stability. Similarly use resistance for hips when the child is only on knees with chest and arms supported by a roll or wedge.

Figure 9.34. Facilitating rising from creeping.

6–9-month normal developmental level

Common problems

Delay in weight bearing on hands and knees, in lifting one limb or alternate limbs, weight bearing on one hand and reaching for objects in all directions, crawling with only hands or only knees. Delay in extension into pivot prone position and begin

Figure 9.35. Rising onto knees against diagonal manual resistance.

pivot. Delay in rising from prone to hands and knees.

Atypical performance of motor abilities, overflexed hips, knees, or feet, internally rotated legs or arms, lack of reciprocation in crawling, *bunny hopping* both knees forward in heel sitting, and asymmetrical weight bearing. Persistence of *mermaid crawl* or *commando crawl*, which is motion by pulling forward on flexed arms with the legs stiffly extended, adducted, and internally rotated. The hands may clench with each *pull* forward and often the legs adduct strongly with this pull.

Lack of postural stability of the pelvis and hips creates creeping on the abdomen rather than on all fours and can mask a child's ability to take weight on hands with a flat stabilised pelvis.

Absence of reactions that are usually present: forward and lateral arm saving reactions and tilting reactions in prone. For persistence of any early reactions, see 0–3-month level.

Treatment suggestions and management

See Figs 9.32 and 9.33a.

Weight bearing on one hand, reach for a toy and on hands and knees lift one arm or leg or alternate limbs. Place the child on hands or on hands and knees over rolls or your arm and when possible expect independent stability and postural adjustment. Other suggestions are as follows.

1. Lift individual limbs as the child maintains balance to a song or counts.
2. While children take weight on their hands or hands and knees, encourage them to stroke different textures on the ground, such as carpets, tiles, grass, and sand. Let them feel cool, warm, scratchy, and smooth surfaces.

While balancing on hands and knees, they might scrub the floor, reach for a dangling toy, roll balls, move small toys on wheels, dig into the sandpit with one hand, or use a spade. On the grass they could pick flowers, handfuls of grass, and so on. They can stretch a leg to kick tinkling bells, or playfully touch a person's hands placed at different heights. These abilities augment postural adjustment with and without resistance (see Figs 9.37 and 9.38).

Crawling. This can be trained with the child suspended in a blanket. Hold each end of the blanket and tip the child in it so that their weight is taken more on one side, releasing the other side for a 'step' forward. Guide the moving knees or arms only according to a child's ability.

Note. It is important to avoid the use of crawlers and the training of crawling in children who prefer other means of locomotion and especially those who have tight hip and knee flexors. In these cases, use a wedge on wheels or a prone-trolley with a roll of towels under the child's chest so that shoulders stabilise on straight elbows with the hands crawling on the floor. The flexed legs are extended on the prone-trolley. Play 'walking-on-hands' or 'wheelbarrow' with an adult supporting the child's legs in a straight hip–knee position. Weight shift from hand to hand develops postural adjustment by trunk muscles. In cases of severe knee and elbow flexion, splintage of these joints should be used as the child gets about on their platform on wheels.

Rolling. Rolling may now be becoming more independent. Encourage rolling on grass down a slight incline, on sponge rubber, on an inflatable mattress, down a mound, and along different surfaces.

Flexion or lack of postural stability of head, shoulder girdle, and hips in extension positions may be treated with techniques on wedges (small and large) already mentioned and with pivot prone. Pivot prone is

initiated with a head raise extending body and legs held in extension and abduction. Physically guide children who are unable to do this.

- This can be carried out on a large ball or roll.
- Also elevate–abduct–externally rotate arms behind the plane of the head to stretch the spine and arms as children reach for toys or push balloons or balls away.
- Older children using pivot prone and the action of their arms can strengthen shoulder girdle-stabilising muscles and trunk by pulling against weights over pulleys opposite to them.
- Pivot to each side is finally taught for some mobility on the floor. Weight shift on the body and pelvis is developed and also overcomes atypical weight bearing on only one side. The extension in pivot prone strengthens back muscles but this is not enough for standing, owing to different gravity conditions.

Counterpoising exercises. The child maintains balance on hands and knees and carries out arm or leg patterns to achieve this postural adjustment. See Fig. 9.36 for a person with instability needing the counterpoising (postural adjustment) exercises.

Leg pattern. Ask the child to bend one knee up to the ceiling; manually resist the knee flexion forward and outward. Then reverse to hip and knee extension with adduction and external rotation (Figs 9.37 and 9.38). Resistance given to a leg pattern will also increase stabilisation at the shoulder girdle and opposite hip at the same time.

Arm pattern. Use a creeping pattern of the child's arm from extension–adduction–internal rotation behind their back, facilitated to elevation–abduction–external rotation as described at the earlier levels (Fig. 9.30). Other arm patterns are arm flexion adduction across the chest, change to abduction–extension–external rotation with trunk rotation backwards. As the child moves one arm against resistance, they increase weight bearing or stabilisation on the other three points. If they are on hands only, abdomen on the floor, shoulder stabilisation and counterpoising are stimulated as follows: they balance on the one hand as a single arm pattern of movement is carried

Figure 9.36. Instability of pelvic and shoulder girdles and poor (postural adjustment) counterpoising. Unstable crawling with reciprocal motion.

Figure 9.37. Counterpoising exercises.

Figure 9.38. Counterpoising exercises. Positions of therapist's hands. Child's leg flexion against hand on thigh or pull against hand on tibia. Leg extension against hand on tibia.

out actively or against correctly given resistance.

1. Continue pivoting in extension or other active limb and trunk extension activities to counter the persistence of any flexion patterns and help to minimise flexion deformities.
2. Continue rising onto hands *and* knees as above or roll-and-rise.
3. Child crawls against resistance given to the knees. Grasp the knees and guide them outwards as you resist each step forward (Fig. 9.39).
4. Augment holding the hands and knees posture against nudge or manual resistance. Concentrate on pelvic girdle stability for children who hop with both knees together in a 'bunny hopping' crawl. Suggestions to discourage bunny hopping are given below.

Therapy techniques of points 3 and 4 overlap into the next stage of development.

Figure 9.39. Crawling against manual resistance of therapist – guidance or resistance of knee into external rotation avoids adduction and offers a wider base for balance.

9–12-month normal developmental level

Common problems

Delay in rhythmic independent reciprocal crawling, maintaining a half-kneeling position with hands on ground, on hands and feet, and other more advanced postures. Delay of rising from hands and knees through half-kneeling to standing while holding a support. There is a delay in ability to change from prone to sitting, prone to squatting, prone to supported half-kneeling while grasping support or hands on floor. Changes of posture are poor.

Atypical performance. A child may crawl with atypically externally rotated knees. They may use excessive adduction–internal rotation of hips in crawling, in half-kneeling, and weight bearing on hands and feet. If the children can *bear-walk* on hands and feet, they have their heels off the ground and/or excessive flexion of the knees with hips internally rotated and adducted. When pulling themselves up to standing using arms and hands, they drag excessively extended and adduction legs with feet on toes.

If they are tipped either downwards, sideways, or backwards, then they may not save themselves in either one or all of these situations. Strengthening exercises for head and back extension normally use extension action at this level, but this may be very weak.

Treatment suggestions and management

Half-kneeling. Seat the child on the side of your lap when you sit on the ground. Bring their outside knee onto the floor, they are then kneeling on one knee, hold the other knee forward and outward. Remove your lap and place their hands on the floor for support. Encourage them to play in this position by moving a car or rolling a ball under the *bridge* of their knee, round their foot, or spend time in tying boot laces, counting toes, painting toe nails, and so on. Later, they should grasp horizontal bars at various levels and place their hands flat on the wall, low tables, or your flat hands. The half-kneeling position should be maintained with the front knee pointing outward. Hold the child's knee out with their foot pointing out and placed out to the side. This is often difficult. Ask them to press their front knee outwards against your hand and also maintain balance. Augment their balance by offering manual resistance to the hips at the side, shoulder

girdle at the side, and shoulder and hip girdles at the same time.

While on hands in half-kneeling and also in upright half-kneeling, grasp a support. Manual resistance to promote balance may also be used in this posture. In addition, head lift against resistance applied between their ears across the lower occiput helps to augment the stabilisation of head control.

Rising from prone to standing. At first, children normally pull themselves up by supporting themselves on their arms in kneeling upright and then up to standing by stretching their legs and going onto their toes. This pattern persists if a child uses spastic hypertonus to extend the legs. Train half-kneeling in a more mature transitional position on the way to standing up. The half-kneeling position is assumed with the child's hands on the ground (like a typical toddler) from hands and knees position or then grasping supports and pulling themselves up to standing via the half-kneeling position. Assumption of half-kneeling takes place using the exercises shown in Figs 9.37 and 9.40. The therapist is helping the child place their foot flat on the ground. Figure 9.41 shows how to hold the knee and foot steady as the child rises. Another method is to hold the child's body under the chest while they control their limbs in rising. You may also ask the child to rise against your hand, pressing their lower back and pelvis, or resisting the knee extension as shown in Fig. 9.41.

Note. The application of manual resistance must be done by physiotherapists as careful control of any overflow of undesirable activity depends on the appropriate degree of manual resistance.

See also other patterns of rising from prone in Fig. 9.165. Children have their own strategies, which are acceptable provided that they avoid recurring motor patterns associated with deformity.

Figure 9.40. Assumption of half-kneeling against the manual resistance or guidance of a therapist.

Figure 9.41. Assumption of standing against the manual resistance or guidance of a therapist.

Weight taken on hands and feet, and bear-walk. The child may place their hands on a low stool if they cannot easily reach the ground. Stabilisation together with gentle passive stretching of tight hamstrings is carried out in this position. In addition, the counterpoising exercises and activities of play, dressing, or other tasks can be done in this position using a low table and are illustrated in the development of standing at the 9–12-month developmental level (Fig. 9.33b).

Stepping with support on hands and counterpoising legs and plantigrade feet can be carried out using a stool on wheels, sliding a low chair, with a sledge, or with a stable wooden toy on wheels. Hold the

child's thighs and knees straight and turned outward if there is any excessive flexion–adduction–internal rotation on weight bearing. Give manual resistance for flexion–abduction to the stepping leg while holding the knee of the other leg straight, to stretch tight hamstrings or increase the action of the stabilisers of that hip. Wearing knee gaiters for the bear-walk or for slow upright stepping prevents the overuse of knee flexion, which compensates for pelvic instability. Keeping the knees straight, or as straight as possible, can activate the stabilisers of the pelvic girdle. Joint compression through hips or knees of the standing leg also helps active stabilisation, so knee flexors do not need to overact to maintain balance.

There are typical children who automatically bear-walk when there is rough or cold ground which is not pleasant for bare knees during crawling. There are also typical children who never bear-walk, but this is desirable in cerebral palsy for stabilisation of the shoulder girdle and pelvic girdle, stretching of tight hamstrings, stretching of tight heel cords (heels kept flat on the ground), as well as for counterpoising of each limb as a step is taken.

Hyperextended knees may also be treated in the bear-walk (see Fig. 9.156). Increasing stability of the hips may be associated with a decrease of hyperextension of the knees, which is another compensation for lack of postural stability of hips and pelvis.

Balance on hands and feet with one foot lifted onto a low wide box prepares a child for climbing stairs on hands and feet.

Tilt reactions and saving reactions in limbs on hands and knees may be stimulated on a rocker board, inflatable mattress, trampoline, or thick soft sponge rubber (Fig. 9.42). However, they are not as important in prone kneeling as in the upright postures, but do activate muscles in cases of weakness.

Changes of posture from prone kneeling (on hands and knees) to sitting and back again, to prone lying and back again, to half-kneeling and back again, and many other changes as in the righting reactions should be trained at this level of development. See the development of sitting at this level. These activities overlap into all the other channels. They have been initiated at earlier levels in prone.

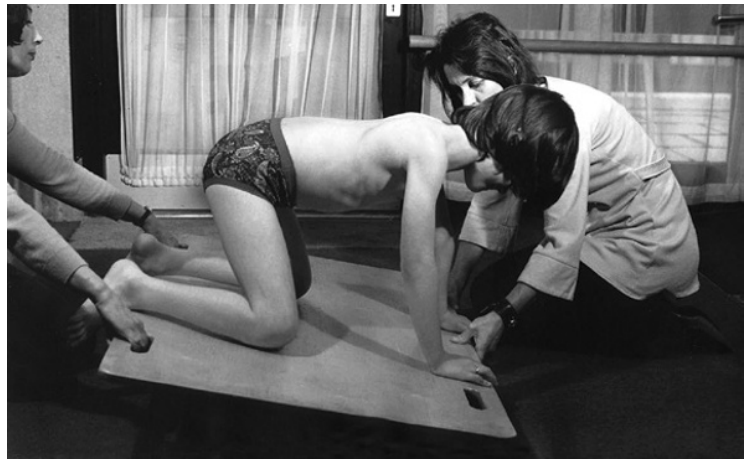


Figure 9.42. Tilt responses activated on a rocker board.

Use of bunny hopping. Reciprocal crawling rather than the continual bunny hopping of both knees forward is expected at this developmental level. Unstable pelvis, excessive tightness of hip and knee flexors, and also habit prolong bunny hopping and aggravate these problems, as well as adding deformities of the feet. A child who bunny hops may well have no other way of getting around. Therefore, offer other means of locomotion such as the prone board on castors for prone lying with hips and knees straight, a tricycle, pedal car, and preferably appropriate walkers, with knees in gaiters, if necessary. Training children to *bottom shuffle* is also a good alternative and easily trained and learned by many children. The child sits with feet in front on the ground. They lean on their hands at the sides, press their feet flat on the ground and stretch out their knees and move their bottoms along the ground, backwards or forwards. Avoid bottom shuffling in side sitting to prevent any hip subluxation or persisting asymmetry in a child with hemiplegia.

Encourage crawling on all surfaces, sand, grass, carpets, tiles, as well as using crawling onto a large step made with mattresses, wood, or firm sponge rubber, and climb in and out of boxes, cubby holes, through play tunnels or made with a blanket over the backs of stable chairs, as well as go under tables. Teach a child how to avoid bumping their head for spatial and body image experiences.

Crawling up stairs. This can be started on the hands and knees or hands and feet onto a low wide bench and then on stairs. Typically these crawling abilities are established later at developmental levels around 20 months.

Discourage crawling in children with tight or short hip and knee flexors and plantarflexed feet. Practise other forms of locomotion with extension of legs. Adolescents usually prefer not to learn crawling. There are children who do not prefer to crawl as they are natural bottom shufflers.

Training upright kneeling. This is discussed here as the child rises from prone positions to this position. Kneeling upright holding onto a support is expected at the age of about 9–12 months while kneeling alone typically develops by about 15 months. Supported upright kneeling activates the trunk on pelvic stabilisation or vertical stability before or at the same time as supported standing with straight knees and plantigrade feet. Treat equinus, knee flexors, and hips for a desirable upright standing position.

Avoid excessive use of the upright kneeling position in children who persist with hip flexion, lordosis, or hip–knee flexion with dorsiflexion in this position. However, these postures may be controlled by giving pressure to buttocks to extend hips while keeping the knees at right angles. The back is held straight by the child if they lean their body against a sofa with the arms placed well forward to reach-and-grasp toys at the back of the sofa seat. A child may balance next to a low bench, leaning on hands below or at waist level. Avoid the arm support at shoulder level or above as this may throw their weight backwards, resulting in heel sitting. However, to control a child's deformities, use a variety of positions, such as half-kneeling on the floor supported at one side of your lap with your hand supporting the chest, to control lordosis. Sway supported child forwards to stretch plantar flexors of the front foot in half-kneeling.

Use upright kneeling for dyskinetic (athetoid) and ataxic difficulties of cerebral palsy. Ability to control milder dystonia may be present. Weight shift at this lower base is easier than in standing. Later train weight shifts while holding on, followed by knee walking sideways, forwards, and backwards. Independent kneeling upright typically develops after standing alone. Knee walking

as well as kneeling on unstable surfaces may be useful in some children. Knee walking pushing a beach ball against resistance by a therapist on the opposite side of the ball. Kneeling upright, holding on, leads to half-kneeling holding on and then removal of hand grasps to balance alone in these postures. Kneeling is used as a transition posture in rising to standing.

Supine development

The following main features should be developed according to an individual's developmental stage.

Postural stabilisation of the head (Fig. 9.43). The typical neonate's head is in midline with physiological flexion but on the side by 1 month. The body is tipped to the same side as the face, as there is no postural control yet and the neck-righting response is active. Head stabilisation in midline is (at 4–5 months typically) on a surface and with head held off the surface (at 5–6 months). This develops from any chin poking to chin in midline and then pulled in to look down. If a baby is held suspended horizontally in supine, they hold their head alone in midline. Full head control is raising and holding of the head as well as head turning. Head turn to look, keeping the body midline or with the pelvis to the opposite side (4–6 months). Head raise (4–6 months) is part of the rising reactions discussed below.

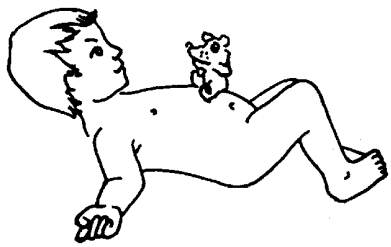


Figure 9.43. Postural stability of the head and head raise.

Postural stability of the shoulder girdle as the child holds the arm up to face in midline or when hands are held in midline (4 months) for hand to mouth and for *hand regard*, which overcomes the shoulder retraction of 3 months. The arm is then held in the air for reach, reach-and-grasp, and hand–eye coordination (4–6 months), including visually directed reach to raised foot for touching and 'mouthing'. There is anticipatory mouth opening to 'mouth' at 5 months. One hand reaches to the foot on the same side and then to the opposite side while the other arm and shoulder often stabilise to hold the leg up for reach-and-grasp (see also section 'Basic arm and hand patterns for all levels of development' and see Table 9.4).

Postural stability of the pelvis with posterior tilt in being pulled to sit (4–6 months; see Fig. 9.51) and, as the child holds legs in the air with feet touching in dorsiflexion–supination (5 months), there is also one leg up in the air (4–6 months) in order to grasp a knee and then a foot and foot to mouth. There is then anterior pelvic tilt and stability (5–7 months) when a child *bridges* their hips in extension with feet on the surface. Repetitive change from posterior to anterior pelvic tilt develops pelvic mobility (see Fig. 9.52). This enhances the ability to shift the body from head to toe, which is used in some back shuffles along the floor.

Postural stability of head, trunk, and pelvis is closely related to counterpoising of limb movements. See the discussion on head and trunk symmetry in the following Note.

Counterpoising the limbs in the air (Fig. 9.44). Children cannot do this when they are on their backs in water. Thus, holding a limb up in the air with the absence of a hard surface increases a demand on the musculature for counterpoising and reveals developmental inadequacy. Counterpoising involves weight shift on the trunk and pelvis, mainly laterally. There is activation

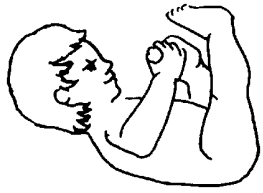


Figure 9.44. Postural stability and counterpoising of the limbs.

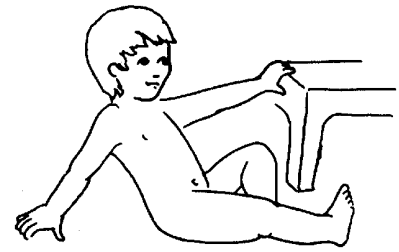


Figure 9.45. Rising from supine.

of limb muscles together with neck flexors, pectorals, serratus anterior, and abdominals (5–7 months). There is associated elongation of the short neck and trunk extensors in any early chin poke and back arching. All this happens when typical babies flex and hold their limbs steady in the air. Pivoting on the back using weight shift to each side counterpoises lateral arm and leg movements so that a child can move in circles (9–10 months).

Rising reactions and actions (Fig. 9.45). These are probably the most important reactions or actions to be trained in supine development. Many atypical postures and reactions are particularly obvious in supine, and a child is particularly helpless in this situation. Training the child to get out of supine involves counteracting most of these problems. This training seems to be as important, if not more so, as spending time training the child's correct position in supine. Supine, *head rising* (righting), and the *overcoming of head lag* (3–6 months) prepares rising out of supine. Various rolling and *rolling-and-rising* sequences of motion enable a child to rise out of supine. If these cannot be achieved, other methods need to be found and pull to sitting or standing using hand grasp. Rising patterns also contribute to a child's learning to get out of bed and turn at night.

Note. Typical asymmetries in supine lying are from 0 to 4 months, becoming symmetrical at 4–5 months. Persistent asymmetry can lead to deformities. Atypical asymmetries in the postural mechanisms against gravity from 4 months onwards need therapy, as this is associated with asymmetrical arm and leg function. However, when postural control is symmetrical, there is more opportunity for a variety of symmetrical and asymmetrical patterns of hand, arm, and leg function for perceptual, cognitive, and communication development.

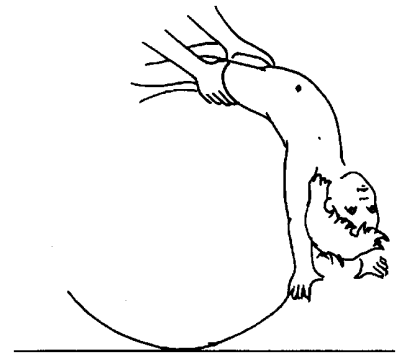


Figure 9.46. Arms saving (parachute) reaction from supine.

Tilt reactions and saving reactions (Fig. 9.46) are less important in supine than in sitting and standing. They may be used only laterally for trunk-strengthening exercises and for correcting a postural scoliosis. Saving and posterior tilt correct round backs and strengthen back extensors.

See the stages in supine development shown in Figs 9.47–9.56.

Figure 9.47. Flexion: asymmetry of the head (*0–3 months*).

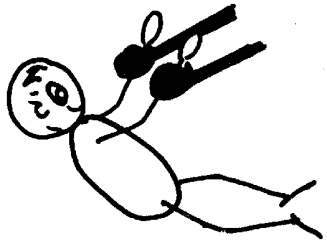


Figure 9.48. Head lag (*0–3 months*).

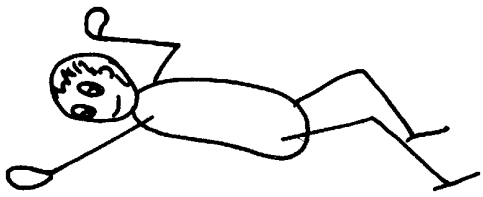


Figure 9.49. Asymmetrical postures (*0–3 months*).

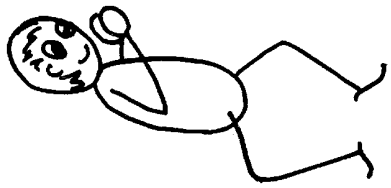


Figure 9.50. Head, hands in midline (*4 months*). Symmetrical weight bearing on head and body.

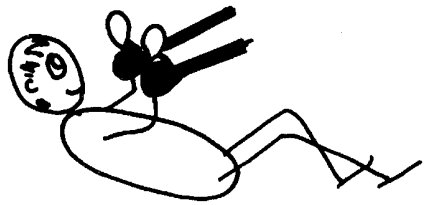


Figure 9.51. Decrease head lag. Lifts head when about to be pulled up (*3–6 months*). Stabilises pelvis.

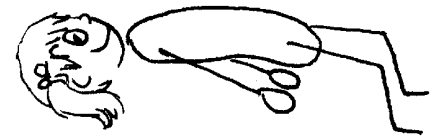


Figure 9.52. Bridging hips (*5–7 months*).

Figure 9.53. Roll over (*6 months*).

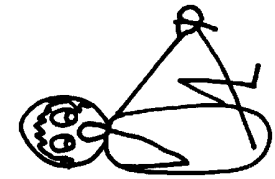


Figure 9.54. Grasp feet (*7 months*).

Figure 9.55. Lying straight, symmetry (*8 months*). Head turn isolated from trunk.

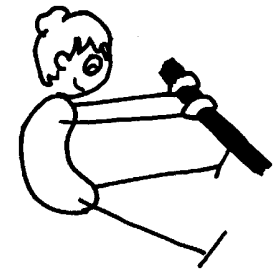


Figure 9.56. Pull self to sitting. Dislikes supine (*9–12 months*).

Treatment suggestions and management

Rolling and rising in supine

From 0–6-month normal development level

Help the child learn *to overcome head lag* using all or some of the following suggestions.

1. Many children only manage to raise their heads if pulled to sitting in diagonal directions and not straight up against gravity. This diagonal direction is often preferable, as this is how the child will later manage to lift their head and trunk up to sitting. This is typically seen at about the 9 month level.
2. Bring a child's shoulder or arm diagonally across the body to the opposite side (Fig. 9.57). Help or wait for them to half-rotate their body and lift their head as they are brought up to sitting. As the child comes up to sitting, they may automatically lean on a forearm or may require your pressure on their shoulder to help them take more weight onto this forearm. If they cannot use their forearm for support, you may hold both of their hands, arms, or shoulders and pull them across and over to one side of their body as they come up to sitting in this diagonal direction.
3. In addition, have the child lying halfway down against a back support or wedge, and encourage them to come up to sitting with your help. Gradually lower the back support so that eventually they raise their head and upper trunk from supine.
4. At first, hold the shoulders well forward, then later the upper arms and, as soon as possible, have them grasp your hands with their elbows straight. In these ways pull the child up to sitting, *waiting* for their own active head raise and later head and trunk (righting) raising. Some children bring their heads up first, their trunks follow. In others, trunks may come up first and stimulate the head next. Hold the pelvis to stabilise it so that 'the lever' of head and body can be raised more effectively. This pelvic stability develops later.

   Note. Carry out methods 3 and 4 slowly from supine or half-lying to sitting and lower the child back from sitting to supine without a collapse. Muscles are then activated well. In methods 3 and 4 observe a child's legs. If the legs stretch, press together, or twist inwards, then hold them apart, turn them outward on either side of a small wedge or on your lap (Fig. 9.58).

   Hold a child's arms with straight elbows and turn arms outward if there is a strong tendency for them to twist inwards from the shoulders or bend tightly to their body.

   If children continue to bend their knees excessively when hip flexion is needed, or if there are tight hamstrings, then hold their knees straight or use knee splints during methods 3 and 4 for rising actions.
5. Encourage their own head raise in supine by holding them firmly just over the edge of a roll, your lap, a bed, or in lying down the incline of a wedge. Call them to raise their head to look at you. At first hold children behind the shoulders and later hold their upper arms.

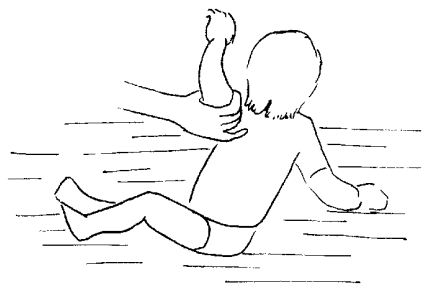


Figure 9.57. Supine rise to sitting.

Figure 9.58. Rising to sitting with the child's legs on either side of the therapist.

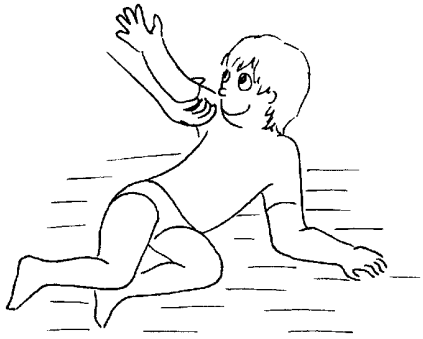


Figure 9.59. Rising to sitting from side lying.

6. Rising to sitting may also be trained from the side-lying position, particularly in those children who are excessively extended in the supine position, have very poor head raising from supine, or require additional action of the shoulder girdle muscles, back extensors, or arm elevation pattern (Fig. 9.59). Child in side lying, hips and knees semiflexed, head forward, chin in, and arm underneath the head with bent elbow. Gently lift the child's upper arm behind the occiput, turn the arm outward from the shoulder, as far as is comfortable for them, then wait for their own active participation as they are being assisted up towards sitting with support of their upper arm. At first they lean on a forearm and later they rise to side sitting, leaning on their hand instead of on their elbow. Check that the palm is down on the ground, the head is lifted up and sideways, and the shoulder girdle, arm, and back are actively rotated backwards with extension. Avoid side lying with any subdislocated hips or when excessive hip flexion–adduction is present in the top leg. Avoid pulling the upper arm too far back to protect shoulder joint.

Reflex rolling or infantile reactions. This is used to strengthen muscles and initiate rolling. In side lying, turn the child's head to one side and hold the jaw firmly. Press down and across the fifth intercostal space towards the *opposite* side. A reaction of rotation will begin at the pelvis causing both knees and then one knee to flex up and over to the side of the child's occiput. This technique initiates rolling in very

Figure 9.60. Reflex rolling.

Figure 9.61. Rotation of the shoulder girdle and pelvic girdle. Knees can be flexed and rotated to the opposite side.

young children and in older children with the presence of severe impairments (Figs 9.60 and 9.61). In side lying, rotate the child's shoulder girdle forward while rotating their pelvis back. Change to rotation of the shoulder backward and pelvis forward and vice versa. If the speed is correct and the rotary stretch on the trunk adequate, these *counter rotations* stimulate an active response in the child's shoulder or pelvis or in both areas. This also treats the rolling *in one piece or en masse* as seen, say, in the neck righting reaction. If rotation of the shoulder girdle is possible against some manual resistance, there is often an associated head raising with the rotation. Rotation of the girdles (pelvic/shoulder) not only facilitates rolling but also initiates arm movements and leg movements.

From 6–10-month normal developmental level

Rolling. Rolling techniques will help children to roll to side lying where their hands might meet and they can see them. Well-chosen rolling methods correct the atypical positions of the legs and arms and can also stimulate head righting, simultaneously decreasing infantile neck righting and activating body rotations at the waist. Some children need rolling for locomotion and exploring space.

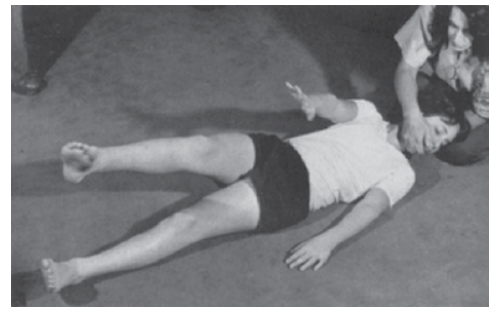
1. Place the child on their back or on their side. Keep their face and nose clear when rolled over into prone on a blanket. Hold each end of the blanket – two adults may be needed – and suspend the child in the blanket just off the ground. Tip the child gently from side to side, waiting for them to complete their roll over. If they cannot do this themselves, you can roll them in the blanket until they pick up the rolling motion themselves. *Do not* do this with a child who needs to arch their back or who overextends in order to tip themselves over to return from prone position. However, training sideways rolling with a child suspended in a blanket prevents arching. This is because a child's head, shoulders, and hips are bent in the blanket to counter extensor arching.
2. Bend both the child's knees across to the opposite side while rotating and holding the upper shoulder back. Release the shoulders and an active roll of the upper trunk follows. This roll might be manually resisted at the shoulder as well, but check that the correct amount of resistance is given so that a full flexion spasm does *not* occur.
3. Child in supine (leg pattern). You bend one hip and knee well over to the opposite side and wait for them to complete the roll over (Fig. 9.62). Use this for their participation during washing and dressing. Stretch one of the child's legs into extension–abduction. Wait for the upper trunk, shoulder, and arm to roll across. A retraction of the shoulder often delays the arm coming over within the child's roll from supine to prone. If possible, augment

Figure 9.62. Supine, leg patterns.

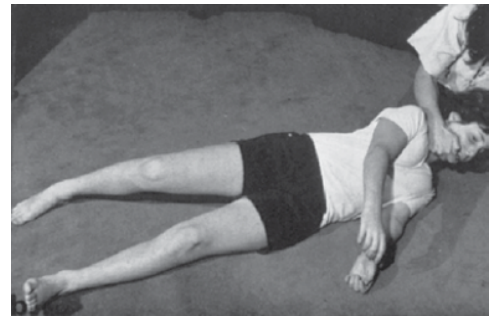
Figure 9.63. Supine, arm patterns.

leg flexion–adduction against manual resistance given at the knee and thigh to augment the roll.

4. Child in supine (arm pattern). Bring one of their arms over to the opposite side with the palm of their hand towards them and reaching out to your face, or to a toy they like on the opposite side (Fig. 9.63). The therapist may guide movement or activate it using stretch and resistance. Offer them a toy to encourage independent rolling from side lying and then from supine. If the underneath arm gets caught, initially hold it straight above the child's head, or once caught rotate the shoulder backwards to release it.
5. Child in prone or supine on a soft thick sponge rubber mattress or inflatable bed. Press down on one side of their body so that they tip over towards you and roll. Rolling on such surfaces is often easier as they do not get *stuck* with their arm caught under their body. At first it is necessary to place the arm that gets caught underneath above the child's head or, if already caught, rotate the shoulder backwards to release the arm.
6. Encourage rolling on all surfaces, floors, carpets, grass, and sand. Make an incline with a pile of mattresses or sponge rubber, or place the child on the top of a slight mound of grass or sand and let gravity help them roll downhill on their own.



(a)



(b)

Figure 9.64. Gentle head pattern to stimulate rolling. *Note* limb action (a) and (b).

Head patterns. Gently raise the child's head into flexion rotation, and wait for the child to follow with rolling towards the side to which the face is rotated. Support the head lightly as the child rolls. You may have to hold the chin as the child reaches prone. The arm patterns above may also activate associated head patterns. Some children may use an arm or a leg together with head patterns (Fig. 9.64a,b).

Rolling to instructions. The facilitation patterns of either head or limbs need to be imitated as experienced for active learning by a child. Instructions used for, say, *supine lying* include: 'Lift your head and one (right) arm up and forwards', 'Move them as far as possible', 'Roll over' *or* 'Bend one knee right across to the other side', 'Move it as far as possible', 'Roll over'.

A child selects the rolling pattern that they can actively manage. A parent/carer works together with child and therapist to learn these methods.

Please note.

1. During rolling over, various leg patterns are themselves stimulated, that is, leg flexes over with the roll from supine to prone in some children. In others the child may use the leg to *push off* in an extended–abducted pattern (Fig. 9.64a,b). During rolling, some children extend and abduct the upper leg. Other children flex the upper leg as they roll from supine. Similarly arm patterns vary. The therapist must select the technique according to the action needed and which a child is most able to either initiate or complete on their own.
2. Combinations of head, arm, and leg patterns also vary.
3. All rolling patterns relax a stiff child, especially when rotation is at the waist. Rolling is enjoyed when repeated rhythmically supine to prone and reversed.

Supine to sitting. This can be carried out by helping a child to reach across their body to grasp a fixed vertical bar with one hand. They then pull themselves to sitting in a diagonal direction with half-rotation of the trunk. They may automatically prop themselves on the other forearm or hand.

Supine to sitting can be accomplished by individual children holding a short pole or stick, held by you diagonally to them as you help them to sit up. Train them to avoid hunching their shoulders and excessively bending tight elbows and wrists to do this. You can press hunched shoulders down or the wrists down overcoming palmarflexion during their grasps.

The typically developing child of around 9 months will first come up alone to sitting from supine in a diagonal direction with a half-roll to one side, leaning on one arm. They will only come straight up to sitting, independently and without their own support much later, in an advanced pattern at around 4 years.

Motivate lying to sitting with your ideas or use a song or the verbal rhythm of 'Up you come', then 'Down you go'. This perception and language may only be understood later.

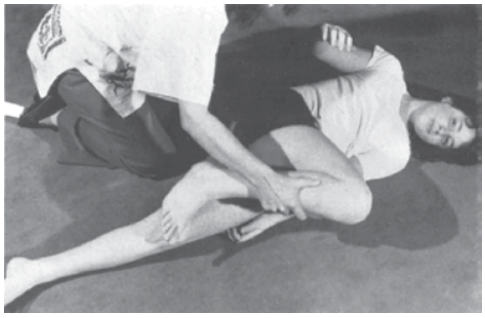
Supine to hands and knees. Train children to roll over from their backs to their stomachs and then continue up onto hands and knees (Fig. 9.65a,b). Bend a child's knee to roll and then lift their pelvis as they get onto hands and knees. This is training children to change position.

0–3-month normal developmental level

Common problems

Delay in gradual overcoming of head lag on pull to sitting. Inability to lift hand to mouth in supine but able to do so in infantile half side lying.

Atypical performance (Fig. 9.66). Excessive extension of head, shoulder girdle, back, or legs, or all of them (opisthotonus). Some arch into opisthotonus in infancy but become floppy later. Babies who are floppy (hypotonic) may have intermittent extensor spasms of head, spine, and hips. They may also lie in 'frog' positions with the legs flexed–abducted–externally rotated, arms limp at their sides or in shoulder abduction, elbow flexion, hands open or closed. Apparently typical flexion positions may



(a)

(b)

Figure 9.65. Roll-to-rise onto hands and knees. *Note* many methods exist for this but must be demonstrated clinically.

also be present in babies who later show spastic hypertonus. Kicking of legs begins and has atypical patterns. There may be atypical asymmetry such that the one leg flexes, abducts, and sometimes externally rotates while the other flexes, adducts, and sometimes internally rotates, or one may kick more vigorously than the other. This asymmetry may become so great that the legs look *windswept* to one side, especially when kicking stops. Later hip dislocation is threatening in the adducted–internally rotated leg. Persistent head turning to one side may occur. Pelvic obliquity and scoliosis may appear early or in later stages (see Fig. 9.68a).

Hands have grasp reactions with frequent clenching typically at 0–3 months, but atypical if still present in an older child. The child may startle with a Moro response and remain in asymmetry, including that of these asymmetrical tonic neck reactions, later than the typical baby. This delay may result in the use of various infantile reactions for function or during motor function

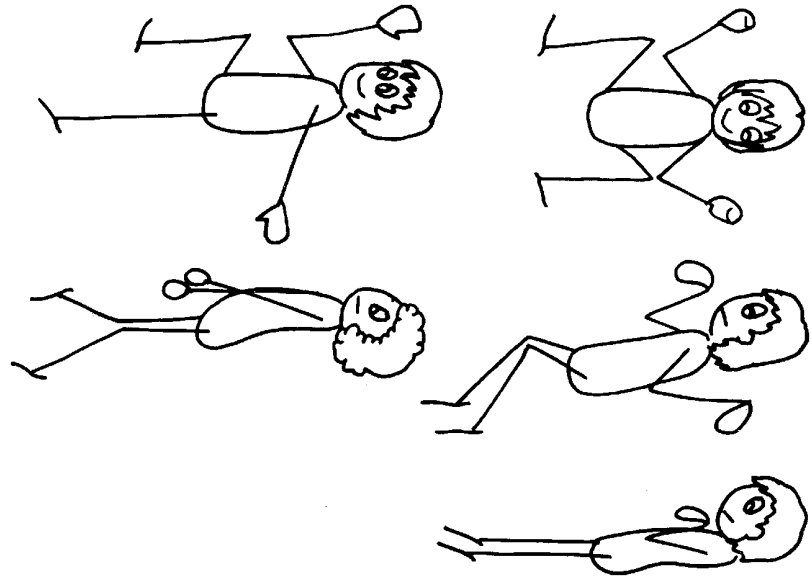


Figure 9.66. Some atypical postures in supine.

in the older child with cerebral palsy. On passively pulling the child to sitting the legs first flex adduct, and by the next 3–6-month level flex abduct. A response of extension–adduction of the legs is atypical. Some children with cerebral palsy even extend the hips so much that their hips come well off the surface. Individual children cannot stabilise the pelvis against a surface and slide easily on it.

Treatment suggestions and management

1. See section 'Rolling and rising in supine' illustrating postural mechanisms from the 3–6- and 6–10-month developmental levels (Figs 9.59–9.65a,b).
2. Bring a child's arms well forward and turn them out from the shoulders so that both hands touch your face, or make the child touch their own hands, mouth, chest, or abdomen, naming these body parts. Stimulate visually and with noises in the centre to encourage them to hold their head in the centre while hands make contact with bells or musical toys dangling in the midline.
3. Eye-to-eye contact with your eyes parallel to the child's, at first in the centre. Keep your face close to the face of a child with severe visual impairment. Stimulate them to follow sounds, lights, and mobiles from side to side (see development of hand function in Table 9.4).
4. Atypical performances are modified as follows.
   a. *Discourage* supine if the child has marked asymmetrical tonic neck reaction (ATNR) after 4 months, excessive Moro after 6 months, or has extensor spasms or leg withdrawal reactions. It is better that the child functions first in prone, side lying head supported with chin in or selected sitting positions with and without support according to a child's level of development. Children who can begin to overcome their asymmetry and infantile reactions need to be training head control in midline and if possible together with the upper trunk while a therapist holds the rest of their bodies in midline. If supine is inevitable during periods in the day, hold the child's head up with the chin in with some flexion in the hollow of a special neck cushion, use a hammock (Fig. 9.67) or special supine lying frames/equipment (Fig. 9.68b) (see also Chapter 13). This overcomes the head falling or pressing back into extension. Head flexion often diminishes the ATNR, Moro, or extensor thrusts. In this position, have the shoulders well forward to counter retraction. Motivate symmetrical arm movements to a parent's face, and use toys, mobiles, and your own ideas. For the *windswept posture* (Fig. 9.68a) use special lying frames (Fig. 9.68b–d).
   b. Excessively extended children should be flexed at head, shoulders, and hips in side lying or supine. The severely extended child, with arms in abduction, shoulders retracted, and elbows bent or stiffly extended, needs to be positioned in side lying with firm support from pillows or in *side-lying* equipment (Fig. 9.68c,d) so that their hands will be able to meet and they can see them, and they can touch their mouth and later be able to reach for toys in front of them Place a toy between their hands that can easily be grasped. In later stages, train children to lie on their side, showing the child how to balance in side lying with one leg on top of the other, as well as one in front of the other.
   c. For a child with atypically straight legs, pressed together, and turned in, use abduction splints or lying equipment (Fig. 9.68b–d). Keep the child's

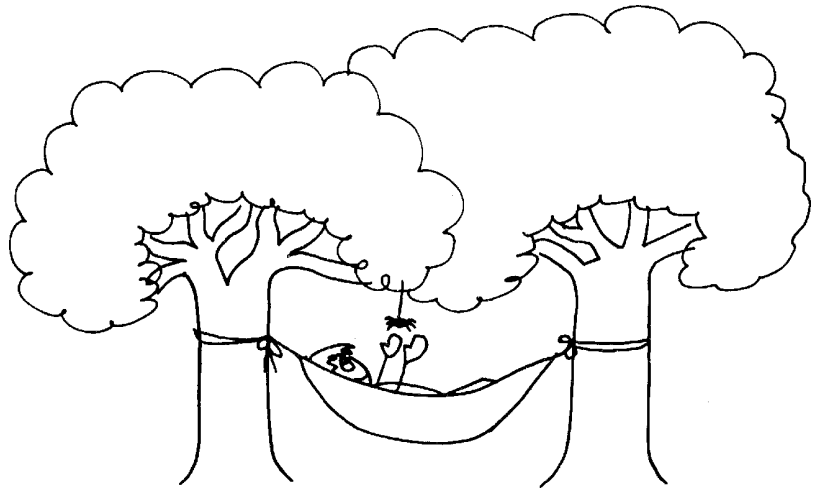


Figure 9.67. A hammock counteracts excessive extension, so the head and arms can be used functionally. A blanket held well strapped to the four corner posts of a child's cot is wider and safer for some young children. *Note. Supervision is essential.*

Figure 9.68. (a) Windswept posture, scoliosis, and arms flexed.

Figure 9.68. (b) Position to correct postures in supine.

legs apart and steady the hips as you assist a child to rise to sitting to activate head and later trunk control (Fig. 9.58). For the 'frog' position use sandbags to keep the legs together or lying equipment, as well as manually stabilising the pelvis with legs together as you train rising to sitting or play with the child in supine. Long trousers or pyjama pants that are well stitched down the centre can be used to bring the legs together when hypotonic legs can easily be positioned.

d. Persistent head turning to one side needs motivating a child to look the other way. A child's bed should be placed on the opposite side of the room. You offer toys, communication

(c)

(d)

Figure 9.68. (c, d) Correcting posture in a side-lying board. Her active arm reach for ball adds correction and communication.

activities, and, in sitting, food from the middle and side towards which the child rarely turns. Carry the child so that they can also look to the side which is not usually preferred. The physiotherapist needs to make sure that the child does not have a congenital torticollis which requires stretching or orthopaedic advice. Plagiocephaly may accompany persistent head turn. This strong head turning or preference has been observed in some babies who subsequently developed typically without therapy (Robson 1970).

e. See therapy for 'Development of hand function', which can be used in supine. A child's hand function levels may differ from supine levels as arms can be less affected than legs. Development of reach up against gravity may be difficult and delayed in supine. Moro, startles, leg withdrawal, or extensor patterns are simultaneously modified in positioning in sitting, in fully supported prone standing frames in children who tolerate them. Rolling techniques (leg patterns, arm patterns, and side lying) simultaneously modify any residual neck righting or extensor thrusts seen in supine.

f. Atypical synergies, such as persisting leg extension–adduction–internal rotation, are best corrected in the creeping patterns in prone development. If prone development is not indicated in a particular child, train reciprocal leg movement in supine with head raised on a pillow if necessary. Carry out active-assisted full range of reciprocal motion to a slow song. Hold the child's knees and bend one hip and knee up and out, holding the other leg straight and turned out. Change the motion by bringing the bent leg down as you move the straight leg up into flexion. This also maintains joint ranges and existing muscle lengths. Reciprocal leg motion is not shown to be directly relevant to upright stepping. Reciprocal kicking continues, though supported reciprocal stepping has stopped (Thelen et al. 1987).

4–6-month normal development level

Common problems

Delay in acquisition of symmetry, in keeping head in the centre, in bringing the arms together, and in hand regard. Delay in the disappearance of head lag and in acquiring

ability to raise the head off the bed. The child is unable to *bridge* their hips off the floor, unable to reach for a toy (see development of hand function in Table 9.4).

Atypical performance. Flexed legs now atypically extend, adduct, and internally rotate in many children lying supine and when brought from supine to sitting. Typically legs flex, abduct, and externally rotate at this level. Persistence of clenched hands (see section 'Development of hand function'). Atypical absence of isolated foot movements or knee movements, or selective joint ranges. Atypical anterior pelvic tilt (Fig. 9.68a). Rolls by turning head and then whole body. Rotations at middle of trunk need to be present.

Reflex reactions. There may be remnants of reactions from 0–6-month levels or some that may not be disappearing.

Treatment suggestions and management

1. See section 'Development of hand function' and Table 9.4.
2. See section 'Rolling and rising in supine'.

Arm reach. Train arm patterns with assistance or against your manual resistance according to a child's ability with the child in side lying and progress to supine. Stimulate flexion–adduction–external rotation with straight elbow for reaching across a child's body. Use movements with bent elbows so a child can touch the mouth or face. Carry this out in side lying and with both limbs in supine (Fig. 9.68c,d). Place attractive objects in positions near a child to encourage their own activation of these and other arm movements. A lack of shoulder girdle stability may cause compensatory shoulder hunching, but your manual guidance or pressure on the shoulders help control this.

Bridging (Fig. 9.69). Hold the child's feet flat on the floor. The child raises their hips

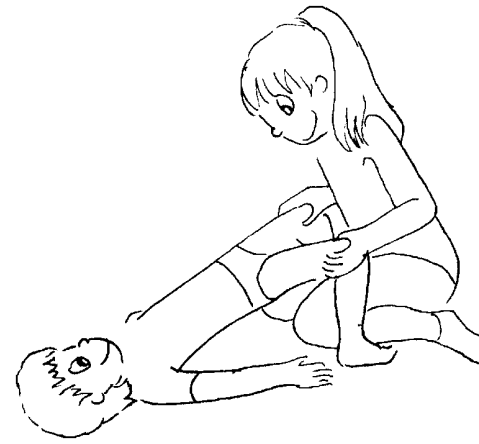


Figure 9.69. Bridging.

to let a toy go *under the bridge*. Check that this is *not done* by using a lumbar lordosis instead of hip extension. Check that arms do not flex up excessively but remain straight. They might grasp the sides of a bench/plinth to keep the arms straight. Hold the 'bridge' steady while 'the wind tries to blow it over'. The child tries to maintain the stability of the 'bridge' as far as possible as the therapist gives appropriate manual resistance at the sides of the child's pelvis, on the anterior superior iliac spines, or one hand in front and one behind to rotate the pelvis. A pillow under the hips may help initially as the child learns to maintain control against your manual resistance as well as sudden pushes.

Note. Semibridging and moving backwards is a form of locomotion used by some children with dyskinesia (athetosis) and more rarely by other children with cerebral palsy. However, this is often atypical as it includes excessive tense or hypertonic arching of head and back and retraction of the shoulders. If excessive, this should be discouraged by training other forms of locomotion which are satisfying. Equipment on castors such as wedges or corner seats and well-supporting special tricycles may be useful.

6–9-month normal developmental level

Common problems

Delay in grasping feet with legs in the air. The child is unable to roll over or pull themselves towards sitting.

Atypical performance. The child cannot lie straight with arms and legs extended, with legs extended, or with legs abducted–extended–externally rotated. A variety of atypical postures may be seen, including asymmetry of head, trunk, or limbs, or all these. Typically, the pull-to-sit should provoke extension–abduction of legs. Anterior pelvic tilt may persist atypically.

Atypical rolling patterns may be persistence of early extension of head looking over the shoulder, with trunk arching to obtain a roll. The child may lead with head and arms but with legs stiff and straight or relaxed and passive or may roll using legs but upper arm bent and retracted at the shoulder. Some roll using an action of *flexion into a ball*. In most atypical patterns there is no rotation at the child's waist, only a rolling action in one piece using the total flexion or extension. There may be rolling to one side only, especially in hemiplegia. The roll is towards the affected side only using the unaffected side to carry out the roll over, or in tetraplegia or diplegia using the less affected side to carry out the roll. An inability to roll may also be due to weakness of limbs, of head raise, and of trunk muscles.

Treatment suggestions and management

1. See section 'Rolling and rising in supine'. Continue these techniques at the 6–9-month developmental levels. Use arm and leg patterns against manual resistance to augment roll, when this is possible, at this stage. See also Table 9.4 for a child's development of hand function. At this stage an individual may show their own strategies of rising from lying (Fig. 9.70). A more efficient pattern of rising to sitting from lying needs to be trained if possible (Fig. 9.71c,d).

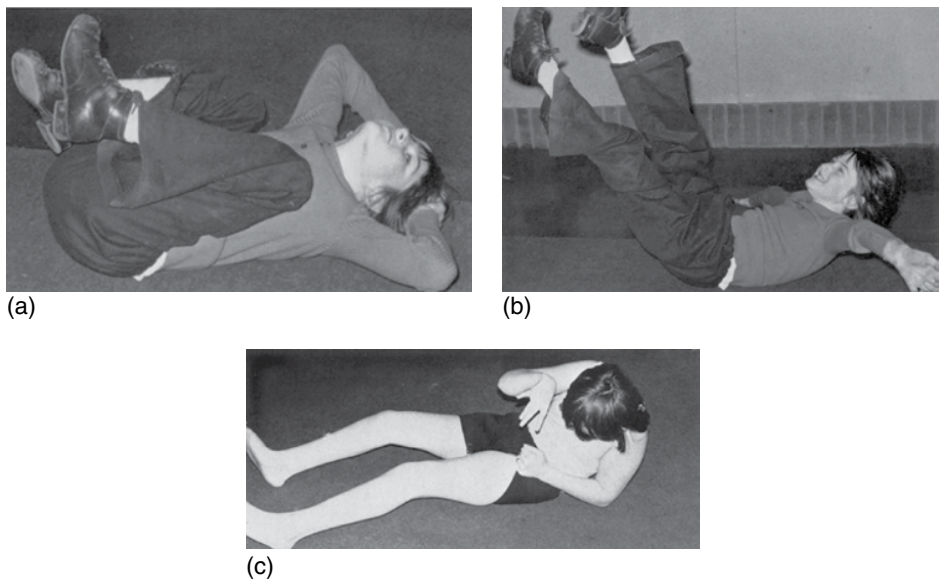


Figure 9.70. (a, b) Individual using her own method of rising (bend knees to chest and swing up to sitting, or grasp clothes and pull up to sitting). (c) Individual using his own method of rising to sitting. He grasps his clothes and pulls himself up alone.

Figure 9.71. (a) This child cannot rise to sitting from a wedge on her own. (b) She can sit upright with wrists held. (c, d) Rising to sitting with minimal manual support to reach her desired toy.

2. Have the child in supine and help them to hold one or both feet. Turn their pelvis with hips and knees outward, bending a leg so that their foot touches one or both of their hands. They can then look at and also grasp their feet and hold them. You may need to bend their hips and lift their bottom off the bed if they are unable to reach their feet. The child needs to actively bend hip and knee to their chest so that the full hip flexion is attained. Ask them to 'Kiss your knee', 'Pull your sock or shoe off your foot', or to 'Hug your knees to your chest'. When you hold the child's legs up above their face, they may enjoy playing 'peek-a-boo' as they open and close their legs. All these actions help overcome atypical pelvic tilts. As you play this game, gently stretch the hamstrings by sliding your hands onto the leg.

   Note. No further training is needed in supine lying, as from the 10-month developmental stages onwards the child typically *dislikes* lying supine and persists in rolling out of this position or pulling up to sitting.

3. Having trained a child to rise from supine to sitting *does not mean they can sit or vice versa*. See section 'Development of sitting' (see Figs 9.77–9.90), which should be trained at the same time as supine development. Levels of development of sitting stages differ from rising to sitting stages. The developmental stage of rise to sitting is at 6–9 months and sitting upright with wrists held is 4–6 months (Fig. 9.71a,b). The postural mechanisms differ as well as the muscle work.
4. Practise rising to sitting with half-rolling (Fig. 9.71c,d). To get out of bed use either half-rolling or rolling over into prone and pivot body and legs to the floor. Later train rolling to prone and then rise into crawl position. Rolling can also be involved in the first part of rising all the way to standing, using arms to push and support.

Development of sitting

The following main features need to be developed as far as possible.

Postural stability of the head or vertical head control with the trunk being externally supported. Head bobs and steadies, set forward, and then erect (0–3 months). Chin may sometimes first poke, then held in, and be pulled in (retracted) to look down.

Postural stability of the shoulder girdle is activated with arm and hand propping or hand grasps for sitting with decreasing adult support (4–6 months). Arm props provide a larger base, protract the shoulders, and are part of a forward lean with legs apart as natural biomechanics for sitting alone. Later, use of the hands also activates shoulder girdle stabilisation and vice versa.

Postural stability of the head and the trunk (Fig. 9.72). Head and upper trunk with upper trunk extension (3–5 months)

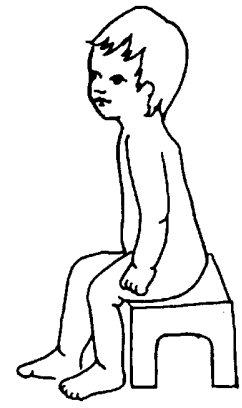


Figure 9.72. Postural stability.

develops to full trunk extension and sitting from hands held to alone (6–9 months). The trunk extension of stabilisation counteracts a normal round back (C-curve). At first, arms are up in 'high guard', retracting scapulae with rhomboids to augment extension for stability (5–7 months), and the wide base of abducted externally rotated legs continues with weight bearing on the lateral sides (3–6 months). Nevertheless, the child cannot risk using arms and hands, which disturb the sitting balance. A baby chair is needed for support (4–6 months). Counterpoising hand use begins later, as does a smaller base used for weight shifts with arms reaching up to shoulder level (7–9 months). Cervical and lumbar lordosis develops (7–9 months). The variety of sitting postures on the ground increases from ring sitting to half-ring to long sitting. There is a smaller base with less leg abduction–external rotation and knee flexion, reflecting increasing stability. There is controlled asymmetry in half-ring (6–9 months), later side-sitting postures with growing independence and reliable stabilisation of the trunk on the pelvis during sit and turn (9–12 months).

Postural stability of the pelvis. Pelvis position depends on the head and trunk stability. The normal neonate has a perpendicular

pelvis with a round back and not a posterior tilt and remains so until sitting alone with anterior tilt (Aubert 2008). The pelvis tilts anteriorly with trunk extension and then posteriorly during forward leg lift with arm support (6–9 months) and without support (9–12 months). The pelvis becomes more mobile to foster balance with the body weight behind, laterally, or in front of the base (9–12 months).

Postural stability is closely related to counterpoising for head and limb movements.

Counterpoising (postural adjustments) for movements of head, for lifting to the vertical (3 months), for looking everywhere and involved in 'hand regard' (4–6 months), and when visually reaching (6–7 months). The arms and hands are used together at first opposite the child's abdomen (7–8 months) and then at shoulder level and later elevation above shoulder level (7–12 months). There are small weight shifts of the trunk within the child's base (7–8 months) then larger weight shifts forwards, backwards, and sideways while maintaining postural control. Sitting and turning the body increases from 7 to 12 months. This allows arm and leg actions and also recovery of balance when a child's body leans well out from the buttocks in grasping a toy out of reach (Fig. 9.73). Weight shift elongates the weight-bearing side with trunk muscles contracting on the shorter side to avoid instability (normally 7–12 months). Postural stability with postural adjustments are integrated with the use of the hands as well as during locomotion, called 'bottom shuffling' (scooting).

Righting (rising) reactions and actions. Head righting or head raising to the vertical position with trunk supported (3–4 months). *Head and trunk righting or rising* to the upright from a slumped sitting or leaning posture. This may be forwards, backwards, or sideways (Fig. 9.74). Normally developed (4–12 months) depending upon the positions and support given to the child to re-erect.

Figure 9.73. Counterpoising.

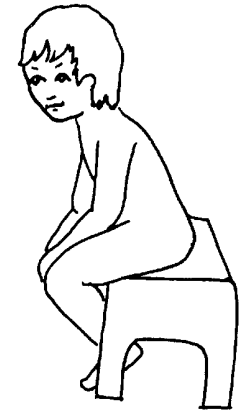


Figure 9.74. Rising to upright sitting and reverse.

Note. Rising to sitting from supine, see sections 'Supine development' and 'Prone development'. See discussion on rising from sitting to standing in the section 'Development of standing and walking'.

Tilt reactions (Fig. 9.75). These responses are activated as a child is tilted sideways, forwards, or backwards with their bottom tilted off the horizontal. This tilt is much further than in weight shifts on a firm surface (9–12 months). Tilt responses are first with head followed by head and trunk adjustments.

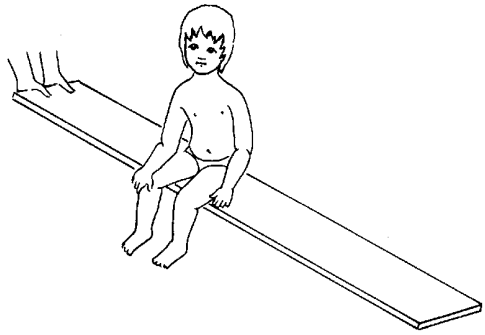


Figure 9.75. Tilt reaction.

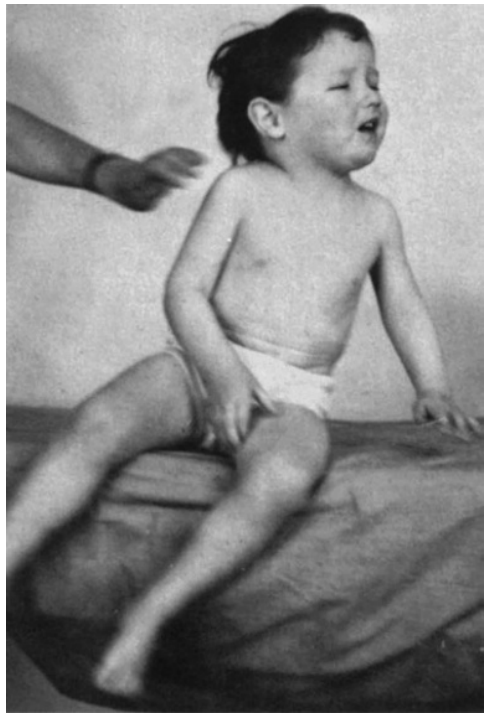


Figure 9.76. Saving reactions in the arms and legs.

Saving reactions (Fig. 9.76) and propping reactions in arms are protective responses if the child tips or falls. Normally developed forwards and downwards (4–7 months), sideways (7–9 months), and backwards (11–12 months). These are important for safety of upright sitting alone.

See the stages in sitting development in Figs 9.77–9.90.

Figure 9.77. Sitting head uncontrolled, flexion in total child (*0–3 months*).

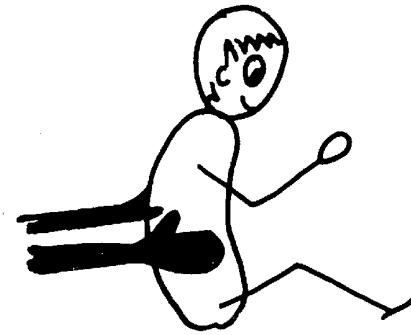


Figure 9.78. Decrease of flexion, vertical head control develops (*0–3 months*).

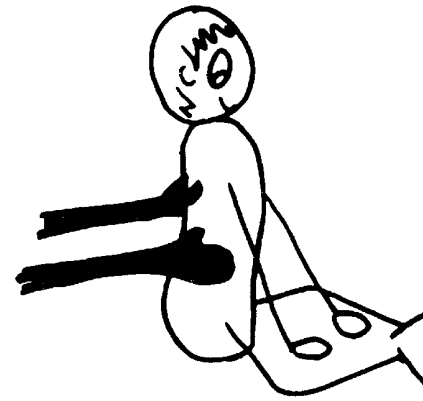


Figure 9.79. Sitting lean on hands, flattening of upper back develops, lumbar kyphosis still present (*4–6 months*).

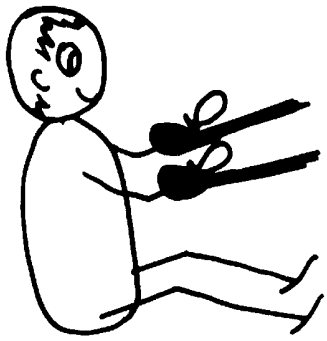


Figure 9.80. Sitting with less support, back straighter, legs straighter, turning out and apart (*4–6 months*).

Figure 9.81. Sitting lean on hands, hips flexed–abducted–externally rotated. Less support and without support (*4–6 months*).

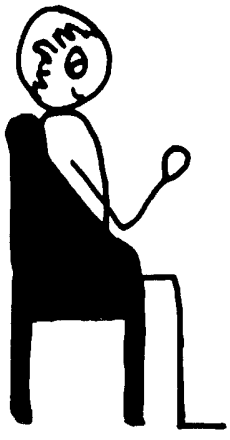


Figure 9.82. Sitting in baby chair with back and sides supporting or propped on a pillow support (*4–6 months*).

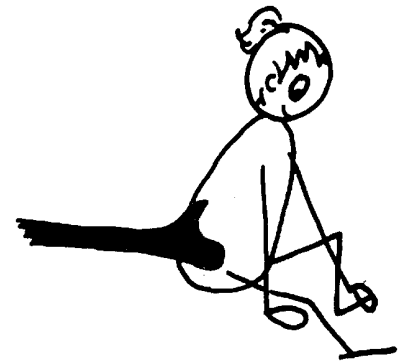


Figure 9.83. Sitting lean on hands and lift one hand to play, with feet or a toy (*6–9 months*).

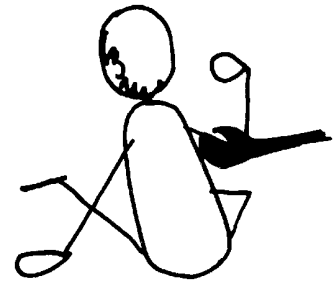


Figure 9.84. Saving reactions and propping in arms (*6–9 months*). Tilt reactions begin.

Figure 9.85. Sitting alone on the ground (*6–9 months*).

Figure 9.86. Sitting reach in all directions, hand support (*6–9 months*).

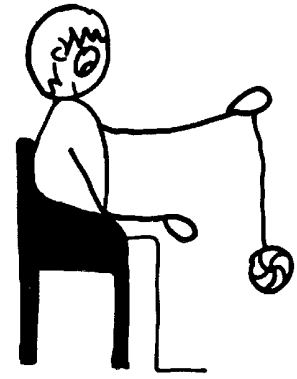


Figure 9.89. Sitting in a chair for daily tasks, no hand support. Sit alone on a stool (*9–12 months*).

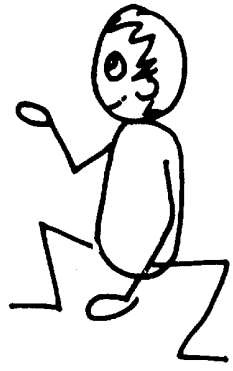


Figure 9.87. Sitting turn reach, no hand support (*9–12 months*).

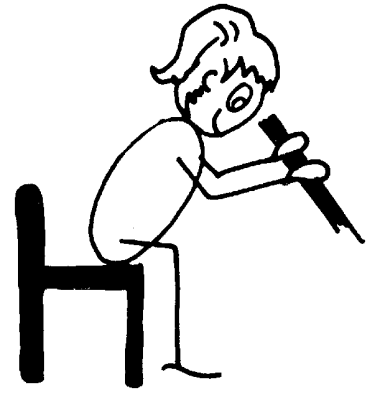


Figure 9.90. Rising out of sitting and getting into all sitting positions. Tilt reactions complete (*9–12 months*).

Figure 9.88. Sitting in various positions (*9–12 months*). Pivot in sitting.

Treatment and management at all developmental levels

The captions to Figs 9.91–9.105 describe the treatment and management suggestions.

The aims of treatment are as follows.

1. *Develop and improve the postural mechanisms*. Figure 9.91 shows a chair to assist a young child with cerebral palsy who has some postural control but needs support for postural adjustment for hand function.

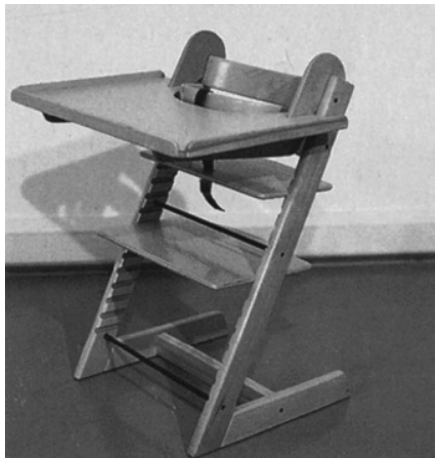


Figure 9.91. Tripp-Trapp chair for a child with some balance (GMFCS levels II and III). It is adjustable for some growth of the child. The child gains sitting experience, leading to more postural control and postural adjustment for hand function.

Figure 9.92. Child is supported with your body when held on your lap or with you close behind her on a therapy roll or floor, then gradually move away from the child's back. Hold her under the axillas then the upper trunk, her waist level, or at her hips and thighs, according to her ability. Later shift the child laterally or anteroposteriorly in preparation for movements.

2. *Maintain appropriate muscle lengths and correct atypical limb positions while training postural control.* Spastic short muscles and overlengthened muscles are seen in atypical sitting postures such as in extended and adducted legs with flexed arms which have short muscles while the antagonists to these muscles are lengthened or overlengthened. The spastic synergies are also used to prevent falling. For example, the child holds on for balance with hunched tight shoulders, elbow flexors, and excessively flexed wrist and hand grasp. A child fixes themselves in sitting on a chair by excessive knee flexion over the edge of the seat and pressing equinus feet against the legs of the chair.

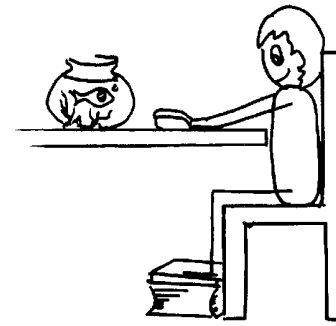


Figure 9.93. Sit with less lean against a table, feet supported, and hands grasping a horizontal bar. Use eyes to follow interesting items. Later, child grasps bar with only one hand, using the other hand in play. Sit more upright' leaning on hands on a table. Vary height of table.

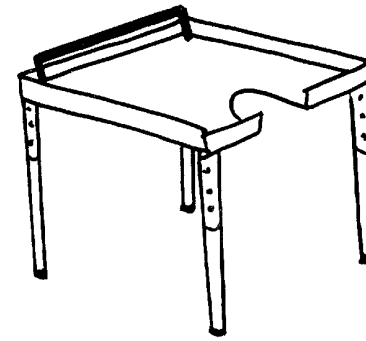


Figure 9.94. Cut-out table of adjustable height, with fixed grasp bar to give support. The cut-out offers support as a child learns to release grasps for support. One hand may grasp during movement with the other arm. Small vertical bars are also suggested for each hand to vary grasps.

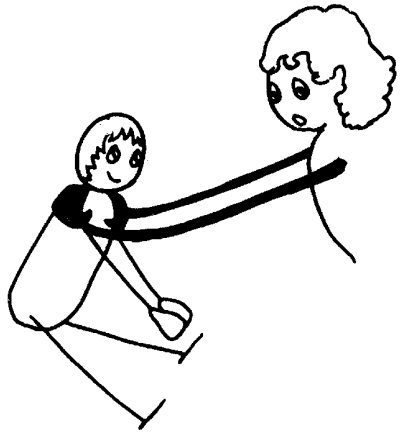


Figure 9.95. In floor or chair sitting positions, support is first given to the child's shoulders, then the waist, then lowered to the hips and thighs, sometimes to the feet only, and finally removed for sitting alone. A floor table may be needed for play and hand function.

Figure 9.97. Use joint compression through the shoulders with the child leaning on forearms on a table. Encourage leaning on one arm and using the other for, say, eating, play, gesturing, or pointing for communication. Place a roll of towels or small sponge wedge to keep forearms away from the chest.

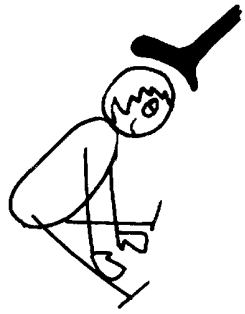


Figure 9.96. Gentle joint compression may be given through the head, kept carefully aligned with the trunk. Joint compression can also be from 'bottom upwards' for a playful experience. Hold the baby/child in careful vertical alignment and bounce them on their bottom on sponge rubber, a trampoline, an inflatable toy, a beach ball, or your lap. Check alignment of the head with chin held in, with trunk and bottom.

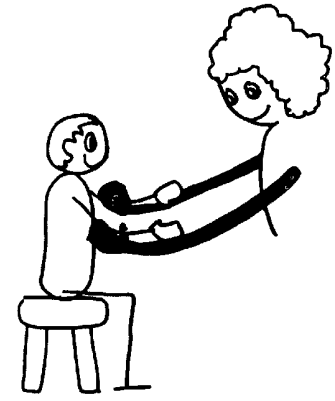


Figure 9.98. Train sitting with support given by an adult instead of by a table. Child leans on their forearms into adult's forearms. Joint compression may be given through the child's forearms held directly below their shoulders. The child may hold the adult's shoulders while the adult supports the child's chest, subsequently their waist, and finally their thighs, knees, or just their feet on the ground. The child may gradually not need to hold on.

3. *Train children with dyskinesia and dystonia* to stabilise themselves. They use atypical postures and their own methods to control their involuntary movements with their muscle tension or dystonia. There are a variety of unusual postures, including flexing legs around chair legs. This aids balance and control of involuntary movements. Heel sitting on the floor and other positions may be useful as they allow hand function, which can be especially difficult for

Figure 9.99. Visual and auditory stimuli at the child's eye level for vertical head and later include trunk control. Upright posture is encouraged if given at the child's eye level. Arm propping may be needed if stability is poor.

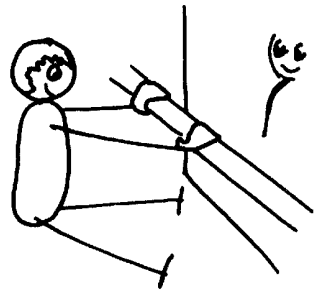


Figure 9.100. Child learns to sit with both hands grasping a pole, back of a chair, a table edge, or an adult's hands. Elbows are as straight and symmetrical as possible. The support may be grasped below shoulder level, at shoulder level, or above shoulder level. Encourage a child to use one arm movement to reach a toy while the other arm is grasping a support. One arm is used for feeding, dressing, and playing. Grasping with one hand and using the other to reach down, in front, at shoulder level, and above shoulder level develops and maintains sitting.

these children. Train postural control in a variety of postures that can be achieved by individuals and find which can be most helpful (Figs 9.92–9.105).

4. Assess and select correct chairs and tables with or without special adaptations for each child for comfort, communication, eating, drinking, and hand function. See Chapter 13.

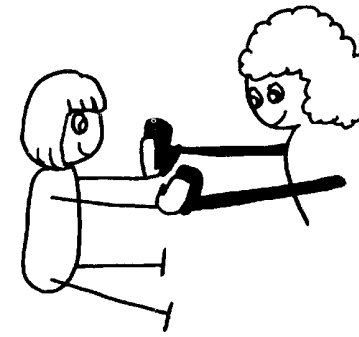


Figure 9.101. Child pushes open hands against an adult's hands with wrists in dorsiflexion. This brings the child into a forward sitting position. Train active re-erecting to the upright and return to forward lean. The child may need to have assisted body support or holding of the arms. The child may have their arms on the back of a more able child and they rock forward and back.

Figure 9.102. Child may also push against a wall to make handprints on powdered or soaped mirror or push a large therapy ball or heavy toy on wheels to another child. From upright sitting, child reaches well forward to touch the wall or toy with the other arm supported on a seat or arm of a chair and later without any arm support.

5. Avoid prolonged sitting, especially on a chair for more than 2 hours. Include *assisted or unassisted* rising to standing, supported standing in standing frames, and strengthening of extensor hip and knees and arm muscles to prevent flexion deformities. Maintaining plantigrade feet on the ground avoids plantarflexion.

6. *All methods* depend on a child's age and size. Methods may be used for sitting on the floor and on the child's chair. Sitting on the floor is emphasised in babies and young children, while in older children at the same early developmental level chair sitting is usually more appropriate.

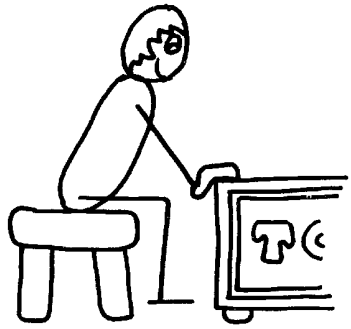


Figure 9.103. Child leans on hands on a seat or low box. If possible, the child's hands are flat with dorsiflexed wrists. Encourage the child to reach forward to a desired toy and then re-erect to an upright position. Hold the pelvis and tilt forwards, sideways, obliquely, and partial rotate for reaching in different directions. Cross the midline for added postural control. Tilt pelvis backward for leg lifting.

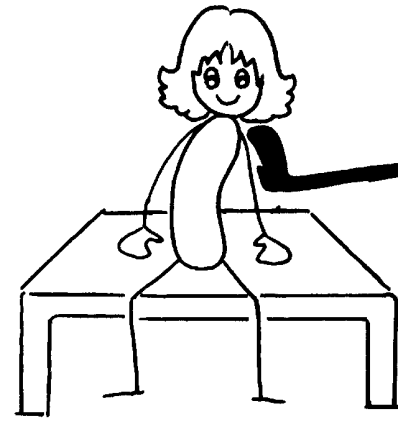


Figure 9.105. Give the child gentle quick and slow pushes, expecting them to maintain balance. Push in all directions to train weight shifts within the base and later out of the child's sitting base without falling. At first the child supports on hands and then without support. Manual resistance may be given at the child's shoulder on the lateral, anterior, or posterior aspects. This strengthens shoulder girdle, neck, and trunk stabilisation muscles. Also give manual pushes or resistance with a child leaning on forearms (Fig. 9.97), on hands (Fig. 9.96), or grasping a support. For these actions suggest to a child to 'Stay there' or 'Keep sitting' according to the child's ability. *Note.* Give the correct amount of resistance so that atypical reactions are minimally provoked in limbs.

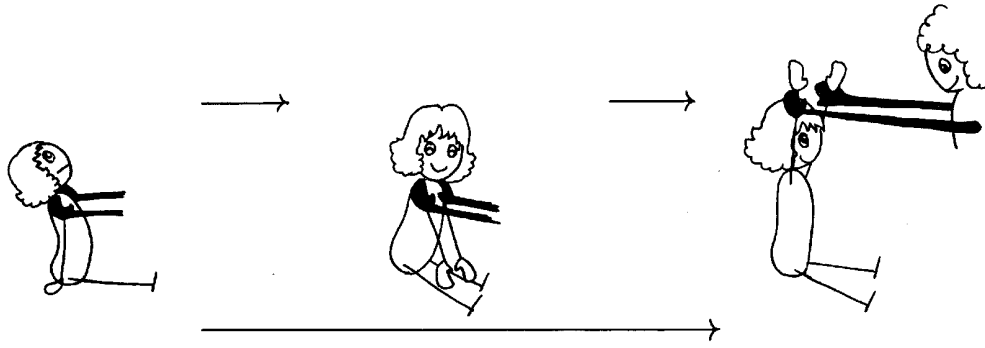


Figure 9.104. Stimulate head control. Later back straightening is promoted using arm elevation by bringing shoulders forward and then taking the upper arms, turning them out while elevating them. Independent achievement later can lead to holding a ball over the head, touching an adult's face, and raising arms for dressing. Make sure that the child's head is slightly forward for balance.

Chairs and tables (see Chapter 13)

Special chairs (adaptive seating) are selected according to the child's developmental level. Controversy about suitable seating in the past arose when clinicians were really comparing children at different stages of development (Figs 9.91 and 9.106a-d). Special chairs and other sitting equipment are part of training sitting (Myhr et al. 1995).

Other equipment for sitting

1. Chair swings, toy trucks, rocking horse, or pedal cars with back and sides for support, beanbag chairs and inflatable chairs, car seats offer sitting experience.

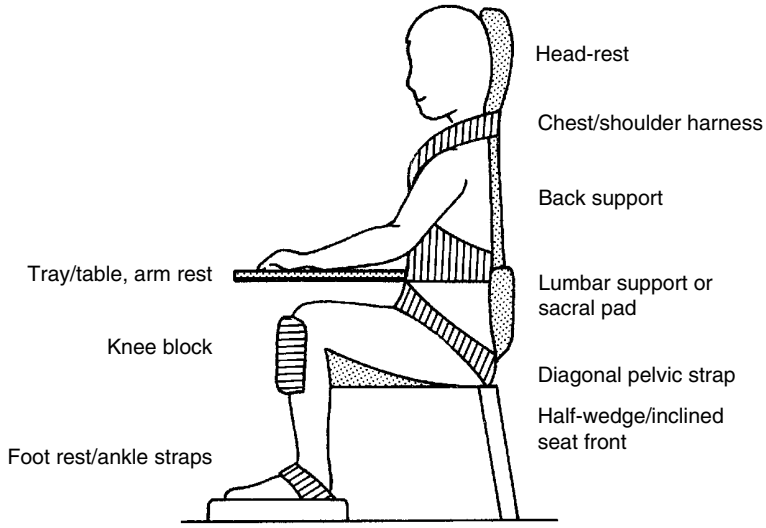


Figure 9.106. (a) First stages.

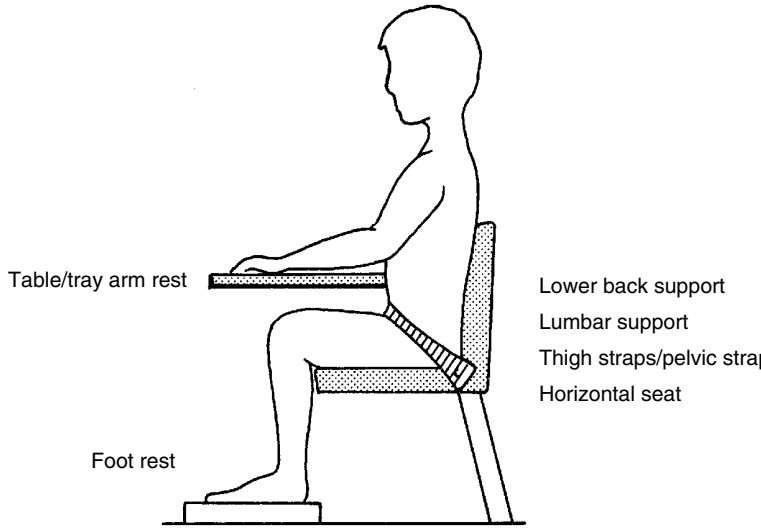


Figure 9.106. (b) Second stages.

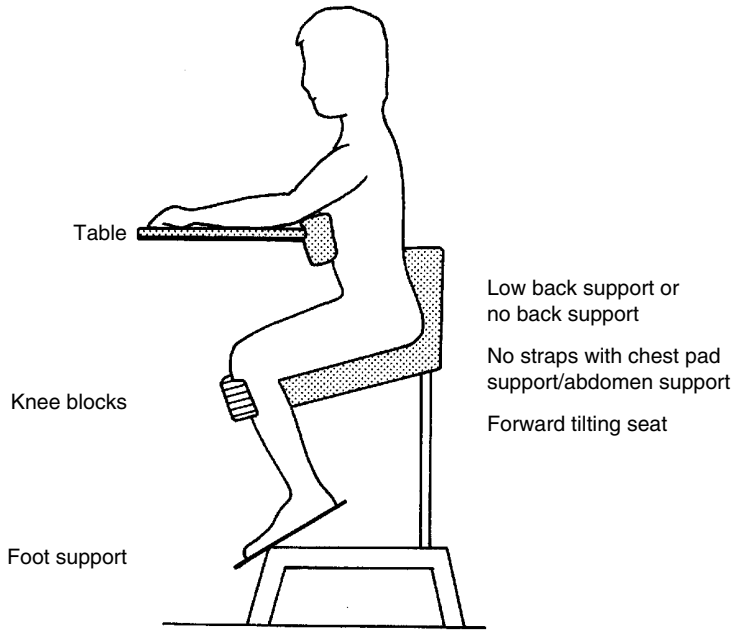


Figure 9.106. (c) Third stages.

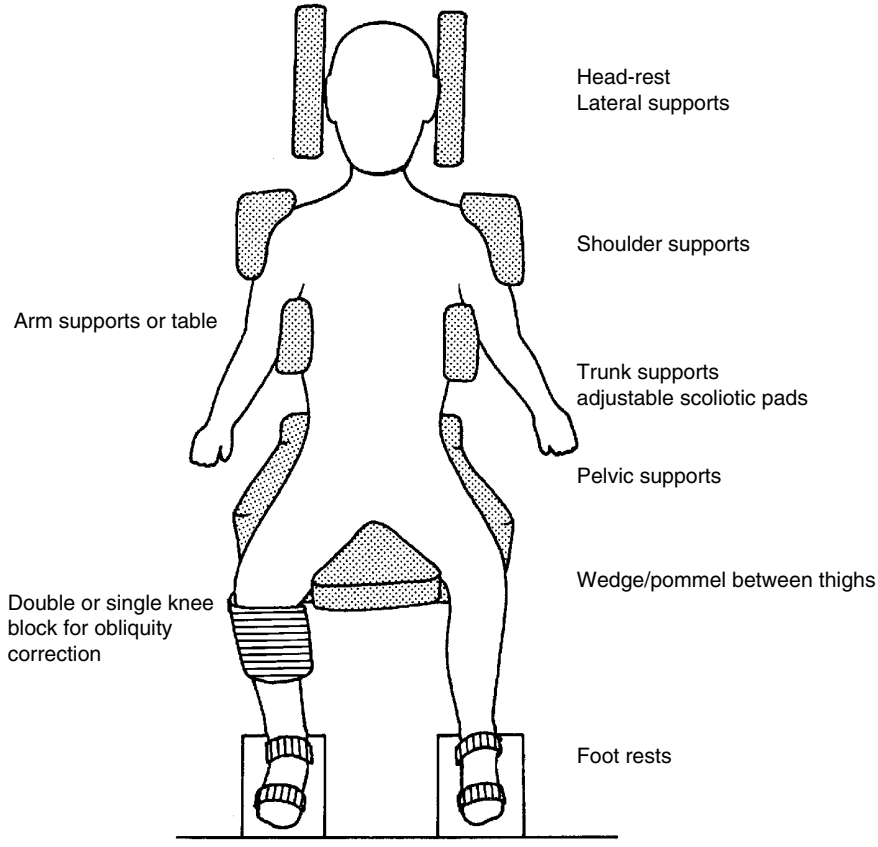


Figure 9.106. (d) First stages.

The slatted back chair enables a child to experience and learn balance in sitting (Fig. 9.107). A roller chair abducts the legs and is used with a cut-out table (Fig. 9.108). A potty chair can give support and is used for training sit-to-stand (Fig. 9.109).

2. See Chapter 10 for activities in daily life (Figs 10.1 and 10.3).
3. See Chapter 13 for seating equipment and wheelchairs.

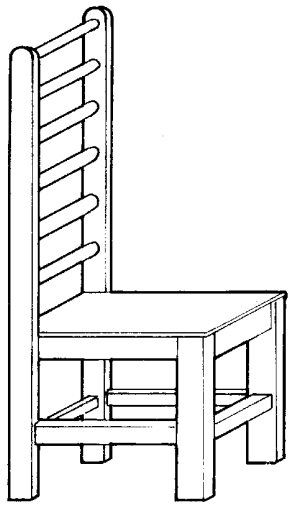


Figure 9.107. Slatted back based on a design by Petö Institute. Child can sit sideways and hook an arm through slats for balance. A box base also prevents legs twisting under the seat when sitting symmetrically. Later use slats for training standing and to push chair for a walking aid. Stabilise base with skis attached. Also see Fig. 9.159c. A ladder-back frame with skis for more able child.

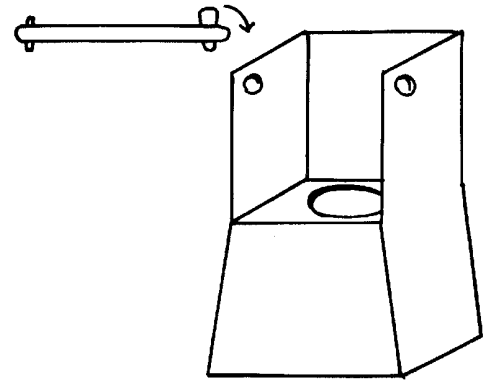


Figure 9.109. Potty chair with all-round support and safety bar. Feet must be on the floor. If the child is very extended use a stable box for increased flexion. For a tall child the back height needs increasing and the seat needs enlarging. Later train sit-to-stand from potty and toilet chairs.

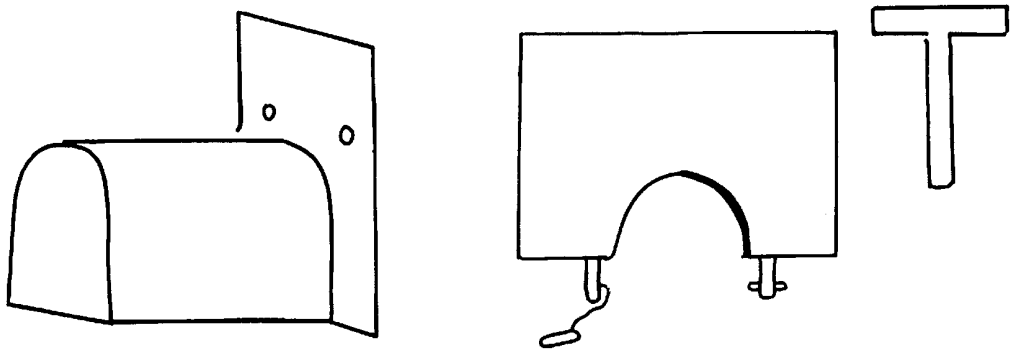


Figure 9.108. Legs are abducted over this roller chair (based on a design by Nancie Finnie). Knees must be just beneath the top of the roll, and the roll not too wide for the child. Feet are flat on the floor. Check that the child does not slide down one side of the roll. An ordinary low table or fitted cut-out table is used. Leave 50 mm (2 in.) between the child's body and the cut-out edge for postural adjustments. A roller chair on wheels with a back and a bar in front was developed so that a child could be pushed around by an older child. The height of the roller chair is adjustable and a simple brake is available (Bower 2009: chapter 21).

0–3-month normal developmental level

Common problems

Delay in lifting the head up from flexed or extended posture when the body is fully supported in a sitting position. There is unsteady head holding in supported sitting. (Head lag in pull to sit, see section 'Supine development'.) There can be a total *absence of postural stabilisation*, resulting in a child falling backwards or leaning back as they slide out of the seat of the chair. When held at the pelvis, in sitting on the floor or on a chair, the child may drop head and trunk forward (Fig. 9.110a,b). Like an infant, such children can sit in a reclining chair with supporting straps at this level of development.

Atypical performance. An older severe child with totally absent postural stabilisation continues persistent backward lean against an inclined backrest, developing hip flexion

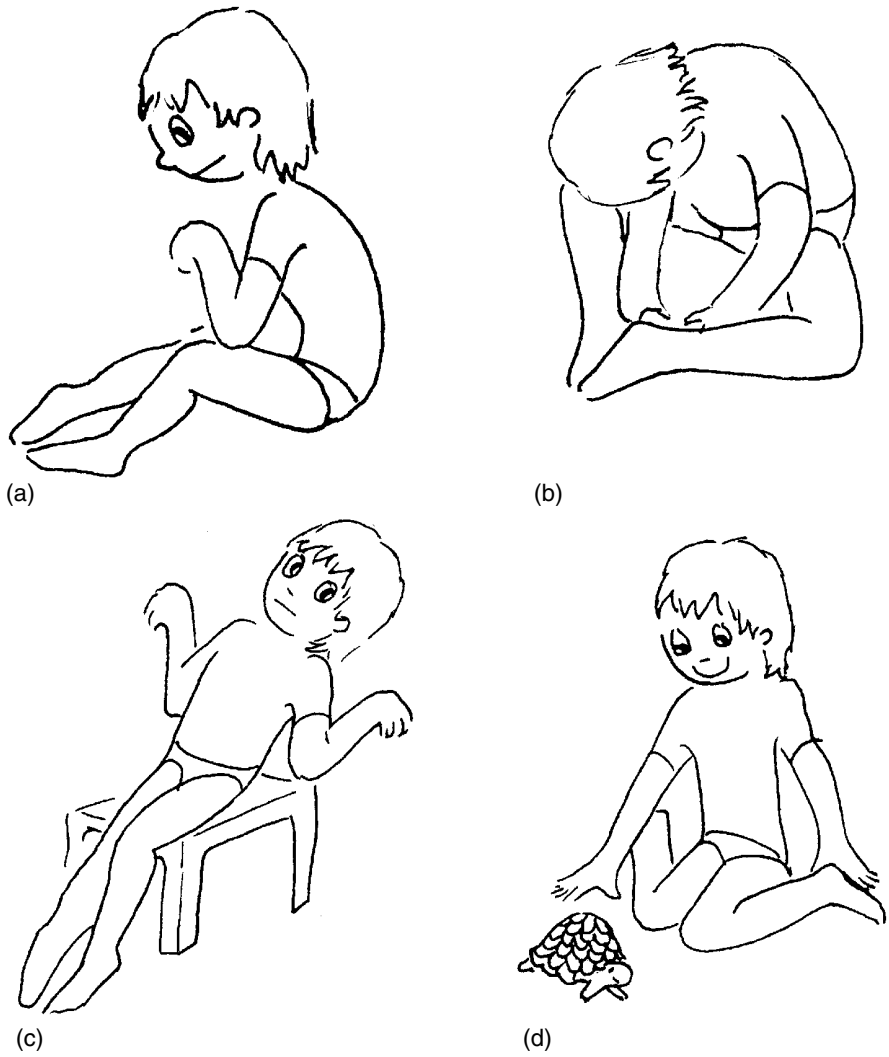


Figure 9.110. (a–d) Some atypical postures in sitting.

tightness, or fixed semiflexed hip deformity, as well as remaining unable to activate a floppy weak trunk. A child may also use hip tightness to prevent falling backwards. Some have infantile excessive extensor thrust. All these children cannot be placed into an upright sitting position. Prolonged sitting with flexed hips and knees creates deformity.

The head is held in an asymmetrical posture either laterally flexed or rotated, or both. Arms, trunk, and legs may be in infantile postures. The back is first rounded with pelvis tilted backwards, like a typical neonate. Rounding of the back may become a kyphosis. Backward pelvic tilt may lead to short hamstrings on semiextended hips and semiflexed knees in this *sacral sitting*. Arms may flex and shoulders hunch tensely as a child avoids falling (Fig. 9.110a). An older child may grasp a support near their flexed arms. If sacral sitting with rounded back is excessive, the child attempts to hyperextend their neck to avoid falling forwards and in order to look up. The atypical postures are on the floor or on a stool.

Treatment suggestions and management

Children in GMFCS level V need fully supporting special chairs with head supports and orthopaedic consultation for trunk orthosis or fixed deformity. Physiotherapy is included to mobilise hips and strengthen trunk muscles.

To train vertical head control, give full body support by holding the child's shoulders or under the axillae. Vertical head control may also be activated with the forearms onto a table as the therapist holds the child's upper arms for support. This develops any of their shoulder girdle stabilisation, which activates head control. The child may need to lean forward against the rounded table edge for additional support.

Carry out any relevant methods suggested in Figs 9.92–9.95 but *giving support* to the child's shoulders and trunk and emphasising vertical head control. Correct asymmetry by holding both shoulders and facing child for communication. Train active head raise from a backward drop by bringing the shoulders or upper arms forward. Correct a forward drop by stimulating head lifting from the chest as you pull the shoulder girdle backwards. Lifting of the head to the vertical and holding the vertical posture prepares a child for eating and drinking and improves breathing.

3–6-month normal developmental level

Common problems

Delay in supported sitting so that specially adapted chairs are needed from 6 months. Delay in looking up, down, or around without disturbing balance. Delay of back straightening from the dorsal area to the whole back; delay of sitting propping on hands on the floor or on forearms on the table without some external support. Delay in re-erecting from lean to upright position (5–6-month level). (For delay in overcoming head lag in pull to sit, see section 'Supine development'.) An older child may still be in W-sitting on the floor (Fig. 9.110d). Ring or tailor sitting with arms propped is used by some older children.

Atypical performance. The therapist can observe or anticipate additional individual atypical postures, including the persistence of the atypical postures from 0 to 3 months. Any atypical posture may require a therapist's manual support at this level. Postures are individual, as follows.

1. A child may lean forward and prop on their fists rather than hands for support. More weight may be taken on the less affected arm or hip, especially in hemiplegia. The arms are sometimes tensely extended and internally rotated with

poor shoulder stability. Head may be hyperextended with chin poking.

2. When a child leans back against their chair, their head extends, their arms may be held up in abduction at the sides with shoulders hunched, neutral, or retracted (Fig. 9.110c). With head extended a child may persist in earlier asymmetrical head and limb postures such as an asymmetrical tonic neck arm pattern. The child may be able to centre the head and lift arms forwards at 45–90° in the air with elbows straight, shoulders hunched in an effort to counterbalance the backward fall or excessive extension. The feet may plantarflex to reach the ground for support or, if the ground is near enough, the toes flex to 'hold on' and the feet may press into valgus for support (Fig. 9.110c). The child is unstable.
3. Some children have overcome their *extensor thrusts* or extensor positions by sitting in excessive flexion. They may even collapse forward with trunk floppiness once extensor stiffness has been overcome by them or by therapy. With no postural stabilisation, the child has no sitting. Many children achieve a position somewhere between full flexion and extension. The falling backwards or stiff extension may remain *in the hips*, but trunk and arms flex and the head extends. The pelvis is tilted backwards and knees bent as hamstrings are in a shortened position. If the child's knees are extended in long sitting on the floor, the child may fall backwards as the hamstrings do not allow this full extension. Less severe children can maintain long sitting with their pelvis tipped back, knees semiflexed and weight on hips and heels (Fig. 9.110a). At this stage, support is usually needed either against a wall or leaning on one or both arms. In the next stage, this posture is maintained without support.
4. A child sitting in the corner of a sofa, on the floor, or on a chair which is too high may stiffly straighten, adduct, and internally rotate their legs in sacral sitting with rounded back. On a child's chair they may find it easier if knees are flexed with feet in plantigrade position. The flexed knees posture decreases the pull of short hamstrings and so tips the pelvis forwards to sit on the buttocks. Upright sitting begins to develop with trunk support. However, knee flexion deformities are particularly threatening, so avoid prolonged sitting on chairs. Some children have stiffness in the trunk, often on one side only. Scoliosis together with torticollis may then be present. Rounded back or kyphosis is also present.
5. If there is much instability, as in a child with dyskinesia or quadriplegia, the child may strongly bend their knees over the edge of the chair, twisting their legs around the front legs of the chair or fixing them against the chair legs to avoid falling. Head and trunk may bend forwards to avoid backward falls.
6. Sitting on the floor with the bottom between the feet and the legs internally rotated and flexed is often seen in a child with cerebral palsy – *W-sitting* (Fig. 9.110d). At this level the child supports themselves on their arms.
7. If a child at this developmental level tips forward from sitting and cannot yet save themselves on their arms, this increases any fears of falling. Arm saving forwards develops between the 4- and 7-month typical developmental levels.
8. A child may sit more on their better side or have stiffness in their trunk. Scoliosis with or without torticollis is present. Round backs may remain unfixed or become a kyphosis. Kyphoscoliosis may develop if a variety of sitting and supported standing postures are not introduced.

The atypical postures above are compensations for lack of postural control, associated with short spastic muscles and asymmetry. *Prolonged sitting* in any one posture causes deformities of the pelvis and limbs, which interfere with standing postures and walking patterns. The need for adequate arm propping and the presence of atypical trunk postures interfere with use of the hands.

Skin pressure points and tissue trauma are likely when a child cannot ask or is unable to change their prolonged sitting posture.

Treatment suggestions and management

Specially adapted chairs. Children aged 7–10 months in GMFCS levels III–V need such chairs for delayed sitting and to correct atypical postures. Hand function and communication can also be promoted. Development of sitting itself involves training without the special chair.

Atypical postures of head, trunk, arms, legs, and feet are often corrected at the same time if the child sits on *both* buttocks (ischial tuberosities), leans forward from the hips against a rounded table edge support, propping on forearms or straight arms and grasping a fixed horizontal bar on the table. The table may need to be at the child's shoulder level and this support is lowered to waist level and finally removed near the end of the next levels (6–9 months). Make sure the child leans forwards from the hips with back kept straight, chin in. Help them by pressing your hand on the small of their back, if they cannot manage alone. Feet should be supported on a firm surface. Legs need to be held apart for a wide base and turned outwards if they adduct and internally rotate. When a child sits on a chair with the feet flat on the ground, improve stability by training them to push their feet downwards into the ground. Support them at hips, if necessary. Once this posture is achieved it is a functional position for feeding, communication, and various hand functions.

W-sitting. (Fig. 9.110d) This is one way in which an unstable child can fix their pelvis and develop head and trunk control in preparation for hand function. Although this posture is seen in typically developing children, it is not held for the many long periods which children with cerebral palsy persist in doing. Tightness of hip, knee, and feet may then develop, if a greater variety of sitting positions and standing frames are not used. Help the child learn how to get out of W-sitting, so that there is more variety in sitting on the floor and changing to other positions.

Equinus and valgus deformities of feet. Minimise or correct them to obtain plantigrade feet, which are extra supports for sitting balance. Use orthoses or special foot supports on a chair.

Hip and knee flexion deformity. Vary sitting positions. See section 'Flexed knees'. Use standing frames and prone lying on wedges as well as sitting postures.

Scoliosis. Make sure the child sits equally on both buttocks. Assist reaching overhead on the side of the concavity as you support sitting and later with less support. Sandbags or a roll of towels on the table under the forearm on the side of the concavity, or under the buttock on the side of either the concavity or convexity, should be tried to discover which props the child into alignment.

Kyphosis is improved by the height of a table and training postural stabilisation in alignment with and later without support. Encourage or assist both arms reaching overhead in supported and much later in unsupported sitting. Check that any habitual head hyperextension, secondary to

kyphosis, is corrected. Both the kyphosis and the head position can be corrected by motivating a child to reach forwards, just above the horizontal while keeping the chin in at the same time. Trunk orthoses or special supports in chairs are needed for many severe children with scoliosis or kyphosis.

Excessive hip, trunk, and head extension is corrected within the chair-sitting posture above, as well as having the child learn to sit on low chairs or in the corner of the sofa or room. Keep hip and knees flexed, feet flat to stabilise a child with dyskinesia or ataxia. Carry the child to a seat in full flexion, to counteract severe extension, just before they are placed into special chairs.

Flexed knees. When knees are habitually in flexion, straighten knees on an inclined leg support, which can be incorporated into a special supporting chair, particularly a floor seat, with trays for various hand activities. Vary the angle of the incline according to the ability of a child to keep their pelvis level, without rounding their trunk. Also make sure that the pull of tight hamstrings is not causing rounding of the trunk. In less severe cases a small raise onto a platform for a floor seat is required. Use knee gaiters for flexed knees. Develop postural control with straight leg down the incline of a large floor wedge. At this level a child needs some support in these postures, but the control improves in the next levels.

Note. Side sitting should be avoided if there is a threatening hip dislocation in one hip or there is too much flexion in the child's hips and knees as well as the atypical adduction and internal rotation. Feet need to be checked in case they are in atypical postures in these sitting positions.

Leg adduction and internal rotation. Correct this position using supported sitting with legs apart and turned out on either side of large toys, a box of toys, bowl of sand or water, a small drum, straddling rolls, soft toys, the corner of the bed or chair, and across your hip or thigh. Avoid having a child straddle anything of too great a diameter as they then increase hip internal rotation with such excessive abduction of the hips. Abduction splints may have to be worn during supported chair sitting for better hip posture. Sit behind a child on a roll supporting them with your body, gradually remove this support, and hold waist or hips. An older child can practise pushing their knees apart themselves using their hands or by having their hands on the floor or lower legs, pushing their legs apart with their forearms.

Sequence of training. This may vary in individuals. Sitting on a child's chair may be achieved before sitting on the floor in children with dyskinetic (athetoid) or mixed types of cerebral palsy. *Involuntary movements* are decreased if a child pushes their own weight well onto their heels. Try tying ankles to a regular chair with sides or in foot pieces with straps, if this does not stimulate involuntary movements in the rest of the child. Grasping and leaning well onto forearms often helps. Train head and upper trunk control supporting lower trunk and pelvis.

In most sitting postures a child develops postural control by first leaning forwards, then they re-erect to the upright posture where more control is needed. A young child leaning forwards in sitting on the floor with the legs flexed–abducted–externally rotated for a wide base to cope with gravity as they play with toys, their feet or pull off socks. Reaching down is initially more achievable than reaching up in sitting.

In an individual, use a horizontal stick grasped by the child with both hands and straight elbows to correct flexed arms, asymmetry, or shoulder retraction, or to

control involuntary arm movements (Russell and Cotton 1994: p. 304; Tatlow 2005).

Additional suggestions are as follows.

- Tailor sitting or ring sitting, with lower trunk supported, corrects inwardly rotated, adducted, and extended legs. This may be used for ball play provided that the child does not have excessive knee and hip flexion tightness and round back. Support head and trunk in a floor seat and tray to correct back rounding and poor arm reaching out due to delay in development of postural control. Ring sit is for symmetry.
- Carry out any relevant methods given in Figs 9.92–9.95 but give adequate support at this stage so that a child can develop stabilisation of the head on the upper trunk. Later, with further training of sitting (6–9-month level), support is lowered to the child's waist and later to the hips, thighs, and then feet. Hold the child's shoulders or body with a slight forward lean for vertical head control. For communication, encourage head hold in the midline with eye-to-eye contact (Fig. 9.95).
- Also train a child to sit on a downward incline of a floor wedge in long sitting to promote straighter back and legs. Knee gaiters may be used to assist knee extension. Correction of a round back is similar to that obtained by the forward seat incline in an adaptive chair (Fig. 9.106c). Sitting with a 20° forward lean is a functional posture for daily activities such as feeding, removing top clothes, and other hand functions at a table.
- Tip a young child while carrying them on your hip. Encourage them to actively come up to the vertical. Holding a young child in against your chest, tilt them playfully from side to side to songs. Give them time to readjust their head or head with upper trunk to the vertical. Gradually move them away from the support of your chest during the song to see if they still manage to adjust themselves. They may not be ready for tilting on a therapy roll but might enjoy being in a special chair seat for a swing. Moving through space gives both visual and vestibular experience.

6–9-month normal developmental level

Common problems

Delay in acquiring independent or even momentary sitting alone, as a child still needs to use one or both hands for support. They cannot then use their hands for other functions. Some children at these levels may achieve sitting alone but cannot yet use their arms and hands or they fall over. This is due to a delay in the postural adjustment or counterpoising of the body for use of limbs. Some children who are delayed in sitting can lean on one hand while using the other. They may manage to grasp a bar attached to a table and begin to use the other hand first on a table surface and later above it to waist level. Individuals vary in their achievements at these levels.

Special chairs with tables are still needed to support a child's body due to a delay in achievement of sitting alone or when using hands.

There is also delay in re-erecting to the upright from backward, forward, or side-leaning positions.

Atypical performance may be as follows.

1. Atypical postures in sitting, which are carried out *without* support to the child (Fig. 9.110a–c).
2. Atypical patterns of arm reach in sitting are associated with poor postural adjustment (Fig. 9.111).
3. A child may not have saving responses if tipped sideways and forwards.

Figure 9.111. Absence of postural adjustment for the arm movement. This may lead to a dynamic scoliosis. The table is too high. The object is too high for the child.

Figure 9.112. Use of grasp for support and lower table to assist until counterpoising (postural adjustment) develops for arm elevation.

Treatment suggestions and management

Sitting on a thick cushion, or inflatable seat on the floor, may give a child more stable sitting, first with support at the mid or lower trunk and then at the pelvis and finally without support. This is useful for play or when sitting alone has been achieved.

Various methods of giving and reducing support. Figures 9.92 and 9.95 show how this is done. Continue to correct atypical postures using methods from the 3–6-month normal developmental level.

Additional suggestions for sitting development are as follows.

- See supine development for methods to develop rise to sitting.
- Upright sitting, with hands propped at sides, is trained, and begin trunk turn to look behind. However, this cannot yet be combined with reaching to the side or behind, as the child will fall.
- Use methods for sitting with the child using *one leg or arm movement*, such as stretching a limb up in the air to receive clothing, a shoe or sock, kick a ball, or place one foot on a foot stool or even on the seat of a chair. The child now has adequate pelvic and trunk control for these activities. Sitting balance is best maintained with back support if both hands are used or without back support but *with* the child's own hand support (Figs 9.112–9.114). These positions may be used in daily activities such as dressing, brushing hair, and washing with one hand grasp, propped or leaning onto a table. Later do this without support (Fig. 9.114).

9–12-month normal development level

Common problems

Delay in acquiring sitting steadily (for about 10 minutes) without support on the floor and on a normal chair; sitting and

Figure 9.113. Leaning on more affected arm during counterpoising improves stability of that arm as the more skilful arm is used. However, develop arm movements of the more affected arm so that counterpoising is activated on each side.

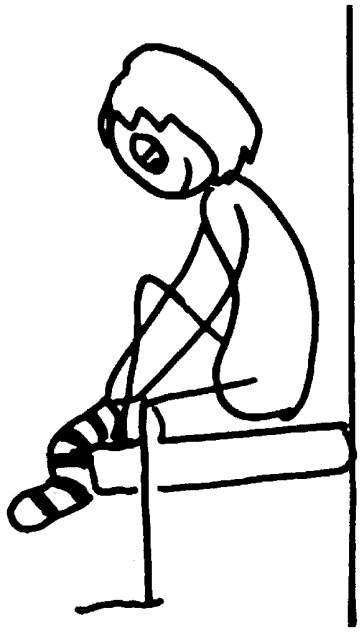


Figure 9.114. Counterpoising (postural adjustment) during daily living activity.

playing without loss of balance; sitting, turning, and reaching out or up without falling; changing from one sitting position to another or to lying; to crawling or sit change to standing. Delays in transfer from wheelchair to bed or chair to chair. Delays in sequences of any change of position, from and to reassume sitting. Delay in positive tilt reactions sideways, forwards, and backwards, in saving reactions of the arms in all directions including backwards. If these reactions are absent, sitting is insecure on any moving surface. A Moro reaction or startle occurs instead of backward tilt reactions. Delay of sit and pivot, of sit and reach across the body, to side and above a child's head. Bottom shuffle is delayed in children who will use this locomotion.

Atypical performance as described in atypical postures in sitting, but carried out *without* support. Stiff, jerky, unsteady, or slow patterns may exist when rising to sitting and changing positions. Unusual patterns of rising devised by a child are acceptable if no other patterns are possible (Fig. 9.70).

Treatment suggestions and management

Use the methods shown in Figs 9.92–9.105, but encourage an increased variety of arm patterns in play and daily tasks, and without supporting a child. Encourage them to reach overhead, across their body, and behind their body. Use both arms simultaneously to reach and hold a ball, reach to touch a familiar face, or for dressing (Fig. 9.104). Specific arm patterns correct atypical trunk postures, for example the child's arm elevation corrects kyphoscoliosis; arm abduction and external rotation and trunk turn with reaching behind a child correct round backs. You may need to hold the thighs for initial support and a child may use one arm support or grasp while using the other in particular activities

(see section 'Development of hand function'; see Figs 9.176–9.183).

Changing postures into and out of sitting position or rising reactions. This can be achieved as follows.

1. Rise into sitting from supine or prone (see sections 'Prone development' and 'Supine development'). Grasp the child's arms or hands if needed.
2. Rise from sitting to standing up from a chair or the floor (see section 'Development of standing and walking'). Initially grasp the child's arms or hands if needed.
3. Sitting on the floor with legs in front of the child, change to prone. The child either places their hands in front of them, between the legs, or to one side and goes down to lying, or the child places one or both hands to one side and moves into side sitting (Fig. 9.115). Help a child learn to change from floor sitting to prone kneeling (crawling position) and back again to sitting.
4. Train the child to get on and off low wide benches of different heights (Fig. 9.116) and then onto chairs (Fig. 9.117). They often need to reach out and grasp chair arms or backs, and to lean on the seat, the back of the chair, or the table nearby.
5. Train children to get in and out of a wheelchair, in and out of a car, toy pedal car, and on and off a tricycle. Enable children to transfer from bed to chair using the child's own arm support and from chair to standing holding on and later without support. Weight bearing on arms for transfers strengthens arms and shoulder girdles.
6. The therapist either moves the child's leg (or legs) or arms, allowing the child to pivot their body. Move one of the child's hands on a table to allow them to move the other arm in the pivot. Try pivot training on each side, so a child can get in and out of seats. Sitting on a stool/box and completely swivelling around on a stool/box is a useful ability for both transfers and independence (Fig. 9.118). Pivoting needs to incorporate the child's active leg abduction, arm action, and postural adjustment.

Figure 9.116. Child learning to get onto a low wide bench.

Figure 9.115. Changing from sitting to side sitting and back again. Change from side sitting to four-point postures or to lying.

Figure 9.117. Getting on and off chairs of various heights and widths.

Figure 9.118. Pivoting on a chair.

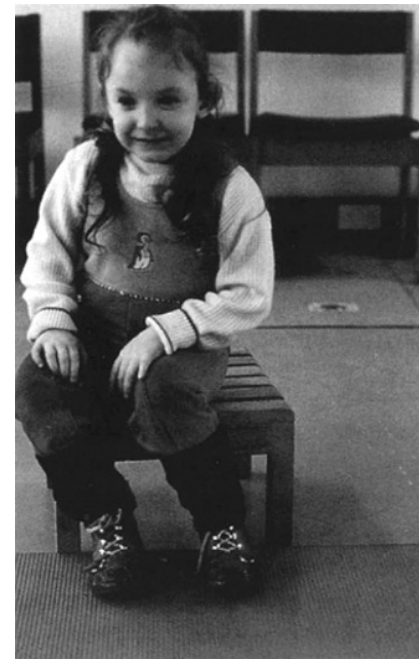


Figure 9.119. Sitting with 'windswept' legs to one side. A mild example that may be much more severe in other children.

Enabling a child to achieve a variety of postural changes can simultaneously involve correction of unfixed deformities such as separation of adducted legs, use of trunk strengthening, improved arm support, and extension of bent elbows. Open hands and bent elbows are corrected by active reaching out and grasping supports or leaning on lower tables. Body rotation patterns are used and these together with other aspects appear to reduce hypertonus and lengthen and strengthen muscle groups.

It is easier for a child to go down to lying from sitting first, before having to learn how to lift themselves up against gravity, to sitting from lying *if* rotation is used. It is not so when straight patterns are used for lying down as a collapse into lying may happen. Slow control of lying down demands more muscle control.

- Practise as many different sitting positions as possible: side sitting (Fig. 9.115); sitting with one foot flat on the ground, the other bent or straight; sitting with both knees bent and feet flat on the ground (crook sitting); sitting in various types of chairs of the correct size and in adult chairs if the child is correctly placed and has adequate balance. Sitting on a high chair or on a bed with legs dangling with no foot support is an advanced posture. Therefore, avoid training sitting on a plinth with feet dangling in early stages.

  Remember. Some children stabilise better on one side of their hips or trunk and prefer to sit sideways onto one buttock. This is obvious in children with hemiplegia (unilateral cerebral palsy) but also in asymmetry in bilateral cerebral palsies. There are also *windswept* legs to one side (Fig. 9.119). Scolioses and pelvic obliquity may result from persistent asymmetrical weight bearing in sitting. If a child can only use one hand or one visual field, this also increases asymmetry in postural stabilisation and

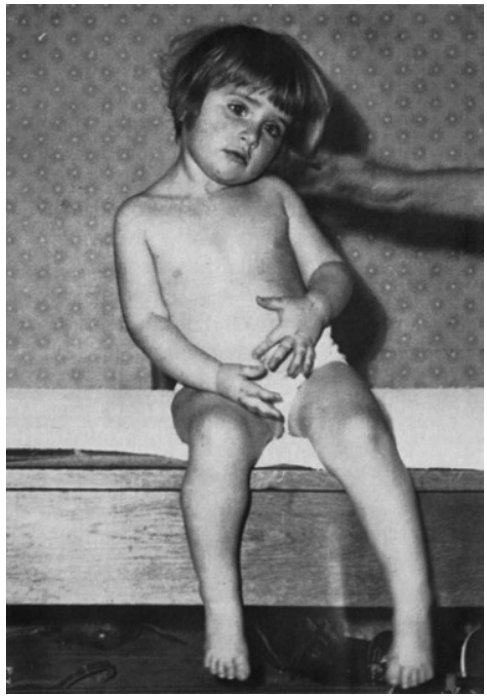


Figure 9.120. Lateral weight shift stimulated by push-off from the vertical. A more vigorous push of a child's pelvis/hips well off the horizontal plane stimulates the tilt reaction. If the child falls, saving responses in limbs are activated.

counterpoising. Avoid side sitting to only one side in these children as windswept legs become associated with dislocation of the internally rotated hip. Special chairs use knee blocks for correction of trunk, pelvis, and windswept hips.

- Augment sitting with manual resistance given laterally, with one hand in front and the other behind to resist rotation and your hands on the anterior and on the posterior aspects of the child's body (Fig. 9.105). ('Stay there' or 'Don't let me push you over'.)
- Postural adjustment during weight shift as well as tilt reactions and saving reactions in the limbs are all stimulated by slow and by quick pushes (Fig. 9.120). Develop tilt responses and a sense of security in sitting by use of rocking chairs, rocking horses, swings, see-saws, a vestibular rocking board, rocker boat, or inflatable toys. Play 'see-saw' games on the parent's lap or body. Pony riding and horse riding also stimulate tilt responses (Fig. 9.121) and a variety of postural adjustments within a child's base.
- Avoid the use of incorrect size and type of chairs, tables, pushchairs, or wheelchairs and of repeated placement of a child in only one or more poor sitting positions.

Figure 9.121. Riding activates tilt responses.

Development of standing and walking

The following main features should be developed according to an individual's developmental stages.

Antigravity support or weight bearing in an infant is on semisupinated or forefeet when held supported under the shoulders. Legs may stiffen with co-contraction. No head control with head forwards. Pelvic tilt backwards with hips flexed, knees slightly flexed with legs on a small base. Normally present at birth and temporarily absent (3–4

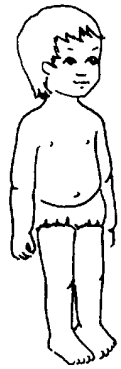


Figure 9.122. Postural stability, head on trunk on pelvis and whole of child in standing.

Figure 9.123. Counterpoising a weight or movement of the arm.

months) in some babies. On tipping the child forwards, automatic stepping is produced and stops at around 2–3 months.

Postural stability of the head and trunk (Fig. 9.122). Supported weight bearing under the axillae is modified when upright head and trunk control develop. At first, the head stabilises on the trunk and then the trunk on the pelvis in supported standing (4–6 months). There is a widening of the standing base, with increased weight bearing, hip and knee flexion, posterior pelvic tilt, and legs increasing abduction and external rotation with pronated feet (5–7 months). Support is still given by the adult while the child takes support onto a table, first on their forearms, then on their hands (7–8 months). At first, the child leans against a table/couch when standing without adult help, then uses grasp or leans on hands (7–9 months) and finally abandons trunk support (8–10 months). The child gradually releases the support of one hand and then both hands to stand alone (10–12 months and more steadily 15–18 months). Arms are held up in 'high guard' abduction–extension for stable scapulae to maintain head and trunk stability for standing and walking alone.

Postural stability of the pelvic girdle in the vertical is first in posterior tilt (0–6 months), then neutral (7–10 months), and then anteriorly tilted between 9 and 12 months in standing holding on and then alone. Also pelvic stability in upright kneeling supported, but only in kneeling unsupported at 15 months.

Postural stability is closely related to counterpoising of head and limbs.

Counterpoising or postural adjustment in the standing position holding on and removing one hand (Fig. 9.123), holding on lifting an arm overhead, holding on, trunk turn, and also bend down to reach a toy with one hand. A child also holds on lifting one foot (10–12 months). Later they lightly touch a bar without holding on or manage alone to carry out these counterpoising actions (12–18 months). The postural control and counterpoising become more varied in the second and third year of life, until the child stands on one foot, not holding on (2½–3 years). Standing on one foot is a most important counterpoising action. The

child can then take weight on one leg for long enough to allow the other to step sideways in cruising or later to swing through and step forward or backward with and without hands supported. The child prepares for one foot balance by weight shift within the base holding on (7–9 months) and with less hand support increasing the amount of weight shifts outside the standing base (9–12 months) for cruising holding on.

Control of anteroposterior weight shift of the child's centre of gravity to initiate walking (propulsion) and to stop (retropulsion) first with both hands held, then with only one hand held, and then alone using a number of the postural controls outlined. Later the child steps in a diagonal direction and in turning (levels 12–24 months).

Control of lateral sway from one foot to the other. This is developed further in cruising with lateral stepping as well as when walking with each hand held laterally by adults. At first the child steps forward and laterally when held by adults or holding onto the sides of furniture or bars (12 months). Lateral sway is very obvious in toddlers and becomes modified with development.

Rising reactions and actions (Fig. 9.124). This is learnt from lying (prone and supine) to standing, from squatting or from sitting to standing, and from kneeling to standing (levels 7–10 months). Support using the hands precedes rising without support. Around 7–8 months a child may pull to stand but be unable to return to the ground, calling for help to do so. Toddlers finally learn to drop to sitting on their bottom without much concern. Other rising abilities have already been discussed in the sections on prone, supine, and sitting development (see also Fig. 9.165).

Tilt reactions in standing are anteroposterior and lateral and later diagonal. They are acquired after standing and walking alone. Tilt reactions are not essential for walking. However, children without tilt reactions will be unsure, especially in the dark and on rough ground.

Perturbations of a child in standing. Nashner et al. (1983) have shown in their studies that the sequence of muscle activation in a child with cerebral palsy differs from that of a typical child. Nevertheless, such a child with cerebral palsy does not fall over. Nashner et al. (1983) have also demonstrated slower timing on the spastic side than on the unaffected side in childhood hemiplegia (unilateral cerebral palsy).

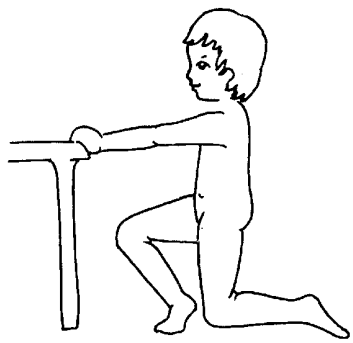


Figure 9.124. Rising to standing.

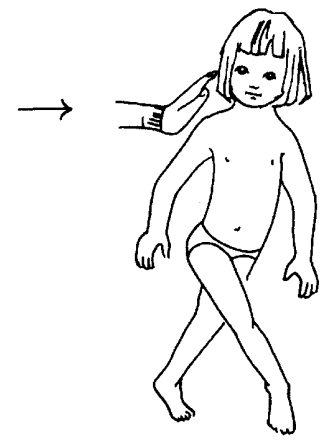


Figure 9.125. Saving from falling with a protective step.

Saving from falling (Fig. 9.125). If pushed from behind the child will first bend forwards, adjusting the pelvis backwards in response to a slight push, but if push is more vigorous the child takes a protective step forwards to save themselves from falling (staggering). Responses are present in all directions. Later small lateral hopping may be used. A child also flings out their arms in protective (saving) reactions. Normally these develop at 12–24 months of age. They are important as the child will have less fear of falling if they can protect themselves, and may then become willing to walk.

See the stages in the development of standing and walking in Figs 9.126–9.137.

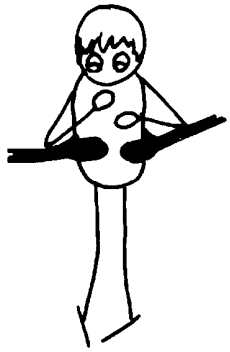


Figure 9.126. Weight bearing on legs (supporting reaction) (*0–3 months*). Body held.

Figure 9.127. Automatic stepping if the infant is tilted forwards, body held. (*0–3 months*).

Figure 9.128. Sinking or astasia (*3–6 months*). Head control.

Figure 9.129. Trunk supported standing and bouncing in standing (*5–7 months*).

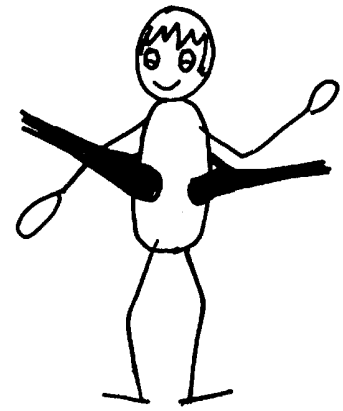


Figure 9.130. Supported standing (*5–7 months*). Weight bearing of legs.

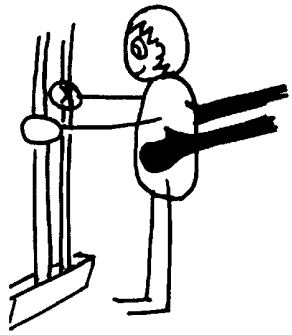


Figure 9.131. Stand holding on to support with pelvic support (*7–9 months*).

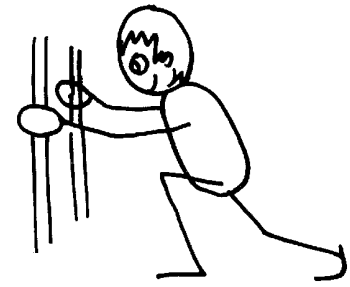


Figure 9.133. Pull up to standing from various positions (*9–12 months*).

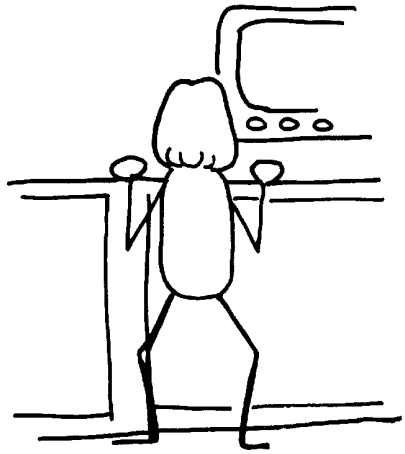


Figure 9.132. Stand holding on to furniture (*7–9 months*). Begin weight shift.

Figure 9.134. Standing holding and lift one leg off the ground or one arm released (*11 months*).

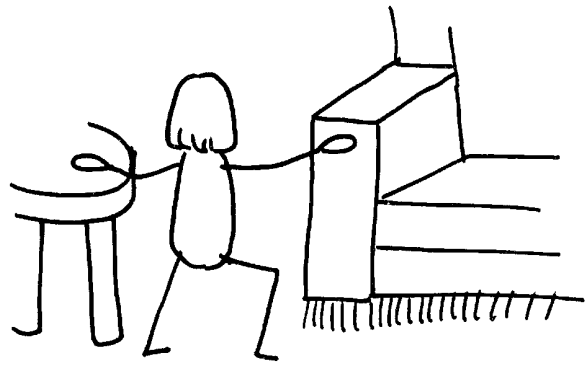


Figure 9.135. Cruising (lateral stepping) (*9–12 months*).

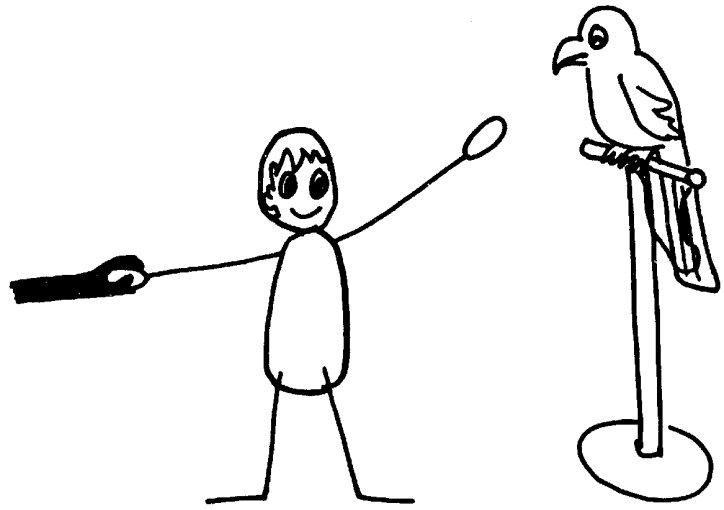


Figure 9.136. Stand supported, reach in all directions (*9–12 months*). Weight shift.

Figure 9.137. Stand alone and walk with two hands, then one, and then no hand support (*12–18 months*).

Prognosis for walking

Montgomery (1998) reviewed seven studies identifying predictors of walking (ambulation). Walking was acquired between 3 and 9 years and was unlikely afterwards. Sitting by 2 years and crawling by 2½ years were strong predictors, but some children who only sat by 4 years did eventually achieve walking. Children with *obligatory* primitive reflexes at 2 years were most unlikely to walk.

Clinicians need to avoid being dogmatic that if a child does not sit by 2–3 years that child will not walk. Other studies have different views, as follows.

Wood and Rosenbaum (2000) have used the GMFCS as a prognosis for walking. However, as mentioned in Chapter 1, individual children can change by one or more levels. In addition, this classification gives only an approximate prognosis, as there may be other non-motor impairments that interfere with motor functions.

Wu et al. (2004) determined the probabilities of walking at ages up to 14 years by using records for a total of 5366 children who could not walk (with or without aid) at age 2–3½ years. They found that children who do not roll by the age of 2–3½ years (GMFCS level V) have about a 10% probability of walking (with or without aid) by age 14 years. Those who can roll but not sit by age 2–3½ years (level IV) have about a 40% probability of walking (with or without aid) by age 14 years, and these children include about 10% who walk well alone. Those who can sit but not walk by age 2–3½ years (levels II and III) have about an 80% probability of walking (with or without aid) by age 14 years.

Beckung et al. (2008), in their study on 9012 children in Europe, found that the probability of walking by 5 years old is related to the type of cerebral palsy, intellectual impairment, severe visual impairment, and active epilepsy.

The National Institute for Health and Care Excellence (NICE 2017) guideline recommends the following information be given to parents or carers about the prognosis for walking for a child with cerebral palsy.

- The more severe the child's physical, functional, or cognitive impairment, the greater the possibility of difficulties with walking.
- If a child can sit at 2 years of age it is likely, but not certain, that they will be able to walk unaided by age 6.
- If a child cannot sit but can roll at 2 years of age, there is a possibility that they may be able to walk unaided by age 6.
- If a child cannot sit or roll at 2 years of age, they are unlikely to be able to walk unaided.

This was based on the studies by Trahan and Marcoux (1994), Wu et al. (2004), and Beckung et al. (2008).

Begnoche et al. (2016) studied which factors predict walking in children with cerebral palsy between 2 and 6 years old in GMFCS levels II and III who were initially not walking. They found that mean scores for functional strength, postural control, and reciprocal lower limb movement were significantly higher for walkers than for non-walkers. However, they concluded that a measure of functional strength and dynamic postural control when transferring from sitting to standing may show readiness for independent walking.

Prognosis for walking to adolescence and adulthood

Beckung et al. (2007) comment that children had the greatest achievement of walking at 9–10 years using the Gross Motor Function Measure, but between 10 and 15 years there was great variability on maintenance of walking.

Details of studies after childhood are presented in the section 'Studies of function in adolescents and adults' in Chapter 4.

Treatment and management at all developmental levels

Aims

1. *Develop postural mechanisms*. Emphasise stability and counterpoising with weight shift and postural alignment in functional standing *first, and also* in phases of gait for a child learning to walk or already walking alone with an atypical gait. A number of atypical gaits involve compensation for poor postural control in standing.
2. *Correct atypical postures and movements as much as possible in the context of standing and stepping*. See Chapter 12 for further details on deformities and gait.
3. *Assess and select appropriate* designs and sizes of standing equipment, orthoses, and walking aids according to the individual. See Chapter 13.
4. *Bone density problems need early use of appropriate standing and walking frames*. Bone density is due to delayed or less weight bearing, nutrition, and some medications for epilepsy. Medications for bone density need to accompany therapy.

The physiotherapist needs to take particular care with selection of techniques according to the abilities of others involved in the management of the individual. Some parents or carers are highly motivated to teach standing and walking and need to learn that they train at a child's individual pace.

Note. Weight bearing and stepping are not walking. Children who are able to bear weight and step needing trunk support for balance are really at the 6-month normal developmental level. These children are frequently

the ones who need support on the chest and lower trunk in walking frames. Some children, mainly with dyskinesia, will use a walker on wheels to run headlong, but are unable to stand alone, having not yet developed the postural stability of head, trunk, and pelvis of later developmental levels. If children with ataxia use wheel-walkers, they stagger in all directions. The training of standing and walking in such children should concentrate on their next levels of development, which build up trunk and pelvic control.

0–3-month normal developmental level

Common problems

Delay in taking weight on feet, when fully supported under shoulders. Poor head control, round back with pelvic posterior tilt, and semiflexed hips and knees. Reflex stepping (primary walking) if tipped forwards until 2 or 3 months. In some normal babies there is a temporary loss of weight bearing (3–4 months), which may perhaps be due to increasing weight of a baby on legs that are too weak to support it (Thelen et al. 1989). Sole contact may also include grasping reflex of the foot on the ground, which is normal until 9 months.

Atypical performance. This is as follows.

1. There may be an excessive antigravity posture onto toes with stiff straight knees in a 'pillar of support' with legs adducted or crossed (scissoring).
2. When fully supported, there may be various atypical stepping reactions as each sole of the foot contacts the ground. There is an *athetoid dance*, when each leg jerkily withdraws outwards with each foot everting. One leg may exhibit a *pawing* repetitive involuntary motion.
3. Excessive infantile *crossed extension response* apparently like the jerky high-stepping pattern seen in older children as the other leg rigidly extends as its sole contacts the ground. This is similar to the automatic stepping above but more obligatory.
4. Withdrawal reflex of both feet on contact with the ground, as opposed to alternate leg withdrawals.

3–6-month normal developmental level

This is the level at which some typically developing babies may not take weight in standing but sag (abasia) and infantile primary stepping is no longer present (astasia). Children with cerebral palsy also sink down without weight bearing for a period. The children may be at this developmental level, which is due to weakness and absent postural stabilisation. Later this is augmented by short hypertonic flexor muscles.

Treatment suggestions and management for both 0–3- and 3–6-month levels

Increase weight bearing on both feet. Develop weight bearing on plantigrade feet with a fully supported child, which counteracts delay as well as the various atypical reactions to foot contact with the floor. Manual extension of a child's legs assists weight bearing. Trunk support, or trunk and pelvic support, is needed at this stage. Encourage head and upper trunk control, which may have been achieved in sitting development between the 3- and 6-month levels.

The methods with *full* support at this level are as follows.

1. Periods of weight bearing in prone standing frames with tables at upper chest level.
2. Desensitise soles of feet by weight bearing on feet with heels pressed down in sitting, squatting, and then in standing. Use shoes and various floor surfaces, sponge rubber, or a trampoline to find which the child can tolerate. The

incline of a *prone stander* allows partial pressure of a child's weight on their feet and promotes toleration of a firm surface on the soles.

3. Prone standers are used to correct postures of trunk, pelvis, and legs. Select support and correct positioning elements for each child. Miedaner (1990) suggests a 20–30° incline for an appropriate posture.

Prone standers or inclined frames do not train standing itself, but correct postures and desensitise soles of feet. Upright positions in standing frames are needed to train correct postures in later stages.

6–9-month normal developmental level

Common problems

Delay in weight bearing with flexible knees, if supported, in active *bounce* when held in standing, and in reciprocal stepping (not automatic high stepping), if held. Delay in achieving upright pelvis and straighter trunk (Figs 9.129–9.132).

Atypical performance. Atypical postures are likely to be seen from this level on, that is, from the 6–12-month normal developmental level.

Atypical postures in standing (Figs 9.138–9.141)

These may be due to the following.

Absence of postural stability. The child may be able to maintain equilibrium, even inadequately, by attempting an atypical posture to compensate for this absence (Figs 9.138–9.141). They may show the following symptoms.

1. *Sinking* into hip flexion, knee flexion, and dorsiflexion.
2. Adduction–internal rotation of the legs.
3. Lordosis may compensate for hip flexion.
4. Round back and head flexion or head thrown back and chin poking.
5. Feet in valgus or in overdorsiflexion. If overdorsiflexion is limited by tightness of the ankle or plantar flexors, the child may stand on their toes.
6. *Children with dyskinesia* compensate for a tendency to fall or for their precarious backward lean, with head flexion, chin poking or head stiffly rotated to one side, hip extension, knees semiflexed or hyperextended, valgus feet. The arms are initially held stiffly extended backwards or in an asymmetrical pattern when the child is supported from the back. When standing alone, arms are brought forwards and up in the air or clasping

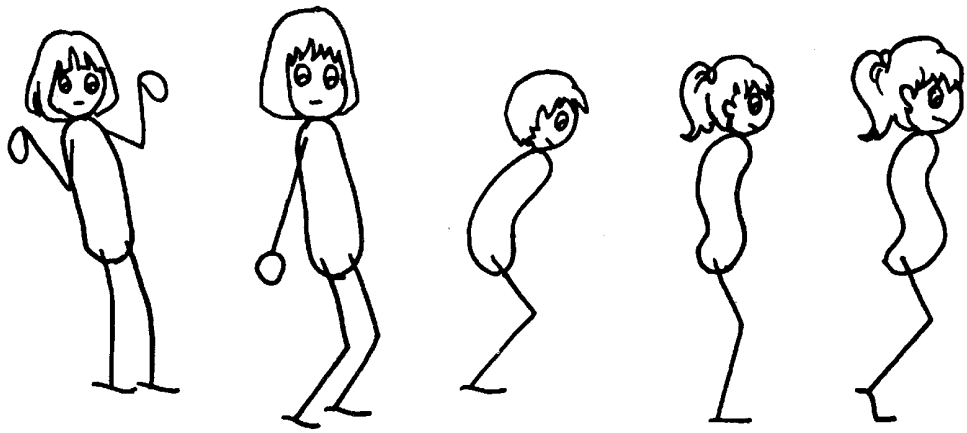


Figure 9.138. Falling or extending backwards is compensated by hip and knee flexion and adduction, lordosis, valgus, overdorsiflexed feet, or plantarflexion.

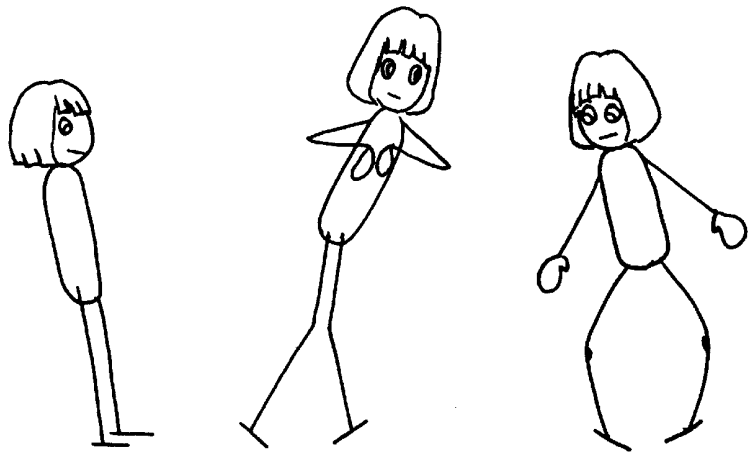


Figure 9.139. Compensation for lack of postural stability (and thus falling backwards) by flexion–adduction of the hips and knees and pronation of feet, wide base, or by hyperextension–abduction–internal rotation of knees, wide base, pronated feet.

Figure 9.140. Compensation for lack of postural stability and/or counterpoising in standing and/or standing on one foot by use of hand grasp or *walk on hands* for support. Children increase spasticity in their arms if they flex and grasp.

hands as additional counterbalance for their body extension behind their feet.

These postures, to maintain equilibrium under difficult biomechanical circumstances, are also seen in typical development with difficulty of balance on slippery surfaces or when first attempting ice skating or skiing. These biomechanical compensations are also seen in young typically developing children before they develop adequate postural stability and postural adjustment for early weight shift.

If a child also has spastic hypertonus with short stiff muscles, they may use that to prop themselves up into the atypical postures above.

If the child has *good* upper limbs or at least a grasp in poor upper limbs, they will use them for support (Fig. 9.140). They bear so much weight on their hands that fatigue of the unaffected arms is common.

(a)

(b)

Figure 9.141. (a) Standing with flexion and asymmetry, and poor postural control. (b) Correction with arms symmetrical elbows extended and both hands either grasping in front, below and in front, or at each side. Equal weight on each leg, head, and trunk in midline, facing mother for motivation.

Fear of falling is naturally appropriate when postural control is so inadequate. Fears exacerbate all these atypical postures.

Asymmetrical postural stabilisation and postural adjustment. The child will take weight on the better side, and the pelvis on the other side with poor postural stability will result in a leg flexion–adduct–internal rotation at the hip, at the knee flexion, and remain propped on the forefoot, or have no weight bearing (Fig. 9.141). An athetoid child may have one leg *pawing* the ground with an involuntary motion.

Scoliosis may compensate for the body weight being distributed to one side only. This asymmetry may or may not also have been seen in other weight-bearing positions such as sitting, kneeling, or standing. Sometimes, it is the postural stabilisation mechanism of the pelvis which fails only in standing, but which may be able to cope at lower levels of development, such as sitting and supported upright kneeling, which provides wider and lower bases than standing on only two feet.

The unaffected side in unilateral hemiplegia obviously takes all or most of the child's weight. The affected leg is usually rotated back from the pelvis. It may be abducted or adducted, internally rotated, knee flexed, straight or hyperextended, and foot flat or in equinus, toes may flex on the ground. If the young child's weight is taken on the hemiplegic leg and the unaffected leg is lifted, the child may collapse or sink into flexion. Lack of postural adjustment for one arm may lead to the child leaning atypically to one side for hand support and balance on the unaffected leg. This creates asymmetrical postures. Presence of tilt reactions to *one* side only may become associated with scoliosis (Levitt 1984: p. 115).

Knee gaiters, knee splints, or long leg orthoses may be used for correcting atypical leg postures.

Absence of protective saving reactions of arms or legs may delay standing in some children because of a justified fear of falling. This absence of saving will create crouching postures as seen in people without cerebral

palsy who fear falling. In addition, absent tilt reactions may make them feel even more unstable and they will increase atypical postures to compensate for this. Postural mechanisms at this level are:

1. Parachute or saving reactions in the arms on falling forwards or sideways (see Figs 9.76 and 9.120).
2. Propping reactions of the arms to *break* the fall onto a sponge rubber surface (see sitting in Fig. 9.84).
3. Tilt reactions in sitting, which may make initiation of standing feel more secure if not directly related to its full acquisition.
4. Presence of toe clenching of the floor in supported standing until about 9–10-month levels is associated with instability.

Atypical postures, deformities, and atypical gaits are discussed more in Chapter 12. A brief review is given below.

1. Unsupported standing or if a child holds on to stand alone.

   Examples of atypical postures of the whole leg or body to maintain a fairly upright posture are the following:
   a. Hip flexion may be dictated by equinus in order not to extend and fall back.
   b. Hip flexion may be dictated by greater knee flexion.
   c. Knee flexion or hyperextension may be dictated by too much hip flexion to avoid falling forwards.
   d. Valgus feet and flexed knees may be dictated by hip flexion–adduction–internal rotation. The feet are apart, wider than the pelvis or not beneath hips. The heel may be down with forefoot in eversion.
   e. Toes may clench and evert.
   f. Trunk may have lordosis, flattening of the lumbar area, kyphosis, or kypholordosis Excessive pelvic tilt backwards is associated with a flat back, pelvic tilt forwards with lordosis.
   g. Hip extension may occur by short hamstrings flexing the knees and tilting the pelvis backwards. A long kyphosis or a flat back may then be associated.
   h. Knee flexion or knee hyperextension may compensate for short, stiff spastic plantar flexors or equinus.
   i. Excessive dorsiflexion may be secondary to excessive hip and knee flexion in a crouch posture. Equinus may instead result if short stiff spastic plantar flexors cannot remain stretched by the excessive dorsiflexion.
   j. Lordosis and kypholordosis compensate for hip flexion.
2. Atypical postures are not only due to the biomechanics of spastic hypertonus but also due to inadequate postural mechanisms controlling balance (Figs 9.138–9.140). The important clue is the presence or absence of postural stabilisation and counterpoising (postural adjustments). In some children, the posture may have normal alignment in quiet postures up against gravity without movement. When voluntary movement is used, these children cannot balance due to a lack of postural adjustment and will compensate with atypical postures. In more severe conditions these biomechanical compensations for poor postural control can even take place during both quiet postures and postural adjustments. Therefore, atypical body alignments are seen during quiet postures against gravity as well as during hand, arm, or leg motion. Body alignment in locomotion is also atypical when poor postural control affects standing.

3. Atypical postures in standing and walking can themselves further disturb balance as they continue to be used during growth.

The child's atypical posture may be different when they are well supported or need to maintain their balance on their own. If well supported, atypical postures in cerebral palsy are similar to those in a typical infant, as described in the following.

Well-supported standing when held by an adult. The components are similar to those of a typical infant held supported under the axillae (0–2 months):

- hip extension or semiflexion, sometimes together with leg crossing
- knee extension
- plantigrade feet or on toes.

Arm and head postures

These are similar to the atypical postures seen in sitting development. However, if the hands are grasped by an adult or the children hold on for support, they may use atypical patterns in arms and hands. The children with hypertonic spasticity usually increase flexion–adduction in the shoulder, shoulder hunching, flexion–pronation in the elbow, palmarflexion with or without ulnar deviation in the hands, and other atypical grasps.

Treatment suggestions and management at 6–9 months with support (Fig. 9.142a–d)

Individual children may use prone or upright standing frames between the 6 and 9 month levels and extended to the 9–12-month developmental levels Children who need to continue training of head control may use prone standing frames to support their trunk, pelvis, and legs. Promote head control and hand function on a table. Severe children (GMFCS levels III–V) who are not at the 6–12-month developmental levels need full supporting upright standers around age 12 months for threatening deformities, especially of the hip. Hip dislocation is discussed in Chapters 12 and 13. For further details of standing frames, see section 'Standing frames' in Chapter 13.

Training methods for development of standing

Make standing interesting with, say, songs, standing at tables of toys, sand and water play tables with other children, as well as watching television.

Remember to smile approval with positive comment for children's own efforts to control aspects of their standing. After all, standing on only two feet is more challenging for children than earlier postures, but the rewards soon become obvious to them in psychological and social benefits.

1. *Equal distribution of weight bearing on each foot. Supported and later unsupported standing according to developmental level. Begin weight shift equally on each foot.*
   a. Check this by the child standing on two weighing scales. Enable them to correct unequal distribution and achieve equal weight bearing on each scale. Also use biofeedback with force plates and visual display for training older children and adolescents (Hartveld and Hegarty 1996).
   b. Head and trunk in midline are first supported and then unsupported if possible.
   c. Assist the child with manual support to waist and pelvis. They may move themselves onto one leg as they place the other on a footprint or picture on the floor. If possible, ask the child to weight shift against your hand placed firmly against the lateral hip, increasing

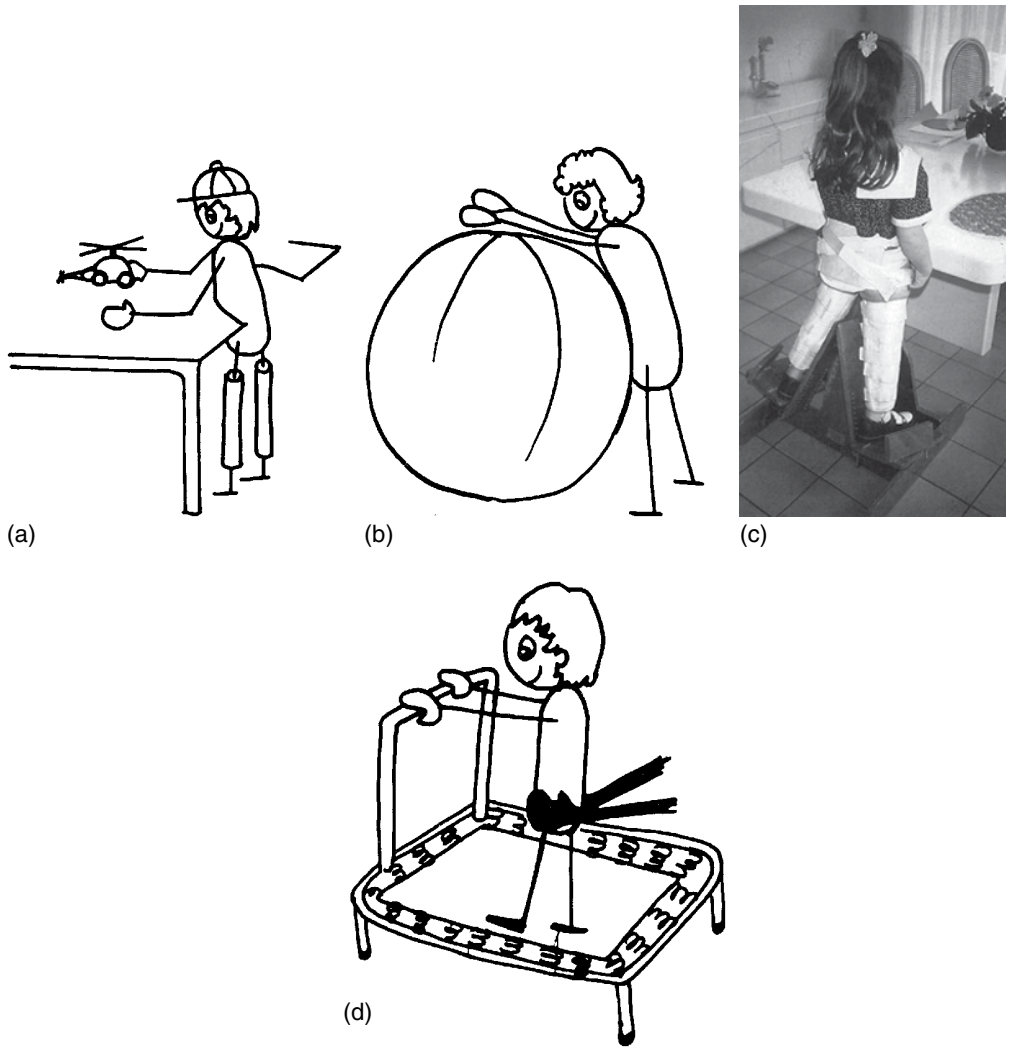


Figure 9.142. (a–c) Child's arms symmetrical, head and trunk central, weight equal on each foot. Keep child's weight forwards onto the feet. The trunk is supported by a roll, a large ball, a table, or a high couch. A table may need to be padded, or have a rounded edge or a cut-out, when children lean against them. Later remove the trunk support and use hand grasp on support, or lean only on forearms, lean on hands on low table. Legs are apart and externally rotated, hips flexed or extended, knees straight, feet flat on the ground. Use orthoses, or splints, according to the child's difficulties. (d) Stand on sponge rubber or a trampoline (*bouncing is restricted*). The trunk may be supported by the child's grasp or your support at the shoulders. Avoid hyperextension of knees and any atypical postures.

manual resistance according to the child's strength. Carry this out initially with support to the child's chest or having them lean on forearms, on hands, or grasping a support with elbows straight. Practise weight shift to free one leg for future stepping. Shift weight from leg to leg using a rhythm. A more able child may practise weight shift holding the hands of a less able child. The therapist will give the less able child physical support.

d. Use a mirror for both you and the child to see that they are in correct alignment with weight on both feet. A white stripe on the mirror gives added visual cue for the midline vertical alignment.
e. Use a wide base and bring both feet together for standing, and then stand with one foot in front of the other to maintain postural control. Do this with and without support.
f. Correct any deformities, especially of the feet, such as equinus, so there are two plantigrade feet for equal weight bearing. Check length of legs in case of growth asymmetries and raise shoe if there is more than 12.5 mm (0.5 inch) difference. This avoids the child needing to take more weight on either the short or the longer leg.
g. Remember to keep the child's weight forwards over both feet and help them avoid any twist or lean backwards. Try *not to have a child lean back* against the wall or against an adult. Avoid a child's arching back in prone and upright standing frames. This aggravates the tendency to fall or extend backwards when developing standing ability.
h. Practise standing the child in a corner with a stable chair in front of them to help overcome fears of falling. They then also actively and equally sway laterally from wall to wall and anteroposteriorly towards the chair and to midline, posteriorly to the wall, and back to midline.
i. Whenever possible face a child. They use your presence as motivation to stand in correct postural alignment with gravity and initiate weight shifts forwards to greet you/touch you in a game Child may need to use support with hands on the therapist's shoulders.

2. *Correct atypical postures or dynamic deformities*.
   a. Place the child's legs apart in line with the pelvis in standing, hips and knees straight, head, trunk, pelvis upright. Knees may need gaiters for keeping knees straight. Feet are flat on the ground (Fig. 9.142a). Trunk can be supported by a large ball, table, high couch, or the body of the therapist behind the child (Fig. 9.142b). Stand the child like this straddling in abduction over a roll, inflatable toy, sponge rubber, or large stuffed toy. There is a simple piece of equipment for a more able child to have legs abducted with knees held straight by knee gaiters (Fig. 9.142c). Hold a child in abduction when you are seated on the floor and their legs are abducted over your thigh or legs. If necessary, hold their knees and thighs apart and in external rotation, to overcome excessive adduction–internal rotation. The toy they straddle needs to avoid valgus knees by keeping both *knees and feet* apart. Press the heels to the ground by pushing down through the knees to the heels (joint compression/approximation). Sway the child laterally and also forwards and backwards to a slow rhythm. A trampoline, sponge rubber, or inflatable mattress may be used for joint compression, keeping the posture corrected (Fig. 9.142d). Child needs support.
   b. Equal weight distribution and weight forwards over feet will correct many atypical postures. Symmetrical postures and head in midline are trained and progress made to asymmetrical control during limb actions on a table. Motivate and facilitate the child's arm reach behind at shoulder level or overhead to touch something that interests them. This activates

muscles to decrease a rounded back or bent hips and knees (see Figs 9.151 and 9.152).

3. *Splints and orthoses reinforce training of active correction*. If atypical positions cannot be actively corrected by the child *in every joint*, at the same time, use splints or orthoses for one joint while the others are actively corrected by the child. For example, correct atypical adduction with a small abduction splint, while the child actively stretches their knees and keeps their heels down with their weight taken on the lateral surfaces of their feet. Another suggestion is to correct bent knees with knee gaiters/splints, while the child actively corrects the position of hips and feet. Yet another possibility is to correct the feet in below-knee orthoses or in plaster casts while the child actively corrects hips and knees, head, and trunk. Later remove knee splints. Rhythmically shift the knees into semiflexion to avoid rigid infantile stance and if the knees are hyperextended. Joint compression through hips and later through knees to increase stability.
4. *Building up children's own stability by a decrease of support given to them*. Carry out manual support under the axilla, shoulders, and then trunk, waist, and pelvis according to the child's stage of stability. Also select standing frames in which supports can be decreased. As children progress, decrease support to the waist and pelvis. Small pelvic hip support, then below-knee orthoses, and finally well-fitting shoes provide stability until children actively control their standing posture and balance. In later developmental levels, just support knees and feet.
5. *Consideration of severe delay of standing and walking alone*. Atypical weight bearing, without the trunk and pelvic control of 6–12-month developmental levels, is seen in severe cases of much older individuals as well as in young children (GMFCS levels IV and V). Excessive antigravity reaction of hip adduction (scissoring)–internal rotation, hip and knee extension, toe standing occurs when the child is held in standing. This cannot be manually corrected. A child may try control by using excessive demands on hands for supports and not be able to use them for other hand skills in standing. There may also be an increase in deformity due to overuse of specific muscles in the upper limbs and trunk.

   Train such an individual with methods of below 6-month levels and have treatment concentrate on lengthening short muscles, practising rising, with arm support in prone, supine, and sitting. Practise upright trunk control with activities in sitting. Improve limb and trunk postures and partial weight bearing in an inclined *prone stander* with correct positions of feet and knees, with abduction for legs and support to hips and pelvis. A child in supported standing can then be placed at eye level with their peers and family. This incline is adjusted to 20–30° for correct weight bearing (Miedaner 1990). A *supine stander* instead of a prone stander is more helpful for children and older people with very poor head control and deformities, particularly of the spine. The standers need to be easily raised mechanically or electronically for manual handling by carers.
6. *Use a well-supported upright standing frame as soon as a child can tolerate this*. There may be excessive increase in tension, involuntary movements, or spasticity. Observe head, arms, hands, or trunk, as well as the withdrawal of legs due to oversensitive soles. Check whether this *overflow* can be slowly corrected with assistance during play and other activities which appeal to a child.

Treatment suggestions for standing are followed if and when the child becomes more able and ready to respond to them. Meanwhile, it is most important to plan other forms of mobility such as standing frames on large wheels ('dynamic standers', Fig. 13.10). If upper limbs are not able to manage large wheels, wheelchairs or play vehicles with special switches can be used (see Chapter 13).

7. Continuation of training of head, trunk, and pelvic stability and counterpoising in all vertical postures as well as standing.

   Train this control mainly in sitting, chest-supported kneeling, half-kneeling, and upright kneeling, according to a child's abilities. *Do not use upright kneeling* if the child has hip or knee flexion tightness or increased lordosis.

9–12-month normal developmental level

Common problems

Delay in standing, holding on with both hands and able to shift weight forwards and back and laterally preparing for limb movement. Standing may be stable but become unsteady if releasing one hand from support, turning backwards, or reaching behind with one hand. Delay in holding on and standing on one leg, stepping sideways, or cruising. Inability to stand alone momentarily, step two-handed support, one-handed support. Delay in rising from prone or supine to standing and sitting to standing and return to sitting with and without help. Delay in development of other transitional positions of squatting, kneeling on all fours, upright kneeling, or half-kneeling. There is no ability to grasp and pull to standing from these postures. Delay in standing first with base wider than the pelvis followed by a narrower base. Delay in typical pelvic tilt forwards with typical lordosis. Weight shift forwards/back laterally is delayed when standing alone with and without support.

Atypical performance. See section 'Atypical postures in standing'. This has similar components to a typical child at levels of around 7–12 months. Typically the pelvis would develop from posterior tilt to anterior tilt, hip–knee flexion to extension, pronated feet to plantigrade feet, and clenched toes to straight toes.

Measures at this stage of standing abilities, sit-to-stand, stand, and reach are given in Chapter 8. Standing alone progresses from 30 seconds after many tries, alone for 30 seconds, then 2 minutes with supervision, and 2 minutes alone and safely. Later progress to standing with eyes closed, standing with feet together, and standing on one leg grasping supports.

Liao et al. (1997) in their research show that standing balance does not automatically lead to walking, although dynamic balance is significantly correlated with walking. They, therefore, recommend that rhythmic weight-shift training is much needed to improve walking performance. Walking very much needs to be trained in walking activities. Balance function and walking have various parameters and they suggest that it is not clear which aspects of standing balance correlate with which aspects of walking and this prompted their research.

1. *Improve stability* with the following techniques. Support children only at knees and feet in standing. To overcome any fears, let children tell a therapist when to 'let go' for them to balance with less or no support.
2. Train children to stand holding onto a support or alone according to ability. During developmental levels 9–12 months children's own hand grasps are spontaneously used for support, but, if absent, place the hands onto horizontal or vertical bars for maintained grasp. Increase the grasps by gently pressing down on the wrists. Stand on different surfaces, for example carpet, sponge

rubber, trampoline, and on rough ground with, and later without, support.

3. At 9–12-month levels individuals become more able to stabilise against the therapist's manual resistance. Start with their hands resting on your shoulders or place them in a corner of a room on a non-slip floor. Apply manual pressure at the hips or shoulders, pushing them just off balance and expect an active maintaining of upright standing – 'Don't let me push you over', 'Stay there'. Do this laterally and also anteroposteriorly (Figs 9.143 and 9.144). Do this with rotation – 'Don't let me turn you'. A way of using manual resistance is to ask the child to push against your hands on their hips or shoulders or on one hip and one shoulder – 'Push against my hands'. Resistance should not be *so great* that the child twists their limbs into atypical positions or increases involuntary movements, or even falls over. At the same time active lateral sway and anteroposterior sway is practised by a child, perhaps to music.

Unsteady balance with arms persistently held up in air (high guard) uses extensor trunk and shoulder girdle muscles for stability. This may even persist after standing is achieved and early walking beginning (see Fig. 9.155). There is still a need for grasping a stable walker. Arms gradually become low guard and swing is a much later achievement. The problems in standing will affect gait, therefore walking alone should not be 'pushed' if standing is absent, unsteady, or very atypical. Fears of falling may increase atypical gait patterns in such cases. Appropriate well-supporting walkers are used until the standing postural control in alignment and postural adjustment become more reliable for walking alone. There are children who use speed as momentum in

Figure 9.143. Stabilisation on hands and feet, then more upright. Lateral sway, anteroposterior weight shift.

Figure 9.144. Activate an individual's own lateral sway against manual resistance and 'pushes' for postural adjustment. Active sway by person/child is the next stage.

'running headlong' or 'hasty walks' as they cannot stand alone nor posturally adjust to release one leg for stepping.

12–18-month normal developmental level

Common problems

Delay of cruising, walking with and without walkers or aids. Delay of postural mechanisms of saving, and protective stepping.

Atypical performance. Atypical gaits. Weakness of stepping patterns.

Typical toddler's gait

This is well described at around 12 months by Aubert (2008) before gait changes rapidly to mature elements until 2–3 years and less dramatic changes until 7–10 years. The characteristics of early gaits are typical when the postural mechanisms are not yet fully developed. Similar gait patterns and biomechanics are present in older children with cerebral palsy as their postural mechanisms are delayed.

Toddler gait patterns include the following.

- Wide base or use of walking aids to widen base. Feet pronated with legs in very wide base.
- Weight shift more excessive to each side ('waddle').
- Pelvic mobility is absent.
- More steps taken per minute (cadence), low velocity, short uneven steps, and stride.
- Pronated feet, sometimes with flexed toes and more double-leg stance used for stability.
- Dependent on supports on each side or in front before toddler gait is fully independent.
- Appears to 'run' as more postural control is needed for slow walk. Unable to stop easily.
- Unable to walk backwards or to turn a corner.
- Hip and knee flexion with abduction–external rotation in wide base on weight bearing.
- Excessive hip and knee flexion with some abduction–external rotation during swing.

Additional features of gait for therapy. These are as follows.

1. Excessive hip and trunk sway more to one side in the pelvic waddle.
2. Excessive hip and trunk sway anteroposteriorly with jerky gait.
3. Asymmetry of weight bearing and unequal steps.
4. Atypical postures of head, trunk, pelvis, knees, and feet (see Figs 9.151–9.156).
5. Atypical stepping patterns, for example *toe walking*, *crouch gait* (overflexed hip–knee and dorsiflexed feet), and *jump gait* with equinus on foot contact and hip–knee extension during stance or equinus secondary to hip–knee flexion as plantar flexors are too short for plantigrade feet.
6. A dyskinetic *running gait*; *drunken gait* in ataxia or dyskinesia (athetosis); *high stepping gait* and *scissoring gait* in either spastic or dyskinetic type of cerebral palsy.
7. Overactive arms to maintain balance, *tightrope walking* patterns, persistent atypical arm postures with lack of reciprocal arm swing. There may be excessive involuntary arm motion seen in dyskinesia.

Delay or atypical walking patterns may be due to the following.

Poor or absent postural stability and postural adjustment or asymmetrical postural adjustment, as follows.

1. Children may *waddle* from side to side, that is, they 'fall' from foot to foot as they cannot maintain posture for any length of time on one side. There may be excessive trunk sway from side to side. The pelvis and trunk may rotate forwards on the side of the swing-through (stepping) leg instead of their having postural

adjustment on the weight-bearing side to release the leg for stepping.

2. Children mainly with dyskinesia may *run headlong* as they cannot bear weight long enough on each side for a step. Children with dyskinesia or ataxia stumble about and were thought to be drunk by some members of the public. There are also children and especially adolescents and adults with dyskinesia who stabilise themselves in stepping to avoid prevailing extension or lean backwards behind their feet. The compensation used is the following:
   a. Head bent down or chin juts forwards, arms held down and forwards, hands may clasp or thumb held. To control involuntary arm movements which disrupt balance, these arm postures are also used.
   b. Hips remain extended with knees flexed, feet plantigrade, and toes clutching the floor.
   c. Stepping may be in flexion (*high stepping*) with rigid extension or knee hyperextension during stance, as compensation for balance.
3. Children with cognitive or perceptual impairment as well as other individuals with cerebral palsy may not wish to walk, show fear of walking, and hang on to adults excessively and on to their walking aids. Cognition and perception are relevant to walking in other situations, such as when instructions need to be understood and that walking through doors needs to be accurate.
4. In any of the types of cerebral palsies there may be excessive arm-flinging movements or emphasis of the saving reactions in the arms or arms reminiscent of tightrope walking, coming into play to help the child balance on each unstable leg. 'Sinking' patterns of standing and compensation for falling back are also seen as in standing (Figs 9.138–9.140) and walking (see Figs 9.151–9.155).

Absence of anteroposterior shift. This makes it impossible for the child to *start* walking. A walking aid on wheels may start a child off. Stopping is also difficult if this mechanism is not operating. They may also *mark time* and then stop, as they are unable to stop or reverse the anteroposterior shift. Some young children only stop by a collapse onto their bottoms as seen in typical toddlers. This is not socially useful and more painful for large adolescents!

Absence of lateral sway. This is obvious in the children with dyskinesia (athetosis) who run headlong and in other children pushing wheel-walkers. This compensates for inadequate postural stabilisation. Develop lateral sway and weight shift with training of standing on one foot (counterpoising), and emphasise cruising sideways and any activities which promote lateral weight shift from leg to leg.

Lack of tilt reactions in prone, supine, sitting, upright kneel, and standing rarely delays walking. This training in walking should not be delayed if these reactions are not yet acquired. Martin (1967) found that adults could walk following labyrinth surgery, although tilt reactions were not possible without their labyrinths. Similar observations have been noted in children who walk but have absent or poor tilt reactions. Nevertheless, tilt reactions should be included in the programme as it makes the child feel more stable in changes of terrain and in the dark. As Dr J. Foley puts it, 'You cannot walk across a ploughed field at night if you do not have tilt reactions' (1974, personal communication).

Saving or protective reaction (arms and legs). These must be trained to prevent the danger of the child falling on their face, and to give them confidence to walk. *Remember* that the protective step in falling is not the same as a voluntary step which the child takes when being trained to walk. Foley observed the presence of voluntary

stepping without the presence of protective stepping and vice versa (1974, personal communication). Therapy must, therefore, train both of these stepping movements. Excessive saving reactions in arms or legs may occur to compensate for the absence of the other mechanisms. It is most noticeable in children with ataxia or dyskinesia. The *drunken walk* may be excessive staggering reactions in the legs. Children with dyskinesia cannot *stand still* but take little protective steps. A wide base is used for better balance by children with ataxia and by those who have motor delay without cerebral palsy.

Leonard et al. (1988, 1991) and Forssberg (1985), among others, have contributed studies on atypical gait patterns and compared them with the gaits of children with typical development. Thomason et al. (2014), Gage et al. (2009), and Miller (2007) provide detailed atypical gait analysis in spastic hemiplegia, diplegia, and tetraplegia (quadriplegia) in relation to orthopaedic procedures and/or physiotherapy (see Chapter 12).

Atypical gaits in the spastic type

All the problems above are included with the addition of the pull of short or stiff spastic muscles and associated weakness. There may be various atypical postures which are associated with each other, as described in the discussion of atypical postures in the section on standing. There is a lack of selective motor control that may contribute to aspects of gait. For example, dorsiflexion cannot be isolated from knee flexion to obtain initial heel contact with extended knee, positioning for mid-stance with knee extension, and during the phases of swing through of the stepping leg (see right leg gait analysis in Fig. 8.3).

Automatic reactions expected are the postural adjustments of dorsiflexion, hip flexion, and beginning of protective forward step (Fig. 9.125). There are also the saving reactions developing in the arms if falling backwards as well as propping on hands to break the fall (see descriptions at the beginning of 'Development of standing and walking').

Treatment suggestions and management 12–18-month normal developmental level

1. Further improvement of stability on one leg with support and increasing motions of greater variety in the other leg.
2. Training lateral sway (weight shifts), anteroposterior sway, and lead this to stepping and to cruising along furniture or parallel bars.
3. Correction of atypical postures as much as possible.
4. Older children and adolescents need to be kept fit during walking as there is *an energy demand* on a person managing to walk with poor balance, weakness, and/or deformities.

Deformities. Those who have potential ability for walking may need stable orthoses on their feet and therapy for plantigrade feet, for stability in standing and walking, and for improvement of atypical gaits. Mild flexion deformities of hip and knees allow standing and transfers, but if feet are very deformed and painful in an older child this is a major hindrance (Graham 2004).

Many individuals with different abilities continue the use of standing frames or knee gaiters to assist passive and active control of hips, pelvis, and trunk. Botulinum toxin A (BoNT-A) for spasticity together with physiotherapy is discussed in Chapter 12.

Select the activities below according to each child.

1. *Improve stability* with the following techniques: the child stands, holding on or alone. At this level, support pelvis, thighs, or knees according to individual ability. To overcome any fears, let a child

say when the therapist should 'let go' so that they can balance with less or no support.

At 9–11 months a child's own hand grasp is spontaneously used for support, but, if absent, place the child's hands onto a horizontal or later vertical bars for maintained grasp. Increase the grasps by gently pressing down on the wrists.

At the 9–12-month development level a child is more able to stabilise against manual resistance. Start with child's hands resting on your shoulder or place the child in a corner of a room on a non-slip floor. Apply manual pressure at the hips or shoulders, pushing the child off balance; they must actively maintain their upright standing – 'Don't let me push you over', 'Stay there'. Do this laterally and also anteroposteriorly (Fig. 9.143). Do this with rotation – 'Don't let me turn you'. Another way of using manual resistance is to ask the child to push against your hands placed in positions on both hips or shoulders or on one hip and one shoulder – 'Push against my hands'. Resistance should not be *so great* that the child twists their limbs into atypical positions or increases involuntary movements, or even falls over.

Once standing is present, practise standing with blindfold or eyes closed and with a veil or in light subdued by sunglasses worn by child. Also have a standing child balance on different surfaces such as sponge rubber, on an inflatable mattress, and on rough ground. Do this with and without use of vision.

2. *Stand and sway* or weight shifts laterally and anteroposteriorly (Figs 9.143–9.146). Continue methods of weight shifts and establish standing against manual resistance 'Don't let me push you', 'Stay there' (see Fig. 9.168). Have the child's body lean laterally against your body at their side or move them laterally holding the pelvis, so they release the other leg for a step. Move the child forward for a step for walking or laterally for cruising. Decrease your guidance as they gain control. Once they have managed sway sideways and to sway forwards, they shift their weight against your hand on the hip, shoulder, or both hip and shoulder as you offer manual resistance described above. Manually resist the forward and backward sway, which is used for step and stop. Assist maintenance of postural alignment of head and trunk upright with slight truncal curve towards the leg with less weight bearing during sway.

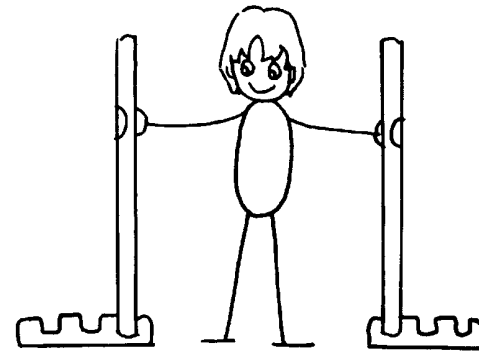


Figure 9.145. Lateral sway practised with lateral grasp for trunk and hips extension. Use externally rotated arms.

Train lateral sway with legs apart then closer together, for a more challenging base for balance.

Check that feet are plantigrade using the articulated orthoses that allow anteroposterior sway.

Encourage a child's active sway in a corner of the room to allay fears of falling. A child may practise sway between two stable chairs or parallel bars and in a static walker. The child's grasp should be in front or at the sides and at waist or shoulder level. Lateral grasp on poles is preferable to parallel bars as it

improves upright, symmetrical weight bearing and trains supinated grasp (Figs 9.146 and 9.147). *All these actions can be done to rhythm and song.* The lateral sways can become steps included in a simple dance routine together with another child as partner.

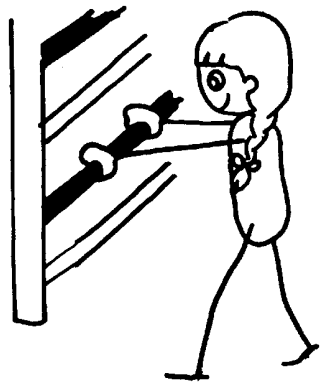


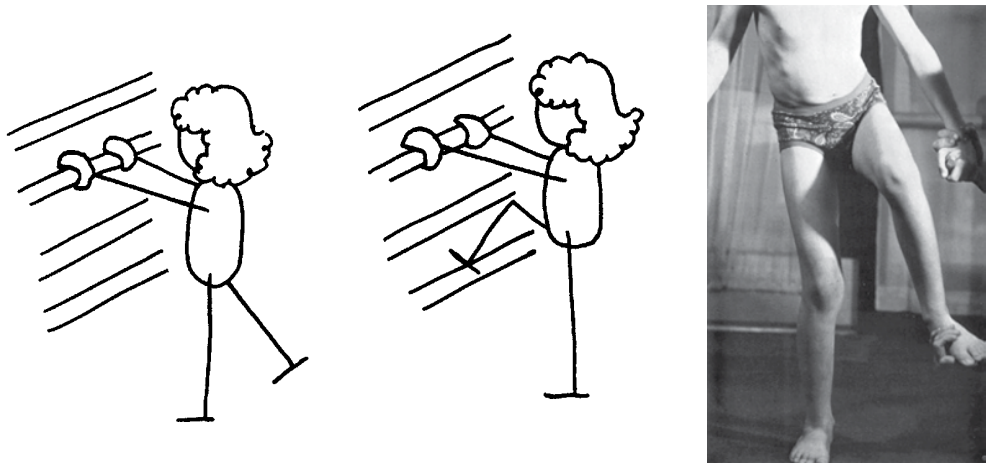
Figure 9.146. Anteroposterior sway in preparation for step.

Figure 9.147. Anterior weight shift with step taken against therapist's manual resistance. Note activation of dorsiflexion.

3. *Standing and counterpoising limb or trunk movements* (Fig. 9.148). The child stands holding on with both hands and then with one hand while lifting one leg to different heights on the bar or in the air. The child could lift one of their legs up in front, to the side and backwards, onto bars, box, a step, a small beachball, onto your hand, or you put their sock or shoe on or off.

Arm patterns for function are shown to a child in the context of reaching for an object or daily care activity while holding on with one hand and later when the child is able to stand alone. Use objects that interest a child to encourage reaching out in all directions. Arm patterns should also be used in the following ways. With the child standing holding a support with one hand or leaning on one hand, correctly facilitate the other arm into elevation–abduction–external rotation without and against resistance. Encourage assisted or active reaching for a toy overhead. A child could also stand and balance while 'walking' their hands up the wall, sliding them up the wall, up a soapy mirror, or in other play activities devised by you. It depends on the task, the postural control, and the strength of a child as to which way the arm elevation is developed.

A child progresses to stand and reach behind them for toys offered, to touch a wall, as well as to stand and bend down to fetch an object on the floor or low box. They could also move hands down or up each wall bar to fetch a toy hung on either the bottom bar or on a high bar. At first, support a child at the chest or pelvis. This activity also helps to stretch hamstrings and stretch elbows to reach toy. Help them re-erect to standing if this is needed. Later increase demands with tasks such as stand and pick up a cup of water or a heavy object and place it back on a table or on stools



(a) (b)

Figure 9.148. (a, b) Counterpoising exercises for walking and climbing stairs as well as for putting on and off socks, shoes and trousers, and for washing and play activities.

of different heights. Assist the grasp, as mentioned above.

When a child stands grasping a support with one hand as the other hand moves, it may be necessary to maintain alignment of the legs during typical asymmetry of the trunk in postural adjustment. Therefore, hold the weight-bearing legs straight or in external rotation. Hold one leg and both arms straight while the child moves the other leg with typical asymmetrical postural adjustment (counterpoising) of the trunk. The weight-bearing leg is straight in Figs 9.148–9.150. Facilitate the movements against manual resistance shown in Figs 9.149 and 9.150 given correctly, which preferably needs to *be shown clinically*. Heavy objects may be pushed, pulled, or lifted by a child who can manage this. It is possible to use desirable arm or leg patterns instead of the habitual patterns that relate to deformities.

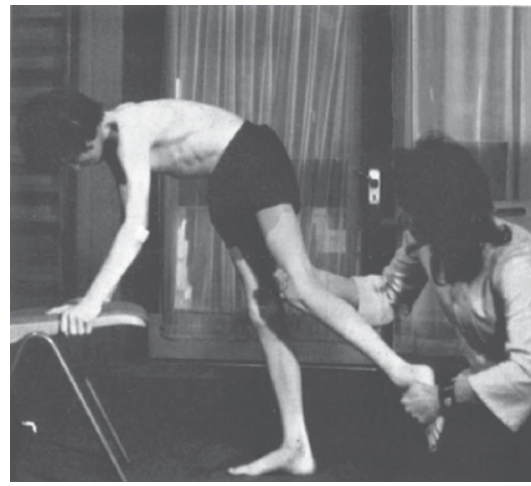
A child is shown leg patterns and weight bearing when walking in parallel bars or in a stationary walker. Leg patterns that may be used are flexion–adduction–external rotation (stepping pattern) from and to extension–abduction–internal rotation (push-off pattern), the knee extended and foot dorsiflexed in *stepping*. Hold toes and forefoot in dorsiflexion in *push off* and to prevent extensor thrust.

Note. Use leg and arm patterns *without* giving resistance if excessive overflow of spasticity cannot be controlled and if methods are not easily or skilfully carried out.

4. *Correction of atypical postures*. The arm and leg patterns (synergies) are not the only ways tasks are managed but selected to activate counterpoising and to correct atypical positions of arms and legs. In addition, rotation of the pelvis and trunk with the arm or leg movements appears to decrease hypertonus and improve postures (see section 'Basic arm and hand patterns for all levels of development').
5. *A functional assessment of strength* in both active and passive ranges can take place in the context of standing and preparation for stepping. A child or older person who can cooperate is placed in

supported standing on one leg, on a block, or on the ground. The other leg to be tested is not weight bearing. The ranges of movement of hip extension and flexion, knee extension and flexion, and foot dorsiflexion needed for the walking patterns are tested. This will not be the full range needed as approximately a range of 0–25° or 35° is usual. Muscle actions of plantarflexion and hip extension for push off (pre-swing), hip and knee extension for stance, and hip flexion, knee extension, and dorsiflexion for initial contact (heel contact) are also tested in this functional position. Training of these elements or components of standing and stepping can follow, and so impairments of strength and ranges are treated within a function.

6. *Correction of some common atypical postures in standing and walking*. These are from approximately the 9-month



(a)

(b)

Figure 9.149. Correction of stepping pattern, that is, facilitation of leg flexion–external rotation, knee extension with dorsiflexion. (a) *Push-off* pattern. (b) *Heel strike* pattern. Progress to stepping while pushing chair/ladder or in parallel bars.

Figure 9.150. From this hip–knee flexion–abduction–internal rotation pattern facilitate *stance* of extension–adduction–external rotation in the child's right leg.

developmental level (supported) to the over 12-month developmental level (unsupported) until adolescence and adulthood (see Figs 9.151–9.156).

a. Flexion and *sinking* posture (Fig. 9.151).
b. Asymmetrical posture (Fig. 9.152).
c. Internal rotation of legs (Fig. 9.153).
d. Hip extension, knee flexion, plantarflexion, arm flexion (Fig. 9.154).
e. Hyperextended knees and lordosis (Fig. 9.156).
f. There is also arm abduction–extension in the air, elbow flexion, wrist palmarflexion, or arms in *high guard* (Fig. 9.155). The extensor muscle of shoulders and upper trunk is used for some stability but is not adequate.
g. Correction may not be indicated in adolescents and adults if biomechanical compensation is effective for them.

Additional suggestions for training walking and gaits other than ideas shown in the figures are as follows.

Correction of a waddling gait or running headlong must include training of lateral sway and this is also developed in cruising around furniture discussed below. Standing on one leg often improves waddle gait as well as other atypical gaits. *Asymmetrical gaits need increased weight shifts* to the more affected side and rhythmic weight shift from side to side and lateral cruising in each direction. Place a more desirable toy on the side which bears less weight for cruising or when reaching out at play in standing at a table.

Crouch gait. Postural stability and counterpoising activities improve this gait if it is due to delayed development of balance. Damiano et al. (1995a) in their research studies showed that strengthening quadriceps in children with mild-to-moderate cerebral palsy improved crouch standing and walking. Both postural training and strengthening are recommended.

Toe walking may be present in typical toddlers. Hips and knees are straight and flexible. The authors have also observed this in toddlers with severe visual impairment without any cerebral palsy. Rising onto toes may be a response to avoid a fall as in a postural adjustment of initial rise on toes before leg protective reactions. In cerebral palsy, persistent toe walking needs modification of the elongated plantar flexors by strengthening the dorsiflexors, stretching any shortness of plantar flexors, and training for poor postural control.

Cruising or stepping sideways. The child holds horizontal bars and takes a step sideways. At first, there is hip flexion for postural control. Emphasise hip extension with abduction in lateral step in both the supporting leg and stepping leg, as soon as is possible. At first, give support and then expect the child to keep their pelvis and/or trunk upright so that they take weight through the standing leg with plantigrade foot. Improve this activity by joint compression through the standing hip or knee

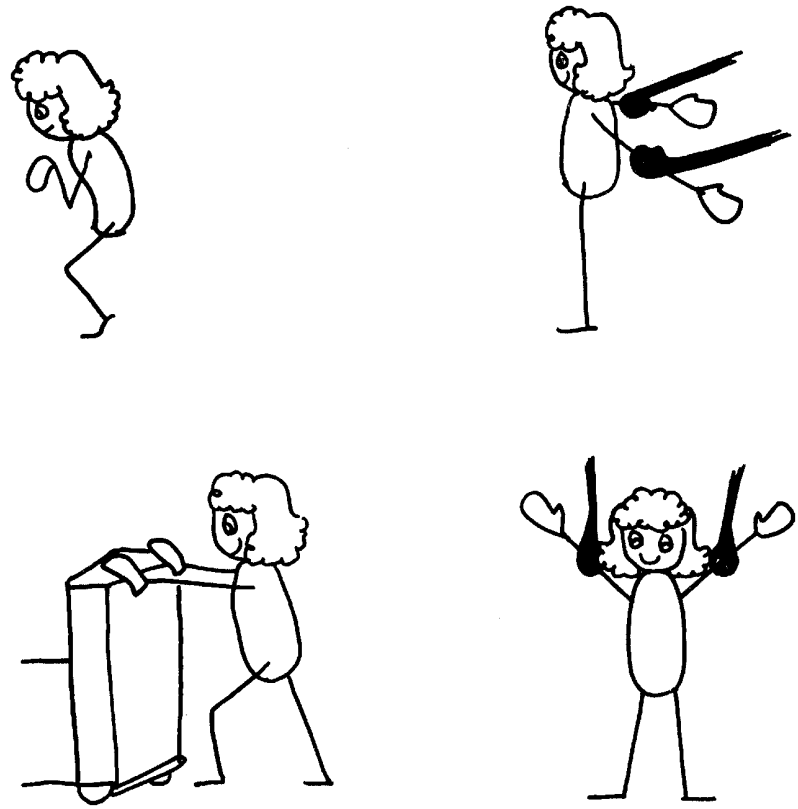


Figure 9.151. Correction of a flexed child whose limbs may also adduct and internally rotate, in standing or in walking. *Keep child's weight forwards as, in these exercises, there is a tendency to lean too far backwards.* Arms are extended and externally rotated. This corrects head, trunk, and legs. Hold child's shoulders, elbows, or wrists. Encourage weight shift from side to side by tipping the child from your hold on his arms. Stand and walk by pushing the walker at shoulder level. Open hands overcomes too much flexion. Keep elbows straight; elbow splints (gaiters) may be needed. Knee splints to maintain extension of knees and/or to get heels down, if required. Calipers or back-slabs for knees may be needed in older children. Slow walk and a long lunge forward when stepping and pushing a truck helps to stretch tight heel cords and tight knee flexors.

while manual resistance is given to the abduction of the stepping leg. Some children respond to resistance of the abducting leg, which automatically increases stabilisation by their own weight through the standing leg. Others may require you to correct any atypical positions of hip, knee, and foot by holding the thigh and knee extended and externally rotated, shifting the child's weight onto the outside of the foot. Observe that a child's pelvis is symmetrical and in vertical alignment (neutral). Manually correct any retraction on one side and tip the pelvis forwards into neutral.

Walk holding two hands or one hand. To prepare for the *walk holding two hands* below, use the technique for weight shift sideways given above for cruising. This developmental level of walking (normally about 12–13 months) is the level at which children are functioning when they walk with walking aids of many different types. The walkers stimulate locomotor actions of

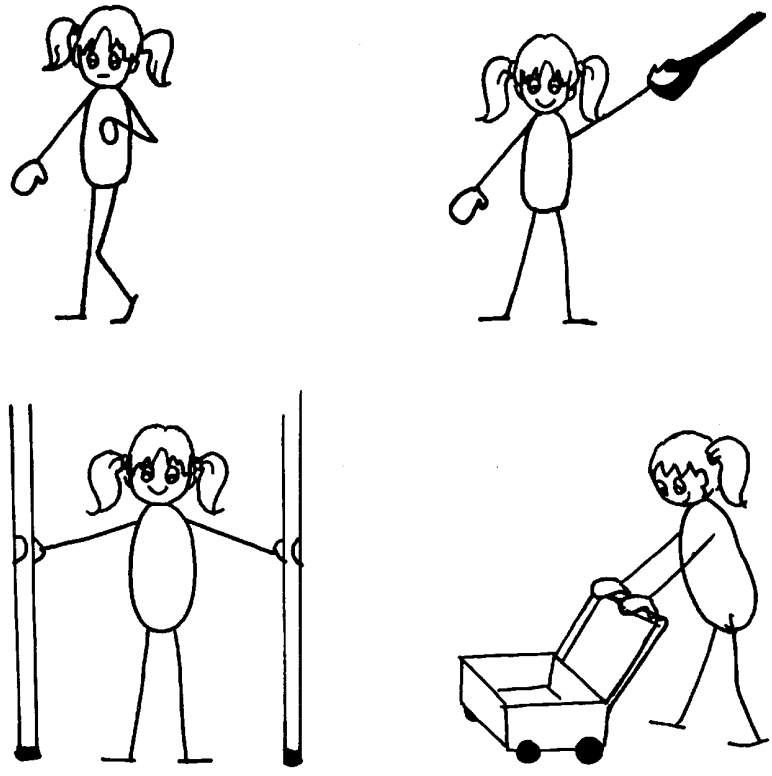


Figure 9.152. Activities to increase weight bearing onto the more affected side or onto the hemiplegic side. Hold the arm in position to counteract arm flexion–adduction–internal rotation. Bring the arm forwards if the shoulder retracts. Symmetrical grasp, or *both* hands open and pushing the truck. Use elbow splints to maintain elbow extension. Weight distributed equally on the feet. Shift weight to the more affected side. Child tries to grasp with her arms apart and turned out or with her arms abducted in mid-position but not with shoulders turned inwards.

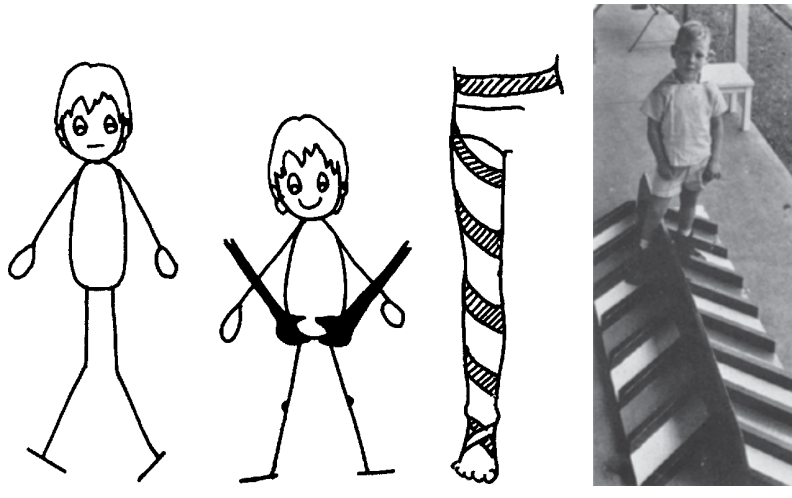
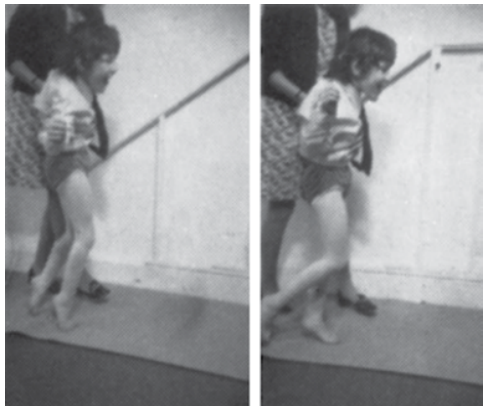
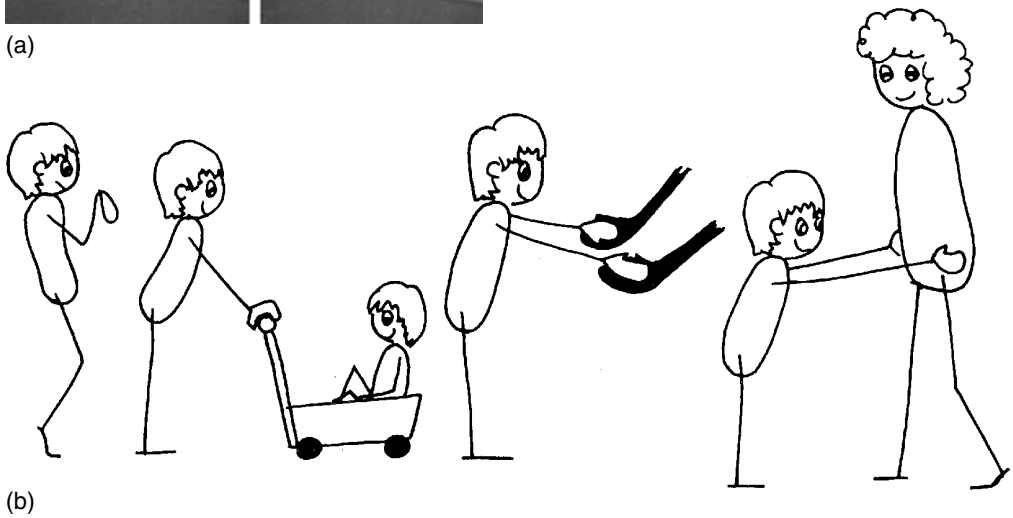


Figure 9.153. Correction of internal rotation of the legs. Hold the child's pelvis and rotate the leg outwards as he takes a step. Trunk at first is aligned and supported by your body and later unsupported. After step press down on that hip to augment weight bearing in external rotation. In milder cases, try using *twisters* to pull the leg into external rotation. Child tries to repeat this on their own. *Point feet out.* Also see methods in Fig. 9.151.



(a)



(b)

Figure 9.154. (a) Hip extension, knee flexion, plantarflexion. (b) Correction of hip extension, knee flexion, arm flexion, plantarflexion (toe walk). For arm abduction–extension in the air, elbow flexion, wrist palmarflexion.

initiation of stepping and lateral sway, used at age 2–6 years and over.

Examples are as follows.

1. Walk holding parallel bars or parallel ropes. If the child has not yet achieved grasp and release, a felt cuff or moving hand grip which slides along the bar may be used.
2. Walk with a walking frame grasping in front or at the sides. Progress from using walkers (Figs 9.157a,b–9.159a–c) to having the child grasp a horizontal stick which is held at each end in your hands. They may hold a small stick in each hand which you grasp at each side. Decrease these hand supports further by having the child grasp rubber rings lightly held in each of your hands (Fig. 9.141a,b).
3. Both of you hold on to a large ball (netball size) simultaneously as you step backwards. Always ensure that the child's weight is well forwards over their base.
4. Walk holding someone's hands on either side or in front of them.
5. Walk pushing a weighted doll's pram, another child in a wheelchair, a stable kitchen or child's chair, with studs for sliding slowly, use large toy boxes on castors, or a large soft toy on wheels or a chair on wooden skis or with a set of runners. They should be stable and checked for size according to a child.

Figure 9.155. Methods to gain confidence and correction of hip extension, knee flexion, arm flexion, plantarflexion (toe walk). For arm abduction–extension in the air, elbow flexion, wrist palmarflexion, or 'high guard' arm posture.

6. Walking using crutches, elbow crutches, tripods, quadripods, or sticks.
7. Walking using vertical poles at either side with thick rubber bases (Fig. 9.152).
8. Walk with both hands grasping for hemiplegia. Walk with the ladder-back chair or walking aid (Petö aids) that improves extension as a child pushes them with wrist extended grasps (Fig. 9.159c).
9. Weight crutches, quadripods, or have weights on ankles for children with dyskinesia.
10. Orthoses provide stability as well as correction of feet.

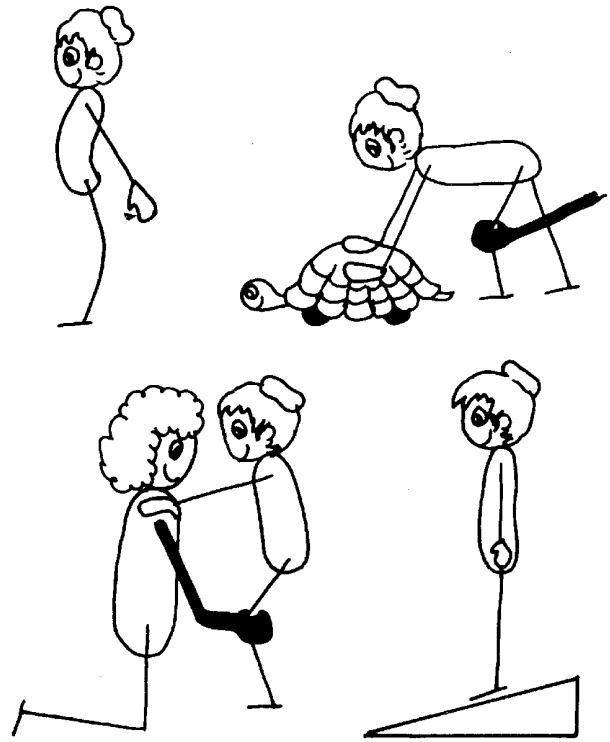


Figure 9.156. Correction of hyperextended knees and lordosis. Check tightness of plantar flexors and stability of the pelvic girdle.

(a) (b)

Figure 9.157. (a) Walker for a person needing chest support. It can be adjusted forward or upright. Forearm supports assist symmetrical shoulder stability and grasp. (Acknowledgement to Rifton for Rifton Pacer Gait Trainer.) (b) The Orlau Walker for a person needing chest support and symmetrical elbow extension with grasp. A similar walker is the Arrow Walker (Pony).

Figure 9.158. Rollator.

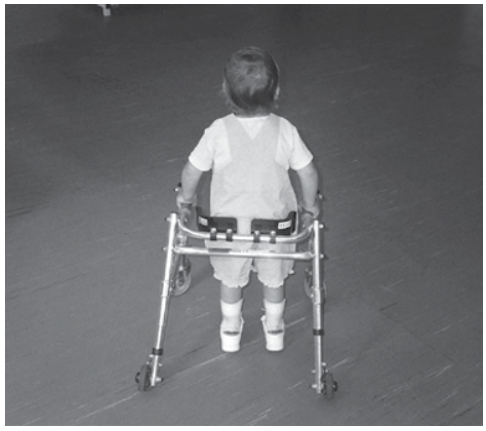
More details of walking aids are given in Chapter 13 as well as environmental considerations.

When selecting and using walking aids consider the following.

Grasping a support at the side of the child tends to train lateral sway for walking. However, if the support involves elbow flexion, this may be contraindicated as the grasp–elbow flexion and hunching of the shoulders increases spastic stiffness in individuals and may also overflow into the legs. The child's grasps need to be low down and slightly in front with straight elbows (Figs 9.157b–9.159). Use elbow gaiters to assist extension. You may instead support at both the elbows or hands holding arms straight (Figs 9.154 and 9.155) as you bring the child's weight within and slightly in front of their base.

Grasping the hands, support in front helps to train the anterior weight shift needed to start walking. Once again avoid shoulder hunching and excessive arm flexion, so use of elbow gaiters to assist in reminding the child to keep elbows as straight as possible is advisable. A posterior walker may be more effective if a child already has an anterior weight shift and is ready to step with hip–trunk extension (Fig. 9.159a,b). Although Logan et al. (1990) prefer posterior walkers, this is an individual assessment which does not apply to all children. Normally, early walking uses hip–knee flexion (similar to a mild crouch gait in cerebral palsy) to maintain balance. It may also be helpful to press a child's wrists down to improve the grasp. Try having them lean forward and down onto open hands or forward onto their grasps. This is most effective in training the active initiation of stepping and continuation of stepping. In Fig. 9.155, note the open hands of the therapist, allowing the child to press down and forwards to actively initiate stepping.

Inadequate hand use for walking aids. Some involuntary movements, tremors, or poor grasp ability with weakness interfere with a child's maintenance of grasp. Children with severe intellectual disabilities or perceptual problems may not manage to use walking aids as well as concentrate on balance and stepping. Hold these children's hands onto the bars directly or by pressing through their wrists as they grasp. Use particularly stable walking frames, weighted trolleys, or a doll's pram. The ladder-back walker or a chair on padded wooden skis is often helpful. Avoid walkers with castors or wheels, which run too quickly for a child. Later, walkers or crutches/sticks with weighted bases may be managed by some children.



(a)

(b)

(c)

Figure 9.159. Walkers to promote extension.

However, older children do use walking aids which suspend a child from an overhead bar in a parachute design between the legs. Weight bearing is taken through both plantigrade feet, and, as some of the suspension lifts the child's weight off their feet, there is less hypertonus and better weight shift.

Children who run headlong are most likely to hang on the rims of any wheel-walker and run dragging their feet. Their walkers should be weighted or a brake applied to the back wheels or, perhaps, remove all wheels. Remind these children to walk more slowly, and in a stationary walker practise standing still with feet together or as little apart as they can manage.

Grasping someone's hand or a quadruped/tripod aid with one hand by a child is usually a progression from walking holding on with two hands. However, if the child takes weight atypically through one side more than the other or if there are asymmetrical postures, then *two* aids need to be used until they walk alone. Some children progress to grasping a quadruped stick in the centre and in front of them,

instead of using two aids. Some children manage aids if they are weighted with small sand bags.

A child leaning heavily on their hands ('walking on their hands') and 'hanging on their armpits' in walking aids so that they hardly take weight on their feet needs to be discouraged from doing so. If not, they will step in this way for years and their independent walking will not have any opportunity of developing. Give extra training in all aspects of head, trunk, and pelvic stability in both standing and sitting development for these children. Try training their walking, restricting holding onto aids but onto more unstable supports such as holding a ball, rings, or sticks that you also hold. Use ropes instead of bars in the parallel bars.

Atypical postures of the head, trunk, and legs need to be corrected as much as possible (Figs 9.141, 9.151–9.159, 9.160e). There are regularly new designs of walkers available on the market. If correction is not possible with a particular walking aid, then explore a better one and, if possible, train walking without walking frames. In most cases train the earlier levels in the development of standing or walking more thoroughly. It is important to find suitable tricycles or wheelchairs for mobility until control of atypical posture improves. Orthopaedic surgery or procedures and muscle relaxant drugs are indicated and discussed further in Chapter 12. Some people may not be able to walk due to severe deformities and multiple impairments. They require suitable mobility aids if walking is considered unlikely.

Note. Pushing a trolley with handles which are too low or sticks and other walking aids which are too low may increase head and back rounding.

Reassessment of abilities and difficulties of an individual is essential. This allows for appropriate walking aids and consideration for alternative mobility aids which need to be available for people who need them, for social and exploratory reasons, to counter fatigue, for longer distances, and at an appropriate speed. Mobility aids such as wheelchairs, standing frames on large wheels, and well-supporting special tricycles are necessary. Children who have not yet learned to walk with or without walking aids may also welcome using playthings on wheels.

Lower limb orthoses for standing and walking

Lower limb orthoses are used for standing and walking depending on assessment of joint ranges, muscle action, and biomechanics. They are used for support, alignment, prolonged stretch of hypertonic muscles, and as part of the whole functional programme. A physiotherapist works closely with an orthotist and/or an orthopaedic surgeon. Gait analyses are used in research and clinical work for the most effective designs for individuals (Morris and Dias 2007). However, the following orthoses are commonly used with clinical assessments when gait analyses are not available.

1. Hip abduction with trunk brace for correction of hip deformities and pelvic and trunk deformities in lying, sitting, and standing positioning equipment and/or standing, walking, and sitting hip (SWASH) orthosis (Fig. 9.160e).
2. Knee gaiters or splints correct and support knees in standing and weight shift and so trunk and hip control and some foot adjustments can be practised. This can also be managed in stationary walkers or a standing frame when supports/straps are removed for training and for periods of the day (Fig. 9.142c).

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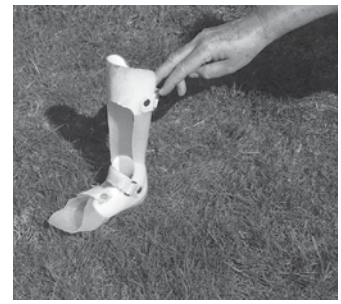
(b)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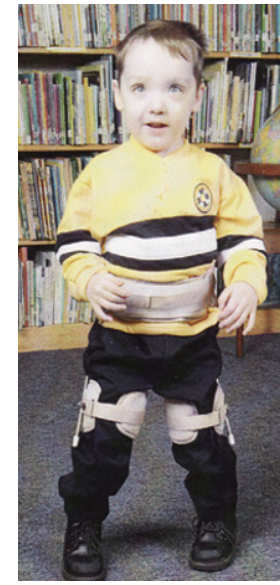

(e)

Figure 9.160. (a) Solid ankle–foot orthosis for dorsiflexion and moulding the foot. (b) Hinged ankle–foot orthosis allowing dorsiflexion for gait, stairs, half-kneeling, and sit-to-stand. Minimal plantarflexion for push off in gait. (c) Ground-reaction ankle–foot orthosis limits excessive dorsiflexion. Knee element maintains knee extension. (d) Ground-reaction ankle–foot orthosis with stiffening at ankle and with extended sole to correct flexion of toes. Front can be moulded to the lower leg in severe crouch walk. (e) The SWASH orthosis, with variable hip abduction, dynamically corrects adduction and/or hip dysplasia. Courtesy of Camp Scandinavia.

3. Ankle–foot orthoses are of a number of designs and can also correct the hip and knee. These consist of the following designs used within shoes, trainers, or boots.
   a. Solid ankle–foot orthosis (AFO) (Fig. 9.160a) of moulded thermoplastic material. It is often set at 2–3° dorsiflexion to counteract the plantarflexion deformity. The range of motion in the ankle with knee straight should be neutral. If not in neutral, then other parts of the foot, especially at the subtalar joint, will compensate and become hypermobile. In addition, the plantarflexion can persist and may become a contracture. There will be rubbing by the orthosis which will alert the therapist that the fit is incorrect. Inhibitive plaster casts for such ankle limitation or surgery will need to be used

before the AFO is recommended. The stability in standing is enhanced, but gait patterns remain in a rigid pattern. AFOs may impede crawling, half-kneeling rise to standing, sit-to-stand, and use of large stairs.

b. Hinged ankle–foot orthosis (HAFO) (Fig. 9.160b). The hinge at the ankle allows some dorsiflexion, so an individual can use correct biomechanics in rising from sitting, from squatting, or from half-kneeling to standing. Weight-shift forwards is better and improves the gait. An HAFO in a hemiplegic condition may allow more symmetry. Orthotists may adjust a hinge to allow minimal plantar and dorsiflexion. The solid AFO sometimes leads to weakening of push off by plantar flexors in gait.

c. Dynamic foot orthosis (DAFO). This is a moulded orthosis for calcaneous, mid-tarsal joint, and toe flexors inhibiting hypertonus. Longitudinal and transverse metaphalangeal arches are corrected. A DAFO can be small above the malleoli when ankle control is needed with minimal tibial forward travel. The DAFO can be incorporated with a tibial component. A plantar stop is usually included (Hylton 1989).

d. Ground reaction (floor reaction) (Fig. 9.160c). Ankle overdorsiflexion may increase a crouch hip–knee flexion posture or not overcome hyperextended knees. A range of motion test of ankle and knee needs plantigrade at the ankle with a straight knee, preferably assessed in standing. The orthosis is moulded to the front or sides of the lower leg to limit ankle dorsiflexion. A knee element or knee piece is necessary to increase knee extension. As the heel touches the ground, there is an associated reaction of knee extension, which also improves hip extension. A posterior walker is best used for extension.

Hyperextended knees decrease if they are compensations for plantarflexor tightness. However, increasing the set of an AFO to 5–7° into dorsiflexion increases the knee flexion and so the midline of the knee is promoted. A hyperextended knee needs assessment to confirm that it is not due to weakness of quadriceps or hamstrings, short spastic hypertonic quadriceps, or anterior pelvic tilt with weak hip extension, which pushes knees into hyperextension. Poor pelvic stability may increase hyperextension for balance.

In older children knee–ankle–foot orthoses may be helpful in cases other than short stiff plantar flexors. Overstretching of knees may lead to pull on posterior joints, creating pain in later years.

e. A night-splint AFO can either be a solid AFO, bivalved plasters, or a hinged AFO with adjustable straps to grade the amount of dorsiflexion over time. This prolonged stretch is used for spastic plantar flexors during sleep. However, positioning lying equipment for postural management includes such correction during rest or sleep (see Polak et al. 2008).

f. Inserts or foot orthoses. These correct the heel position in footwear. However, the forefoot often also needs correction, so the heel cup is extended to include correction of longitudinal and transverse arches. The sides of the inserts may be raised for extra support, the forefoot moulded, or sponge and leather inserts included. The flat foot of early walking is seen in typical children

under the age of 3–4 years and may be present in delayed walkers with cerebral palsy. Discussion with orthopaedic surgeons is advisable as orthoses can prevent the activation of small muscles during weight shift, which corrects flat feet during standing and walking.

Shoes or special trainers should be checked for correct fit and support for all children whether worn with or without orthoses. Slow range of motion and stretch are useful before orthoses or shoes are applied.

Research studies showing the value of AFO continue (Radtka et al. 1997; White et al. 2002). See critical reviews by Morris (2002) and Figueiredo et al. (2008). Different materials are being developed as well as modifications of designs based on studies and experience, and the important reports by parents, children, and older individuals. Check comfort, pressure points, and ease of application. Parents' and individuals' understanding of the purposes of orthoses is an important consideration for cooperation. Studies have shown prevention and correction of deformity, reduced plantarflexor hypertonicity, greater stability, improved gait, and less energy expenditure in walking.

Botulinum toxin, baclofen, and other drugs as well as orthopaedic surgical procedures aim to correct atypical hypertonic postures. Physiotherapy precedes and follows these procedures with the methods above (see Chapter 12).

Special boots or shoes

These may:

1. be padded at the tongue to fit well around the ankle
2. have a strap to cross the front of the ankle to press the heel well down
3. have an inside mould at the inside arch to control valgus
4. have an external heel extension on the inner side of the sole to prevent pronation (valgus) of the foot; on the outer side of the sole to prevent supination (varus)
5. have a raise on the heel, with a flare on the inner side for valgus; outer side for varus.

In addition:

1. Boots may be worn with special orthoses.
2. Boot may have a sole raised to provoke forward weight shift to step, or to stretch heel cords. Just removal of the heels and thick soles may stop toe walking due to mild spastic hypertonus.
3. Boots or shoes may have a weighted base to add stability for, say, ataxia.
4. Stiffening on the boot leather may be given on the inside or outside to stop the foot rolling over into either pronation or supination, respectively. Heel cups on their own or with moulded extension to correct all foot arches may be needed.
5. Toes of boots often have to be protected with thick rubber, plastic coatings, or metal to avoid the frequent wearing of the leather in toe walkers or crawlers who are just beginning to walk.
6. Crawling children or non-walkers have boots and shoes to keep their feet warm, without any modifications. Booties or *trainers* stay on their feet better. Crawling is not possible in below-knee orthoses.

Note. Putting boots and shoes on and off is facilitated by the use of laces down to the toes as in Piedro shoes. Toes can then be held flat during application of boots. Velcro instead of laces makes it possible for some children to put their own shoes on and off. A tab on the back of the boot helps the child to pull on the boot.

There are various special trainers for children with cerebral palsy.

Treatment suggestions for rising to standing (6–12 month level)

Mobility in bed and transfers

All the rising abilities trained are valuable for a child's independence in turning in bed and getting out of bed. Training includes the use of hand grasps with elbow extension for pushing blankets down and for support as well as the hand propping used in developing this independence.

Prone to standing. At earlier developmental levels the child has learned to roll over and get onto hands and knees or rise from prone onto hands and knees (0–6 months). Train them to rise to half-kneeling and then to standing (6–12 months) (see section 'Prone development'; see Fig. 9.165). Some individuals may rise onto hands and feet to standing. Avoid the pattern of pulling up to standing by dragging legs into extension and onto toes. However, this is a pattern seen in typical toddlers, but it persists in cerebral palsy. It can be corrected using a roll and during bed mobility exercises when lying prone, dropping legs over the edge of the bed and rising to standing (Fig. 9.161). Pushing on straight arms tends to press heels down with straight legs.

Supine to standing. Rising from supine to sitting into squatting on both or one foot and pulling up to standing may be preferred by a child, rather than using the half-roll pattern. Help them to develop this by taking both hands when they are sitting on the ground. Stabilise their foot with your foot and wait for them to pull themselves forwards over their feet and then extend their legs. From crook sitting or squatting, assist rising if a child can actively stretch their legs. Use a hoist on their trunk if they are tall or heavy. The full rising can be carried out from supine to squatting and up to standing by holding the child's hands and feet flat on the table. Hemiplegic or asymmetrical children can be encouraged to take weight on the more affected side as they squat and rise (see section 'Supine development'; see also Fig. 9.163). Rising from the ground using squatting is a necessary skill in cultures where people use floor activities in daily life.

Sitting to standing. Rising from sitting on a chair (Fig. 9.162) or from squatting to standing (Fig. 9.163) can be carried out in a variety of ways.

Face a child on a chair with both of you grasping the same stick. Assist the child to push the stick towards you to bring their weight forwards as they stand up. Use manual resistance applied on the top of the child's thighs. The child's thighs are carefully kept apart and in external rotation by the therapist who is either behind or in

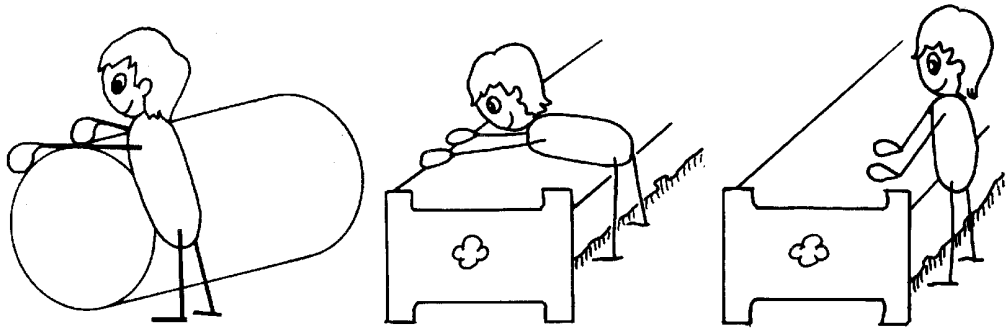


Figure 9.161. Assume standing from prone lying across a roll, large ball, or bed. Check that heels are on the ground, knees and hips straight, and, if necessary, turned outwards.

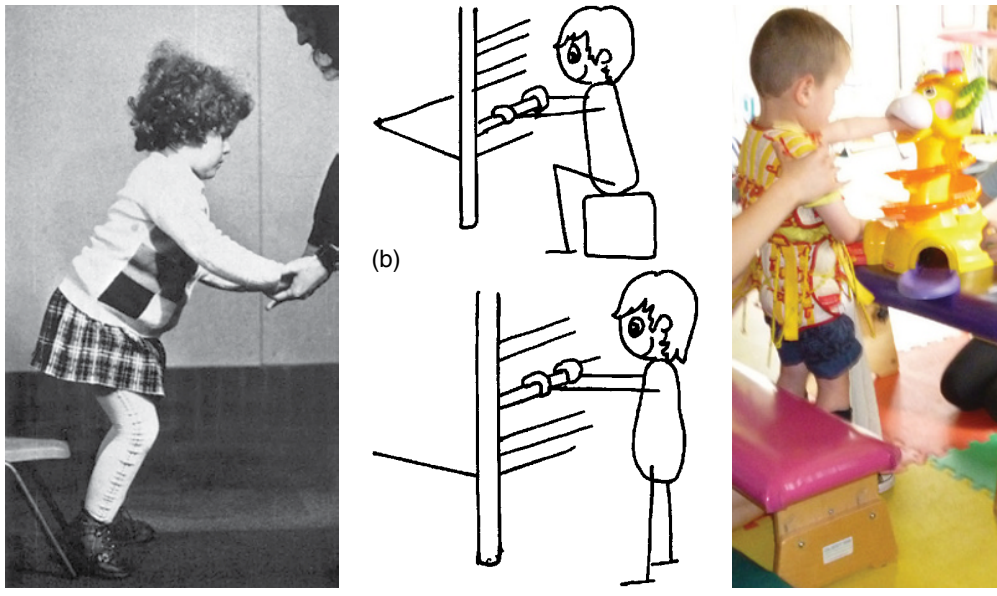


Figure 9.162. (a–c) Sitting to standing. (d) Active sit-to-stand in order to post a ball into the mouth of a toy.

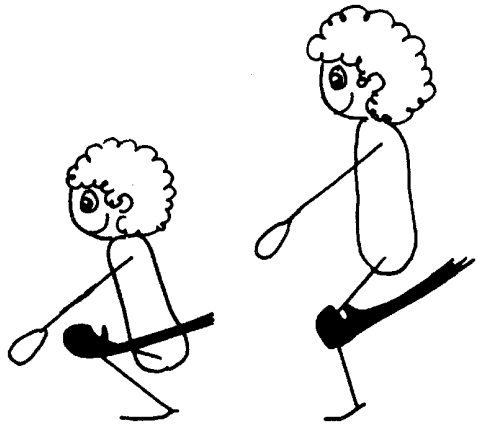


Figure 9.163. Squatting to standing.

front of the child. If the therapist sits on the ground in front of the child, he or she has the advantage of making sure that the child's weight comes well forwards over the feet. The child may learn to bring their own weight forwards over their feet if they are also told to reach forwards and down to the floor and *raise their bottom* off the chair. In some children, resistance may be given at the lumbar area to augment this movement. Rising from the floor and from a chair to standing can be taught by careful verbal instruction. For example, rising from a chair involves 'Put your feet flat on the ground, bring your nose over your toes, lift your bottom and now stand up'.

Teaching a child to bring their weight forwards or *nose over their toes* is important or they will not become independent in rising. They will tend to use an extensor thrust or get up atypically by pushing on their feet, leaning backwards, and grasping your hands, being totally dependent on you in order to rise to their feet. Develop squat on a stable potty or from sitting on a toilet chair to practise the correct use of this rising action daily. Legs are exercised, grasp may be practised on a bar, and independence is promoted. Sit-to-stand is an important motor function for many daily activities in school or in the community.

Teach getting up to standing from kneeling (Fig. 9.164), holding crutches or other

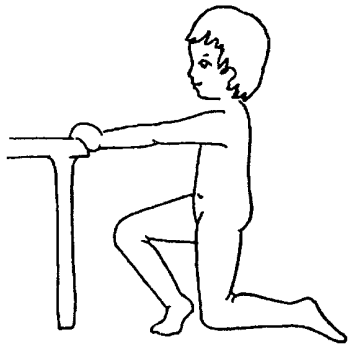


Figure 9.164. Half-kneeling to standing.

walking aids. Other rising problems have to be solved. Rising from bed to sit/stand must be included. Figure 9.165 gives various sequences for rising reactions. A child, parent, and therapist work together to choose which sequences suit their daily lives.

Supine lying to squatting and then to standing is only learned by people functioning at the 3–5-year developmental levels, which involves a straight lying-to-stand pattern with no/minimal rotation, with a child often using hand support on the floor. *Slow rising and hold* prepares for attainment of maintained squatting, perhaps at play, in the next stage. Individuals use momentum to rise from different postures, as postural stability in each transient position is not necessary for independence. It is the training of slow controlled rising sequences that augments stability in the transient postures and establishes safety.

Strengthening of trunk muscles. A weighted jacket used during rising from sitting to standing, or from squatting to standing, provides strengthening of trunk muscles. The jacket can also be used for other motor functions. This depends on the individual's abilities.

Transfers. The rising experiences above are used in transfers, but specific training of transfers is needed. Transfers use arms and hands as supports when a child moves from chair to bed and vice versa, or a person needs to give support. Transfer from a chair without arms to a chair with arms and progress to seats without arms using less and less of a child's own arm propping for support. In Fig. 9.118, a child is being taught to pivot on a chair for transfers, and pivot in standing is also a way for a person to transfer from, say, bed to stand, to chair.

Transfers are achieved or established in the next stages of development. They are important for carers as well as allowing the child to feel that they are participating in changing position. Hoists or turntables may still be needed for more severe cases.

Stand and stoop to floor now without giving the child support. Use wall bars to move hands down from bar to bar and move up bars. Child rises or re-erect to standing from stoop to floor. Make this activity more meaningful by inviting the child to pick up clothes, socks, or soft, hard, large, and small toys. Hold the child in standing with legs apart as they stoop to push a ball between their legs to another child. They rise to standing and play throwing a ball over head to another child. At first, a child may tend to topple forwards in reaching for an object and be unable to reach the floor. Start with objects on a low box and progress to the floor. Use assistance and then gradually remove it. This is motivating as a child clearly sees their own achievements over time and would enjoy this as a 'goal'.

Such activities provide both counterpoising and rising elements, as well as perceptual experiences with hand function.

18–24-month normal developmental level

Common problems

Delay in walking alone, immature walking pattern, for example narrower base, arms

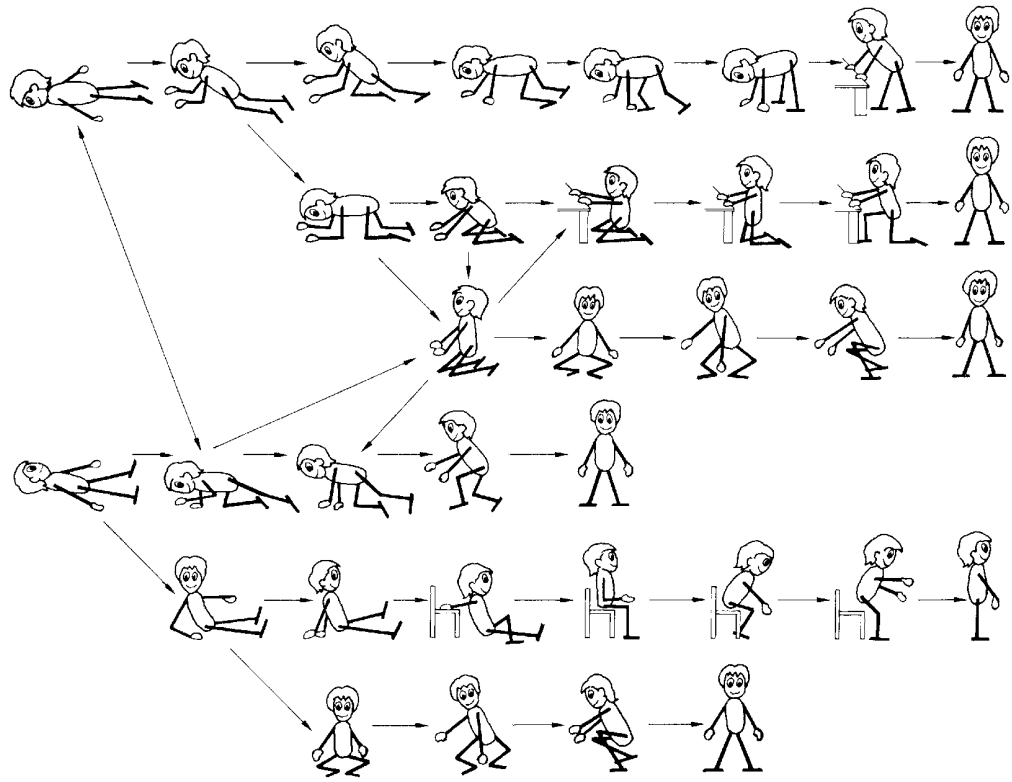


Figure 9.165. Some patterns of rising to standing. There are various sequences for rising. A child, parent, adolescent, and adult work together with the therapist to choose which sequences suit their daily lives. This will involve the full sequence or only a *partial* sequence. For example, the full sequence is to rise to standing. However, there are also partial sequences: to roll over in bed, to change to a position for play on the floor, to rise to sitting on a chair to watch television, or to rise to upright kneeling at a low table/couch for play.
See also Appendix 1 for wheelchair transfers.

coming down from being held up in abduction high guard to medium guard and later arm swing. The steps need to be more rhythmical, equal, and smoother. Delay in stable standing alone and during play in standing. Delay in rising to standing completely independently, starting and stopping walking with and without sticks, stair ascent and descent, use of inclines, and walk on rough ground is not achieved or does not improve until the second year (and still further in third year). Delay in walking, carrying an object with both hands, as well as a cup of liquid or a heavy object. Delay in standing, picking up an object from the floor.

Atypical performance. See section 'Atypical gaits in the spastic type', for a variety of motor patterns.

Reflex reactions. The following are expected at this level.

1. Saving from falling by staggering (protective) reactions in lower limbs, forwards, sideways, backwards, crossing over, and hopping.
2. In standing, tip child backwards, which results in dorsiflexion of feet (see

Fig. 9.168), then trunk flex forwards, and, when the child is pushed more vigorously, a protective step results. When the child is pushed forwards, this results in back extension, with or without a rise onto toes. A lateral push results in the trunk incurving towards the upright, inversion of the foot opposite to the push, and pronation of the other foot (see Fig. 9.169). If the tip (push) is slight, only feet respond symmetrically. A tilt board is also used to activate these reactions.

3. Rotating the child in standing, feet apart, results in one foot inversion on the backwardly rotated side and the other foot in pronation.

Arm-saving reactions become more established in all directions.

Shumway-Cook et al. (2003), in a study of standing balance in six children (four with spastic diplegia and two with hemiplegia), demonstrated a significant improvement in their ability to recover stability following training. Woollacott et al. (2005) explored possible neural mechanisms that contribute to improvements in balance control on a movable platform. Both these studies were on reactive balance control. More evidence is given in Shumway-Cook and Woollacott (2017).

Treatment suggestions and management

Standing. Practise lifting heavier objects or toys, maintaining standing balance. Stand and stoop to pick up a toy from different table heights and the floor. Stand, stoop, and re-erect; stand, kick, and throw balls.

Gait. See Figs 9.151–9.155. Continue improvement of gait. Child becomes able to self-correct gait and control balance.

Other techniques. See the 9–12-month level without walking aids. *Stair climbing* is also dependent on standing on one leg long enough for the other to deal with the step (Fig. 9.166). This should be trained on and off a low box, progressed to higher boxes as well as staircases, pavements, and wall bars or stable ladders. These activities also train perception of height or space. Use of banisters, two hands, one hand, and independent stair climbing and descent is achieved by 3–4-year developmental levels (Tables 9.1 and 9.2).

At first a child uses an exaggerated foot lift, but by 3 years there is an economical foot lift to stair.

Train walking and stop, walk and turn, walk between and around objects. Teach walking with the child pushing and pulling large toys. Walk on different terrains with or without support (Fig. 9.167a,b). *Develop walking up and down inclines*. Walk

Figure 9.166. Standing on one leg long enough to allow using a stair.

Table 9.1 Motor developmental stages, 2–7 years

Age	Developmental stage
2 years	Climbs onto furniture
	Pulls wheeled toy by string
	Ascends and descends stairs holding on, two feet per stair
	Gait pattern changes from wide base, short, flat footsteps to narrower base, more heel–toe action established by 3 years
	Arms held in abduction during gait come down to relaxed flexion at child's sides
	Legs change from external rotation to facing forwards
	Walks, runs, and stops alone
	Avoids obstacles while running or walking, steers wheeled toys
	Throws ball without good direction and with excessive effort
	Arms held out when asked to catch a ball
	Walks backwards, sideways, between obstacles
	Walks into a ball to attempt kick
2.5 years	Jumps two feet together
	Ascends stairs, holding on, alternate feet
	Descends holding on, two feet per stair, ascends two feet, no hold
	Propels tricycle with feet on the ground
	Stands and kicks ball with one foot
	Stands on tiptoe by imitation
3 years	Ascends stairs, no holding on, alternate feet
	Descends stairs usually two feet per stair, no holding on
	Jumps from bottom stair or pavement
	Climbing furniture, apparatus well
	Runs and turns, runs and pushes large toys
	Walks on tiptoes, on heels, heel–toe action in walk up inclines, uneven ground
	Balances on one foot alone, momentarily, enough to walk on line unsteadily
	Pedals tricycles and pedal cars
	Imitates movements, e.g. wiggles thumb, asymmetrical arm position unless very complicated
4 years	Throws and catches ball with more control, less effort, more direction, and does not need to place arms out to catch
	Bounces ball, picks up ball or object with bend from waist
	Walks on wide balance beam, near ground, walks heel to toe on line steadily
	Stands on one foot for 3–5 seconds alone
	Hops on right or left foot increasing distance
	Imitates finger plays, including fine pincer actions
	Gait pattern now with arm swing, stops suddenly, turns on the spot

Table 9.1 (Continued)

Age	Developmental stage
5 years	Climbs trees, ladders, apparatus
	Expert at sliding, swings, 'stunts'
	Dances, hops, and skips to rhythms
	Throws and catches a ball in various directions, smaller balls
	Kicks ball on the run
	Counts fingers by pointing
6 years	Wrestles, tumbles
	Roller skates
	Jumps rope, begins skip with rope
	Stands on one foot with eyes closed
	Bounces and catches balls
7 years	Walks on narrow and high balance bars
	Throws ball about 9 metres (30 feet)
	Begins team sports

Source. Based on the work of Mary Sheridan updated by Sharma and Cockerill (2014).
Note. Movement development shows improvement in speed, precision, and decrease of effort or extraneous movements, and increase of endurance. Perception of space, timing, and rhythm become integrated with many of the motor skills.

backwards. Increase speed of walking (see Moreau et al. (2016) for interventions to improve gait speed). Begin developing running by holding a child's hand.

Train a person to pivot (turn) in standing by assisted trunk turn while they move their legs in steps to turn. Once achieved, pivoting is usually valuable for transfers and turning in small spaces.

Train protective and staggering reactions. First push the child's anterior pelvis slightly backwards for dorsiflexion with or without hip flexion (Fig. 9.168). A more forceful push results in a protective backward step. Also hold hips and sharply rotate the child to provoke a protective step. Hold the child's upper arm and push and pull them in all directions to stimulate staggering or hopping reactions. One foot may be held instead and the child pushed forwards and a protective step provoked.

Tilt reactions (Fig. 9.169). Tilt the child back, sideways, or support them at the hips. Tip (push) slightly at the shoulder/trunk. Use a rocker board.

- In order to stimulate the tilt response, tip the child well off the horizontal to develop a safe postural control. A child also tries to sway themselves forwards and backwards using an active postural adjustment to maintain balance. Later try to increase postural adjustments laterally with supervision.

  Perturbations on a moving surface can be developed on a train, tram, or in moving floors at the airport.
- Provoke a reaction in the feet on a rocker board. See also the discussion

Table 9.2 Character sketch of developmental stages, 1–7 years

Item	Stage by age (years)	Stage 1	Stage by age (years)	Stage 2	Stage by age (years)	Stage 3	Stage by age (years)	Stage 4	Stage by age (years)	Stage 5
Gait in walking	1.6	Early toddler	1.9	Late toddler	2.3	Young child heel strike	6.0	Adult. Heel–toe push off		
Upstairs	1.0	Creeps on hands and knees	1.9	Walks two feet/ step + hand. Exaggerated foot lift	2.3	Walks two feet/ step + hand. Economical foot lift	3.0	Walks one foot/step and hand	4.0	Walks one foot/step. No hands
Downstairs	1.3	Sitting, bumps or creeps backwards	2.0	Walks two feet/ step + hands (giving much support)	3.0	Walks two feet/ step + hand	4.0	Walks one foot/step and hand	4.6	Walks one foot/step. No hands
Tiptoes	2.0	Balances momentarily but lowers heels to floor before walking	2.6	Walks on toes but with much ↑ ↓ movement of heels, which touch floor often	3.6	Walks well on toes with no ↑ ↓ movement of heels	4.6	Runs well on toes		
On heels	2.0	Toes raised when standing but lowered to floor before walking	2.6	Walks with toes raised and whole forefoot off the floor only for some steps	3.0	Able to walk on heels with forefoot only occasionally sinking	3.6	Walks well on heels		
One foot balance	2.0	Tries but unable (may *cheat* by holding on to something)	3.0	Momentarily succeeds for 0–2 seconds	4.0	3–9 seconds	5.0	10–12 seconds	6.0	12–16 seconds
Hopping	2.0	Unable – may jump up and down two feet together	3.6	1–4 hops	4.0	5–8 hops	5.0	9–12 hops	6.0	Over 12 hops

Source. With acknowledgements to Dr P.M. Sonksen from her thesis (1978) for MD entitled: *The neurodevelopmental and paediatric findings associated with significant disabilities of language development*, University of London.
Note. Ages given are in years and months.

(a)

(b)

Figure 9.167. (a) Walking on different surfaces using a walking aid. (b) Negotiating different surfaces when walking with tripods and ground-reaction ankle–foot orthoses.

Figure 9.168. Tilt reaction backwards using hip flexion with dorsiflexion. Slight push activates dorsiflexion only.

Figure 9.169. Tilt reaction sideways.

on the treatment of valgus feet in Chapter 12.

More advanced counterpoising on one foot is shown using a scooter (Fig. 9.170a) and when stepping over benches or toys of different heights (Fig. 9.170b) as well as in activities such as climbing and kicking balls (Tables 9.1–9.3). Throwing balls or beanbags is shown in Fig. 9.170c. Figure 9.170d shows a child stooping to pick up a small ball from a bowl then placing it in another bowl on a bench.

(a)

(b)

(c)

(d)

(e)

Figure 9.170. (a) Counterpoising on one foot using a scooter. (b) Variety of benches for stepping over, and for walking along. (c) Standing and throwing balls, beanbags, and other similar activities develop postural adjustments for arm elevation. The demand on the boy's postural adjustment is evident, showing mild difficulty. (d) Picking up a small ball from a bowl then placing it in a bowl on the bench. (e) Stepping, bending, and stretching in reciprocal leg motion.

All these activities improve postural adjustments as well increase strength and keep children fit.

2–7-year levels (Tables 9.1–9.3)

Teach tricycling with an adapted or a regular tricycle, hop, skip and jump, and the variety of activities at the different developmental levels described in Tables 9.1 and 9.2. Functional strength training can be motivating in groups such as circuit training classes (Blundell et al. 2003). Strengthening can also be carried out on standard gym equipment (Fig. 9.170e).

Sports can be carried out with a number of special aids such as runners or cycles together with and without adult-assisted cycling attached behind a child. There are an increasing number of wheelchair sports such as boccia and basketball. Children with crutches or sticks can play football with each other depending on their abilities. (See section 'Motor function for leisure' in Chapter 10.)

Development of hand function

The development of hand function not only depends on the motor control of the shoulder girdle, arms, and hands but also on visual, perceptual, perceptual–motor, and cognitive development.

The *main motor aspects* of hand function involve the type of grasp, the pattern of reach, the pattern of reach-and-grasp, the ability to manipulate, and the pattern of release. These aspects may develop independently of gross motor abilities. Such development of upper limb function depends on well-supported lying, sitting, and standing postures, so a child can concentrate on fine motor development through engagement in functional tasks.

Table 9.3 Developmental stages of the kick, 1–8 years.

Stage I: boys <1 to 2.6 years/ girls <1 to 3 years	The child walks, runs, or *straddle toddles* towards the ball, and then walks into it, displacing the ball rather than actually kicking it. Some children who are standing near the ball or have come to a stop near it, lift up one foot and then step onto the ball. Children at this stage sometimes overbalance and fall.
Stage II: boys 1.6 to >7 years/ girls 2.6 to >7 years	From a standing position the child propels the ball forwards by flexing the leg at the hip and maintaining balance on the other leg. If the child has run to the ball, they will stop just in front of it, adjust themselves and/or the ball, and then kick the ball.
Stage III: boys 1.6 to >7 years/ girls 2.6 to >7 years	The child can now run towards the ball and kick it while running, propelling it forwards with some force and good direction. They anticipate the kicking position and bring the supporting leg at the side of the ball before swinging the kicking leg forwards. The latter leg is not kept fully extended throughout the kick, but is kept slightly flexed during the swing and then fully extended for the actual kick.
Stage IV: boys 4 to >7 years/ girls 5.6 to >7 years	The child and the ball are moving towards each other, and the running child can now kick the oncoming ball with good direction and force. They can anticipate the slight modification of the ball's position moving towards them as they bring themselves to the kicking stance, and they hit the ball end on, suddenly reversing its trajectory towards the examiner.

Source. After P.M. Sonksen.

However, although hand function can develop if a child is well positioned and appropriately supported by equipment, this can limit opportunities for the development of other skills. All arm and hand actions activate the anticipatory postural adjustments, so children should also practise using their arms and hands while they are less well supported. Assess a child's level of postural control in prone, supine, sitting, and standing development to plan support or activities for interaction of postural control with upper limb function.

As postural control can be at different motor levels from hand function, therapy and management are planned to accommodate this discrepancy using appropriate support. It is essential to develop fine motor ability in its specific developmental levels for the following reasons.

1. Use of hands is helpful for perceptual development, cognitive development, and for communication with and without augmentative and alternative communication aids and digital assistive technology. The use of gestures is important to support social communication and the development of as much self-care as possible is essential in increasing independence. Essentially, increased hand function enables engagement in a wider range of activities, which promotes participation and therefore provides emotional satisfaction and socialisation of the child and is important for quality of life.
2. Use of hands is particularly important for a child with motor disabilities so that they can use them for support on open hands or grasp to maintain balance in sitting, standing, walking, or to pull into any position.
3. Hands can be used to help establish shoulder girdle stability, which is fundamental to many of the fine and gross motor skills. This is distal to proximal control. Depending on a task, both proximal-to-distal and vice versa in upper limb function is used in therapy. The principle of proximal-to-distal does not apply in upper limb function in cerebral palsy.
4. Observation of typically developing babies reveals hand use in breastfeeding, thumb sucking, and hand placing when the dorsum of the baby's hand is touched against a table/toy. Children with dyskinesia first benefit using maintained hand grasp or weight bearing on forearms to stabilise shoulder and trunk. Atypical patterns may not only be due to spasticity, athetosis, or ataxia, but include arm and hand patterns seen in typically developing children at an early age of development and not at the chronological age of the individual with cerebral palsy. These are outlined below and there may be much variation between individuals.
5. Hand function development may not correlate with developmental levels of gross motor function (Eliasson et al. 2006).

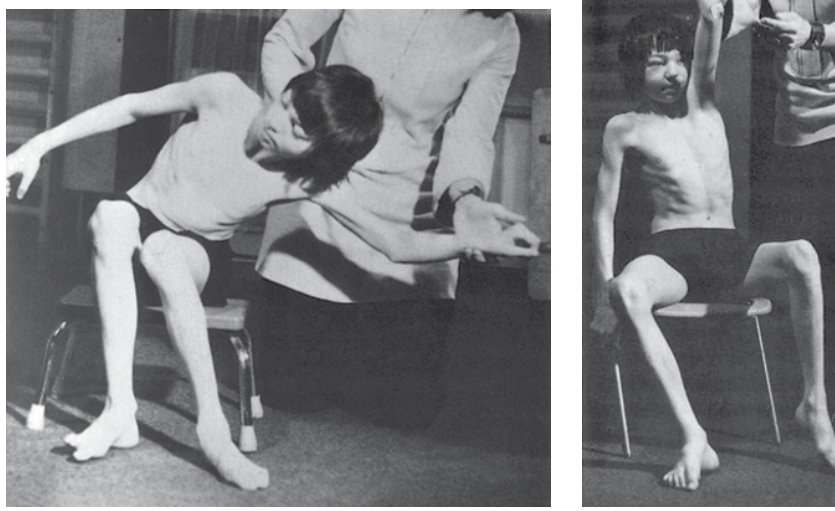
Aims

Upper limbs and the postural mechanisms

1. Establish head control (stability and movement) for hand/eye coordination.
2. Establish postural stability and weight shift of head, shoulder girdle, trunk, and pelvis in many gross motor activities in prone, supine, sitting, standing, and stepping, which are also necessary for hand function. This allows arm and hand function in postures other than in lying.
3. Develop particular stabilisation of the whole body, shoulder girdle stabilisation on arm/forearm support, and wrist stabilisation with fine motor activity. Non-slip surfaces, stable furniture, and stabilising of objects by child or therapist need to accompany training.

For example, body, shoulder, and wrist need to stabilise for pouring liquids onto a stable container.

4. Decrease manual or other supports in developmental stages, especially in sitting, standing, and upright kneeling, so anticipatory postural control is associated with arm and hand function. If not, essential anticipatory postural adjustment for daily function remains dormant (Fig. 9.171). There is more support when a child concentrates on new or difficult skills. The supports or straps in chairs and standing equipment are increased at such times. Some therapists recommend the use of two chairs, one for learning postural control (balance) with hand function and the other to provide increased support for activities that require greater hand function and dexterity such as feeding, or to enable physical access to a communication device.
5. Develop rising reactions. Hands and arms are used to help in the change of various postures or the assumption of posture in gross motor development. A child also needs to assume a position in which they will carry out chosen activities in various environments.



(a) (b)

Figure 9.171. Training reach (strength, synergy, and postural control). (a) Absence of postural adjustment (counterpoising) in the trunk leads to the child falling over the arm during its movement. *Note.* Attempts to use the better arm for grasp or arm support by a child are used initially and progressed to trunk adjustment without arm support or grasp. (b) The trunk is adjusting for the arm movement. A variety of arm movements need to be trained together with postural adjustment, in all positions. *Note.* The height of the chair controls the position of the legs. A lower chair is used to prevent excessive leg extension, to use feet flat on the ground, or foot supports for stability or to diminish athetosis.

6. Develop saving reactions in the arms. The upper limbs are thrown into various patterns involving active contractions of the muscles in synergies (patterns) to save and prop the child as they fall off balance. Although the hands and arms participate in *automatic* saving and propping reactions as well as in various rising reactions, these will rarely be enough to contribute to *voluntary* movements. Development of the voluntary movements of reach, grasp, and release have to be promoted through engagement in functional activities.
7. Some of the arm synergies trained for gross motor function are also used in voluntary reach (Fig. 9.172). However, these patterns need to be practised in the context in which they are used in daily tasks. There is then integration with sensation, perception, and understanding. If the task is chosen by a child, or special interest is shown by the child, then emotional satisfaction, motivation, and social needs are satisfied.

Upper limbs and atypical motor behaviour

1. Treat atypical postures of the whole child, including the atypical postures of the arms and hands (Figs 9.173–9.175). Improving the posture of the whole child often positively improves the arms. Conversely, correcting postures and arm patterns may improve the rest of the child (Fig. 9.176). Deformities

Figure 9.173. Shoulders protracted or retracted with arms flexed–adducted and hands clenched in a predominantly flexed child similar to the newborn. Inability to reach out or can only reach near their body. Problems of release occur if hands flex or clench excessively. Asymmetry may exist with visual input only available from the hand on one side.

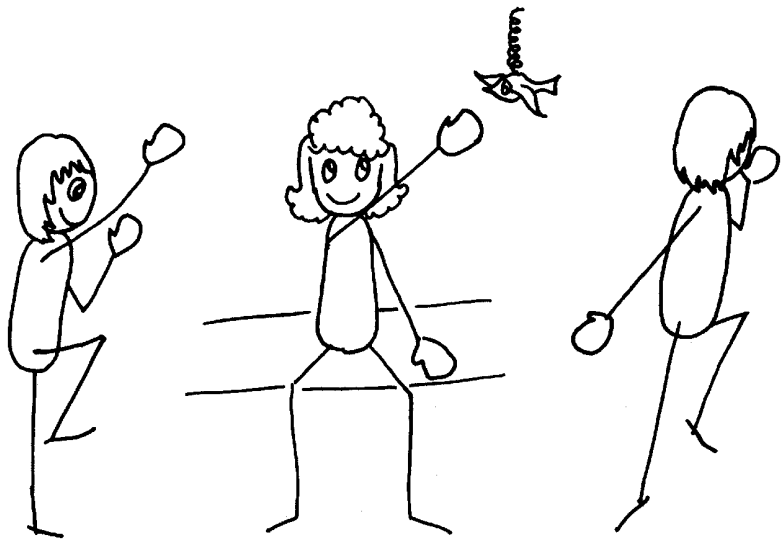


Figure 9.172. (a) Arm pattern of shoulder flexion–adduction–external rotation trained within training of rolling. (b) To reach a toy in lying or sitting. (c) Arm pattern of shoulder extension–adduction–internal rotation within rolling prone to supine, or within creeping pattern in prone, may be used in reaching back and behind child as, say, in putting on a coat.

Figure 9.174. Arms flexed–adducted and internally rotated with elbows flexed and pronated, wrists flexed or mid-position, and hands clenched or open. Shoulder flexion–adduction–internal rotation may also occur with elbow extension–pronation. Shoulder flexion–adduction may also occur with elbow supination and flexion in children with dyskinesia who *fold their arms in* towards their bodies.

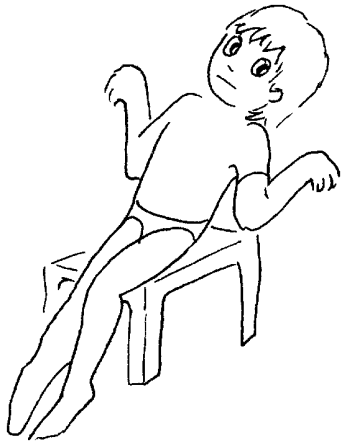


Figure 9.175. Arms held up in the air in abduction–external rotation, elbow flexion and supination with palms facing towards the child. Elbows may also be flexed and pronated with palms facing outwards. Hand may be hanging down or clenched; this is also called the *bird-wing position* and is seen in supine, sitting, and standing positions. This may alternate with an asymmetrical tonic neck reaction or other asymmetry. There is inability to reach forwards, bring hands together, and develop *hand regard* and bring hands down for support.

are minimised by specific arm and hand actions to avoid secondary deformity and secondary impairments. This avoids blocking further function. However, in children or adolescents with a higher Manual Ability Classification System (MACS) level, some atypical hand postures can be used effectively for function. For example, wrist flexion to open a tightly flexed hand and grasping with marked wrist extension.

2. Consider how to decrease involuntary movements in the hands or whole arm, which disrupt hand function. These involuntary movements may stem from the whole body. There may be

Figure 9.176. Correction of asymmetry of arms, flexion–adduction–internal rotation and other atypical postures of the arms also corrects atypical postures of head and trunk (kyphosis, kyphoscoliosis) and vice versa. *Note.* The child tries to maintain postural fixation in vertical alignment and not fall backwards against the therapist. Use arm elevation for dressing, ball play, and other activities.

involuntary motion in another part, for example the 'kicking motions' of legs or sudden extension of legs hitting tables, which affect the use of the hands.

3. Counteract any asymmetry where possible. For example, only one side is used; fisting of one hand is greater. Various visual problems affect one side and reaching across to the opposite side. This should not be confused with bilateral hand function when a child stabilises on one arm while using the other more able or dominant arm, as this is required for many functional tasks such as writing.
4. Develop the ability to rotate the trunk and shoulder girdle to reach across the midline. This first develops in supine and much later, between 2 and 3 years, in sitting and standing.

Basic arm and hand patterns for all levels of development (Table 9.4)

Although one should not be dogmatic about the pattern in which a child uses their arms and hands to achieve their goal, it is important to select efficient patterns in treatment for the following reasons.

1. Atypical patterns can be inefficient. However, some are efficient because they are easier for children with cerebral palsy, but they offer a limited repertoire. These grasps are not suitable for more developmentally advanced tasks and for different situations. The repetition of cerebral palsy grasps tends to create deformities that often make control more difficult.
2. The child with poor hand use has much less sensory experience or perhaps loss of sensation. They may have no idea on how to move and need training in basic neuromuscular patterns. They may later modify these patterns within their individual development and discover what they find to be the most effective hand use through experience and learning. Visual impairments or other perceptual difficulties may result in the choice of atypical or ineffectual hand function.

There are unusual grasps the authors have observed in various able-bodied receptionists and bank clerks which are efficient for writing.

Constraint-induced movement therapy (CIMT)

CIMT is a treatment for children with unilateral cerebral palsy (hemiplegia) based on the view that the affected arm and hand are restricted because of lack of experience and practice (Taub et al. 2004; Gordon et al. 2005; Charles et al. 2006). Therapy involves restriction of the unimpaired limb so that the child has to use the affected arm to carry out tasks, thereby enhancing perceptual–motor function and motor learning with that arm and hand. Therapists encourage movement of the affected limb through 'repetitive practice of unilateral and bimanual activities and CIMT aims to overcome "learned non-use" by intensive, targeted practice with the more affected limb during restraint of the less affected limb' (Charles and Gordon 2005). Initial studies examining the effectiveness of dosage varied in regards to how long a child would be required to wear the constraint, from 3 to 6 hours a day (Sung et al. 2005; Hoare et al. 2007; Huang et al. 2009). Subsequently DeLuca et al. (2012) identified that the question around dosage would be a key component in regards to both utility and feasibility of protocols at a local level. Their study reporting on immediate and 1-month outcome data following 21 days of CIMT demonstrated that results for young children who received a moderate dosage (63 hours) appeared to be comparable to those receiving a high dosage (126 hours).

In recent years, therapists have carried out research studies involving the modification of the plaster of Paris restraint

Table 9.4 Development of hand function and eye–hand coordination (assessment guide)

Age	Function
0–3 months	Eye-to-eye contact (parallel eyes)
	Fixes eyes on light; eyes follow object to midline (1 month), to past midline (2 months), over 180° (3 months), eyes down, then up; hands opening from closed posture
	Reflex reactions: tactile grasp; stretch grasp; blink; doll's eye reflex; Moro; ATNR; reflex hand flare open
3–5 months	'*Grasps with eyes*' when interested in an object
	Hand regard or studies hands, brings hands together in midline, clutches and unclutches hands
	Visual exploration of environment, visual tracking targeting, and visual-directed reach begins; swipes at objects when lying
	Clumsy reaching, bilateral; corralling an object; early hand shaping to object
	Clutches clothes; touches body, mouth, face
	Grasps object placed in hand; abducted thumb
	Reflex reactions: Moro, ATNR disappearing, absence of grasp reflex
5–7 months	Reaching successfully in all directions, depending on trunk balance; often trunk stable
	Bilateral reach, unilateral reach; anticipatory excessive metacarpophalangeal/finger extension
	Grasps feet in supine and sitting – bilateral then unilateral; thumb pressed into opposition
	Maintains grasp (grip) on stationary object
	Ulnar grasp changing to palmar grasp; wrist flexed becomes straight
	Mirror movements of grasp in the other hand
	Moves head to see things, eyes converge and focus on pellet at 3 metres (10 feet); smaller pellets seen by 9 months; rakes pellet with flexing–adducting thumb, raking actions of all fingers. Thumb out of palm
	Continues to mouth everything, hand to mouth movement with object
	Reflex reactions: saving and propping downwards, forwards, and beginning laterally; posteriorly later (12 months)
7–9 months	Transfers object from hand to hand
	Unilateral reach-and-grasp; wrist extends; trunk weight shift; sitting alone
	Radial grasp, beginning use of fingertips with opposed thumb
	Holds one block while given another
	Offers cube, but cannot release it; drops objects
	Releases cube by pressing it against a hard surface
	Bangs two objects together; compares them. Uses sticks to bang all over a large surface
	Pats, bangs, strokes, clutches, rakes, scratches/pats mother's face, pats image of face in mirror; thumb abducted or opposed

(*Continued*)

Table 9.4 (Continued)

Age	Function
9–12 months	Protrudes index finger, pokes objects with finger, other fingers flexing
	Grasps between fingers and thumb, then one finger and thumb (crude to fine pincer grasp)
	Pick up and place in and out of large containers, then smaller containers; places lids
	Reach-and-grasp possible in all directions, with supination and improved control of shoulder, arm; appropriate anticipatory grasp
	Release with gross opening of hand, then more precise until places small objects in jar, peg in hole, for appropriate anticipatory release
	Looks for fallen toy (permanence of objects); casts toys
	Reflex reactions: saving and propping backwards behind child; lateral and oblique
12–18 months	Casting of toys stopping; mouthing stopping
	Watches small toy moved across room up to 3.5 metres (12 feet)
	Builds tower of two cubes; places pellet into bottle
	Pushes and pulls large toys
	Drinks alone from cup, often spills
18 months–2 years	Delicate pincer grasp and release
	Takes off shoes, socks, vest, hat
	Turns pages of book
	Strings large beads, later smaller beads (29–36 months)
	Scribbles with pencil; whole hand grasp, supinated
	Feeds self clumsily
	Hand preference more obvious
2 years	Pencil grasp, pronated fingers, wrist deviates
	Throws ball inaccurately
	Unwraps sweet
	Screws and unscrews lids, toys
	Imitates vertical line; scribbles and dots
3 years	Takes off all clothes, puts on most clothes
	Feeds self completely, using fork
	Copies line, circle; static tripod pencil grasp
	Draws a man simply
	Cuts with scissors
	Washes alone

Table 9.4 (Continued)

Age	Function
4 years	Draws simple house, more detailed man
	Brushes teeth, dresses alone except for buttons and laces
	Constructive building, including three steps with cubes
	Matches and names four colours
	Copies cross; static tripod grasp modified
5 years	Copies square, triangle, letters; dynamic tripod pencil grasp
	Matches 12 colours
	Drawing and copying improved
	Uses knife and fork
	Dresses and undresses completely

Source. Based on the work of Mary Sheridan updated by Sharma and Cockerill (2014).
Note. Assessment measures of detailed hand function interwoven with conceptual, perceptual, and activities of daily living development are carried out by occupational therapists and psychologists. (See also section 'Physical ability assessment guide' in Appendix 1, and sections on developmental stages of feeding, speech and language, dressing, play, and perception in Chapter 10.)
ATNR, asymmetrical tonic neck reaction.

previously used on the uninvolved upper limb, replacing this with an arm sling, ski glove, or mitten on the uninvolved hand. In practice, therapists have also offered toys and other items on the side of the hemiplegia with their fairly unobtrusive holding of the uninvolved arm. Although the initial research was with a plaster on the uninvolved limb in order to gain intensive motor function in the involved arm, this approach is now more child friendly. However, even with a modified approach (mCIMT) therapy still needs to be fairly intensive with significant commitment of the family and carers. Care must be taken not to frustrate a child with difficult tasks, and the family consulted regarding when it is best to trial this technique.

Salimi et al. (2008) caution that CIMT is thought to be detrimental for infants under 12 months, as it may impair the further development of unaffected areas of the surviving corticospinal tract from the intact hemisphere. CIMT might be more effective if combined with bimanual training (Gordon et al. 2008).

The overall effectiveness of CIMT has been well documented (Taub et al. 2011; Hsin et al. 2012), with Novak et al.'s (2013) systematic review concluding that CIMT is a green light intervention based on empirical evidence. However, there continues to be debate regarding the intensity of the treatment and concerns about caregiver ability to comply with dosage demands (Wallen et al. 2011). Steenbergen and Gordon (2006) reviewed evidence that lack of arm function may be due to impairment in motor planning, which is improved by bimanual therapy. The uninvolved hand activates motor planning in the hemiplegic side.

Bimanual therapy

For many years bimanual therapy has been used by occupational therapists to promote the use of two hands in children with

unilateral cerebral palsy. This approach was formalised through the establishment of a published protocol by Charles and Gordon (2006) and was more recently described as 'a process of learning bimanual hand skills through the repetitive use of carefully chosen, goal related, two-handed activities that provoke specific bimanual actions and behaviors' (Hoare and Greaves 2017).

Effective use of this intervention is dependent on knowledge of child development as it requires the therapist to choose toys that will naturally promote the development of the perceptual and cognitive skills required to know that two hands are required to complete a task (Hoare and Greaves 2017). It therefore encourages the child to use their 'affected' hand without restricting perceptual input to the unaffected hand with a constraint as used in CIMT.

Over recent years, research has been conducted into the effectiveness of bimanual therapy, much of which has focused on dosage similarly to the studies evaluating CIMT. It has also often been compared with CIMT or mCIMT, with the authors of a systematic review (Dong et al. 2013) considering whether one or the other has been proven to have a greater effect. Their conclusion suggests that CIMT results in greater improvements in uni-manual ability on the affected side, while bimanual therapy has a greater effect on bimanual performance.

The effectiveness of bimanual therapy is acknowledged through its inclusion as a 'green light' intervention in Novak et al.'s (2013) review of the literature. Direct comparison with CIMT should be avoided given the fact that research suggests the effects are different and contemporary guidance suggests that the two approaches should be considered complementary, with CIMT used to address uni-manual capacity and bimanual therapy used following this to support functional skill development (Eliasson and Holmefur 2015; Hoare and Greaves 2017).

0–3-month normal developmental level

Common problems

Delay in eye focusing, visual fixation, visual following of an object. Clenched hands; thumb still held in palm. Opening begins and continues into next stage.

Atypical performance. See the atypical patterns of arms and hand in supine, prone, sitting, and standing. If a child has hypersensitive palms, this can be associated with a lack of experience in using the hands.

Reflex reactions. Grasp reflex, Moro reaction, tonic neck reaction, flexor or extensor spasms.

Treatment suggestions and management

Eye focus and following (hearing and vision)

1. First offer visual interest in the midline and help the child keep their head in midline. You may need to hold both of their shoulders forwards, occasionally backwards to allow the child to keep their head upright in various postures.
2. At first, place your face or toys close to the child's eyes at about 20 cm (8 inches) from them. Then gradually move further away with encouragement to follow you.
3. Eye-to-eye contact is of first importance before interest in objects. This is best done at the child's eye level, whether they are in side lying, supine, prone, supported sitting, or supported standing.
4. Associate vision, hearing, and head control with face-to-face singing, talking. Vary tones of voice. Encourage a smile and general communication as the child attends, follows, and looks for your *voice*.
5. Help the child to look at and follow your face and then at shiny, moving,

colourful, noise-making mobiles, toys, fishes in a tank, marble runs, a torch light. Use coloured ribbons, Christmas decorations, shiny bottle lids, and also objects which do not make any sounds. Following a visual lure on its own is more difficult for some children.
6. Use red, yellow, or primary colours and black and white pictures.
7. Use jingling noises and not high-pitched or sudden loud noises as the child may still have a startle reflex.
8. Hang tinkling bells, jingling beads, or mobiles in the window or doorway, so they make a sound as the wind blows. Guide any visually directed early arm reaching with full body support of the child (von Hofsten 1992).
9. Put a child in different positions, but start with well-supported upright sitting as well as lying on their back, side, or stomach to carry out active looking and listening activities.

Use of vision is fundamental for hand function. There is therefore delayed development in children with visual impairment and research has established norms of development for children with a visual impairment that are comparable to norms for sighted children.

3–5-month normal developmental level

Common problems

Delay in hand regard, visual exploration; bringing hands together and to mouth, touching self. Delay in active grasp of an object placed in their hand, and delay in reaching for, grasping, and the shaking of a toy. Grasp is typically on the ulnar side of a hand, and this palmar grasp uses fingers but not thumb at this level. The clutching of the child's hands on their own clothes, or those of their parent, may be delayed. Hands are fully opened by this developmental level.

Atypical performance. Asymmetrical bringing of hands to midline; beginning of reach or a grasp is mainly, or only, on one side. Child is touching with semiflexed or closed hand. Sensory experience is therefore limited.

Atypical patterns in reaching becoming more obvious in the next level. Imprecise reaching is typical at this level. Atypical grasps also become more obvious at the next level. The early ulnar or lateral grasp is not atypical at this level.

Treatment suggestions and management

Hand regard and bringing hands to midline and early reach to a visual stimulus

1. Place the child in side lying or lying equipment, or in well-supported sitting, with shoulders brought forwards and both arms placed in front of the child's eyes. Have a child sitting and leaning with their body against the table with arms along the surface for easier movement with such support. Guide early visually directed reaching along a surface. In supine, reach sideways from the child's body, along the ground. Specialist equipment to support children in a side-lying position is available (see Chapter 13) and can be used to help a child bring their hands into view. This should be considered for children whose movement patterns result in their arms assuming a position through abduction, extended bilateral, or asymmetrical patterns and well back out of their view (see supine development in Fig. 9.68a–d, and in sitting and standing equipment).
2. Once the child's hands are in front of them, the child can be made aware of them by your touch and songs, shining a torch on them, putting stickers of stars or pictures on their hands, playing with their fingers, putting thimbles,

rings, coloured ribbon, bracelets or bells on the wrist and fingers. Continue guided reach along a surface at a table or in supine along the floor for severely visually impaired children.

Opening of hands and support on arms

Opening of flexed hands is fully achieved at this level, which is a necessary aspect for the development of release. Later active hand opening to grasp differently sized and shaped objects will be needed. There may be a *total inability to let go of* an object placed or grasped with excessive flexion by a child after the 5-month developmental level. See correction of the whole child's postures in all developmental levels, as these also correct arms and hands.

The following are suggestions.

1. Try to gradually desensitise a child's whole palm by introducing different textures during play activities. Help them open their hands and rub their palms together, move their hands to stroke and touch their face and body, and guide clapping hands, patting the table, and making handprints in sand, on a soaped surface, and with painted hands on paper. Weight bearing on hands on different surfaces, with or without stroking of the surface with one hand, integrates sensory and perceptual experiences. Later improve active hands held open by assisting interlocking of fingers in a clasp, pressing together the heels of the hands. Children learn to do this alone if practised by them.
2. Rhythmical shaking of a child's arm to relax it but without shaking their whole body.
3. Stroke the ulnar and dorsal aspect of the hand, which activates flaring open of little finger and hands.
4. The therapist or the child may press the heel of their hand down on a firm surface combined with their weight bearing on that arm. Use a lower stool to place the child's hands open with the therapist giving pressure (joint compression) through a straight shoulder and extended elbow (see Fig. 9.191). Use a child's weight bearing on elbows and/or on hands to decrease hand clenching, within prone, sitting, and standing development.
5. Hold the child's upper arms, rotating the limbs into external rotation. Children with less severity may only need to have the forearm supinated, so the palm faces up. The child actively turns their elbow into supination as far as they can to hold a toy, ball, or see a picture drawn on their hand.
6. Have the child's arms well away from their body. This avoids clenching in some children. Open the child's hand over a variety of textures but *avoid textures or toys* that stimulate clenching, such as 'squeezy' toys.
7. Open hands when the child is prone leaning on elbows or hands, on hands and knees, sitting leaning on hands, and standing leaning on hands. Open their hands by any of the above methods, pressing the heel of the hand down. Pull the thumb or fingers out from the base and not from their tips.
8. Hands may open within the arm pattern of elevation–abduction–external rotation, or extension–adduction–internal rotation, in techniques of creeping, rolling and reaching out in lying, and fully supported sitting during reach described in the next level.

Hand grasps

Begin developing hand grasps at this level and continue into levels 5–7 months according to capacity. Use the above-mentioned methods to open hands just before hand grasp development. Also, begin active

grasp training before the grasp reflex has fully disappeared.

1. Place different objects before the child so that they choose what they prefer. Let them clutch materials and toys which are soft and easy to grasp. Start with objects of different sensations, for example beanbags; fur, velvet, and suede objects; sandpaper; crinkling chocolate paper; shoe brushes; wooden, metal, and natural objects. Use sand and water, dough, clay, and modelling materials. Name these sensations for the child as they feel them. Invite a child to have their hands in a bowl of dry beans or leaves, cones, or other natural objects. Supervise a child in case small objects are taken to their mouth. Mouthing is useful for objects that cannot be swallowed!
2. Depending on children's ages, offer teething toys, hoops, quoits (rubber rings), rattles, toy dumb-bells, small balls, thick tubing with coloured liquid inside, cotton reels, sponge rubber toys. Avoid either squeezy or tiny toys.
3. Have a variety of objects that fit into the whole palm of the child's hand, so they are not too big for small hands. Grasping a cone with the large end on the side of the little finger often helps to overcome hand clenching (see Fig. 9.189). Some children first learn to grasp soft objects more easily than hard ones or vice versa. At this level a child cannot grasp objects smaller or much larger than their palm.
4. Light objects are often easier than heavy ones. Later strength increases with graded heavy objects.
5. Place the child's hands around large hand grips, handles, bars, so they can sit up, kneel up, or stand up to enjoy a ride on a scooter, tricycle, swing, rocking horse, or see-saw.
6. Thicken handles of spoons, pencils, or toys with rubber or foam. Use a cone to place fingers on the larger side so that they are opened up with thumb and index meeting. Reverse to fingers on the smaller side of the cone so that fingers and thumb are opened.
7. Continue to look at what the child is grasping as some children with cerebral palsy have persistent head turning away from what they are doing.
8. Encourage the child to hold rusks or a spoon in feeding. Hold their hand on the spoon handle. Encourage them to hold a piece of their clothing as you help them undress, to hold a sponge in the bath, or hold a wet washcloth. If they have bent fingers, stretch them out onto a cloth between fingertips and thumb and progress to pulling off clothes, pulling up trouser tops.
9. Besides placing objects of different shapes in their hand, make sure that the child has had adequate mouthing experience to understand them. Help them to grasp and bring objects to their mouth to suck, lick, bite, or chew, or to their nose to smell.
10. Develop *grasp and press*, say, a bath sponge or large woollen pom-pom; *grasp and shake* a toy, rattle, or maracas; *grasp and wave* a toy flag, ribbons, bells. *Grasp and drop* is present, but it is not grasp and release yet. *Grasp and pull or rake* one end of a soft cloth with a small toy on the other end, which encourages the child to pull the toy towards them.

5–7-month normal developmental level

Common problems

Delay in successful reaching in all or one direction, voluntary grip, palmar grasp, and use of both hands together or alternately. More accurate reach-and-grasp, taking weight on one or both hands. Dropping of the object is normal but by 7 months a child usually holds a second block in the same hand and does not drop the first. Delay in

hand to mouth activities to *mouth* everything; in bilateral then unilateral grasp of the feet, to play with toes.

Atypical performance. There may be persistence of atypical patterns from the 3–5-month level. Atypical hand grasps, reaching actions, and release are discussed below.

Reflex reactions. Saving reaction in arms down and forwards is expected.

Treatment suggestions and management

Reaching actions

Reaching accurately depends on vision, proprioception, and postural stability of the trunk and shoulder girdle and counterpoising of the arm as well as perceptual abilities of direction and size of an object.

Range of motion and adequate strength of the arm are relevant to a task (see Fig. 9.184b).

Although these are discussed at this developmental level, the methods need to be continued at future levels, depending on the tasks and an individual's difficulties.

There are various arm patterns, or individual joint motions, which can be found and which also correct atypical synergies. Select those which are directly related to the use of the arms *in function*. Basic arm patterns (mainly taken from proprioceptive neuromuscular facilitation; Adler et al. 2008) which do this are as follows.

1. Shoulder flexion, elbow extension, pronation, hands open or grasp (Fig. 9.177).
2. Diagonal, shoulder elevation–abduction–external rotation, elbow extension or flexion, supination, hands and thumbs open (Fig. 9.178) for reaching upwards; for example, to dress, brush hair with elbow flexing.
3. The opposite diagonal to point 2 is down into adduction–internal rotation, elbow pronation, hand closed (Fig. 9.179), or open for reaching downwards for an object or self-care.
4. Diagonal flexion–adduction–external rotation, elbow supination, flexed or extended (Figs 9.180 and 9.181); for example, touching face, mouth, or hair in self-care, including wash or wipe mouth, face, and nose.
5. The opposite diagonal to point 4 is arm extension–abduction–internal rotation (Fig. 9.182), elbow pronation, hand closed or open (Figs 9.182 and 9.183); for example, to reach into coat sleeve or pick up an object.
6. Besides alternating diagonal patterns, useful arm actions are also alternating arm flexion with extension as in cleaning a mirror/window or wiping the floor or table top.

Figure 9.177. An individual attempting the basic pattern of bilateral shoulder flexion with elbow extension and dorsiflexion of the hands. This pattern not only corrects many atypical patterns as in Figs 9.173–9.175 but is functionally useful; for example, shoulder flexion, elbow extension, hands flat or grasping support for sitting and standing well; in movements to reach for shoes or socks down at the child's feet, in pulling off a jumper over the child's head, reaching down to pull up pants or to push them down to the ankles. *Note*. Hands in poor anticipatory action.

Figure 9.178. Arm elevation–abduction–external rotation corrects atypical patterns in Figs 9.173–9.175 and is used to reach out for an object, to dress, or to brush hair (elbow flexion/extension).

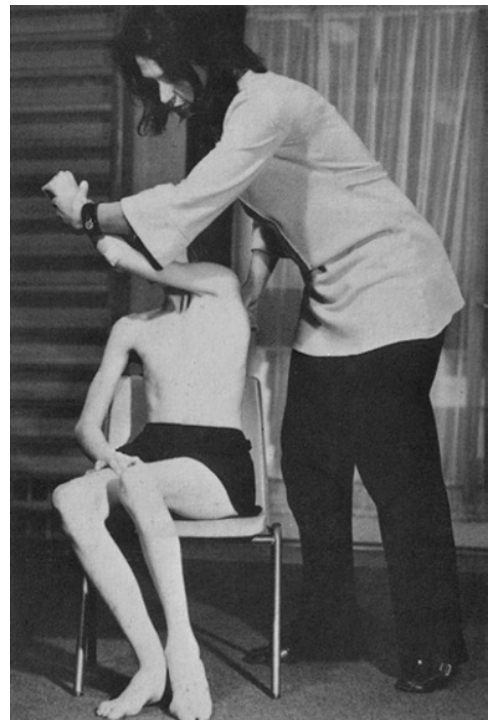


Figure 9.180. Arm pattern flexion–adduction–external rotation corrects arm patterns in Figs 9.173–9.175 and is used to reach for an object, touch own face, blow nose, dress, or eat.

Figure 9.179. Arm pattern adduction–internal rotation corrects atypical arm pattern in Fig. 9.175 and is used to reach down for an object, dress, wash, and other functions.

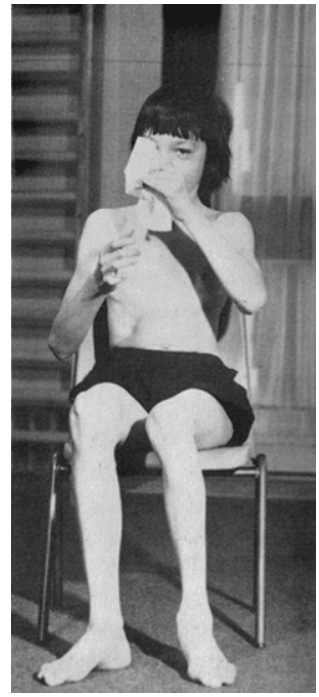


Figure 9.181. Arm pattern in use for wiping nose or face (from Fig. 9.180).

Figure 9.182. Arm extension abduction–internal rotation corrects arm patterns in Figs 9.173–9.175 and can be used for dressing, reaching out, and pulling trolleys in play.

Figure 9.183. Arm pattern in Fig. 9.182. in use for putting on a jacket.

There are *many variations* on the basic patterns described above. However, they do not reinforce the patterns a child with cerebral palsy may already be using. They offer variety as well correcting dynamic deformity.

Practical points

Positions. Carry out the active reaching patterns in all positions given in the following gross motor levels.

0–5 months Arm reach in side lying, supine, prone on elbows.

5–7 months Arm reach in prone, supine, rolling, and then reaching, or arm reaching to roll, lying reaching up against gravity. Reach with one arm in sitting while propped on the other hand.

7–9 months Arm reach in crawl position, 'on hands', or in upright kneeling, with child supporting on the other arm. Arm reach above or behind the body in sitting. Arm reach control forwards may be assisted by wearing weighted bracelets on the wrists. Some children with mild dyskinesia or ataxia have found this helps them.

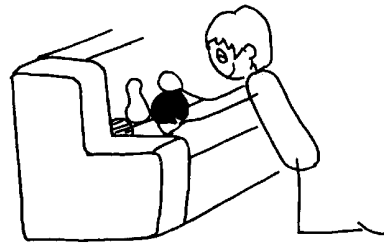
9–12 months Arm reach down in standing and when standing and stooping (Fig. 9.184c,d).

12–24 months Standing reaching in all directions, including elevation.

9–12 months Holding on with one hand.

Reach, grasp, and later reach-and-grasp and release of objects that interest the child are practised in these positions. Trunk rotation with reaching must be included, especially if resistance is given to the child's arm movement, or heavy objects are lifted. Start in well-supported positions for success and progress to less support to challenge a child.

Direction of reach is first in the midline, low down, then horizontal and forwards at shoulder level, to the side, above, and then behind. This progression is easiest for most children. It uses gravity to help or challenge a child. However, active or supported postural control is needed.



(a)

(b)

(c)

(d)

Figure 9.184. (a) Both arms stretch towards toys and palms face inwards to hold toys. In this way, elbow extension, supination is encouraged and simultaneously corrects atypical motor patterns. *Note* that the rest of the body is also in better alignment, associated with a better arm pattern (synergy). Use of *both* arms corrects asymmetry, particularly in hemiplegia. (b) The child pushes a ball against manual resistance of the therapist. This strengthens the arms and shoulder girdle and stimulates weight shift forwards. (c) A child reaching for a small object (magnetic dart) with the arm excessively internally rotated and using an *atypical grasp*. Postural control is typical. (d) The same child using *his unaffected arm and hand* to pick up and throw a dart at the dart board.

Facilitation. Arm patterns can be facilitated with a variety of methods. For example:

1. Touch, pressure, stretch and resistance, and good rotation of the child's shoulder girdle and/or trunk.
2. The therapist may manually rotate the shoulder girdle, protract shoulders forwards or retract shoulders backwards to initiate automatic arm patterns in creeping and rolling techniques (see the discussion on creeping patterns in prone development, 0–3 months, and reflex rolling in supine development). This activates arm synergies and ranges of motion that may be useful for reaching for toys in severely involved children.

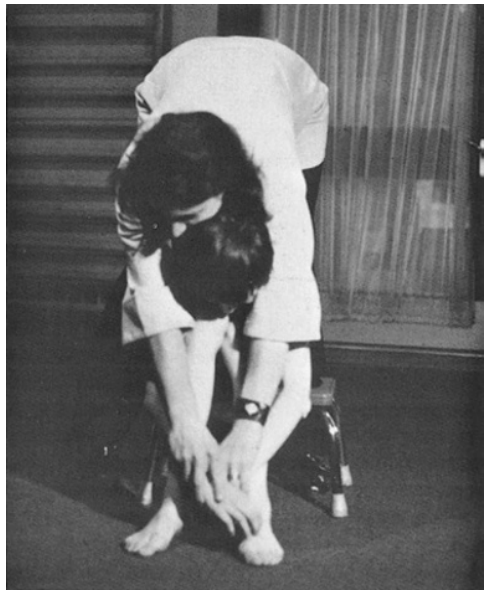


Figure 9.185. Bilateral arm patterns against appropriate manual resistance in diagonal patterns. Use to reach feet or the floor for daily activities. The postural mechanism is also assisted.

3. It is preferable to develop reaching to grasp/touch food, for toys, or to take part in a play activity selected to activate specific arm patterns (Figs 9.177, 9.181–9.185).
4. The child can be asked to concentrate on strengthening the arm for reaching; for example 'Stretch your arm up and back', 'Stretch your elbow'. However, only draw their attention to the pattern once they are clearly working towards their interest (goal) for reaching or within the chosen task.
5. The daily activities of feeding, dressing, washing, and bathing may use many desirable arm patterns, including those described. Activities chosen specifically for use within isolated therapy sessions should always be meaningful and of interest to a child or older person, as well as developmentally appropriate.

Vision and arm reach. It is important to continue developing the child's visual abilities and to associate these with development of hand function. A child's eyes need to focus, track, and maintain attention on the object while looking from hand to object. Encourage a child to look at their hands and object; later a child uses proprioception to guide reach (Case-Smith 1993). Make sure postural control is available and give support when necessary.

Unilateral and bilateral arm patterns need to be included in the programme. For example:

1. Unilateral patterns such as moving one side only; leaning on one hand and moving with the other; grasping a support with one hand and moving the other (normal asymmetrical work) (Figs 9.178–9.183); and grasping or fixing and steadying an object with one hand to allow the other hand to manipulate it. Apply in daily tasks with all children, particularly in those with unilateral cerebral palsy (hemiplegia) and dyskinesia.
2. Bilateral patterns with both of a child's arms in the same direction (bilateral and symmetrical) for support and for motion. This takes place to counteract asymmetry during function, involving the whole body (Figs 9.184–9.186). Use a child's less affected arm together with the affected arm for symmetrical pushing of walkers or balls or grasping larger toys. Activation of a hemiplegic arm through associated reactions may take place during such activities.
3. Bilateral patterns with each arm in opposite directions (bilateral and reciprocal). This takes place in creeping, reciprocal arm swing, or motion using play equipment, pulleys, or hand pedals.
4. Bilateral patterns with each arm in a different direction, for example one sideways, the other forwards (bilateral and asymmetrical), which is used in advanced perceptual motor training and for highly complicated counterpoising activities and hand skills.

Figure 9.186. Bilateral arm patterns against appropriate manual resistance in diagonal patterns. Note the facilitation of wrist extension.

Atypical hand grasps

1. Atypical grasp patterns may be present in association with atypical whole body posture or may appear in isolation when the rest of the child's body is minimally affected.
2. Limited joint motion, weakness, and problems with isolated finger and thumb movements are all found in atypical grasps.
3. Grasp may appear to be atypical because it belongs to a lower typical level of development.
4. Anticipatory grasp is distorted by an inability to open clenched hands and by cognitive delay or intellectual disability. Lack of experience in hand use also causes such a delay. Proprioception, perceptual discrimination, and cognitive abilities are essential for anticipatory shaping of a hand according to an object's features and for fingers' force to be regulated according to the properties of different objects.

Treatment suggestions for some atypical grasps

Grasp only possible in one position of the child's arm. Train grasp within all the corrective arm patterns (above, in different directions, and in different body positions). Movements to increase range, weakness, and isolated finger and thumb exercises may contribute to hand grasp and release. However, activities directly related to tasks are more important and may well treat these problems at the same time.

Wrist flexion with palmar or pincer grasp or inability to grasp in this position (Fig. 9.187). Press the child's wrist down as they try to grasp; place the object above the level of their wrist; ask them to lift their hands to the object (see Figs 9.186 and 9.189). Some children may need a wrist splint to train grasp with the wrist in midline or extension (dorsiflexion). In some children with hypertonus, the wrist extension needs to be only at mid-position as there is excessively tight finger flexion with full wrist extension. This also prevents the child from opening their hands to release the object held.

The Lycra hand and wrist splint, or arm splint and a flexible splint encouraging midline and dorsiflexion, are used to decrease excessive palmarflexion. There are various off-the-shelf hand and arm splints on the market, some of which are customisable to promote a functional wrist position or to accommodate contractures. Thermoplastic tailor-made hand splints have been used historically by occupational therapists to provide a passive stretch to maintain ranges and prevent contracture, as clenched hands and flexed wrists impact on functional hand use and may affect skin integrity. BoNT-A and casting or splinting is mentioned in Chapter 12.

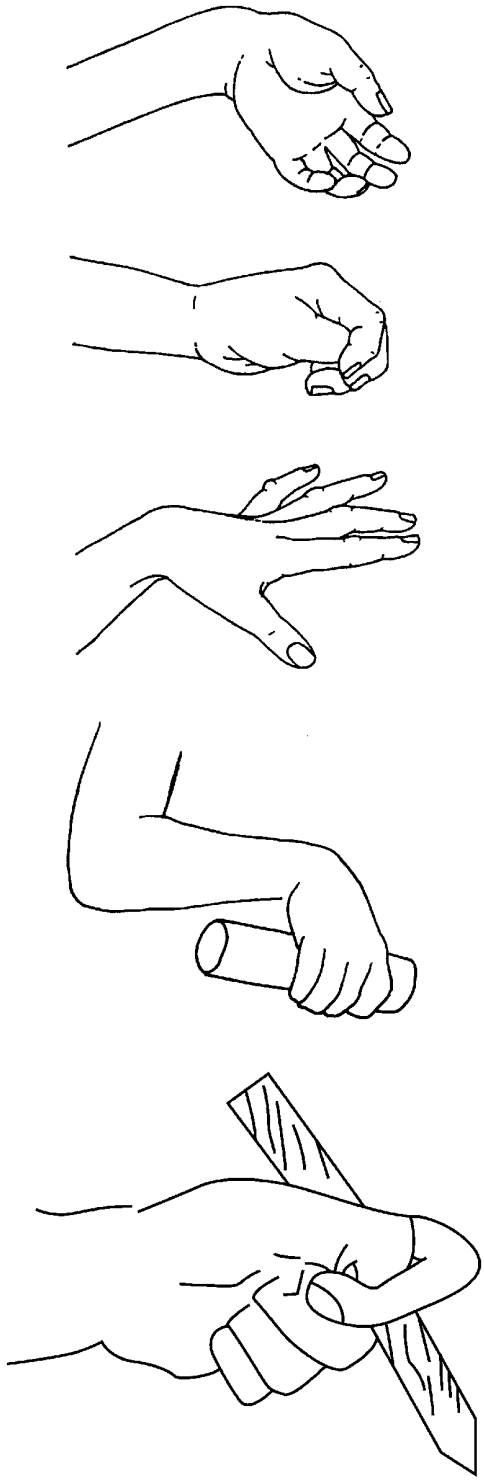
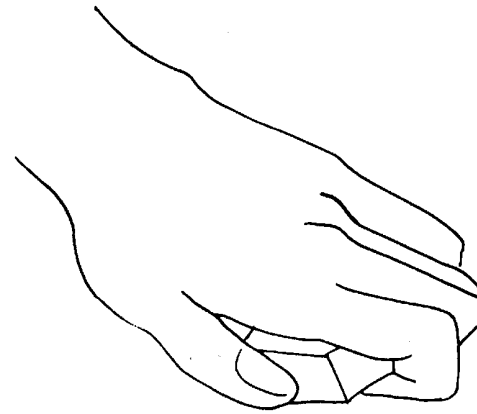


Figure 9.187. Common atypical patterns of arm, wrist, and hand.

The use of glove puppets, banging toys, lifting toys out of small containers, rings off a stick, and similar play activities may help to gain active wrist extension for grasp and release. In some cases, grasping with the wrist in extension may be achieved at the cost of opening the hand in this particular position.

Excessive finger flexion in grasp. With or without hyperextension of the metacarpophalangeal (MP) joints (Figs 9.188 and 9.189). Place the child's hand over thick, larger objects such as bars and handles.



(a)

(b)

Figure 9.188. Atypical grasp with excessive finger flexion and no flexion or even with hyperextension of the metacarpophalangeal joint is being corrected by the therapist in (b) during lumbrical grasp and release.

Avoid the hand clenching onto squeezy toys. Hold the dorsum of the child's hand, lift their MP joints and they or you can then press their fingers straight over the large ball, box, or square bar. This may be done with the child's MP joints pressing on the edge of a table as they try to hold on to the edge, or the solid edge of a truck or box. Counteracting this atypical grasp will prepare the child for grasping with their fingers straight, using fingertips later. Grasping edges of cards or lids is one way of training this straight finger grasp.

Adducted thumbs and ulnar grasp. The adducted thumb may grasp or be non-functional. It can be seen with ulnar grasp (Fig. 9.187). In some children the ulnar grasp may result when the child tries to compensate for or avoid the adducted thumb. When the thumb is abducted, a radial grasp may occur. In other cases, the child grasps their fingers in mid-position with an adducted thumb. Adducted flexed thumbs (thumb tucking) may also accompany palmarflexion, or excessive finger flexion (index curl grasp). The child should be encouraged to move their hand towards the thumb side, for example to push rolling toys away towards the radial side, bring a spoonful of food towards their mouth, and other activities that encourage them to move their hand towards the thumb side. The child may not manage this unless you hold their hand in midline during grasp. Hold the child's hand between their thumb and forefinger on one side and hold down the ulnar side as they grasp (Fig. 9.190).

The little finger and ring finger may be taped during specific functional activities to encourage grasping of objects with the radial side; this should only be done if it does not cause the child distress.

Check that the child is not given handgrips on walkers, handles, and other supports that encourage an atypical ulnar grasp. The handles at the sides of rollators or on crutches may do this. Avoid angled spoons for those children in whom these utensils create an ulnar grasp, unless no other grasp is possible.

Splints are available to correct thumb positions. For example, adducted thumbs may be held out with figure-of-eight thumb splints or made together with hand and wrist splints in a variety of materials.

Remember. To take an adducted thumb out of a fist or hand, never pull it by its tip or you may dislocate or sublux the MP joint. Sometimes the other fingers flex more as you pull on the thumb. Rather, turn the whole arm or forearm to face palm up to the ceiling and abduct the thumb out from its base. It is important to accompany this

Figure 9.189. Overcoming excessive wrist flexion, overflexion of fingers by the task selected, and the therapist pressing the wrist down. Press on a child's wrist as they grasp bars of walkers, spoons, cups, and other tools.

Figure 9.190. Guided abduction of thumb and pincer grasp.

procedure with placing the child's hand over a toy, to promote a palmar or radial grasp. Some children can abduct their thumbs over the edge of a table with their hands pressed open on the top of the table. See methods in sections 'Opening of hands and support on arms' and 'Splints and casting'.

Anticipatory grasp. The methods to reduce tight fingers and thumb contribute to opening of the hand to anticipate the size of object for grasping. More experiential learning is usually needed for practice with different sizes and weights of everyday objects (see the developmental levels of 7–9 months). Check the results of assessment tests for perception and cognition.

Inability to use both hands simultaneously. Although this is typical in many children under the 6-month developmental level, it may also be due to the following.

1. Lack of head control in midline, so the child uses the hand that they can see; lack of midline head control in persistent head turning to one side. Head turn is sometimes easily overcome and may be spontaneous in babies.
2. ATNR to one side which is 'used' to reach to that side and sometimes when the head turns away to grasp the object on the occipital side.
3. Hemiplegia, unilateral cerebral palsy, or greater involvement of one arm in children with dystonic movement patterns.
4. Excessive spasms or involuntary motion on one side, rarely presenting in children with athetoid movements or dyskinesia. Some children with dystonic patterns may also experience greater involuntary movement in one arm.
5. Sensory loss on one side, especially astereognosis, two-point discrimination in the hand, or visual field defect, usually found in some children with unilateral cerebral palsy.

During training of prone, supine, sitting, and standing development check that both hands are given objects to grasp simultaneously or to grip for support. Use play activities which require two hands, for example play in water and washing, sand, clay, dough, larger toys, handles on bowls, rolling pins, sieves, sticks with dangling bells, broom, bicycle pump, toy concertina, small cymbals, maracas, or toys which make a noise if pushed at both ends. Inability to grasp on one side will often result in the inability to hold with one hand and carry out an action with the other. Practise activities which include each hand in a different action; for example, hold a toy with one hand, carry out an action with the other or winding up a toy or stabilising an object with one hand while the other is using various actions with that object. For example, stabilise a container with one hand while the other opens the lid or lean on one hand to fix an object during action with the other (Fig. 9.191). See developmental levels for choice of play and for use of hands in self-care.

Associated grasping or clenching on the child's affected side when grasping with the unaffected or less affected side. This is usually seen in children with spasticity; associated *mirror* movements of the hand not in use are normally seen in very young children but should disappear over time. If these mechanisms persist, they can prevent the child's transfer of objects from hand to hand and holding with one hand while using the other hand. Hold the more affected elbow straight with hand flat on the table while the other hand grasps. Try having the child lean on the more affected arm with hand open. Carry out joint compression to facilitate support on the more affected hand while the other hand is used by the child (Fig. 9.191).

Other parts of the body may also tense or assume atypical postures during grasp. Check that these excessive motor activities

Figure 9.191. Support on the more affected hand, which is pressed open, while the child uses the more skilful hand. The affected hand stabilises the paper or toy during use with the other hand.

are controlled as much as possible by the child with the assistance of the therapist. Assess whether better positioning or support with equipment for the rest of the body during hand function is needed. Motor tasks too advanced for an individual can increase tone or involuntary movements. Understanding a child's current developmental level is therefore extremely important (Fig. 9.192).

Involuntary motion disrupting hand use. Train conscious control of manipulation where possible. With practice involuntary movements can be controlled by a child to a greater or lesser degree. The child, parent, and therapist discover atypical ways in which control is achieved. Help the child by encouraging them to use their hands while leaning on their forearms, or reach for toys through a thin padded hoop, which limits the excursion of the involuntary motion. Wide upright poles may also limit involuntary motion as the child reaches between them for toys or objects. Use a dowel, stick, or rubber ring for grasping and to practise maintained grasp. Maintained grasp with both or one hand also helps to stabilise the

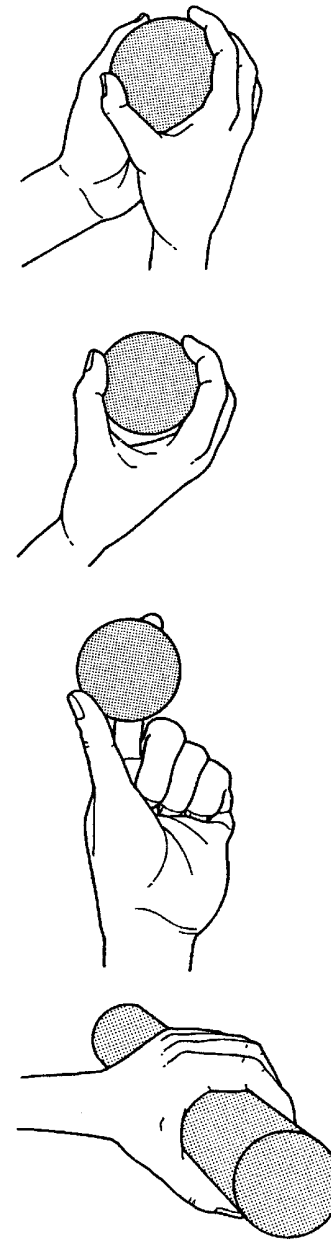


Figure 9.192. Grasp patterns.

whole child. Select whole hand grasps are shown in Fig. 9.192.

Note. All the patterns of grasp and release are also disrupted by visual loss, any sensory loss in the hands, cognitive delay (or later intellectual disability), and by a lack of

visual, perceptual, or perceptual–motor development, as seen in children with developmental incoordination disorder who do not have any neurological involvement.

Sensory loss of two-point discrimination in children predicts an inability to adapt fingertip force to texture in manipulation (Lesný et al. 1993; Yekutiel et al. 1994). Gordon and Duff (1999) found that various impairments of grasp in children with unilateral cerebral palsy (hemiplegia) may relate more to sensory deficits than to motor impairments.

7–9-month normal development level

Common problems

Delay in transfer from hand to hand, unilateral reach-and-grasp, grasp more than one block at a time, radial grasp, hand patting, banging, clutch, stroke, rake, scratch, bang two blocks together, release against a hard surface, and use of hands in feeding and in holding on during sitting and standing. *Scissors* grasp (inferior pincer grasp) and use of fingertips may be delayed. Delay in anticipatory grasp in relation to size, shape, weight of object (9 months; see studies by von Hofsten and Ronnqvist 1988).

Reflex reactions. Saving and propping reactions are expected at these levels.

Treatment suggestions and management

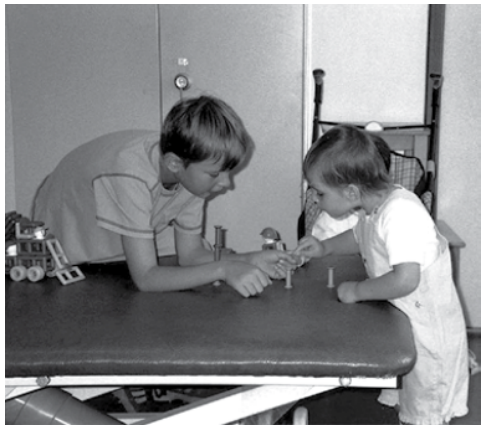
1. See methods for reach, grasp, and opening of hands.
2. Train the child's active grasp in feeding, dressing, washing, toileting (see Chapter 10). Begin training release by having the child release a block against a hard surface with the heel of their hand held down against the surface, or on their other hand or body. Release may be impossible if hand opening has not yet been developed. See methods at the 3–5-month level for training of hand opening.
3. Ulnar grasp now develops into radial grasp.
4. Transfer from hand to hand, using a firm rubber ring for palmar grasp and release. Then use a variety of objects. Practise banging blocks together and also holding on with one hand or leaning on one hand during unilateral banging, stroking, or raking; this is particularly important for children with hemiplegia or asymmetrical function. Crude pincer grasp begins (Fig. 9.193).
5. Play with suitable toys, dough, sand, water. Encourage the child to transfer objects from hand to hand, to grasp more than one object at a time, as well as patting, banging, clutching, stroking, raking, scratching, and releasing against a hard surface.
6. Patting with open hands and other repetitive actions may become a persistent pattern in some children with severe learning problems or visual disability. Meaningful activities involving grasp and manipulation at the child's developmental level may counteract these and other *mannerisms*, although, for children with specific neurodevelopmental disabilities such as autism, repetitive motor mannerisms may be part of their behavioural repertoire.

9–12-month normal developmental level

Common problems

Delay in finger/thumb opposition and development of crude and fine pincer grasp, no protrusion of the index finger. Delay in casting haphazardly and beginning to develop more control from 12 months. Delay of increasing control of accurate release into containers of different sizes. Delay in a child's searching for a fallen

(a)



(b)

(c)

Figure 9.193. (a, b) Brother playing with sister (with cerebral palsy) activating pincer grasp and fine release. (c) Hand function during play in a standing position. Promoting symmetry, hand opening, grasping toys of different sizes as well as socialisation. (Reproduced with the permission of Jenx, Sheffield.)

object, cast object, or hidden object perceived immediately before disappearance (permanence of objects). Supination may not have developed. Delay in developing anticipatory grasp. Delay in improved shoulder, elbow, and hand control. There may be delay in grasp and pull, grasp and push, and grasp and place using a variety of grasps and directions and containers.

Arm and hand saving and propping backwards is expected at this level.

Atypical performance. There may be persistence of atypical hand grasps, release, and whole arm patterns.

An excessive avoiding reaction may prevent release becoming controlled as well as preventing maintained controlled grasp (casting toys is typical at this level of development but excessive hand splaying in extension is not).

Treatment suggestions and management

Control of release

Release only possible if the wrist is flexed. The child may use their other hand, chin or even forehead, or a hard surface to press the back of their hand to obtain wrist flexion. Teach release with the wrist in midline using a splint, manual support, and active control by a child.

Release an object against a hard surface after 11 months of age. These problems of release

are discussed in the appropriate developmental levels.

Release with thumb adducted and flexed in the palm. Support the development of release with the child's active hand opening together with thumb abduction following supination of the forearm by the therapist. Sometimes external rotation from the shoulder is indicated. Thumb splints may help. Isolated thumb abduction and extension is very difficult and is best acquired using larger objects placed in the hand.

Release with ulnar deviation can be improved if objects are released into a container on the radial side of the hand.

Release with excessive splaying of the fingers, that is, hyperabduction with hyperextended MP joints. A similar but less pronounced pattern is also seen in typically developing babies casting objects at about 11–15 months of age. In addition, this pattern is seen in excessive avoiding reactions in the hands of children with dyskinesia. There may also be plantar and/or a visual avoiding reaction with the avoiding reaction in the hands caused by tactile and visual stimuli, respectively. Grasp smaller objects and train release into a defined area or container. Hold the ulnar side of the child's hand and train release on the radial side and later with thumb and finger. Training a more precise release is closely allied with the training of pincer grasp (Fig. 9.193a,b).

Hand and visual avoiding reactions can be helped if one introduces the object slowly into the child's visual field and into their hands. Encourage the child to maintain their grasp on a desired object to gradually assist them to become less sensitive to the stimuli. Avoid the hand-over-hand method to maintain a child's grasp if they are sensitive. This is particularly unwise if a child is severely visually impaired and can lead to marked avoidance of touch on their hands. Allow the child to release in their own time with the reward of hearing an object drop. A light pressure on the dorsum of a child's hand helps release.

Grasp and release in dyskinesia. This is seen in children with dyskinetic movements, when they attempt to grasp an object but immediately withdraw their hand, splaying it open. This can present itself as a repeated involuntary movement in the hands. To treat this problem, it is advisable to reinforce the child's active grasp or grip using your hand placed over their hand, or pressing an object gently against their palm with their wrist fixed on the table. Encourage maintained grasp for as much of the day as possible on bars, handles, in front, at their side, above, or below them in various activities during the day (Russell and Cotton 1994). When the child is sitting in a classroom, on a toilet, at meals, or in a buggy, place their hands to grasp bars. Frames or manual supported standing and walkers need to have bars for grasp. If children wear weights on their wrists this can produce better motor control.

Training of reach-and-grasp, especially grasp in supination and improving more accurate grasps.

Techniques in developmental levels for reach and for grasp are now used to gain reach-and-grasp.

Problems in anticipatory reach-and-grasp formation and for force regulation can be due to poor understanding of the properties of an object. Perceptual and cognitive difficulties require assessment and intervention and may best be provided in conjunction with a clinical psychologist.

To develop fine grasp improve isolation of the fingers and promote the development of index finger action (Figs 9.189–9.194).

Use finger plays and action songs to isolate finger movements; for example, 'walking' fingers on a table, pushing away

Figure 9.194. Developing index finger pointing and pressing and a fine pincer grasp during action of pull, push, and later to turn an object, as in a screwing movement.

an object using abduction of the thumb, index, or fifth finger are among many ideas which can be devised by the individual therapist. Use *finger plays*, particularly for the index finger or middle finger in addition to other fingers.

Index finger approach to object, isolated finger pointing and pressing. If the child cannot manage to isolate their index finger, hold their little, ring, and middle fingers flexed until they can do this alone (Fig. 9.190).

1. Help the child to use ordinary telephones, using their index finger for dialling; contemporary mobile phones are usually accessed using the thumb.
2. Use the index finger to press into dough, clay, or sand. Later make lines and scribbles in sand.
3. Put paint on a fingertip and make dots and scribbles. A child may enjoy popping soap bubbles with one finger.
4. Press-studs on clothes should be attempted. Press small buttons on cause-and-effect toys that result in interesting sounds or visual appearance as, say, a jack-in-the-box or other pop-up toys. Help the child to access buttons and switches around the home, for example light switches and the TV remote. Press Velcro straps on clothes or their own orthoses.
5. Use finger puppets.
6. Practise on the keys of a piano, computer keyboard, cash register, or with an abacus. While tablet touchscreen technology requires finger isolation and accuracy, it does not provide the tactile and proprioceptive feedback that help to consolidate learning. On many apps, inaccurate activation will still often result in some form of 'effect'.

Finger pointing is also most important for communication and to access educational materials. Physical access to digital assistive technology and augmentative and alternative communication will be important as children get older (see Chapter 12).

Pincer grasp. Begin with larger objects and then progress to smaller objects. Thumbs and all fingertips (Fig. 9.194) are used first before thumb and one finger; usually the index is used (crude and fine pincer grasp). At first, steady the thumb against the table, and the child brings the index finger down to touch it, imitating a pincer position. Then try lifting the hand off the support. Initially the grasp is with fingers and thumb and later index finger and thumb. Encourage the child to rake small items towards them and into a container.

1. Pick up pieces of cereals for young children, or small pieces of food or pasta and place in their mouth. The child may like to pick up buttons, wooden beads, or marbles *under supervision* as they may pop them into their mouth to swallow them.
2. Hold thick crayons and, if possible, pencils and thick chalk for making marks on paper or later writing with tripod grasp.
3. Use toys with small knobs and of small size for fitting shapes.
4. Hold small cup handles for drinking.

5. Wind a clock and turn its knobs, press an alarm bell to stop, press doorbells. Various toys have knobs and buttons to press and turn. Use playdough or soft clay, and with paint on the finger a child makes dots on paper.
6. Begin a screwing action with large screw-toys, large lids, etc.; progress to medium and fine screwing later (usually around the 15-month developmental level).
7. Pincer grasp includes thumb tip to fingertip, thumb to index-and-middle finger together, and a ('key') lateral thumb to index pinch. Pick a card out of its holder. Pull sticking labels off the surface and open small notebooks and wallets. Pull thick strings, ribbons, and pipe cleaners through large holes. For example, hold finger-to-thumb to create 'eye spectacles'.
8. Develop a greater variety of grasps (Fig. 9.195 and your own ideas).

Continue training release. This involves dropping objects (beanbags) into a container on the ground below the child's chair, in front of the chair, at the side, and behind the chair. Help them to look and see 'where it dropped'. Later encourage the child to place small objects in smaller containers until they learn to fit a peg in a formboard and build one block on top of the other. Precise release is required for building a tower of blocks as well as for gaining perceptual and conceptual adequacy. Building blocks may be made of sponge rubber shapes, wood, or plastic or be household objects, boxes, tins, or pots to develop hand function in this developmental period.

Figure 9.195. Some hand grasps to take hold of an object and to grip. Spherical with palm or fingertips only, hook grasp, cylindrical grasp. Others are lumbrical (Fig. 9.188) and pincer (Figs 9.193 and 9.194) with sides and with tips of fingers. *Remember* to train grasps in vertical, pronated, supinated, and other hand positions.

Boyd et al. (2001) have made a systematic review of many research studies on hand function, seating related to hand function, behavioural therapy, splintage, and use of medication.

Manipulation and perception/conception

Manipulation is by now integrated with perceptual development of:

1. Space and depth in, say, well-coordinated reach-and-grasp activities.
2. Form in placing a round peg in a round hole and similar matching.
3. Size in placing objects into containers, according to size. Sorting objects of different sizes, shapes, and textures.
4. Colour and shape in use of matching toys (but not naming them), such as various posting boxes, mosaics and other sorting activities, jigsaws.
5. Discrimination of soft, hard, scratchy, smooth sensations.
6. Other cognitive and social activities such as waving bye-bye, pointing to a visual stimulus, patting the child's own face in a mirror and smiling at self, and playing pat-a-cake and similar games.

Manipulation becomes bimanual and later 'in-hand manipulation' in the third year of life with motor planning for novel tasks from 2½ to 3 years in typically developing children (Case-Smith 1993).

Perception, conception, perceptual–motor integration, and fine motor manipulation continue to develop in such activities as threading large beads, smaller beads, other threading toys, scribbling, drawing, painting, pasting, using pegboards, formboards, draughts, jigsaws with knobs, using sewing cards, and a large variety of constructional toys, screwing toys, posting boxes, and many more suggested in toy catalogues and by toy libraries. Eye–hand coordination and rhythm, speed, and precision of movement will need to be developed further after the basic arm and hand actions are trained.

Eliasson and Burtner (2008) have edited a book on hand function in children with cerebral palsy.

Splints and casting (Figs 9.196–9.199)

Hand splints have been used for many years by occupational therapists to address difficulties at the body function and structure level, and more recently to promote functional control. A systematic review (Garbellini et al. 2017) considered both the rationale for prescription and the effectiveness of upper limb orthoses, with the individual studies reporting improved hand function, greater dexterity, and the ability to grasp objects without

Figure 9.197. Lycra arm splint.

(a) (b)

Figure 9.196. (a, b) Girl with right hemiplegia using both her hands as she assists her typically developing brother.

Figure 9.198. Hand splints.

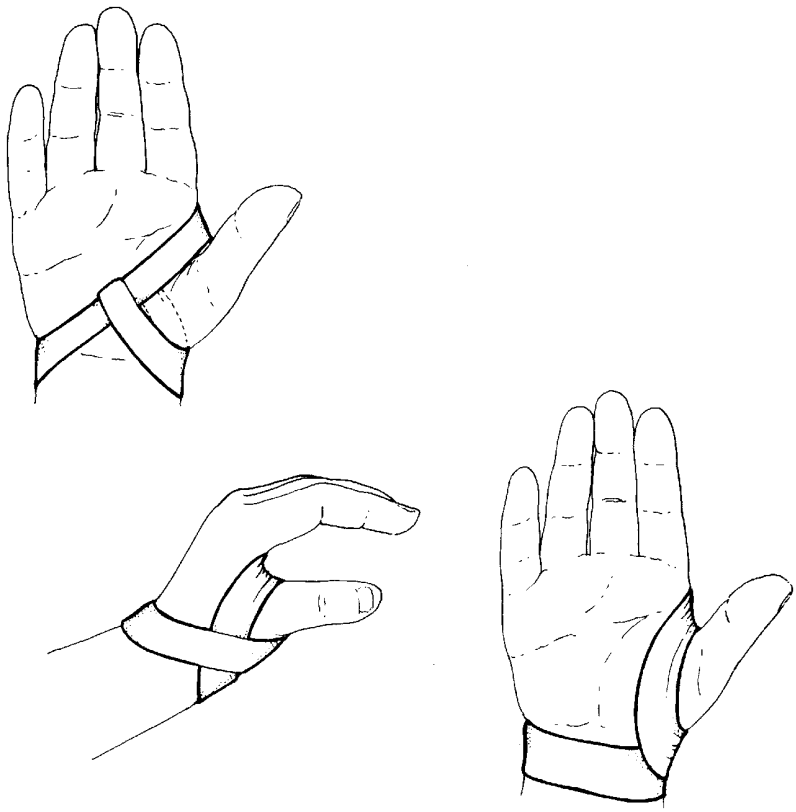


Figure 9.199. Thumb splint to correct adducted–flexed thumb. A cock-up wrist splint to midline may be incorporated if palm flexion is excessive. Figure-of-eight thumb splint at the base of the thumb and over the wrist in soft pigskin or simply a handkerchief may be adequate for babies and young children.

assistance of the dominant hand. However, while the overall conclusion indicates a lack of evidence to support the use of upper limb orthotic intervention (most of the studies included have some level of bias), the authors do acknowledge that this apparent lack of evidence may be due to the inherent difficulties in carrying out empirical research to evaluate multifactorial interventions, rather than because upper limb orthoses have no effect. They suggest that further research is required to establish the effect of these types of interventions, with emphasis placed on linking the clinical reasoning behind prescription to intended outcomes, which are then measured using an appropriate outcome measure.

NICE (2012) guidelines on the management of spasticity recommend that orthoses should be considered for children and young people with spasticity based on an individual assessment and that use should be clearly linked to agreed goals. More specifically NICE recommends the consideration of elbow gaiters to maintain extension and improve function, rigid wrist splints to prevent contractures and limit flexion deformities, and dynamic orthoses to improve hand function.

NICE also recommends that, following treatment with BoNT-A, upper limb orthoses should be considered as a means to stretch the temporarily weakened muscle and to allow the child to engage in and practise functional skills. This guidance also indicates that, if limitations in passive range of movement prevent the use of an orthosis, serial casting should first be used to stretch the muscle 2–4 weeks after BoNT-A treatment.

Techniques for carrying the child correctly (Figs 9.200–9.205)

1. To stimulate head control.
2. To correct any atypical postures.
3. To suggest easier ways for a parent/carer to carry a child with cerebral palsy.

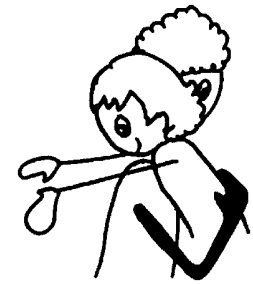


Figure 9.200. Both the arms are over the adult's shoulder for symmetry, straighten the back and raise the head. Keep the legs apart and hips flat if necessary in spasticity. Bring tight arms away from their habitual positions next to the child.

Figure 9.201. For head control and correcting an excessively extended child, help bring hands down and together as this helps in control of an athetoid or floppy child.

Figures 9.202 and 9.203. Use of both arms, eye-to-eye contact, separate tightly adducted legs or very extended legs. Move the child to points around the adult's hips to find the most corrective posture of legs for the child.

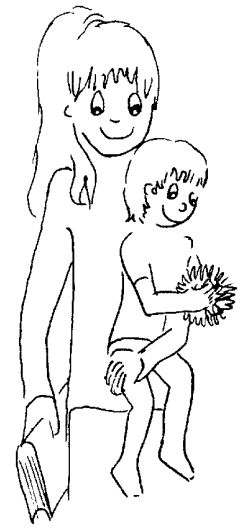


Figure 9.205. Stimulates greater head and trunk control for floppy and other children. Hold child at the chest and under the armpits and/or under the buttocks as well.

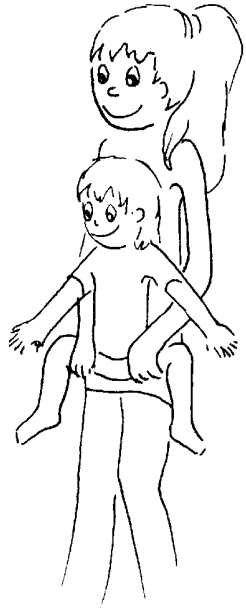


Figure 9.204. Head and trunk control, if the child is moved slightly away from the adult's chest. Correct extended–adducted–internally rotated legs.

10

Function and the child's daily life

Chapter 9 has presented ways in which the child may develop various postures, maintain those postures or balance during movement, get in and out of postures, obtain various forms of locomotion, and acquire the use of the hands. However, the therapist needs to consider how development of these motor functions can be used within activities of daily living to enhance independence. Historically occupational therapists specialised in developing an individual's daily living activities. Community physiotherapists and occupational therapists now use specialist sessions in children's centres as well as visits to homes, schools, and community. (See Chapter 2; section 'Practice and experience' in Chapter 3; and section 'Issues of concern for adolescents and adults' in Chapter 4).

The debate between whether bottom-up interventions, which focus on impairments, or top-down functional approaches are preferential has presented itself as a long-standing debate within occupational therapy (Weinstock-Zlotnick and Hinojosa 2004). More recently, the Royal College of Occupational Therapists in the UK has strongly advocated the use of *occupation-centred* practice (COT 2015b), in agreement with Kielhofner (2009). Within their daily life, individuals engage in occupations of self-care, productivity (such as school /work), and leisure (COT 2015a). Although the ultimate goal(s) set by occupational therapists must relate to daily life occupations rather than to underlying impairments (Wilcock 2006; Fisher 2013), unique task analysis is still needed. Physiotherapists have also embraced the importance of motor function and task analysis. They also consider impairments of body structure and body function, drawing on their in-depth knowledge of anatomy and physiology. The Association of Paediatric Chartered Physiotherapists has also issued guidance on good practice, including ethics (APCP 2016). In line with the World Health Organization's (WHO) current *International Classification of Functioning, Disability and Health* (ICF) (WHO 2001), body functions and body structures that may be relevant to activities and participation are considered in this chapter. Participation includes the communication and relationships of an individual.

Treatment of Cerebral Palsy and Motor Delay, Sixth Edition. Sophie Levitt and Anne Addison.
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Motor function in communication

In typically developing children, speech production follows a trajectory that passes through certain milestones. As with all skills, development is individualised and the ages at which children reach certain stages can vary. However, communication begins when the child and their primary caregiver interact. At the very beginning, a baby's communicative intent can be heard in their cries, facial expressions, and body movements, which they use to gain attention. As the baby develops, their physical abilities enable them to consolidate cause-and-effect understanding through their own actions, while learning to make early choices through their physicality alone. Between 4 and 7 months babies learn to direct their attention and focus on a particular stimulus. At around 9 months children are able to make preferential choices between objects even though they do not yet know the name for the things they are choosing from. In the second half of the first year, children are also able to intentionally signal a wish to their caregiver using accurate reaching, which begins to develop around 4 months (Berthier and Keen 2006), or pointing, which usually develops between 8 and 12 months (Reilly et al. 2006). It is clear, therefore, that communication begins at a very early age, and that children express preferences to people or objects before they have the language capabilities to make choices through speech. A focus on early choice-making skills is important, as, if we do not support children to identify personal preferences, 'professionals are at risk of mistaking lack of protest for informed consent, habitual behaviour for active choice, and resignation to one's lot for contentment with one's lot' (Shevin and Klein 2004: p. 161). The following provides a brief summary of the development of children's communication skills.

0–3 months Differentiated cries, eye-to-eye contact, and express self with facial expressions and body movements. Make sound during kicking and feeding. Still to noise. Smile at parent.

3–6 months Sounds vary, vowels predominate. Give clear signals of likes/dislikes. Anticipate food by opening mouth. Babbling begins, increasing intonations. Watch adult's lips. Turn to sounds and parent's voice. Laugh, squeal, and annoyed scream. Excited limb motions as social responses.

6–9 months Lip and tongue sounds. Syllables (ba-ba, da-da) with self-imitation. Actions anticipating being lifted. Use voice to attract attention. Bounce on laps, showing pleasure and may indicate 'more'.

9–12 months Double syllables, first word. Use gestures, especially pointing. Wave goodbye. Turn to sounds that interest them instantaneously. Continue vocalising to make personal contact. Imitate rhythmical sounds with movement. Playful turn-taking with familiar adults.

12–18 months Understand more than they express. Follow repeated simple directions by an adult if given with contextual gestures ('Give me', 'No', 'Arms up'). Respond to their name, single words. Real object labels. Imitate sounds and intonations, develop baby jargon language.

18–24 months Imitate adult speech (echolalia). Begin to imitate other children. Respond to and discriminate sounds, respond to simple commands. Development of meaningful words and two- or three-word phrases. Have a growing vocabulary. Continue to love listening to stories, enjoy jingles and movements to nursery songs.

2–3 years Simple short sentences to express self, especially likes/dislikes, many questions and verbal explosion. Give own

name. Join in nursery rhymes, talk to themselves during play, and use imaginative play, which will increase with complexity after 3 years. Normal stutter, for example 'm,m,mummy'. Repetition of sounds and words. Unique dialogues.

Early communication requires skills within the perceptual, motor, and cognitive domains, all of which may be affected in a child with cerebral palsy. Difficulties executing fluid upper limb movements will impact on early use of reaching and pointing as described above, and, as the child gets older, will limit their ability to utilise natural descriptive or informative gestures that support verbal communication. Reduced head control makes it more difficult to develop visual attention and impacts on a child's ability to initiate joint attention through gaze shift. Conventional communicative head movements, that is, nodding or shaking one's head to indicate a 'yes' or 'no' response, will also be affected. If certain reflexes fail to integrate as a result of the child's movement difficulties, this can also have an impact on effective communication; for example, persistent presence of asymmetrical tonic neck reaction beyond 6 months in a child with cerebral palsy will result in difficulties coordinating looking and reaching.

As typically developing children grow, the reasons they communicate increase and move beyond a means to gain attention and get their basic wants and needs met. They will begin to protest/deny to demonstrate that they do not want something, or to show that they like or want more of something through smiling and laughing. Demonstrating preferences forms the basis for choice-making skills. As language is acquired children can begin to replace informative gestures and vocalisations with words to indicate choices, and then move towards requesting and giving information, and asking questions. However, the ability to communicate is built on more than just reasons to do so. In 1994, Money and Thurman first introduced the 'means, reasons and opportunities' model, which is still used frequently in the speech and language therapy literature as a framework for assessment and intervention for individuals with learning disability (RCSLT 2009) and individuals who utilise augmentative and alternative communication (AAC) (Calculator 2009). The model presents and depicts the theory that, in order to communicate, individuals require a means to do so, opportunities to communicate as part of a dyadic interaction, and the reasons that provide the motivation.

The means by which children with cerebral palsy communicate is affected by both speech and language impairments and communication limitations, both of which occur frequently in cerebral palsy (Pennington 2015). Research suggests that disabilities in expressive/receptive communication are present in 50–75% of children with a Gross Motor Function Classification System (GMFCS) level I–III, increasing to 100% in children described as GMFCS level IV or V; children with severe cerebral palsy (GMFCS IV or V) often have severe dysarthria or anarthria (Geytenbeek et al. 2015). Increased understanding of communication difficulties experienced by children with cerebral palsy have led to the development of the Communication Function Classification System (CFCS) and, more recently, the Viking Speech Scale (VSS) (Barty et al. 2016).

Individuals with expressive language or speech production difficulties who do not have a physical disability or movement disorder have the option of developing signing as an alternative means of communication, or can utilise other low-technology or high-technology AAC strategies in a conventional way. However, in children with cerebral palsy, hand function may also be restricted (as classified by Manual Ability

Classification System (MACS) levels). This will affect the child's ability to gesture/sign and will impact on their ability to interface with technology that might otherwise compensate for their physical disability (Gaytenbeek et al. 2015).

Opportunities for children to communicate occur naturally throughout the day. However, many children with cerebral palsy experience communication difficulties because their motor impairments affect the range, speed, strength, and consistency of movements needed to produce speech, gestures, and facial expression. Research has shown that, as a result, conversation between children with cerebral palsy and their familiar partners follows restricted patterns characterised by 'high levels of partner control and children's responsivity' (Pennington et al. 2004: p. 151). It is important to note that these restrictive patterns have also been demonstrated in children with cerebral palsy who have cognitive skills within normal limits, those with intelligible speech (with minimal contextual cues), and those who effectively utilise AAC devices. Their role in conversations centres on responding to questions and talking about topics raised by others (Pennington and McConachie 2001). Pennington et al. (2017) discuss parent-mediated communication interventions with preschool children in their systematic review for the Cochrane Database.

As therapists, we can support communication partners to recognise and respond appropriately to children's communication signals and to actively create opportunities for children to take a more equal and independent role in conversation. A specific therapeutic framework has been established to observe communication interactions between parents and children (parent–child interaction) within the field of autism (Solomon et al. 2008), but as yet no similar approaches have been developed and researched for use with children with motor delay or cerebral palsy. We therefore need to provide parents with practical suggestions based on our understanding of a child's abilities and knowledge of how motor function impacts on communication.

Practical communication suggestions

1. Follow the general guide of developmental levels and individual assessment by speech and language therapists and psychologists. This guides communication during the development of functional independence within daily activities.
2. General motor functions and positions to promote speech, language, and communication are similar to those utilised when developing occupations within the domains of self-care, productivity, or leisure. However, the ability to see the other person's face is imperative for eye contact, joint interaction, and gaze shift utilised for confirmation. Supporting a child who is unable to sit from behind may therefore be less conducive to the development of communication skills than it is to the development of other abilities. Other positions may therefore need to be utilised (supine lying, prone over a wedge or roll, etc.), if there is not another adult available to provide physical support.
3. Respiration is closely associated with several facets of speech sounds (Shin et al. 2015). Positions that promote respiration may therefore also support speech development, although there is limited research in this area.
4. Provide frequent opportunities for each individual child to initiate communication in any way that is possible. Avoid anticipating a child's needs. Create situations that tempt a child to request, for example, being swung again by you, have a song repeated, or a musical toy wound up. A child may request 'more' of a favourite song, more of only a few

bouncing or rocking actions, after only a few finger plays that are all deliberately given.

5. Respond positively to all attempts at communication by a child, even when they do not appear to be deliberate. During play, giving a child the benefit of the doubt may encourage motivation to engage. For example, if a sound could be interpreted as a word, say that word again to establish a likely meaning. However, remember that, if the child is being encouraged to make an important choice that will impact on their quality of life, we should not assume communicative competence.
6. Avoid asking questions that require a yes/no response. On asking 'Do you want milk or juice?', wait for the child to make their choice in whatever way they can. Help the child to make the choice by saying 'You are looking at the juice, so you want juice'. Accept eye gaze, gestures, reaching, pointing with the whole hand or a finger. A child may also vocalise. Give time and more occasions for a child's attempts to express his or her levels of communication.
7. Try to communicate with the child with noises (at first not too loud or sudden), songs, smiles, gestures; talk near the child and with face-to-face contact.
8. Speak slowly and distinctly but not with exaggerated articulation that sounds like 'baby talk'. Wait for any response by a child and acknowledge them.
9. Say names of familiar objects used during feeding, washing, dressing, and playing, say what they are used for, and demonstrate and name parts of the body, and talk about the child's own experiences. Parents/carers are expected to let their therapists know about their child's interests and experiences. Where possible, use language that a child is able to understand and stop when that child loses interest.
10. Children need to be able to see your face in a good light during speech. Try to be at their eye level whenever possible and help with control of head and body. Check where you need to place yourself for children with visual impairments to see you.
11. Enjoy and respond to a child's participation. However, do not pressure a child to speak but create informal situations, including play, for conversations, especially in groups.
12. Do not finish children's sentences for them or give an answer for them. Allow adequate time for individual children to respond.
13. When a child has an identified gap between their receptive language understanding and expressive ability, therapists need to explore AAC with the support of speech and language therapy colleagues. A multidisciplinary team (MDT) approach is essential, with the physiotherapist and occupational therapist being present to establish effective and reliable movement patterns that enable a child to independently interface with communication materials or technology (see information on equipment/assistive technology in Chapter 13). Remember that low-technology systems are essential even when a high-technology system is in place because of the potential for technology to break, run out of charge, or being ineffectual for use outside in weather extremes.

Motor function in self-care activities

Children with cerebral palsy may have developmental delays and difficulties engaging in self-care tasks (dressing, toileting, feeding, etc.). Parents of children with neurodisabilities most frequently identify goals relating to independence in

self-care (Allard et al. 2014). Children need to develop sitting unaided on the floor, on a chair, on the side of the bed, or on the toilet, have postural adjustment when reaching outside of their base of support, and get in and out of sitting. It takes longer for them to learn the required motor abilities and specialist equipment or manual support is needed initially (Fig. 10.1).

Children take an active role in most of their self-care when they achieve components of *vertical head control, and adequate trunk and pelvic control to maintain upright sitting without specialist equipment*. See training sitting for daily activities using developmental stages in Chapter 9. Figure 9.110 shows postures that are improved within daily activities. Select from Figs 9.92–9.95, 9.97, 9.99, 9.100, or 9.114 for daily living activities.

It is important to give appropriate support to avoid a slumped position with pelvis tilted backwards or weight bearing asymmetrically. Frequent readjustment of the child's hips may be needed. Atypical postures can also interfere with some activities. Children frequently experience musculoskeletal difficulties that impact on sitting posture. For example, short hip and knee flexors result in a posteriorly tilted pelvis in a seated position (Sahinoglu et al. 2016). This increases rounding of the back (kyphosis), causing difficulties in hand function.

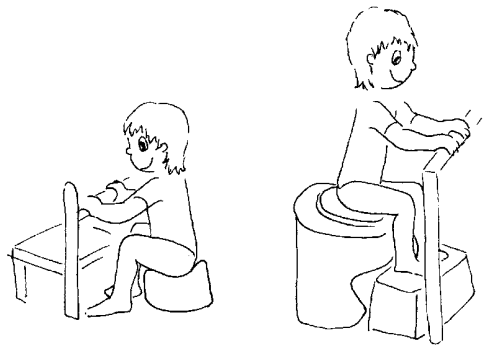

Figure 10.1. Holding on for support during toileting.

Shoulder girdle stability and sitting is initially gained through sitting leaning on forearms, then lean on one forearm using the other hand. Reaching out, reach-and-grasp with one or both hands all develop shoulder stability and control. Achievement of trunk control and postural adjustments is also needed for coordinated control of arms and hands. *Use of the hands* is obviously required for all activities and cannot be condensed unless a particular activity is discussed in detail. Hand function is considered further in Chapter 9.

Supported standing enables development of other aspects of self-care. An individual leans on or holds onto stable objects such as furniture for dressing. Permanent grab rails are used in the bathroom for washing and toileting. Support on hands on a parent's shoulders can be managed with a young child. Severely involved older or heavier individuals can have their upper body in prone on a table and feet on the floor as they have their legs washed or have trousers/skirts, socks, and shoes put on (Fig. 3.3).

Transitions to standing can be developed with physical support (see Chapter 9, developmental level 9–12 months). It is important to note that children in GMFCS levels IV and V are most unlikely to attain standing during daily activities and will require specialist equipment (discussed in Chapter 13).

Development of feeding

The promotion of feeding, eating, and drinking skills of children is mostly carried out by occupational therapists and speech and language therapists. However, physiotherapists are very much involved as well for head control, sitting, and hand function (Howe and Wang 2013). Seating and positioning are important so the advice of an occupational therapist or physiotherapist is often paramount. When parents or carers

cannot position a child safely, therapists will enable them to learn how best to do so for their child. Specialist seating may be needed. This is discussed in Chapter 13 in the section on feeding.

As detailed in Chapter 2, when using the collaborative learning approach with both individual parents and children and parent groups, Levitt and Goldschmied (1990) found that feeding was the most frequently desired theme for learning.

Research has demonstrated that there is a high incidence of physical difficulties in feeding, eating, and drinking in children with cerebral palsy (Rogers 2004; Snider et al. 2011). These are linked directly to nutrition or negative health outcomes, including aspiration and subsequent respiratory complications (Blackmore et al. 2016) as well as inadequate intake that may affect growth (Pinto et al. 2016). Suggestions from a dietician are helpful. There are also emotional implications for both the child and their parents and family arising from feeding difficulties (Snider et al. 2011). For most parents and carers, maintaining oral feeding is an important goal.

Benfer et al. (2016) suggest that gross motor function is the best indicator of dysphagia in preschool children with cerebral palsy. Clinical descriptions and case studies find that dysphagia is common (Arvedson 2013).

See the Eating and Drinking Ability Classification System, which indicates when coughing and gagging begin and when to increase safety (Chapter 1).

Gastrostomy

Safety is considered most frequently by medical specialists and specialist speech and language therapists.

In children who experience feeding difficulties in the longer term, in regards to both safety and ensuring adequate nutrition, the best and safest option for their overall health may be to receive some, most, or indeed all of their food via a percutaneous endoscopic gastrostomy or jejunostomy. However, if this type of medical intervention is required, the importance of positioning remains paramount for many children because of reflux and discomfort. Therefore occupational therapy or physiotherapy will continue after surgery. When considering specialist adaptive seating for this purpose, as with children who are orally fed, specific attention will need to be paid to the functionality of the seat in regards to backrest recline and tilt-in-space features as upright head posture is essential for feeding.

Typical developmental stages of feeding

0–3 months Rooting reaction, sucking, and swallowing reflex. The mouth and gag are sensitive, having normal cardinal points reflexes. The tongue moves out and there is often an open mouth and dribbling. When sucking, the tongue moves forwards and back together with the up and down movement of the jaw. A baby rests a hand on the breast or bottle, and sucks hands.

3–6 months Sucking dissociates from swallowing as the child transfers liquids for swallowing. All reflexes have disappeared. Bite response followed by release. Takes liquids or, later, liquidised food from spoon. Recognises bottle. Cup may be accepted for drinking. Experiences many tastes before textures. Mouthing hands, objects, clothes, and later feet. Begins to temporarily grasp and suck a biscuit.

6–9 months Takes mashed foods and semi-solids. Bites food if placed to the sides of the mouth, and sucks if centrally placed. Picks up and holds a biscuit, may drop it or crumble it in their hand. Around 8–9 months some guide mother's/carer's hand on a spoon or cup to their mouth and can hold the bottle. Likes to feel food.

Up and down jaw motion in chewing, tongue movements changing and less association with jaw action. Swallows with mouth closed. Gags on new textures but gag response is much less sensitive. Babbles with mouthful of food. During drinking, loses liquids and tongue protrusion is slight. Mouthing continues to explore toys and objects.

9–12 months Wants to control eating and drinking. Enjoys prodding, squeezing, and smearing food. Finger feeding, with more varieties held in hand. Firmer foods are chopped, textures accepted, and chewing with lateral tongue motion. Holds and drinks from a bottle and, with help, holds, lifts, and drinks from a cup. Helps parent with filled spoon to mouth but cannot do this alone. Plunges spoon into food and bangs spoon on the table. Lips used to remove food from spoon held by an adult.

12–18 months Feeds self clumsily with a spoon and the variety of foods increases. Uses a spoon but turns it upside down before reaching mouth or within mouth. A child cannot scoop food so uses the other hand to push food onto the spoon with much spilling. Holds and drinks from a cup, may bite on cup edge, often spills. Therefore avoid using a glass. Controls bite on a biscuit. Chewing established. Lateral and rotatory jaw motion. Pretends to feed another person and dolls.

18 months–2 years Loads and uses spoon correctly, occasional spilling. Holds a glass and a cup for drinking without biting the edge but may suck the edge or tip the cup and spill. Drops saliva or food while chewing. Understands what is edible and inedible. Begins straw drinking, but bites edge. Imitates other children.

2–3 years With small amounts, feeds self completely with a spoon, later with a fork. Pours liquids, obtains own drink from tap. Prefers a little amount to drink, using one hand. May be fussy about food, have variable appetite, and imitates other children about likes/dislikes and being independent.

3–4 years Serves self at table, spreads butter, cuts food. Pours from different jugs. From 4 years onwards a child is learning to use a knife and fork. A child learns to hold a fork with pressure by the index finger isolated from the others grasping the handle. There is increasing experience of new mealtimes in new situations. Enjoys help with cooking and more complex imaginative play such as with toy tea sets, dolls, shops, toy kitchens.

Practical feeding suggestions

Feeding is an extremely complex sensorimotor function integrated with cognitive understanding, communication, body image, and perceptual function. Such integration depends on developing feeding, drinking, and eating as a pleasurable experience for the child and the parent/carer. For many children who may have been born prematurely or have multiple impairments, feeding will not have been pleasurable from birth.

Children with bilateral cerebral palsy, GMFCS level IV or V, usually have the most feeding problems. We need to find individual suggestions to overcome difficulties such as hand-to-mouth actions, holding an object for mouthing, controlling their heads to use vision, and developing prerequisite physical and perceptual skills for feeding. Children who have more gross motor and manual abilities (GMFCS and MACS levels I–III) physically manage early levels of feeding but may be asymmetrical in their actions. In some children, a kyphosis posture may also lead to decreased head control, demanding moving their upper body anteriorly or posteriorly to maintain balance. The result is further complications in swallowing (as well as speech).

Careful positioning for feeding is needed. Figure 10.2 shows positioning for excessive head extension and tongue thrust.

Swallowing or dysphagia is a considerable risk and is explored in several studies (Calis et al. 2008). Children with moderate to severe feeding difficulties have poor health and nutritional status. Occupational therapists work closely with speech therapists for children's safety and health. Dieticians may need to be consulted for nutrition.

When demonstrating safe feeding to a parent or carer, explain that the adult needs to hold the child's head (or when possible the child holds it by themselves), in a forwards, upright position with their chin tucked in. This position should be maintained while the child is taking food, during eating and drinking, and especially while swallowing. Swallowing with the head back is more difficult and increases the risk of aspiration (food/fluid entering the airway). With the head upright, a child not only protects the airway but also allows active learning to eat and drink. Gently press a child's chest to help the head come forwards and up, and, if their head drops down, give minimal support under their chin. If children can prop themselves on a

(a)

(b)

(c)

Figure 10.2. (a) Head extension and tongue thrust interfering with drinking and eating. (b) Holding the child's head upright and forwards, supporting her chin, and stroking under her jaw trains drinking. (c) Wait for the child to remove food from the spoon held below her mouth. Keep her head and shoulders well forwards as she takes the food.

stable surface (table or tray) with their elbows this should be encouraged as it will activate shoulder girdle stabilisation, which assists head stability. Control of hand-to-mouth action is also increased as the elbow steadies the arm on the table. Babies and young children with visual disability can also be supported to find food by searching along the table surface when they are ready to do so. Gently banging the cup on the table alerts a child, indicating where to reach for picking up a cup.

Parent–child relationships

These will be fostered by good methods used during feeding, as a child's difficulties will often create worries. A parent or carer may feel more anxiety as each expects that they should be able to cope. Support and explanations about the neuromotor problems and reassuring approval of any coping abilities by them or any family member is essential. Any emotional difficulties of parents or carers about feeding need sensitive management; at some stages they may not feel able to take on the feeding training completely and will require additional support.

It is important to give due consideration to the fact that feeding is a dyadic process between parents or primary carers and children. Unhurried feeding gives time for a relationship to develop and for the child to respond to being fed and later to develop eating and drinking. Give time for the child to accept new tastes and textures and participate by opening the mouth, taking food, and swallowing. The speed of feeding should be slower and similar to the speed at which the child's own early attempts will start. Being fed, and later eating and drinking, needs to take place in as social and pleasant an atmosphere of an unhurried meal as you can make it. Communication, including babbling or words, often occurs during such mealtimes. Sitting at meals with the family and other children at school also motivates eating and drinking, and, when imitation develops, a child's independence is enhanced. Naturally a child needs to join the family or others for the mealtimes, but if they have difficulties give something that does not present particular challenges in regards to feeding or drinking.

Remember that making demands on self-feeding may compromise oral–motor skills and should not be at the expense of intake, safety, and emotional upset. Recognise that a child has to manage more oral–motor, developmental, and emotional difficulties. When a child's ability to imitate is limited because of cognitive or sensory difficulties, or because others are eating too fast for them to feed independently at the same mealtime, one-to-one therapeutic intervention may be required. When a child has much difficulty with feeding or eating, a parent may experience a high level of anxiety that requires specialist intervention. As with the development of any functional task, feeding interventions should be carried out within a naturalistic context, at a time when the child would typically feed. However, environmental adaptations will be important in order to reduce distractions and allow for concentration on active achievements. Both within and outside of direct therapeutic intervention, snack times are particularly valuable for developing self-feeding as they involve eating a small amount of food.

Children who have one arm that is more affected than the other should be taught to use the more affected hand to support themselves by holding a rail or the table, or to hold the bowl or plate to stop it from moving (Fig. 10.3). The less affected arm can then be used for eating and drinking. While promoting bi-manual upper limb function (Fig. 10.3) (see Chapter 9 for more detail), this is much less frustrating than insisting that the child attempt to use their more affected hand. When both hands are

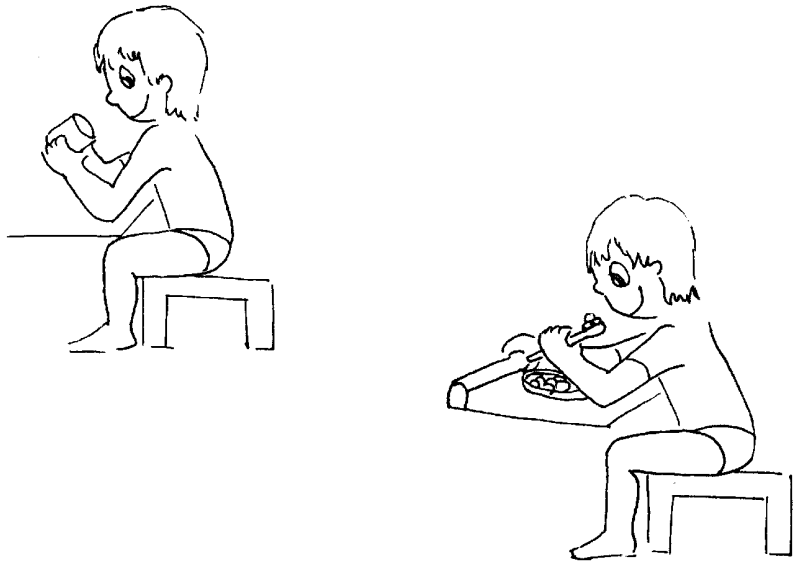

Figure 10.3. Drinking using both hands for symmetry and eating using one hand for support.

used, a child is helped to sit symmetrically, looking at food in the midline, if they can use their eyes in that visual field. As a result, twisting of the neck and body is avoided.

Mouth actions in taking in the food, keeping the mouth closed during eating, chewing, and swallowing can be facilitated by your hands, supporting under the child's chin. Speech and language therapists are best placed to demonstrate techniques to carers of children who are at risk of aspiration. Weaning from liquids to tolerate various textures and tastes through semisolids to solids is extremely important and may take longer in some children with disabilities. Children who have multiple sensory impairments or cognitive difficulties may be particularly reluctant to change. Smooth, thick liquids are often easier to manage as they move more slowly and provide greater sensory experience within a child's mouth. In the weaning process, the adult can spoon from a cup of thickened fluid before moving on to spoon mashed food from a bowl. Many children who experience these feeding difficulties are fussy about textures, demonstrating hypersensitivity, which requires the use of additional methods to gradually normalise sensation.

Children may experience *gagging or choking*, which may be due to gastro-oesophageal reflux and associated with aspiration into the lungs. In babies, medication and positioning are used and many overcome this by 18 months. Medical opinion is essential, especially for older children. When gag and choking occur in other children without reflux, calmly and quickly tip the child forwards and down. Basic life support techniques specific to choking should be followed; all allied health professionals working with children should ensure that their training in this area is up to date. Gagging can sometimes be behavioural, which means that small amounts of food should be given at a time, slowly, so that the child has time to make the decision to take the food and to swallow. Children may sometimes gag on the foods they dislike, to which they are allergic, or if they have learnt this as a behavioural response. They may be reacting against a new person feeding them, an unfamiliar place, especially when in hospital, or they may be

seeking the fuss and attention they get if they gag and vomit. Casualness in people's reactions and 'ignoring' their performance may stop this behaviour (see section 'Behaviour'). It also occurs in children with hypersensitive faces and mouths, which can be neurological or due to visual disability with fears, loss of body image, and unfamiliar situations.

Specific difficulties

Hypersensitivity of the face and mouth can be treated by gradual normalising of the sensation with methods used and suggested by speech and language therapists. Physiotherapists and occupational therapists can demonstrate guiding a child's hands to touch parts of their body in a game, moving towards their face and then the mouth. Sensitivity is also improved during the development of eating. It can be helpful to use gentle wiping and washing of the mouth area as well as guiding a child to wipe off food around the mouth. Remember that desensitising a child's face is best done with the child's own hands rather than those of an adult.

Weaning to solids is important in regards to both enabling increased engagement in social activities and improving nutrition. However, it is important to understand that some children will never achieve the ability to safely feed orally. In this case, special feeding equipment is needed to ensure that these children receive adequate food and fluid. A nasogastric tube gives food to the stomach for a short time. It is also used to administer medications. However, it should not be used for prolonged periods. When long-term non-oral intake is required, a gastrostomy is usually preferred by medical consultants. This decreases negative associations by the child with their mouth and allows for the development of oral–motor skills. The gastrostomy tube is inserted through the abdominal wall directly into the stomach. The catheter is secured. When not in use, a button for a feeding tube is less obtrusive and is usually preferred. Parent and nurse are responsible for feeding a child via a gastrostomy and will advise therapists about handling at appropriate times. Improvements in nutrition provide a child with more energy for therapy and physical engagement in self-feeding more generally.

Training self-feeding begins with finger feeding so that the child feels their own fingers on their mouth and learns to take in a small amount of food. Learning how to manage early hand-to-mouth abilities and experiencing the texture, temperature, and smell of the food all helps with skill development. The use of baby biscuits, which dissolve easily, and other food made of bite-and-dissolve textures ensures the child can safely munch and swallow independently. At first the child will push it all into their mouth and in time release with a finer hand control. Train finger feeding one item at a time so there is learning to finish each item before putting the next piece of food into the mouth. As previously described, when working with children with visual impairment it is important to place food in a consistent position so as to enable independence.

Feeding with a spoon follows, with the adult guiding hand to mouth and if needed supporting the child in an effective sitting position. However, adaptive seating may be required for those children who need to concentrate more on difficult mouth control and swallow. Guide hand-to-mouth action from slightly behind and to the side of the child. Guidance is all the way from the bowl to the mouth with gradual reduction to letting go when a child's active moving is detected. Difficulties grasping the spoon can be reduced through the use of adaptive cutlery. Scooping food against the sides of a bowl on a non-slip mat develops later.

Guide using your hand over the child's hand on the spoon or fork. Keep your hand alongside the child's hand on the handle, or by directing the elbow or whole arm. Stiff, flexed, and adducted arms may have to be held with the upper arm well away from the body to release tightness. On taking the food to their mouth, the child must be taught to keep their head upright and chin in, with trunk forwards, for swallowing and to prevent falling or extending backwards. Extending or thrusting into extension allows more unwanted jerking mouth opening, gagging, or choking, and may cause loss of hand grasp. If problems of extensor thrust or head and arm control are excessive, then, at first, control of these basic movement and posture patterns will have to be taught without food and drink for easier learning.

Behaviour. Behaviour varies according to a child's developmental stage, diagnosis, culture, and temperament. For example, teaching eating needs to take account of a child's level of understanding, the relationships between the child and objects, and between two objects such as spoon and food, spoon and bowl, as well as the child's physical ability (Kitzinger 1980). The outline of developmental levels previously described provides information on the behaviours typically seen at different ages, but may appear later when a child has developmental delay or cerebral palsy. Feeding behaviour is changed by the neurological problems or medical conditions causing gastro-oesophageal reflux. Positive change is promoted with important sensory experience of feeding gained by ensuring that a child can tolerate a wide enough range of tastes and textures for nutritional requirements.

The suggestions given above for therapists and parents/carers and any family member enable a child to manage the developmental and medical aspects of eating and drinking while minimising stress in both child and parent/carer. Remember the following main points influencing a child's behaviour.

1. Give opportunities for a child to make a choice about what is offered (see the section on communication).
2. Give time for a child's decision to take the food or drink offered.
3. Give small portions.
4. Concentration is needed by a child learning to eat and drink. Check positioning and give more physical support than in other situations. Make sure that the pressure of tables or positioning straps against a child's abdomen is not causing discomfort and even vomiting. Reduce auditory and visual distractions within the environment and minimise talking while the child is physically engaged in the activity. Consider the length of the concentration span of each child; usually this is approximately 20 minutes, after which the adult should accept the amount eaten without any remark.
5. During therapeutic intervention, when a therapist is providing support and/or advice during a mealtime, feelings of failure in parent and child can be reduced through reassurance that any developments are positive, no matter how small or slowly they are taking place.
6. Naturally, a child is never forced to eat when there is refusal. Adults should not attempt to persuade, cajole, or trick a child into eating. An anxious and worried child may refuse to eat despite your good methods and may push food away, turn away or cry, or even throw food away. Remain as relaxed as you can and calmly put the spoon or cup down. Wait and try again slowly and calmly. Should refusal continue, calmly remove the food completely and not as if the child

is being punished, so the child does not eat at all. Good practice in regards to behavioural management dictates that positive 'reinforcers' are preferable to negative 'punishers' at all times.

7. Find ways in which a child can help with food preparation, choose the size of a food helping, and, when more able, help to set a table.

When inappropriate feeding behaviour occurs that is demonstrative of psychological difficulties rather than, or in conjunction with, physical or medical problems, a multidisciplinary feeding team with a behavioural focus needs to be consulted.

Oromotor dysfunction. It is not uncommon that children with cerebral palsy may also experience difficulties controlling the muscles that will affect feeding (Gupta and Appleton 2001). *Worster-Drought syndrome* is a term used to describe a supranuclear (pseudobulbar) palsy in which specific difficulties are observed (sucking and swallowing problems, excessive salivation, severe dysarthria, increased jaw jerk), often in combination with mild lower limb spasticity and/or some upper limb involvement. Evidence of any of these difficulties, or observations of difficulties closing the mouth, tongue thrusts, gagging, or hypersensitivity, should lead to a consultation with a speech and language therapist. Specialist feeding interventions may involve the use of special cutlery to reduce tongue thrust, but must be used in conjunction with positioning that supports the child's head in midline, with firm support provided to ensure an upright and forward position is achieved. Bite responses are also best managed with non-metal spoons to prevent damage to teeth, and chewing development can decrease the early bite responses. Active biting and lateral tongue movement can be encouraged by positioning the spoon at the side of the child's mouth between the teeth. Some therapists have occasionally used pleasant-tasting ice lollies to reduce the spasticity of tongue and mouth muscles, although evidence for this remains anecdotal. Floppy mouths associated with excessive dribbling can be helped by training of feeding, chewing, and general stimulation of the mouth muscles with touch or pressure, but, as with all the approaches discussed in this book, these should be carried out in a functional capacity. *Further information* on the occupational therapist's use of feeding equipment is included in Chapter 13.

Development of dressing

Dressing is an extremely complex task involving the use of motor, cognitive, and perceptual skills. Development can vary greatly for typically developing children, and is therefore even more complicated for children with motor delay and cerebral palsy who may require task adaptation and/or compensatory strategies to promote independence. Attention and concentration is also a key factor, as is motivation, especially for children who may also have social communication difficulties. The following outline describes the typical developmental processes, which enable independence in this specific self-care task.

6–12 months Dressed in lying and now supported in sitting, later supporting themselves on hands. May put out an arm or leg for dressing and cooperate in other ways between 10 and 12 months (Fig. 10.4).

13–18 months Postural control improving, so one or both hands are becoming free to take off socks or hat. Takes off gloves and shoes and can unzip around 18 months.

18 months–2 years Cooperates more with undressing. Takes off pants. Pulls of T-shirt if placed on the child's head. Puts on shoes, hat. Unable to replace clothes but may sometimes help more with dressing.

Figure 10.4. The child is held flexed for dressing and play. Tailor sitting is being obtained. Press beneath the big toe and bend hip and knee outwards in order to overcome excessive leg extension–adduction for, say, a nappy change, sock removal, and getting the child into tailor sitting.

2–3 years Gradually able to take off all clothes. Confusion of back and front, right and left, top and bottom, two legs in one hole of trousers and so on.

3–5 years Gradually becomes able to dress self, can be careless about details such as tucking in shirt, which foot to put in which shoe. All buttons, laces, ties not possible until 6 years.

Practical dressing suggestions

1. Given the variation in development that occurs in this area, it is important that adults do not expect too much of a child. Dressing is not an easy task, involving the training of perception, motor planning, balance, hand–eye coordination, reach, grasp, manipulate, and release. Bilateral hand use is also required in the development of both balance and the ability to manage fastenings.
2. Receptive language understanding is an important factor to consider when deciding which strategies will support the child. If language acquisition is affected by the child's disability, the use of simple short instructions and utilisation of visual supports may be beneficial. However, dressing may also present a functional opportunity in which a child can develop their language, including their understanding of the names of body parts/clothes (nouns) and prepositions.
3. Dressing practice should be carried out when the child needs to get dressed or changed, but not as an isolated exercise.
4. The use of backward chaining will support a child to develop skills at each step of the dressing task, while enabling the child to experience success. Start by completing each stage of a task except for the final one, which the child should do. Next have the child complete the final two stages, and so on, until they can complete each step in the correct sequence so as to demonstrate independence.
5. Vary stable positions for dressing to discover the easiest one for the child. The child should be positioned so as to minimise dyskinesia and spasticity, and given just enough support so as to encourage and enable as much independence as is possible. Try to maintain symmetry of head and body, let the child see your face and what is happening. For example, side lying may enable a child to dress, take off socks and shoes. Lying and bridging allows the child to stabilise on feet while removing clothes from the lower half.
6. Type of clothing: loose-fitting garments, large sleeves and arm holes, elastic necks

and waistbands, large buttons, zips with zip-pulls, and Velcro fastenings can all be used effectively to reduce the motor demands required.

7. When a child has unilateral involvement of the upper limbs, teach them to dress the affected arm first. The use of both hands should be encouraged, with one used for stabilising if necessary, or to provide strength in pulling.
8. Use of specific strategies to aid motor planning. The use of task-specific interventions has been increasingly indicated in recent years (Novak et al. 2013) and there is now emerging evidence for the use of the Cognitive Orientation to Occupational Performance (CO-OP) model while working with children with movement disorders (Jackman et al. 2014). Task-specific interventions have been discussed in detail in earlier chapters.
9. As with all functional tasks, an individual approach can enhance a child's motivation.

Motor function for productivity

Children with cerebral palsy are likely to have problems in the classroom depending on the severity of their gross motor or manual dexterity difficulties. Therefore it is difficult for children to be productive at home and school. We need to liaise with our colleagues within the education system so that we can develop a greater understanding of the level at which children of a certain age would typically be performing and to ascertain the types of school work they might be expected to produce.

As noted in previous chapters, working alongside our psychology colleagues will also be required if we are going to develop a formulation of a child's abilities across domains. A full understanding of a child's cognitive and linguistic abilities will enable us to provide and/or recommend school-based therapy programmes that are in keeping with a child's level of understanding and support effective differentiation of the curriculum to promote participation. Failure to acknowledge difficulties beyond the physical will probably result in the therapist missing *the broader effects of the condition* and pitching their interventions at a level above or below a child's capabilities (Action Cerebral Palsy 2015: p. 13). However, our primary goals, as described above, must always be participation within functional activities that make up the school day.

School visits by community therapists can enable them to share their suggestions with staff who have questions about school-based tasks for their children. This includes toileting, washing, dressing, and feeding. *Handwriting* is one activity which may need to be specifically differentiated for children with delay and cerebral palsy, to both increase participation and offer an opportunity for skill development.

Development of handwriting

The ability to record written work is necessary in order that a child can demonstrate their learning and understanding in school and to achieve their potential in the 'productivity' domain.

Children spend 30–60% of their time in school engaging in activities that require handwriting (McHale and Cermak 1992). Handwriting itself is an extremely complex perceptual–motor skill, which requires motor coordination, visual–perceptual, visual–motor integration, kinaesthesia, and cognitive and linguistic abilities, all of which may be impacted by the range of difficulties that are intrinsic to cerebral palsy. Evaluation of these skills is therefore important and will require an MDT approach. Historically, children with handwriting difficulties have frequently been referred to occupational therapists for assessment of the component skills, which may be impacting on performance

(Lockhart and Law 1994; Case-Smith 2002). In recent years, in line with a move towards the focus on participation described above, a top-down approach to handwriting has been encouraged (Ziviani and Muhlenhaupt 2006), but understanding of the underlying skills remains important if we are to consider all areas of the *ICF* (WHO 2001), and to be able to adjust the task and/or environment in order to support independence. A clear understanding of the difficulties experienced by an individual will also ensure that we can enlist the support of our professional colleagues appropriately.

12–18 months Typically able to imitate scribbles on a piece of paper with a crayon or pencil held in a fisted hand. Children should start spontaneously scribbling on paper rather than banging it.

19–24 months Starts to hold a crayon or pencil in a transactional grasp, with fingers and thumb, but will still use the whole arm to colour. By 2 years typically able to imitate vertical strokes, horizontal strokes, and circles on a piece of paper.

2–3 years Typically able to accurately copy vertical lines, horizontal lines, and circles.

3–4 years Develop the ability to draw around the edge of a basic shape template. Imitate an adult drawing a cross at about 3½ and be able to trace on top of a thick horizontal line without going off very much. By 4 years starting to copy some simple horizontal and vertical letters, such as *E, L*, and *T*.

4–5 years Typically be able to copy a cross, square, triangle, and 'x'. Able to draw a basic person with three different body parts and will be able to colour mostly within the lines. More advanced drawing skills – drawing inside the path of a simple maze, connecting dots – are starting to develop. This is also the age for a child to begin practising the formation of the letters in their first name.

5–6 years Typically have hand dominance established for fine motor activities. Hold a crayon like an adult does, with thumb and fingers near the tip of the crayon, and able to print some capital letters without copying. By 6 years children should be able to copy or write their name and be able to write the alphabet without omitting letters. Children should also be able to write the alphabet in uppercase and lowercase letters without switching forms throughout.

7 years No longer reverse the letters of the alphabet while writing (example: 'b' versus 'd'). Children should also use appropriate capital letters and punctuation to write complete sentences.

Practical handwriting suggestions

1. In order to develop the refined hand movements required for writing, children require a stable base that promotes controlled, fluid upper limb movements. Children with motor delay or cerebral palsy, who achieve independent sitting later than their peers, will have reduced opportunity to practise drawing and therefore to develop prerequisite skills for writing.
2. Handwriting is a bi-manual task, which involves the effective use of two hands together. Those children who have a hemiplegic presentation can be supported to develop effective handwriting by reducing the task demands. Securing the paper to stop it from moving will mean that the child does not have to hold it down with their affected hand.
3. Holding crayons and pencils, especially in an adult way, requires selective muscle movement of the hand and the ability to move the fingers dynamically, independent of the wrist and forearm.

However, the need for more sophisticated grasp patterns can be reduced through the use of thicker writing implements.

4. Before a child can write, they will need to be able to draw all 'pre-writing shapes' from which all letters are formed. Practising these shapes during play is likely to increase motivation and make it possible for the child to feel as though they are not being forced to do more 'school work'.
5. The use of a multisensory approach, which utilises all of a child's senses in order to aid memory and learning, can be used throughout the development of writing. Examples include forming shapes or letters out of play dough to provide tactile input; talking through formation to provide auditory input; walking over letter patterns on the floor to provide vestibular input.
6. Handwriting, as with all of the activities discussed in this chapter, is best learnt and mastered with a functional approach.
7. Focused attention is crucial when engaging in tasks, such as handwriting, that require such a wide range of component skills. 'Interventions directed to improve motor function may be related to aspects of cognitive function, which should be considered as part of decision making in early intervention' (Surkar et al. 2015: p. 21).

Motor function for leisure

In addition to self-care and productivity, the therapist must also consider leisure or play opportunities, which are a fundamental aspect of child development. Children with motor disabilities face obstacles in activities and participation as well as from physical aspects of their environments (Dickinson and Colver 2011). This may limit their opportunities to engage in recreational activities, which offer both social experiences and physical therapeutic benefits. The concepts of accessibility and inclusive design have somewhat paved the way to support all children's engagement, but literature suggests that as a society we are far from establishing completely accessible environments, or equal opportunities for individuals with disabilities to engage in leisure pursuits and facilities (King et al. 2006, 2007; Majnemer et al. 2008; Fauconnier et al. 2009). There is still a pervasive lack of understanding of others within society who are outside of the health and social care field.

A study by Anaby et al. (2017) compared the practices of physiotherapists and occupational therapists working with children with cerebral palsy, quantifying their focus for assessment and intervention within the main areas of the ICF. They found that physiotherapists were more likely to select interventions classed in the *body functions and structure* category than their occupational therapy colleagues (34–42% and 18–20%, respectively). However, today this would link with sports as a recreation for children. Both professions focused on activity and participation (34–61%), although attention 'was mainly directed towards task-oriented activities such as activities of daily living and mobility'. Participation in leisure or community-based activities received far less attention, and was the focus of around only 2–15% of physiotherapy and occupational therapy input. It is important to remember that children should be given opportunities to make choices regarding leisure activities and tasks; they may experience a high degree of participation even if they are dependent on others (Perenboom and Chorus 2003). A study of children with cerebral palsy in a specially designed adventure playground found positive play experiences using motor abilities with and without adult assistance (Levitt 1975).

Development of play

Play is perhaps a child's first conscious occupation. While the very young baby will sleep, engage in feeding, and communicate with its caregivers, purposeful play is the first activity in which the child engages above and beyond ensuring that their basic needs are met. It is through play that a child develops their choice-making (see the section on communication), learns social interaction and social communication skills, develops hand function, postural control, locomotion, intersensory relationships, and perceptual–motor control. See Chapter 9 for more information on therapy procedures, at different developmental levels often within play. The section on hand function particularly has many suggestions for play. Play differs at different ages, but it is impossible to have it strictly classified as the child's personality, opportunities, and cognitive level affect this. Social and cultural backgrounds also affect play, and therapists learn much about this from families and children.

Play is usually a synonym for exploration and experimentation and, as described above, is extremely important in the development of skills across domains. The child's intrinsic motivation to engage in play tasks is one of the things that separates it from other occupations, alongside the fact that it focuses on the means of the activity rather than the end; 'play is process – rather than product oriented' (Rigby and Rodger 2006: p. 178). Play can also be relaxing, offer opportunities to work out emotions, offer the chance to imitate reality in order to understand it in imaginative play, and support development of the child's personality. It is often messy, dirty, untidy, and destructive, as well as creative and constructive.

The correlation between play development and the acquisition of skills in other areas means that children with cerebral palsy may potentially have difficulties playing independently, understanding the rules and instructions for games, and utilising their senses to interact with play materials effectively. From a motor perspective, as with the other occupational domains discussed in this chapter, positioning is extremely important and needs careful consideration. The ability of the child to access play materials can vary, with some demonstrating minimal difficulties, while others may require adapted play materials, the use of assistive technology, or full adult support when vision, hearing, or other sensations are impaired.

0–6 months Visual fixation and pursuit, hand–eye coordination and bring hands to midline and grasp, drop, reach and grasp, touch and mouthing. Play with parts of body, parent/carer's face, nearby materials. Finds pleasure in using all senses and movement to concentrate on exploratory play on his own. An attentive adult is nearby for safety but not guidance, unless baby shows need. This allows a baby's own discoveries.

6–12 months Rolling, crawling, supported cruising, and other gross motor activities to explore, strengthen body generally, and enjoy moving. Hand function development continues using toys or objects. Investigates and experiments with increasing energy.

1–2 years Solitary play but imitates another child or adult. Uses large equipment, swings, balls, toys on wheels to push and pull. Sand and water play. Enjoys small objects such as shells, pebbles, buttons, but needs supervision as child often takes them to the mouth until 15 months of age.

2–3 years Rough and tumble play. As above, only with more perceptual and conceptual ideas. Begins imaginative play ('Let's pretend'). Solitary and parallel play also emerge.

3–4 years Plays with other children. Imaginative play, dressing up, and feeding dolls. Less energetic activities such as looking at books that require concentration and play with more complex construction toys.

5–6 years Games with rules, arts, and crafts. 'Tricks' with body and hands.

Practical play suggestions

1. Children with cerebral palsy have less opportunity to engage in spontaneous play. Give helpful positioning, guidance, and support to use existing abilities to enjoy learning from play.
2. Select objects and toys in a size that can be handled and those that can be understood, but especially those that interest an individual child. Offer choices between toys to support communication and enable a sense of autonomy.
3. Show the children how to use toys, but, wherever possible, see if they can find things out for themselves.
4. Do not interfere with any child who is concentrating on a play activity unless absolutely essential. Before helping, recognise that a child needs their own time and speed to reveal their abilities and initiatives to themselves and to you, especially when there are cognitive or sensory impairments.
5. Choose toys that provide a 'match' for a child's abilities. This may mean toys that are easier to hold or require fewer manipulation skills; toys that provide experiences to develop cause-and-effect understanding; toys that provide increased sensory input.
6. For children with severe cerebral palsy, who have limited motor abilities, assistive technology may provide a means by which they might engage in play activities with some level of independence. See Chapter 13 for further information on equipment/assistive devices.

11

Therapeutic group work

Children's need for group activities has long been recognised in the habilitation of children with disabilities. Such children are often isolated from their peers. Owing to motor disability, they may not be able to run up and join a group of children, put an arm round a friend, or even push away an annoying child. Parents may find it difficult to bring their child into contact with other children whether disabled or not. Children need group treatment for contact with other children, sharing an activity with others, feeling part of a group, and responding to competition and cooperation. Group work in special or inclusive education as well as in therapy offers opportunities for the child's social and emotional development.

Groups have been used in a variety of ways:

- *In speech therapy* for stimulation of communication and development of speech and language.
- *In occupational therapy* for perceptual training, for play involving perceptual motor function, for recreation, social interaction, and learning to play a game involving rules and taking turns and so on.
- *In physiotherapy* for training children with a specific diagnosis to carry out a set of exercises, for games involving gross motor activity, for swimming and activities in water, and for various sports for disabled people. Circuit training groups have benefits (Blundell et al. 2003).

As the aims of these different therapy groups overlap, it is possible to carry out *interdisciplinary groups* of two kinds, as follows.

Playgroups, including toy libraries, adventure playgrounds, special or ordinary nursery schools, opportunity groups, or nurseries, are orientated to each child's developmental levels and special problems. The therapists may advise or themselves work in the group setting, stimulating a few or occasionally all the children with play activities which involve gross motor, fine motor, perceptual, and speech and language activities. The therapist may be in the playroom or nursery, relating to one child with specific problems and may or

Treatment of Cerebral Palsy and Motor Delay, Sixth Edition. Sophie Levitt and Anne Addison.
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may not also bring in other children in the same activity. Classroom assistants are trained to position and handle children appropriately.

The children may all be in the same room and may or may not feel themselves to belong to the same group in all activities.

Songs, story time, percussion band, games, and music are well-known sessions when all the children carry out the same activity. Therapists are, therefore, working closely with teachers, psychologists, child-care staff, nursery nurses, and nurses in the therapeutic playgroups and classrooms. Parents are often present in playgroups including therapeutic goals for their children. Children's siblings may also participate in playgroups or games with them.

The structured group works to treat or train a specific area of function. These groups integrate the gross motor, fine motor, perceptual, and speech and language activities, but with more focus on any one of these areas. This focus may be on the major disability of the children in the group, for example motor problems in cerebral palsied children. The focus may be on a specific area of function in one group session, whereas the focus will be on another area for that same group in other group sessions. These groups were influenced by conductive education and modified with the staff of the Cheyne Centre for Children with Cerebral Palsy (1969–1979).

Some of the main observations are as follows.

1. Individual sessions sometimes create too much pressure on an older child and aggravate any rebelliousness in them. In the group, such children often cooperate because all the other children present are doing what is expected of them.
2. The one-to-one relationship in individual treatment may be too similar to the one-to-one relationship in the mother–child situation. This is expected in children under the 3-year developmental level. Children with physical disabilities, however, are often over this age and need to relate to their peers, *even though* their physical function may still be under the 3-year developmental level.

   Although a child may need some private tuition in their school life and some disadvantaged children and children with very severe learning disabilities may still need this one-to-one relationship, many more need to 'grow out' of it emotionally and socially. Perhaps some of those who refuse to cooperate may be protesting at the dependency felt on being handled by the therapists all the time in this one-to-one situation.
3. In the group, children follow a programme and imitate the other children. Imitation helps children with partial hearing loss or learning disability to understand what is required of them. In addition, the children in groups are observed to instruct and help each other carry out the programme of work.
4. Speech is stimulated as the adult's concentration on all the children seems to take off the *pressure* on one child to speak.
5. Concentration of the children who are working at their own pace is great. The attention span is far longer than in individual sessions; children work hard in groups lasting 1.5 hours while in individual treatment for only 20–40 minutes.
6. The programme consists of integrating essential aspects of physiotherapy, occupational therapy, and speech therapy together with group work. It is planned by the team but carried out by one therapist and one or two aides or assistants. In this way a number of children are helped at the same time with economy on staff and on time

spent getting children to and from each therapy department, as well as on time required to establish rapport with each different professional.

7. Physiotherapists, occupational therapists, speech therapists, teachers, and nursery nurses welcome interdisciplinary groups, as they can then see the total child and the relationship of their specialty to those of the others in the child's total function. On planning and using the structured group session the different disciplines are enabled to share their knowledge with one another so that practical integrated group activities can be created. Different disciplines have then to clarify their main aims with each child and make certain that they are understood by everyone in the planning of the programme and in its execution. It is not possible for professionals to convey all their expertise to the other different disciplines, but rather to learn how to discover the overlap of their particular discipline with others. In this way the overlap becomes a practical achievement and enriches the teamwork.

General management of groups

Number of children. This varies according to the numbers of children in each centre, school, or unit, from whom selections may be made. No matter how many children are in a group, they must be *involved* and preferably participating.

Staff. One staff member leads the group with another assisting him or her. The assistant should be from another discipline. If the children are all severely disabled, more help may be indicated. However, the adults present must be kept to a minimum, or their one-to-child relationship rather than a child-to-child relationship may occur. The leader may alternate with his or her assistant each week or alternate days in conducting the group.

All assistants need to work according to the leader's action and not divert the child's attention away from the group by private conversation with them or with each other.

Venue. The group is best done in the child's own classroom or where there are no unfamiliar distractions and a coming and going of adults or other children.

Arrange children during the group session so that they can see the leader of the group at all times and also so that the children see each other. Semicircles or L-shaped seating arrangements are best, but the positions will change in a class with particular motor activities and walking exercises.

Length of sessions should be planned for 1–2 hours depending on the children's ability to continue participating and the programme of work.

Frequency. Group sessions are best done daily or three times a week depending on the aims of the group programme. Some aims only require twice a week. The main object is that the children work together for not less than two or three times a week so that they know each other and develop a group dynamic.

Behaviour. If children refuse to join in, make sure that the programme is not too difficult for them. If it is not, let them watch for a while, ignoring them. The other children may be given a particularly pleasant activity, or they may occasionally be told 'Let's do that again for so-and-so to try as well'. Other ideas may be offered by the parent or team members who know the child. However, if non-participation continues or if the child seems oblivious to other children and cannot imitate others, the group cannot 'carry' him or her indefinitely. The child may not be ready or not suitable for

group treatments, and this is not always obvious in the beginning.

Children with behaviour problems may become disruptive to the group. Hyperkinetic children may be particularly difficult. However, try a trial period of partial sessions with the group, increase to full sessions and the techniques above. Restless children may settle down and join in with the others. Finally, good selection of children and programme planning makes organised management easier.

Selection of children

The basis for selection varies and ideas are still developing. The early days of group treatment for both staff and children seem to be easier if the disparity between the children is not great. A group with children who have hemiplegia and who are at the walking level and at approximately the same chronological age and have intelligence forms a group that works well. Such a group is best for inexperienced staff and for those professionals beginning group work. The hemiplegic group might enlarge itself to encompass other diagnostic types of cerebral palsies who have asymmetry. Mental levels of children may be varied. A variety of developmental levels among motor developmentally delayed children may be contained in one group. The following points influencing selection may be helpful.

Problems of children

Motor problems

Selection of children according to diagnosis is not usually helpful. Select the children according to their problems. Although it is difficult to generalise them, motor problems are usually some or all the following:

1. head control – postural stability, particularly in the upright position
2. head and trunk in midline, symmetrical arm and leg postures
3. head and trunk counterpoising so that arms and legs can move into various asymmetrical postures or movements
4. grasp to hold on, and grasp and release
5. corrective movements and postures for any recurring atypical positions of any joints, for example in spastic hypertonic or dyskinetic/dystonic conditions, elbow flexion, shoulder retraction, hip extension or semiflexion, adduction, knee flexion, equinus feet
6. form of locomotion
7. ability to sit or stand
8. ability to rise from the floor or from a chair.

It is possible, say, to have a *pre-sitting group* with a selection of motor activity building up to sitting, prone to hands and knees, and weight bearing on forearms on a table (see 0–6 month levels in developmental channels in Appendix 1). It is possible to have a group on *sitting and pre-walking* with activities taken from the channels of development of 6–12 months (Appendix 1) or an ambulant group, 12 months and over (Appendix 1). The motor abilities selected for training will depend on the children. It is obviously essential to have individual assessments to plan for any problems. The other impairments and disabilities in the child should be considered, although motor problems are primary.

Age of child

Children should be around the same chronological age, as their developmental levels alone will offer a range of children. It is sometimes an unhappy situation if a large boy aged 11 with a developmental level of, say, sitting equal to about the 6–9-month normal developmental level is in a group with 3-year-olds also at this developmental level.

Cognitive level

The cognitive level should not cross too wide a spectrum. Some prefer keeping

intelligent children in one group, while others find it useful to mix, as the cognitively impaired child will imitate the intelligent child in carrying out the motor activity or other activities that do not demand high intelligence. Intellectually disabled children may also be better at movement than, say, children with severe physical disabilities, and intelligence as, say, in dyskinesia. The programme, therefore, allows each child to demonstrate his or her assets and abilities.

Personality and behaviour

The personalities of the children is rarely a consideration unless a child is excessively disruptive and management ideas for behaviour fail (see 'Behaviour'). A child's emotional and social stages of development influence whether he or she is suitable for a particular group.

Other disabilities

Deaf, partially sighted, or children with severe visual impairment may find it more difficult to join a group if the focus is on the motor disability. However, again some children with partial hearing loss and some children with partial sight have responded well to groups through imitation, lip reading, or augmented visual clues, as well as the fact that a good group session focused on problems other than specific hearing and severe visual problems. Children with profound intellectual impairment may be too oblivious of the group dynamics being used and remain in their own world, and be unsuitable for such group work.

It must be remembered that factors for selection are still being explored by those working with groups in therapy and education.

Whatever the basis for selection the 'answer' to the best way to select children finally rests on whether group programmes of work can be created by the staff and on the ability of the leader of the group to weld the group of children together, so they work together and there is a group spirit.

The programme

1. It is essential to have this prepared before the group commences.
2. It can be modified once used and *must* be changed as the children change and progress.
3. The group leader needs to have the programme in front of them so that they do not delay and lose any group impetus and collaboration gained. The leader must know 'what comes next' to maintain group concentration.
4. The programme should not be too long, but it is better to spend more time on each item. The items are after all only chosen because they are to be trained and repetition is needed. Time is given, so each child can be active.
5. Occasionally, have an easy item already achieved, as well as items *just beyond* the capacity of the children. If the children experience a successful achievement, this motivates them further.
6. Use action songs to carry out motor activities for the children; as they use the same songs each time, their familiarity is often appreciated. For many children, the programme should contain familiar elements, songs, the same assistant and leader, the same room, the same time of day or days of the week, and the same general outline. However, the activities must gradually develop and change and not remain so predictable that the children do not progress or become bored.

Items of the programme

The programme and its further modifications need to be assessed and reassessed not only by the group leader but also together with the other professional workers in the centre. Ongoing consultations are necessary to make sure that the items

selected for the children motivate *all* the children and that any child is not 'carried' as a non-participant for too long.

Select items from the treatment suggestions in the chapters on developmental training and the problems of deformity. Give preference to those items that do not depend on holding or handling the child, or there may be too many adults required. The presence of many adults disrupts the growing child–child relationships in the group. Select items that are at first easy and become more difficult as the children develop in the group programme. In addition, such selected items may be used in groups to allow some children to function better than the others. This motivates the others to work towards these more advanced levels, which they can observe in their peers. In this way the therapist can have children at different levels of motor development in one group. The therapist must have components selected, so they *build up* a particular motor function.

Examples

All the children sit around a large table. Children at the 3–6-month developmental level of sitting will have to lean their trunks against the table and grasp a horizontal bar attached to the table or grasp a slatted table. The children from the 6–9-month level do not lean against the table, but only grasp the support, and the children from the 9–12-month level, who can sit alone, do so with their hands at their sides or on their laps. All children may sing or use language and visual activities while practising sitting.

Similarly, standing may be modified from standing leaning on arms or against the table with grasp support, stand and grasp, and stand alone.

Also prone lying raise head, prone lying raise head and rise onto elbows, and prone lying raise head and rise onto hands can be included simultaneously. With careful planning and assessment of the children, many more examples will be found.

All motor activities must be associated with perceptual experience of direction, spatial relationships, colour, body awareness, various matching activities in relating shapes, sizes, textures as well as speech and language, social awareness, and of course the fun of children working and playing together (Fig. 11.1).

Music and movement, songs, action songs, fingerplays, and any other children's

Figure 11.1. The fun of working together to achieve therapy goals.

songs and music are enjoyed in group work. However, as with the other activities, these are modified to relate to the children's levels of development and interest. Imaginative activities such as 'Pretend you are a tree in the wind' or 'Let's wave our arms like birds' which are used for children's groups are not advisable unless the children understand them and are at the 'let's pretend' level of play development. This is about the level of understanding of typically developing 2–3-year-olds.

Children's group games and party games may also be adapted and used in group work. Whatever items are selected, they *must not* be random but selected according to the aims of therapy with each child. There will be aims of therapy which cannot fully be realised in the group sessions, or not at all. *Individual sessions* will be necessary for the children. However, if a child has the items well chosen for him or her in the group, individual sessions may not be essential for that child, for a period.

It is not possible to give programmes for groups, as these must be composed around the children themselves. However, the following are necessary for groups.

1. Start and end with a dressing activity, for example taking shoes and socks off, or taking a cardigan off.
2. Fetch and put away any equipment for the group.
3. Use gross motor activities for one session, integrating this with perception and language activities.
4. Use hand classes for a session, integrating this with perception and language activities.
5. Have a meal or tea for the group in order to include feeding training and washing hands.
6. Suggested group games for walkers and non-walkers. These may include crawling hand ball, passing ball or objects in sitting, throwing beanbags into large containers, obstacle course, croquet, ring toss, deck quoits, carpet bowls, shuffle board, rolling balls on the table or floor, ping-pong with the ball attached to a high horizontal wire for ball retrieval, and other play activities. Board games need to have large counters or handles on the draught pieces or holes for the pieces and other adaptations. (Catalogues of adapted playthings are available from organisations for children with disabilities.)

Summary

Interdisciplinary group work is valuable in the treatment of cerebral palsied and motor delayed children. They require consultations between staff to:

1. assess children's functions in all areas before and *during* group sessions
2. plan, monitor, and progress the items of the group programmes.

It is best for one person to carry out the programme with perhaps other professionals occasionally assisting but *not* interrupting during the group session itself. Adjustments of the programme can be discussed after the session is over.

Teachers and therapists depend on each other to create dynamic group sessions and therefore need to work closely together.

12

Management of deformities

In cerebral palsy atypical positions of limbs and body parts rarely appear as isolated deformities due to biomechanics. Although one joint with its muscles may be more deformed than the others within a motor pattern, it is important to *check each joint* as well as observe the *pattern of atypical posture and movement*. The positions and movements are initially limited by the weakness, lengths of muscles, limited ranges of joints, and changes in soft tissues (ligaments, connective tissues, and muscles).

Most babies with cerebral palsy do not have deformities, though these may be anticipated by their preferences for postures and movement patterns. Deformities become evident with growth and development, especially when weight bearing becomes present. Explanations have to be given to those parents who may be confused as they were correctly told that the brain lesion will not increase. The deformities are anticipated and treated, as they can be progressive.

Each deformity may be dynamic, that is, *unfixed*, which means that passive or active correction can take place. Deformities can be mild and do not restrict some children or become a serious problem in others. Dynamic deformities are less during sleep and absent under anaesthesia. Some or all deformities may have become *fixed* or contractures when there is adaptive shortening of muscles, tendons, and other soft tissues (Lin 2004). This later leads to joint and bony changes. The range of motion (ROM) is limited in a contracture, so full passive or active correction cannot take place. Fixed deformities remain during sleep and under anaesthesia (Graham 2004).

Dynamic deformities can coexist with contractures, particularly in older children. This may be contributing to the same joint position or be dynamic in some joints with contracture in other joints in limbs. A primary deformity in one joint can lead to deformities in other joints owing to the biomechanics of movement and posture. For example, equinus of the ankle can cause compensatory hip and knee flexion, though hip and knee are not necessarily deformed on ROMs. Deformities and contractures vary with the degree of stiffness, weakness, and immobility of a child.

It is necessary to point out that in the literature the words 'deformity' and 'contracture' can be used interchangeably

Treatment of Cerebral Palsy and Motor Delay, Sixth Edition. Sophie Levitt and Anne Addison.
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without a clarification of whether either is fixed or unfixed. The definitions given above are kept throughout this book to avoid confusion.

Preventing, minimising, and, if possible, correcting deformities with conservative early therapy and ongoing daily management are particularly important. This minimises secondary contractures (fixed deformities), which cause more disability, discomfort, and pain. A number of medical and surgical treatments are also available together with physiotherapy and occupational therapy.

Although this chapter focuses on the musculoskeletal features, they cannot be separated from the developmental and neurological aspects. Remember that neurological mechanisms interrelate with biomechanical strategies. The therapist needs to consider compensations for any absent postural mechanisms which result in *atypical postures and movements* as they are linked with the causes of deformities.

Causes of deformities

1. Immobility.
2. Hypotonicity.
3. Hypertonicity.
4. Weakness – general or specific.
5. Co-contraction and synergies (movement patterns).
6. Atypical reflex activity.
7. Asymmetry.
8. Involuntary movements in one repetitive pattern.
9. Growth factors.
10. Biomechanics.

Most of these causes are interwoven and their relationships are discussed.

Immobility

General immobility is associated with persistent atypical posture and very few, if any, movements in a child. The causes may be due to:

- *Physical impairment* of hypotonicity, hypertonicity, weakness with limited ROMs, a few inefficient movement patterns, impaired postural control, and prolonged atypical postures. The combination of dystonia and spastic hypertonia causes more severe immobility.
- *Other causes* such as sensory loss (mainly severe visual impairment), emotional problems causing a child to be excessively fearful of moving and balancing, severe intellectual impairment, social deprivation and malnutrition, together with physical impairment. Most of these reasons tend to create lethargic, unmotivated children, who prefer to be immobile. Some of the more severely involved children (Gross Motor Function Classification System (GMFCS) levels IV and V) can acquire a few atypical postures and stereotyped movements for partial mobility. When children have multiple disabilities they are particularly prone to their deformities becoming contractures.

Hypotonicity

The floppy baby or very young child with hypotonia due to cerebral palsy may become hypertonic, dyskinetic, or ataxic as they develop. Children who develop spasticity retain trunk hypotonia with stiff limbs. Children who become dyskinetic retain hypotonic trunks with fluctuating tone. They are initially immobile and may sometimes be left lying for long periods in one or two positions, which can create deformities. For example, the *frog position* of the legs in prone, supine, or with the child propped up on pillows in the half-slumped sitting position all lead to deformities, especially in the spine and hips. Anterior subluxation or dislocation of hips may be found in such cases. Additional

deformities are round backs in sitting and standing, lordosis, hyperextended knees (*back knees, recurvatum*), valgus knees (*knock knees*), varus knees (*bow legs*), and pronated feet (*flat feet*).

A common characteristic of most floppy babies is the absence of all or some of the typical early postural mechanisms which activate postural muscles. Fair, though weak, voluntary movement may be present, but it is not enough to make children mobile so they cannot get out of their few positions during the day and night.

Hypertonicity

Many workers focus on deformities in spastic hypertonus, the commonest type of cerebral palsy and most liable to progressive deformities. Deformities are associated with immobility in habitual atypical positions, stiffness, muscle shortening, weakness, as well as absence of selective motor control and in-coordination.

Types of hypertonicity. The dystonic–dyskinesia type of cerebral palsy is less liable to have deformities owing to fluctuating tone. There is a persistent type of dystonia together with spasticity, as well as a specific rigidity type in post-traumatic cerebral palsy, which cause deformities. In these children a *lead pipe* rigidity is felt on stretching throughout their joint ranges.

Use of spastic hypertonus for compensation. If children have no postural stability and postural adjustment mechanisms they will *use their spasticity* to *fix* themselves against gravity in the upright position. Thus, if a child is *standing on spasm*, they will collapse to the ground if their spastic hypertonus is removed by physiotherapy, drugs, or surgery for the involved muscle groups. They may be left with straight legs but completely lose their independent standing or even their previous ability of stumbling around. Spastic legs are also weak.

Muscle imbalance. Although some orthopaedic workers may still talk of muscle imbalance, they unfortunately say that the spastic muscles are *strong* and the antagonists are *weak* which causes deformity. This is rarely so. It is the *pull* of the short spastic muscle that is strong, and not the spastic muscle action itself, which is weak. The antagonists were working at a mechanical disadvantage to the tight pull of the stiff, short spastic muscles. In time they become weak from disuse and inability to be active through their full ranges. It is necessary to prevent deformity by obtaining as full a range as possible for all muscles and strengthening them.

Ross and Engsberg (2002, 2007) have investigated the relationship between spasticity and strength and also found that there was no 'muscle imbalance' at a joint. They also found that the degree of spasticity (velocity-dependent resistance to passive stretch) had no relation to the amount of strength in that muscle. They consider that 'muscle weakness, and not spasticity may be a prevailing impairment' in cerebral palsy and that their research on individuals with spastic diplegia found no significance of spasticity with function, but strength was correlated with a number of functional measures.

Weakness – general and specific

1. General weakness is present in hypotonicity and when there is absence or poor postural control available to activate the muscles.
2. Specific weakness is the weakness of the spastic hypertonic muscles and of their antagonists.
3. Asymmetrical weakness occurs in hemiplegia (unilateral cerebral palsy) and in asymmetrical diplegia or tetraplegia (bilateral cerebral palsy). In the bilateral cases, greater weakness may be of one arm or leg on different sides or on the same side of the body. In unilateral

cerebral palsy limbs on one side and of the trunk are weak.

4. Short spastic muscles are initially inelastic ('hypoextensible') and weak (Tardieu et al. 1982).
5. Gough et al. (2005), in their critical discussion of theories underlying botulinum toxin-A (BoNT-A) injections, as part of managing deformities, draw attention to the importance of weakness rather than muscle fibre length. In children, Lieber and Friden (2002) also did not find decreased muscle fibre length in fixed flexion deformity of the wrist. Shortland et al. (2002) in studies of fixed deformity of medial gastrocnemius in children with spastic diplegia found decreased fibre diameter and shortening of the aponeurosis secondary to muscle atrophy rather than short muscle fascicles. The studies of Fry et al. (2004) indicate that fixed deformity might relate to muscle atrophy rather than muscle fibre length changes. The decrease in muscle belly length has a relative increase in tendon length. These studies support the importance of weakness in children with spastic diplegia.
6. Assessment of strength of a muscle group on the couch may not relate to its action in function. For example, shoulder girdle muscles may work well in crawl position but not in a muscle test on the couch. Back extensor muscles may be well activated in prone but not in sitting or standing. Extension of the elbow is greater when a child reaches out for a desired object than in muscle tests. This can also be observed when a muscle is active in lying but not in a gait analysis, which is more complex (McMulkin et al. 2000).
7. In this book, strengthening procedures with and without manual resistance are used *within* developmental functions in Chapter 9. Active exercises are given later in this chapter. Progressive strength training with resistance for specific muscle groups, in children over 4 years, is included for both dynamic deformities and later in postoperative rehabilitation when the individual is able to manage this (see 'Strength training' in Chapter 5).
8. Damiano et al. (1995a,b) have markedly improved crouch gait in ambulant children with strengthening exercises against resistance for quadriceps and hip extensors. Presumably the deformities were dynamic. Andersson et al. (2003) report similar positive results in adults with cerebral palsy.
9. Engsberg et al. (2006) in a pilot study on 12 children in a 12-week strength programme with three sessions per week found the following. The majority of subjects increased ankle dorsiflexion and plantarflexion separately and together compared with the controls. Measures used were the Gross Motor Function Measure score for the dimension of walk, run, jump, which increased. They also measured quality of life, and that improved significantly in child and parent reports.

Atypical co-contraction and atypical synergies

Compensation for absent or poor postural mechanisms may activate excessive co-contraction to maintain balance. The legs appear to be stiff and straight similar to the positive supporting action seen in typical infants. There can also be compensations for lack of balance or weakness and atypical postures, as mentioned in the section 'Hypotonicity'.

The atypical postures can be combined with atypical movement synergies, which include co-activation (co-contraction) and atypical recruitment patterns (Tedroff et al. 2006). However, postural co-contractions

and co-activation in movements are also seen in early typical development or early stages of learning a new motor skill. They do not create deformities. There are also atypical movement synergies associated with lack of selective motor control. For example, a child cannot easily dorsiflex an ankle without also flexing hip and knee. Muscles for grasp may not be activated without flexion of wrist and elbow. If a particular movement-stereotyped synergy is used repeatedly then this may cause muscle shortening, limited joint range, and deformity as well atypical gait

Atypical reflex activity (see Table 8.2 for reflex reactions)

These reflex infantile patterns may be used by individuals with dyskinesia or spasticity as their only resource available to them to move. It is not the reflex reactions *as such* that lead to deformity but the recurring unwitting stimulation of them by the individuals or those handling them. This perpetuates the reflex patterns which lead to deformities. However, not all children depend on a strategy of moving by activating reflexes, and are not being dominated by any reflexes. Examples of reflex patterns are as follows.

Asymmetrical tonic neck reaction (ATNR) may be used by turning the head to the side of a more useful arm for it to reach for a toy with reflex arm extension. A subsequent head turn away from this extended arm obtains a reflex flexion on the occipital side of the head. This arm flexion brings the toy to midline. Another rare example is of a child with asymmetry, walking with head to one side to stiffen reflex leg extension for stance and head turned away from the extended leg to allow it to bend for stepping. The persistent ATNR to one side creates asymmetry which may lead to deformities of the limbs, a scoliosis, and/or a torticollis. In some cases, 'windswept' legs may be associated with persistent ATNR to one side. This position is combined with the effect of gravity.

Symmetrical tonic neck reflexes or remnants of them are rare but may occur in some very severe cases together with immobility. The deformities may be within these patterns.

Reflex stepping may aggravate hypertonic plantar flexors, adductors, and extensors if this reflex is used to frequently 'walk' the child. However, the flexion phase of stepping can modify the pattern although the equinus of the feet may persist.

Excessive supporting reaction or antigravity reflex may be overstimulated by, say, *baby bouncers or inappropriate walkers*. Use of extensor thrust or total extension in playthings or to achieve rolling or creeping with 'mermaid' stiffly extended legs may increase the deformities of equinus and extensor–adductor postures. *Excessive use of* withdrawal reflexes in kicking, during rolling, crawling, kneeling with persistent hip–knee and ankle flexion may result in flexor deformity. It is the variety of synergies that is needed for avoiding deformities.

Asymmetry

Deformity may be due to the following.

1. Asymmetrical distribution of hypertonus with muscle transformation and asymmetrical weakness.
2. Excessive weight bearing on one side of the body, arm, or leg associated with asymmetry of postural stabilisation. Using only one hand or limb when the other is more impaired develops postural adjustment (counterpoising) more to one side.
3. Asymmetrical development of tilt, saving, and rising postural mechanisms.

4. Asymmetrical use or persistence of the asymmetric tonic reflex reaction.
5. Asymmetrical growth of legs mainly in hemiplegia and marked asymmetry in diplegia. For example, weight bearing on the longer side leads to an equinus on the shorter leg in order to reach the ground. Weight bearing onto the shorter side leads to the hip flexing or both hip and knee flexing on the longer side to tend to equalise the balance. Scoliosis to one side may occur to compensate for leg length. This is mostly observed in hemiplegia (unilateral cerebral palsy) and asymmetrical diplegia (bilateral cerebral palsy).
6. Spastic hypertonic muscles and weakness affect the whole limb. There can also be biomechanical effects on the whole body so that an individual cannot maintain an adequate upright posture. Thus, a spastic muscle group with weakness or with weak antagonists should never be considered alone in treatment with or without orthopaedic surgery.
7. Hemianopia (of visual field), absent visual acuity in one eye, or deafness in one ear may augment the above asymmetries.

Involuntary movement in one repetitive pattern

Any repeated flexor spasms or involuntary dyskinetic kicking with hip and/or knee flexion, or a flexor involuntary repeated pawing of a leg, may give rise to tightness in the knee or hip. Miller (2007) reports loss of standing for transfers due to knee flexor deformity in young adults or adolescents with athetosis (dyskinesia) combined with spasticity. Similarly and less commonly, children have repetitive extensor spasms or rotary involuntary movements, which may create tightness and pain. Older people with dyskinesia may use muscle tension to control involuntary movements, which result in tense atypical postures with muscle pain.

Growth factors

There are three main factors which cause or aggravate the development of deformity.

1. The mechanisms of growth and deformity have been of interest to a number of workers (Cosgrove 2000; Graham 2004; Thomason et al. 2014). Reduced activity is mainly due to weakness, poor balance, and atypical selective motor control rather than the spasticity. Activity is needed to provide the frequent stretching which contributes to muscle growth (Graham 2004). In deformities, muscles and soft tissues grow but more slowly in relation to the bones. BoNT-A injections are used to maintain muscle length and to delay surgery.
2. The specific bony structure of the hip does not change as it normally would with growth due to stiffness of adductors and internal rotators, persistent atypical posture, and non-weight bearing. The neck of the femur remains in anteversion and the shaft/neck angle of valgus does not decrease. This is associated with hip deformity and dislocations.
3. Spurts of growth in adolescents are linked with increase of deformities. The unequal growth of bone and muscle in hypertonia increases with their increasing height and especially weight. Usually there would also be less mobility, as adolescents need to spend longer hours at their studies.

Biomechanics (see sections 'Atypical postures in standing' and 'Atypical gaits in the spastic type' in Chapter 9)

The biomechanics related to deformities are as follows.

1. The spastic muscle groups, particularly those that flex one joint and extend another, such as hamstrings, rectus femoris, and gastrocnemius, act on

bony and joint levers. Atypical limb alignments result which persist, especially with weight bearing. In time, they become established, producing bony torsion and joint subluxation. The muscle actions are then even more ineffective. Bony torsion or joint subluxation reduce the muscles' ability to generate an effective moment. Stiff soft tissues and muscles, and bony and joint impairments affect the biomechanics of gait (Graham 2004; Gage et al. 2009).

2. There is an effect of one joint deformity on the whole limb and the whole body in the biomechanics of short spastic muscles and weakness. For example, equinus can increase hip and knee flexion in standing. Equinus of one foot can produce an apparent leg lengthening with associated asymmetry of the pelvis and secondary postural scoliosis.
3. Orthopaedic workers find biomechanical causes of balance problems due to the limb deformities. However, an important clue to balance problems is also the poor or absent postural mechanisms of stabilisation and postural adjustments. In some children, the posture may or may not have good alignment in quiet postures against gravity without movement. When voluntary movement is used, these children cannot balance due to lack of postural adjustment and compensate with atypical postures. In standing (and stepping), legs may be stiffly held in flexion–adduction as if the child is standing on ice or a slippery surface.

Atypical postures, if uncorrected, can further disturb balance due to increasing atypical alignment. Green et al. (1995) have observed atypical biomechanics in lying, sitting, and standing. Butler et al. (2010) have observed these biomechanics in upright postures. Gudjonsdottir and Mercer (1997) clearly describe the development of hip and spine deformities for clinical work.

Therapy goals

Conservative treatment methods are usually favoured in young children as their growth may decrease or delay the need for surgery. In addition, conservative physiotherapy avoids the potential risk of surgical overlengthening, infection, scarring, and perhaps anaesthetic problems (Jefferson 2004). Surgery is delayed until children are over 6 years.

Therapists, and especially those involved in the daily care of individuals with cerebral palsy, avoid or correct atypical postures and movements which appear *in function as a priority*, as well as maintain elongation of short muscles and soft tissues with exercises, plasters, orthoses, and equipment.

Frequent changes of a person's posture through 24 hours with and, when possible, without equipment. This avoids stretching only one group of stiff spastic or dystonic muscles. Positioning of legs in lying with extension–abduction of 20–30° avoids a risk of subluxation (Hankinson and Morton 2002). However, some standing frames need more abduction. Gough (2009) and Pountney and Green (2006) have stated that 'cohort studies provide limited evidence' to support 24-hour postural management programmes and that more research is needed on the benefits. Gough also quotes studies of pain, sleep disturbances, extra demands on parents and carers, and poor quality of life of children when using 24-hour positioning equipment. He calls for definition of a subgroup of children who would benefit from this postural management.

1. Conservative physiotherapy with 24-hour management is difficult for some families and careful education and support of families and carers is most important. Explain the importance of the postural management programme to parents and carers. Enable them to decide whether

experiencing this intervention is suitable for them and whether negotiation is indicated.
2. Selection of equipment maintains postural correction during use of hands within daily activities, and for speech and language development, visual experience, and social interactions.
3. Monitor posture and movement throughout the lifespan of a person. Take particular care during growth spurts in adolescence.
4. Correct excessive asymmetry in postures and movements. However, postural adjustments for movements are asymmetrical but are not as excessive as the atypical asymmetry discussed above.
5. Treat pain due to deformities and check if orthoses or equipment may be causing pain.
6. Develop postural mechanisms, particularly stability and postural adjustments, for limb motions. Improve postural alignments and weight bearing both actively and with orthoses.
7. Strengthen muscles using gravity for assistance, eliminating gravity for neutral actions, and increasing muscle actions against gravity for strength and assist an individual's active movements. Strengthen agonists and antagonists with exercises in as full a range as possible. Progressive strength training and/or developmental motor functions with and without resistance are recommended for individuals above age 4 years.
8. Use interesting playful activities to motivate actions and as much mobility with or without appropriate assistance throughout the day.
9. Adapted environments assist children to become more mobile.
10. When reflex reactions or partial reactions persist in some children, train developmental motor functions and vary motor patterns so that infantile patterns of reflexes need not be used.

Chapter 9 offers practical suggestions and orthoses used to treat deformity *within* the training of developmental gross motor and hand functions. Equipment is discussed in Chapters 9 and 13.

Deformities and gait

Reviews of deformities in different topographical types and orthopaedic surgical procedures are found in Thomason et al. (2011, 2014), Horstmann and Bleck (2007), Miller (2007), Gage et al. (2009), Graham (2004), and Graham and Selber (2003). Chin et al. (2005) focus on the management of the upper limb. Surgeons have different views of surgery and the follow-up rehabilitation, so the therapist cooperates with an individual orthopaedic surgeon.

Assessment of gait for surgery is based on instrumented three-dimensional gait analyses or, if not available, with observational gait analyses. These analyses are carried out together with other examinations of ROM and strength.

Gait analyses for conservative therapy without surgery are given in Chapter 8. Chapter 9 presents conservative physiotherapy in Figs 9.151–9.156 for gaits.

Spastic hemiplegia

The upper limb deformities are shoulder girdle protraction, shoulder flexion, adduction, and internal rotation. A few may develop subluxation or dislocation of the glenohumeral joint. There is tightness of pectoralis major and subscapularis. There is elbow flexion with pronation. The tight flexors and pronators together with very weak supinators are present and may occasionally lead to subluxation of the radial head. The wrist and fingers are flexed with thumb flexed, adducted in the palm. The metacarpophalangeal joint in the thumb may be a secondary deformity. Wrist ulnar deviation rather than radial is more common. In individual gaits, a hemiplegic arm may also be retracted and hang down

straight with elbow pronated and does not swing or is held in the arm position above without swing. A very young child or one with mild-to-moderate involvement will only show the flexed arm pattern on running or jumping. Early therapy usually prevents the arm from becoming more severe.

Orthopaedic surgery. Surgical transfer of the flexor carpi ulnaris to the extensor carpi radialis releases the deforming wrist flexor–ulnar deviator so activating more wrist extension–radial alignment. The transferred flexor carpi ulnaris also becomes a secondary supinator. The pronater teres is rerouted to reattach on the dorsoradial side to act as a supinator (Chin et al. 2005). Other surgeons plan lengthening of pronator teres or other muscles or stabilisation of the wrist joint. Occupational therapy or physiotherapy is used in the follow-up of surgery to improve available function with associated cosmetic appearance. Splint with stretches and gentle exercises gradually increased with grasping everyday objects. Transplants of muscles are indicated for Manual Ability Classification System (MACS) levels I and II, and in MACS IV and V the contractures and pain need surgery so that dressing and cleaning the arm or hand is assisted. Before surgery BoNT-A and splinting for selected muscle lengthening are used for better results. Surgery may include lengthening and releases of muscles.

Both the arm and leg become shorter or thinner as the child grows.

The lower limb. Thomason et al. (2014) report the following types of gait.

Type I Drop foot in swing phase due to loss of selective motor control or weak dorsiflexor in dynamic deformity, no contracture of gastro-soleus in second rocker.

Type II True equinus in stance and foot drop in swing phase. Spasticity of gastrosoleus gradually becoming fixed contracture.

Type III Equinus, gastrosoleus ankle, reduced ROM of knee, co-contraction of hamstrings and rectus femoris.

Type IV Equinus ankle, flexed stiff knee, involvement of hip or incomplete hip extension. (Gastrosoleus, ankle, hamstrings, rectus femoris, psoas involved.)

Miller (2007) has the following observations. Equinus gait or 'toe-stepping', which may at first have a straight hip and knee with a minimal limp. Compensation for the equinus may be a vaulting action to assist with clearance. Later if severity increases equinus is accompanied by hip–knee flexion with adduction–internal rotation of the affected leg. Use of valgus of the foot to obtain a plantigrade foot is a compensation for equinus. Miller reports that some children with hemiplegia avoid a limp by 'toe-stepping' on both the affected and unaffected sides.

A gait in hemiplegia may have the affected side retracted with weight in front on the other leg. A momentary stance on the hemiplegic side only allows a short step with the other leg.

Interventions by Thomason et al. (2014) include the following.

Type I Leaf splint or hinged ankle–foot orthosis (AFO).

Type II BoNT-A, calf surgery, hinged AFO.

Types III and IV Single-event multilevel surgery (SEMLS), BoNT-A for pain relief and prevention of spasms (Thomason et al. 2011).

SEMLS, which relies on biomechanical assessment using instrumented gait analyses, 'includes soft tissue corrections such as lengthening musculo-tendinous units and transferring tendons of contracted spastic muscles and bony deformities treated with osteotomies and bone stabilisation procedures' (Thomason et al. 2011).

Gait is affected not only by weakness but also by inadequate length of plantar flexors in swing phase and stance phases.

Below-knee plaster (casting) or orthosis has been used in the early stage. A hinged AFO with or without an injection of BoNT-A is used for the early dynamic phases. Casting together with BoNT-A may be another option. These procedures delay surgery until a child is well over 6 years. In more severe cases there is co-contraction of short hamstrings with quadriceps and equinus, valgus, varus, and foot problems. For the hip, knee, and foot deformities there are various surgical procedures according to the severity of the hemiplegia (Graham 2004), which are followed by a solid AFO or ground-reaction AFO. However, many children with mild hemiplegia (GMFCS levels I and II) achieve walking without walking aids following conservative physiotherapy. Later they may or may not develop fixed deformities.

Spastic diplegia

Generally, the walking of children with diplegia is much slower than in typical children, and their choice of velocity is most efficient but in later years their inefficient walk leads to fatigue. Deformities may be mild, not interfering with walking, but if more severe may lead to deterioration of walking.

Upper limbs. There may be persistence of arms held up in the air in toddler 'high or medium guard', or in a 'tight-wire walking' position, as well as excessive arm-saving reactions. In early independent walking, reciprocal arm swing is absent. Atypical postures of both arms in the hemiplegic-flexed pattern are mentioned above.

Lower limbs. In the *toe-stepping gait* in young or mild diplegia, there is initially a toe-walk in equinus with a normal or stiff knee extension and mild internal rotation of hips. *Toe first* and not the normal heel strike on initial contact following the leg swing is common. With arms in high guard a child can walk fast on toes and falls rather than stops. This is managed with AFOs and physiotherapy to gain balance and control. Walking with a plantigrade foot becomes possible in this case.

Knees may overflex on swing and on weight bearing. Hip and knee flexion may occur to allow a plantarflexed foot (or equinus) to swing and clear the ground, and, once on the ground, hip and knee flexion occur to push the heel to the ground. However, as mentioned above, there may instead be equinus on initial foot contact with hip and knee straight. Lack of heel strike after swing may be compensated by flexion of hips with hyperextension of the knees to press the heels to the ground in pronation. This is usual with extensor patterns or excessive antigravity stiffness as the forefoot strikes the ground. Hyperextended knees, if untreated in middle childhood, may cause much knee pain in adolescence and a wheelchair may later be needed (Miller 2007). Miller suggests a calf-length articulated AFO that limits plantarflexion to assist hamstring strengthening over time to counter the knee hyperextension. Hyperextension can be treated with operations for equinus if that is the cause.

A child may become stiffer with spasticity and the equinus and varus increase. In these cases, BoNT-A injection is used to assist tolerating the AFOs in children under 6 years. Physiotherapy continues together with passive stretching and strengthening exercises for feet and legs as well as balance training.

A diplegic gait that is more common is presented in the following pattern. There is hip flexion–adduction–internal rotation with knee flexion and equinovarus, or feet flat with valgus. In diplegia the hips may adduct and legs cross when the child is supported, and adduct, internally rotate, and flex when

the child is walking independently. A wider base of the feet is achieved with flexed closely adducted (valgus) knees as the child cannot balance on the small base created by adduction of the legs. Feet may also be in valgus to overcome equinus.

Rodda et al. (2004) classified diplegic gaits into four groups. Group I has true equinus and straight legs and needs a hinged AFO. Group II has a '*jump gait*' of hip and knee flexion with equinus on initial foot contact followed by hip and knee extension during stance. This has a jump-like appearance and also needs a hinged AFO. Group III has an apparent equinus which is secondary to hip and knee flexion, so BoNT-A is *not* used for plantar flexors. A solid AFO is needed. Group IV has a crouch gait (hip–knee–ankle flexion). These children may have been toe-walkers with straight or mildly flexed hips and knees before becoming adolescents with a crouch gait. BoNT-A at the time of surgery is used for pain relief and prevention of spasms (Barwood et al. 2000). Various surgical procedures are used by different surgeons. Ground-reaction AFOs may be used in milder crouch gaits before surgery and following operations on muscles and soft tissues in less severe cases.

With increased severity the flexion contractures are seen together with bony torsion deformities and joint problems in hips, knees, and feet due to the biomechanics of walking (Graham 2004). Various operations are recommended to overcome hip–knee flexion in crouch gait, such as hamstring and psoas lengthening and correction of bony deformities if present. SEMLS is recommended to improve severe crouch gait (Rodda et al. 2006). Surgery is suggested when there is increased or fixed knee flexion in both foot contact and mid-stance phases of gait, together with a markedly increased popliteal angle on physical examination. Examples are partial hamstring tenotomy, hamstring slide, hamstring transplants, with various lengthening procedures and transfers of other muscles. Surgery to lengthen short hamstrings has been used when hamstrings create a kyphotic sitting posture in adolescents or adults. Postoperative physiotherapy may include knee splints, ROM exercises, and strengthening of both extensors and flexors of hips and knees. Treat the hamstrings for two-joint muscles. Rehabilitation teaches individuals to move with their 'new legs' and work on extension. Postoperative weight bearing depends on the advice of the surgeon.

Many children with diplegia have asymmetry between the legs of individual weak muscle groups but pelvic asymmetry and scoliosis may not always be present. However, when scoliosis is present, it is due to unequal weight distribution and/or difference in leg length. There may be limited mobility in hips, pelvis, and lumbar spine. Backward tilt of the pelvis with a flat lumbar spine may be present in some children, or excessive forward pelvic tilt with lumbar lordosis. There may also be round backs (kyphosis) with lordosis and the hip flexion. Spastic hypertonus and deformity are more in the psoas, hamstrings, rectus femoris, and gastrocnemius. Postural malalignments may be secondary to limb problems or persist from atypical sitting postures and poor postural mechanisms against gravity.

The pelvis often rotates atypically in all 'spastic gaits'. The rotation may be backwards, so the leg appears *retracted* and behind the other. Usually the front, more able leg takes more weight. However, there may be the situation when a back leg may take more weight and allow the forward leg to step, take its momentary weight, and then transfer onto the back leg, which only has time to take a small step and *cannot* get in front of the forward leg.

If the child takes a step, the stiffness may be so great that the child has to lean back to push the leg forwards. The child has an anteroposterior jerky walk. Lateral 'waddle' is associated with spastic adductors and weak abductors. It is also involved with inability to stabilise the pelvis or to adjust the trunk when counterpoising in standing on one leg. The trunk and head may lean forwards to help overcome stiff spastic extension or use much head and trunk mobility to counter the lower body stiffness to maintain balance (postural control). Orthopaedic surgical procedures are indicated for excessive hip extension with atypical pelvic tilts (Horstmann and Bleck 2007).

If a child has an early gait that is efficient, this is frequently maintained until adulthood. If the child is struggling to walk and just managing with foot drag and increased falling or much flexion, then surgery can be helpful. Weight gain and prolonged sitting will decrease the future likelihood of walking with or without aids.

Spastic tetraplegia (quadriplegia)

This type is usually more severe with weakness, loss of selective motor control, use of residual infantile reflexes, muscle imbalance, and atypical postures. The whole body is much more involved than in the other types of cerebral palsies. Deformities of limbs, position of pelvis and trunk, and poor weight transference are similar to unilateral spastic hemiplegia and bilateral spastic diplegia, usually with greater asymmetry and severity. The leg deformities can be accompanied by unilateral or bilateral hip dislocation, pelvic obliquity, and scoliosis. As hip problems are frequently encountered, these are discussed later in this chapter. Children with tetraplegia may have good cognition, so focus on education, and hand function warrants more time than the training of walking. Nevertheless, there are adolescents who continue household walking with an appropriate walker.

General considerations related to surgery

The therapist should understand the aims of surgery. The child and family and an older person with cerebral palsy need to have information and understanding of the following points.

1. The surgery is not a cure, but an episode in the total rehabilitation programme. The degree of drive and *sometimes* intelligence of the child affects the results of surgery.
2. There will be a setback before the ultimate progress is more obvious.
3. How to look after the child in plaster. How to apply any splintage or orthoses to maintain improvement by surgery.
4. Generally how to help with postoperative details of home rehabilitation. There will be new demands on home therapy, which the family need to consider as that is important for follow-up therapy to help regain function. Families need to stipulate who will be able to do this before surgery is undertaken.
5. Families need support so they can try and maintain confidence and an encouraging atmosphere for their child.

It is best if the child's own physiotherapist can be the one to treat the child before the operation and to follow up in the home or centre. Otherwise, the therapist and the parents should at least introduce the child to the hospital environment and meet some of the staff and the hospital therapists involved. Generally, let the child know what is going to happen and what will take place at the hospital. Surgeons have their own pre/postoperative protocols and periods of immobilisation and orthoses. Guidelines are presented for therapy but may need modification according to the surgeon.

Hip flexion–adduction–internal rotation

One component may be greater than the others. The shape of the hip joint may be atypical. The acetabulum is shallow, neck of femur anteverted, and subdislocation and dislocation may occur in time in bilateral cerebral palsy (Hiroshima and Ono 1979; Cosgrove 2000). The excessive pull of adductors, internal rotators, and even minimally shortening flexors causes the hip to migrate laterally until it dislocates. This process may take 3–4 years or up to 6 years in non-ambulant children. Migration over 15% in children not walking 10 steps at 30 months should be referred to an orthopaedic surgeon for surveillance (Scrutton and Baird 1997). X-rays are essential by 30 months for children with bilateral cerebral palsy. Scrutton et al. (2001) in their studies found that none of 69 children who walked alone by 30 months had a hip problem, 8 of 52 children walking between 30 months and 5 years had a hip problem, and 109 of 202 children unable to walk at 5 years also had hip problems.

Hip subluxation is diagnosed if migration is between 33% and 80% and dislocation if over 80%. Hip dislocation 'may be silent' (Graham 2004) as it is not always obvious in the individual's function and in the clinical picture.

Hip subluxation or dislocation is common. This is associated with deformity in hips, pelvis, and spine, and may cause pain and interfere with standing and daily care. Delayed weight bearing in standing is significant in causing dislocations. Scrutton and Baird (1997) and Scrutton et al. (2001) in their studies of hip migration also found that children who did not walk by 5 years had a one in two chance of hip dislocation. Late sitting or walking together with hypertonus, asymmetry, and no weight bearing in standing are risks for hip dislocation.

Orthopaedic surgery for hip deformities and dislocation. This is for muscle imbalance and relocation of the femoral head in the acetabulum. There are many different views and the surgeon involved will advise. All team members need to know what the objectives of the surgery are. Surgery may be soft tissue surgery in younger children whose hips are not as severely migrating out of joint as others (Cosgrove 2000). Soft tissue surgery includes muscle, tendon, and connective tissue lengthening, and transfer or releasing of adductors, flexors, and proximal hamstrings (Turker and Lee 2000). Tenotomies and myotomies are treatments frequently chosen as muscle transfers were controversial. Bony surgery includes reconstruction of the proximal femur and acetabulum, femoral and/or pelvic osteotomy, and arthroplasty (Miller 2007). Soft tissue releases with bone surgery may be used as well (Cosgrove 2000; Graham 2004; Horstmann and Bleck 2007). There are potential risks of surgery, and it is best undertaken at a *specialist centre* where a surgeon is experienced in paediatric orthopaedics.

The surgeon will advise on weight bearing and the postoperative rehabilitation. There are strengthening exercises for antagonists to the deformities and good postural management to prevent recurrence of malalignment (Turker and Lee 2000). Postoperatively the child will need to learn how to use his or her different body in function.

Therapy and daily care

Prevention of hip dislocation

At birth the hip is normal in children who will be diagnosed with cerebral palsy. Positioning of a neonate and premature infant is needed as part of general development care for neonates and premature infants (Grenier 1988). Excessive hip abduction, external rotation and flexion, or hyperextension need special attention in very

young, unwell babies. Positioning reduces the risk of subluxation/dislocation and uses mid-range positions of shoulders and hips, well supported but not restrictive of movement. The positioning is carried out by nurses and parents under supervision of physiotherapists in hospital and home.

Positioning in supported standing is essential from around 12 months of age (Gericke 2006), when a child prefers an atypical hip posture (with flexion–adduction–internal rotation) during the night and day. This is particularly when the preferred posture is combined with delayed development of weight bearing in standing. Hypotonia or hypertonia and dystonia/dyskinetic conditions with marked asymmetry and scoliosis are associated with unilateral hip dislocation. Hypotonia and lack of weight bearing may result in an anterior dislocation from hip–abduction–external rotation.

All children at risk of hip subluxation or dislocation need positioning in a variety of well-aligned positions and upright supported standing for weight bearing through hips, straight femurs, and plantigrade feet. Hip abduction is important in the growing years in order to develop location of the femoral head in the acetabulum. Side lying with correct abduction and body alignment is also used if supine or prone is not acceptable for a child. Hip abduction needs to be available in a standing frame.

If there is any pain and decrease in a child's hip ROMs, there should be referral to an orthopaedic surgeon immediately. It is interesting that a study of pain in 29 adults with spastic quadriplegia revealed that 71% of 38 dislocated hips were not painful, 11% had intermittent pains, and 18% were painful (Knapp and Cortes 2002).

Conservative positioning and physiotherapy in early treatments for children at risk of hip dislocation may prevent or delay surgery. This may be combined with BoNT-A injections with or without surgery. If hip migration continues, pain will increase and clinical/functional examinations will suggest further procedures. Positioning in any posture needs special care when one hip is subluxating or dislocating. Prevention of hip displacement and windswept posture will prevent or minimise the associated scolioses.

Positioning. Prone lying straightens hips with gravity, assisting pulling the pelvis down, legs apart on a conical-shaped pommel, in prone wedges, prone lying, or supine positioning equipment, standing frames, in sitting with legs apart, or with external rotation, sitting in chairs with pommels, and corrective symmetrical hip–knee adaptations; stand-or-sit straddling equipment of rolls and horse riding for special disabilities are helpful. When carrying these children, position their legs apart, slightly turned out and pressing a child's hip flat. Use thick nappies or padding in milder cases. Extension–abduction is a most therapeutic position (Goldsmith et al. 1992; Goldsmith 2000; Hankinson and Morton 2002). Positioning provides a maintained muscle–tendon soft tissue stretch, preferably when a child is relaxed and asleep. This is usually accompanied by daily manual passive stretch with active holding of position by the individual and in active exercises given later in this chapter.

Abduction padding/wedge or a pelvic abduction splint are used in all positions. The pelvic abduction splint may be used to prevent surgery as far as possible.

Outcomes of surgery vary as they are difficult to compare owing to heterogeneous subjects and different combinations of procedures and assessments used (Stott and Piedrahita 2004; an American Academy for Cerebral Palsy and Developmental Medicine evidence report). Young et al. (1998) found windswept deformity in 54% of a follow-up of young adults despite surgery for the hip. However, Graham (2004)

and Miller (2007) have experience of having to carry out 'salvage surgery' in people with hip displacement who did not have earlier soft tissue surgery and who used excessive compensation for function which became disadvantageous over the years.

Surgery presents a difficult consideration for children and families as it causes disturbance. Such family and child stress needs careful consideration as part of the professional team's assessment for surgery.

Postsurgery physiotherapy. Physiotherapy tailored to the individual includes positioning, active assisted exercises, and graduated strengthening. Later, strengthening new functions and, when ability increases, use of progressive strength training. Hydrotherapy, recreational and fitness activities are recommended. Postoperative orthotic and assistive devices are used for standing and walking.

Surgery for feet in all types of cerebral palsies depends on the other joint deformities. BoNT-A injection for plantar flexors with and without casting, mentioned later in this chapter, delays surgery until children are over 6 years old. Postoperative physiotherapy may follow plasters, and gradual strengthening becomes the main aim. Use of orthoses varies as to how long they are worn during the day as there may be very weak muscles postoperatively, needing active assisted or active movements without the orthoses. Several older children with more skeletal maturity may have various types of triple arthrodesis and some have peroneus brevis lengthening for valgus and transplants for equinovarus or varus. Various foot problems such as forefoot deformities are also treated by surgeons (Miller 2007). Postoperative physiotherapy for feet emphasises graduated strengthening and later training of standing and gait using orthoses to maintain correct positions of feet.

Therapy and daily care

In Chapter 9, therapy for postural management and postural control is given at each developmental level. Additional methods and comments which augment those in Chapter 9 are the following.

1. *Ice treatments* (cryotherapy) to whole limb or on the spastic muscle groups to decrease spasticity or to stimulate a muscle action depending on application (Shumway-Cook and Woollacott 2017).
2. *Prolonged stretch to spastic muscles* in correct positions in plasters or moulded orthoses and postural equipment. There are bivalved plaster casts as night splints that can be removed for activities during the day. The positioning for stretch in postural equipment is usually routine in school and home for GMFCS levels III–V.
3. There is some evidence, though limited by rigour in studies, that short-time passive movements for ROM are less effective for spastic muscles (Pin et al. 2006). Pin et al. (2006) prefer prolonged stretch, as do Tremblay et al. (1990). Tardieu et al. (1988) found that stretch needs to be maintained for 6 hours daily to have an effective increase in muscle extensibility (length). This can be obtained when the child is asleep in positioning equipment or splints depending on the child's condition and family views.
4. *Note*. Selection of positioning during sleep is used providing there is no contradiction such as seizures, vomiting from gastro-oesophageal reflux, threats of aspiration and breathing problems, excessive opisthotonus, and nocturnal hypoxaemia (Martin et al. 1995). The bed needs to be correctly tilted for these problems without causing the child to slip down in the bed. Prolonged stretchings are progressed to assisted active or active movement. Prolonged stretchings

and ROM need to be worked out with parents and others involved directly with a child or older person. Parents, carers, and a young child enjoy the slow rhythm and song with the touch associated with communication during passive ROM. It is easily done during dressing, nappy changes, and at bath time and during swimming. Parents and carers need to report any pain, discomfort, and change in ranges to a therapist.

5. *Activation of antagonists and agonists* assists the correction of deformities. This takes place in strengthening exercises for short or overlengthened muscles.

   Exercises are given later in this chapter for:

   a. active and full ROM of antagonists to hypertonic muscles, especially in middle and inner ranges
   b. active and full ROM of hypertonic muscles, especially in middle and elongated ranges.

6. *Holding a corrected position*. This takes place passively with orthoses, special seating, standing frames, and lying equipment. Passive positions may give a sensory picture of body image but not an active learning experience of body image. Motor learning needs to be more active for better effect (Chapter 3). Children, adolescents, and adults are trained to actively hold the correction. Manual assistance may first be given and withdrawn as they show ability to do this alone. Follow with manual resistance to legs, trunk, and pelvis with the method of 'hold and relax' (Knott and Voss 1968; Levitt 1970a). A child often prefers to practise holding a position for the duration of a rhyme or song. Limb movements need to be stimulated through play in order to activate them together with head and body postural adjustments and limb positions in purposeful activities.
7. *Rotation and diagonal movements* have been observed to decrease spastic hypertonus and dynamic shortening rather than in the straight flexion and extension ranges (Knott and Voss 1968; Adler et al. 2008).
8. Treat asymmetry in unilateral hemiplegia or bilateral diplegia and quadriplegia, which may lead to various deformities and atypical gaits with or without equipment/aids.

   Symmetrical and reciprocal weight bearing on legs is emphasised in therapy together with both upper limbs and hand grasps in front. Strengthening of the hemiplegic weak leg in unilateral cerebral palsy and both legs in bilateral cerebral palsy, especially of gastrocnemius for push-off and dorsiflexion for heel strike on initial contact, is important. In particular gaits, strengthen weak hip, knee, and arm muscles on one or both sides, as assessed.

Active control needs to be translated into play and relevant activities of daily life (Chapter 10).

Use of plasters (inhibitory or tone-reducing casts)

Indications for below-knee plaster (tone inhibitory casts) for dynamic (unfixed) deformities are the following.

1. When a child pulls up to stand on toes only, or continues standing on toes.
2. When a child stands with heels down but walks on toes.
3. When a child is ready for standing and walking but cannot balance on deformed feet which are in either equinus, varus, or equinovarus. When sitting balance is poor and feet are habitually in plantarflexion or with feet twisted inwards, so they cannot be used for stability.
4. To prevent any of the above becoming fixed deformities.

5. To delay orthopaedic surgery in young children as surgery results may be unpredictable in a delayed developing nervous system.
6. To train a better walking pattern using the proprioceptive responses and body image of weight bearing with the heel down and the possibility of heel strike on stepping forwards, made possible by the corrective plaster. The plaster also correctly moulds the feet with toe flexion reduced.
7. To stretch short tight muscles and connective tissues. There is then also correction of overlengthened antagonists so that a child can tolerate orthoses. Lengthening of short muscles aims to improve movements, postures, and gait.

Collaboration with parents is essential for good results, thus explain the purpose of the plaster or thermoplastic splint to both parent and child who can understand. The importance of parents' help and encouragement for their child is essential to make sure the child wears them. Discuss with parents and teachers when times are convenient for application of splints. Enable parents and carers to practise home exercises and know when weight bearing commences for the training of standing and walking.

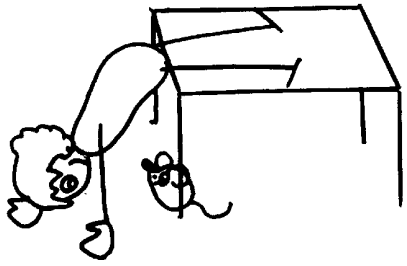
The athetoid (dyskinetic) type of cerebral palsy has involuntary movements which either preclude wearing a plaster or mean that it cannot be worn for more than a week at a time. BoNT-A is preferred for dystonia rather than plaster casts. However, the weight of the plaster cast seems to help the development of stability. Casts are usually followed with an orthosis. Phillips and Audet (1990) have used knee plaster casts in adolescence. BoNT-A injections are used together with plaster casts. There are various studies mentioned in the section on BoNT-A injections.

Miller (2007) points out that new materials such as thermoplastics can be correctly moulded to limbs and sole and have the same effect as plaster casts for prolonged stretch and corrections. Miller (2007) has heard from parents of the inconvenience to them and their child of the need to have a series of plasters, so many weeks of childhood may be spent in casts, with difficulties in dressing, washing, and general lifestyle. Orthoses made from thermoplastic materials are preferred.

Exercises in plaster, thermoplastic moulds, or orthoses. Emphasise extension movements of the knee and hip, and back (Figs 12.1–12.10); for example, straight leg lift backwards, knee stretching in sitting, side lying extension. Weight-bearing exercises after 3 days. Standing weight shift from leg to leg sideways and forwards and back. Shift the pelvis forwards over the weight-bearing foot, counteracting hip retraction. Sitting stretch up and stand up 'tall'. Stand and walk as much as possible, with weight distributed onto both sides equally. Tilt reactions in standing on sponge to increase weight bearing through the leg in plaster, moulded splint, or orthosis.

A long leg back plaster slab from hip to ankle for knee deformity is used and needs to be removable for washing and exercises.

Upper limbs. Lannin et al. (2007) critically reviewed casting in children and adults but found insufficient high-quality evidence to either support or abandon this practice in more severe cases. There are serial and drop-out castings for adults with 5° or 10° less than full range of elbow extension with forearm in neutral. However, compliance of children and adolescents is poor and caution is advised for severe cases of spasticity, owing to myositis ossificans, skin breakdown, and sensory deprivation in the hands.



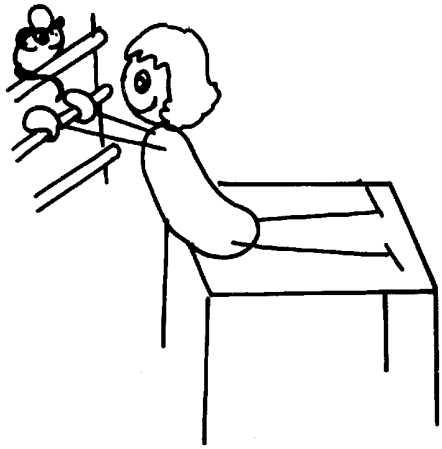


Figure 12.1. Bend over the edge of mother's lap, a large ball, or a couch, raise body up and bend down again. Hold rungs and 'walk up' for level of hip extension. Keep legs apart and turned out if necessary. Child raises head and trunk up in association with hip extension. Initial support may be given by the mother's hand on the chest. Avoid atypical extensor thrust or excessive lordosis.

Research studies

There are many recent research studies on casting, which usually accompany studies on BoNT-A (see section 'Botulinum toxin A'). Bertoti (1986) has researched casting without BoNT-A, comparing casting with no casting in a randomised controlled trial.

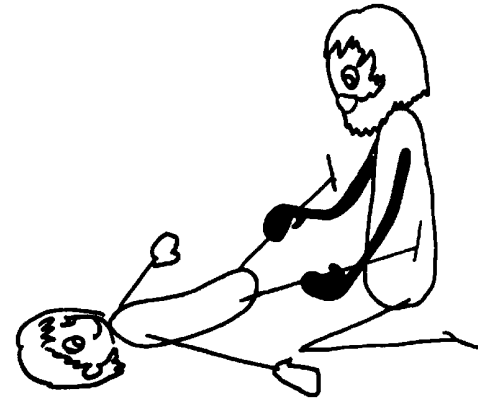


Figure 12.3. Legs of the child held in abduction–external rotation. Active raise of the child's hips into extension. *Avoid* use of lordosis to do this. Legs may be on the lap of the therapist, on a low stool, or with feet flat on the ground for 'bridging' the pelvis into extension. Manual resistance may be given to the anterior superior iliac spines to augment extension. Obtain flexion by asking the child to bend knees to chest, and then repeat hip extension activity. Use this action during play, dressing, and washing.

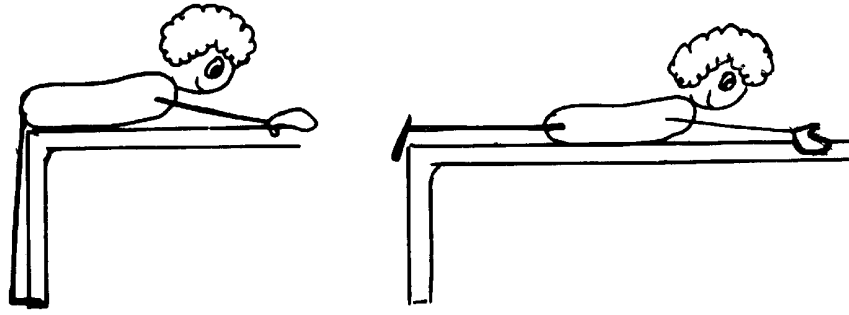


Figure 12.2. Child's legs over mother's lap, edge of bed, a large ball, or a roll. Bring legs down to floor (hip flexion) into bed (hip extension). Hold knees and thighs apart in external rotation to encourage hip extension–abduction–external rotation if required. Raise *one* leg at a time to control lordosis (see Fig. 12.6). Child may grasp the side of a table, or both arms need to be held elevated–abducted and externally rotated by an adult, if excessive flexion in arm and trunk is present. Use these movements when getting up onto a bed/plinth *or* getting out of bed.

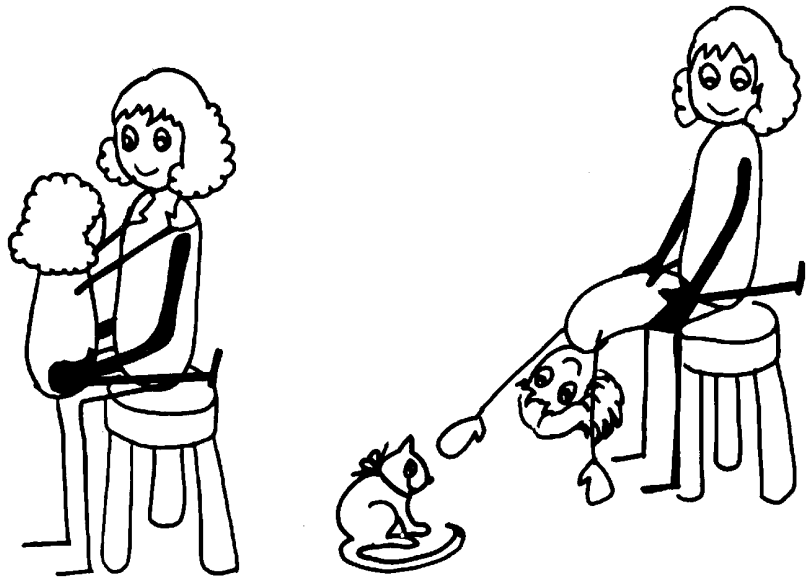


Figure 12.4. The child actively stretches down and comes up to sitting with or without grasping your hand. For babies, you may use the large ball or roll. The child may also bend sideways to the floor for scoliosis correction.

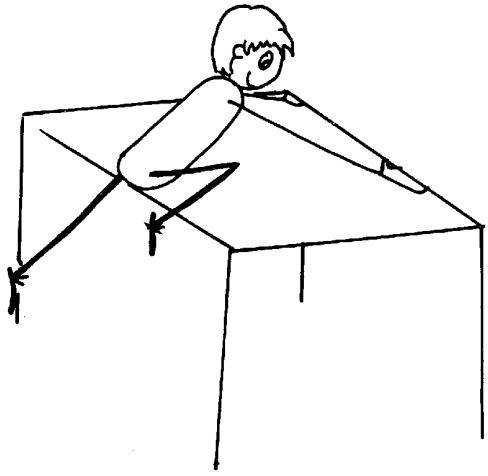


Figure 12.5. One knee held bent to chest during hip extension of the other leg to counteract lordosis. Carry this out in side lying or in prone. Also flex–abduct–externally rotate the extended leg for action of those agonists.

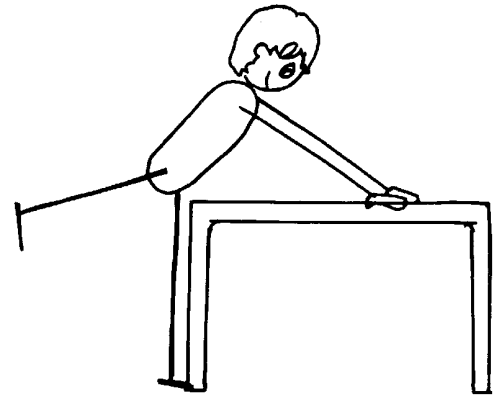


Figure 12.6. Child leans forwards onto a ball, table, or roll, during active hip extension of each leg. Lordosis is more easily controlled this way. Next, flex the leg so that the foot reaches a high bar or even a table.

According to the review of many research studies by Blackmore et al. (2007), this study was rated highly as II and found that casting improved stride length, whereas differences in other gait components were not significant. McNee et al. (2007) studied short-term serial casting in children with spastic cerebral palsy. Their results showed increased passive and dynamic dorsiflexion and changes in some elements of gait.

They state that the dorsiflexion with straight knee and functional changes were small and short-lived. However, Cottalorda et al. (2000) have found serial casting to be more positive for children who were toe-walking. Plantigrade feet were obtained in these children.

There is also the view that the aim of casting to reduce shortening is not always supported by evidence (Pin et al. 2006). Shortland et al. (2002) found in their research that muscle weakness was the

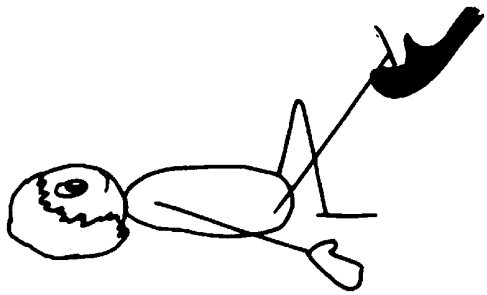
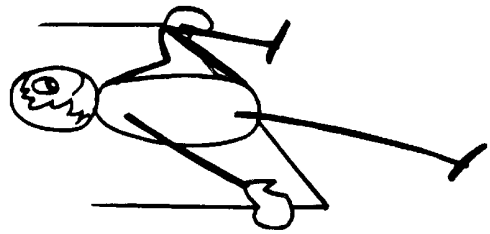


Figure 12.7. One knee flexed to the chest or flexed with foot flat. Press the other leg into extension into an adult's hand, sponge rubber surface, or soft couch. Child's hips raise into extension with the child's weight on one foot. Full flexion of each hip should be carried out actively if required. Arms straight, and hands pressed flat or grasping the edge of the bed.



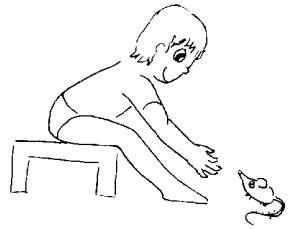


Figure 12.8. *Activate agonists and antagonists* and full range of active hip and knee motion. Use of arm extension is incorporated in these exercises.

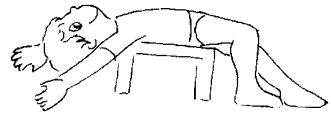


Figure 12.9. *Activate agonists and antagonists* and full range of active hip and knee motion. Use of arm extension is incorporated in these exercises.

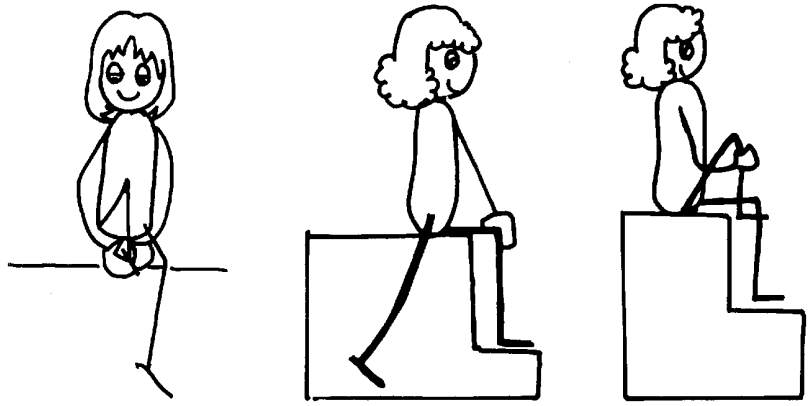


Figure 12.10. *Activate agonists and antagonists* and full range of active hip and knee motion. Use of arm extension is incorporated in these exercises. Use leg flexion during dressing/washing.

main problem. The shortening is due to the aponeurosis secondary to muscle atrophy.

If casting needs to be applied so that tolerance of orthoses is assisted, then a short period of casting for a week is recommended. To avoid weakness, active exercises are important for periods after casting and when orthoses are removed for a period after school or during weekends.

Botulinum toxin A

BoNT-A injections are often used as treatment for spasticity and dystonia. Multilevel injections are used (Scholtes et al. 2006), although focal injections are more common. Lower and upper extremities are treated. More recently, trunk muscles have sometimes been injected. The aims of BoNT-A injections are also for function of hands, cosmetic reasons, and hygiene (Cosgrove 2000; Desloovere et al. 2007).

BoNT-A blocks the release of acetylcholine in the nerve endings at the neuromuscular junction. There is a reduction of spasticity of the individual muscle injected, which commences between 24 and 72 hours. Muscle relaxation is most evident after 2 weeks following injection and disappears between 3 and 6 months; sometimes it may last longer. Repeat injections are indicated but may be limited as long-term damage is not yet known (Gough et al. 2005).

General clinical recommendations for BoNT-A are as follows.

1. Usually unilateral hemiplegia and bilateral diplegia are preferred but bilateral tetraplegia is also selected for limbs.
2. The candidate responds best when full joint ranges are present on static examination, though dynamic shortening of spastic hypertonic muscle takes place during activity (Eames et al. 1999). Fixed contractures need BoNT-A together with orthopaedic procedures.
3. Frequency of injection is at intervals of 6–12 months and at a minimum of 3-month intervals.
4. Parents and child need to know that their postoperative participation is most important. They need to be told the aims of injection and that it is given with a local anaesthetic with a mild sedative, or maybe under a general anaesthetic. Multilevel injections of BoNT-A usually need an anaesthetic. With a local anaesthetic, 2-hour rest is given post injection so that a child can overcome sleepiness before returning home.
5. Explain that a child will have an initial feeling of weakness of an injected limb. If in a lower limb, a child may begin falling due to weakness and the change in body image using a different base, say, plantigrade feet or more abducted thighs. The physiotherapy programme in which all participate improves all this and maintains the correction of deformity as long as possible.

The aims of BoNT-A

Selection of cases continues to be studied and the physiotherapist's view is expected by the team. The report on BoNT-A by the Association of Paediatric Chartered Physiotherapists (APCP 2008) is prepared in the UK for evidence-based practice.

Selection is based on identification of the specific muscles causing a child's main functional difficulty.

Examples of aims include use of calf injections for dynamic equinus and hamstring injection for dynamic knee flexion greater than 20° during gait. There are aims to improve crouch gait, scissoring, and equinovarus and valgus. Aims of injections in adductors are to avoid hip problems and in adductors together with hamstrings to improve seating and for ease of care in severe conditions.

In the upper limbs, injections are used for tight thumb adduction, atypical wrist

position, or elbow flexion. Aims include improvement of function and cosmetic appearance and to counter marked asymmetry of limbs.

The specific times for BoNT-A are when:

- a child pulls to stand and cruises, particularly with 'on-toes' pattern
- a walking (ambulant) child is at a plateau in walking skills, is losing balance, is continuing to have falls, and a gait pattern is not improving
- a child wishes to progress to pedalling a bike (tricycle), climb stairs with less support, kick a ball, and try other motor skills involving a better base for postural stability and counterpoising
- a short muscle or muscles need stretching to allow improved posture and movement
- spastic adductors and plantar flexors limit transfers and base for sitting or walking
- spasticity blocks nappy changes, hygiene of perineum, or difficulty in washing tight hands
- there is pain or painful spasms
- high-energy expenditure is causing poor endurance or decreasing distance walked in a specified time or decrease in motor repetitions
- there are anxieties of child, adolescent, and families concerning appearance of gait
- there is difficulty applying orthoses and skin intolerance to them; serial casting may precede or follow the injection with BoNT-A
- surgical intervention needs to be delayed in young children as growth changes the results of surgery; BoNT-A can maintain muscle length during growth.

Injections are used in diagnosis before surgery and as analgesic for pain and spasm immediately after surgery. Reduction of spastic shortening of a muscle group shows the likely postsurgical biomechanics in the individual. The degree of surgery is also optimised following injections with continual physiotherapy.

Research studies and reviews of BoNT-A

There have been more than 100 studies to establish the effectiveness of BoNT-A since around 1993 (Cosgrove et al. 1994). There is a large multicentre study by Baker et al. (2002) and Koman et al. (2001).

Bjornson et al. (2007) carried out a randomised controlled trial, which included parent satisfaction measures and electromechanical measures of joint range among the 14 separate measures of outcomes. Physiotherapy continued throughout the study of 33 children with spastic diplegia at GMFCS levels I–III. The findings were that despite mechanical and physiological improvements the families did not perceive meaningful changes in their goals and in societal participation. Therefore, clear goals for BoNT-A treatments need to be confirmed with families and child.

Jefferson (2004) has a helpful detailed review of 24 studies.

Lannin et al. (2006) have carried out a systematic review of research on therapy after BoNT-A and found only three studies of a good enough design (levels of evidence II and III). However, these studies did not produce significant findings and more research is needed.

Simpson et al. (2008) in an assessment of 80 studies found only four research studies in class I (American Academy of Neurology criteria), plus one on adductor spasticity and one on the analgesic effect of BoNT-A in class I. The list of studies in their review is of interest to the clinician for evidence-based therapy.

Upper limb studies of BoNT-A

These include research by Wallen et al. (2007), who investigated the outcome of BoNT-A and occupational therapy in the upper limbs. They found that BoNT-A with occupational therapy accelerated

attainment, as shown by the Goal Attainment Scale and the Canadian Occupational Performance Measure. However, the Melbourne Assessment of Unilateral Upper Limb Function, Quality of Upper Extremity Skills Test (QUEST), Paediatric Evaluation of Disability Inventory (PEDI), the Child Health Questionnaire and ROMs did not show any significant effect of either BoNT-A or occupational therapy alone or together.

There are studies by Fehlings et al. (2001) in hemiplegia showing functional improvement using the QUEST and parent report. Friedman et al. (2000) showed functional gains with occupational therapy, and they also assessed the appearance and ease of management of upper limbs by carers. The study was rated IV (Lannin et al. 2006). Speth et al. (2005) found that the wrist dorsiflexion gains after BoNT-A were clinically useful, but no statistically significant results were obtained for supination and function. They report that the Melbourne and PEDI measures were not sensitive to effects of BoNT-A. Both the treated and untreated groups were on intensive occupational therapy, and as functional differences between both groups were not large it would seem that the occupational therapy was achieving more than BoNT-A.

Corry et al. (1997) found that BoNT-A injection in the upper limb of children with hemiplegia significantly increased active elbow and thumb extension, reducing tone at the wrist and elbow. There was a modest functional change and in some cases a temporary deterioration. Desloovere et al. (2007) carried out multilevel BoNT-A injections that improved gait in children in GMFCS levels I–III. They considered this minimised the need for complex surgery at a later stage.

BoNT-A and casting

Blackmore et al. (2007) have carried out a systematic review of casting for equinus in cerebral palsy. They reviewed 22 research studies which examined the effects of casting, either alone or in combination with BoNT-A. They concluded that 'there is no strong and consistent evidence that combining casting and BoNT-A is superior to using either intervention alone'. They also found that there is no evidence that casting before BoNT-A has any different effect from casting after BoNT-A.

Glanzman et al. (2004) in a retrospective analysis of serial casting, BoNT-A, and combined treatment for spastic equinus found no significant difference between casting with or without BoNT-A. Both improved the ROM of the ankle to a greater degree than did BoNT-A alone. Corry et al. (1998) compared BoNT-A with stretching casts and found that they gave equal results but that BoNT-A was quicker, more convenient, and lasted longer.

Marshall et al. (2007) in a systematic review of treatment strategies for motor impairment found strong evidence for serial casting. They found moderate evidence for casting being as effective as casting with BoNT-A. All the studies reviewed were of people with acquired brain injury.

The studies of Gough et al. (2005), Fry et al. (2004), and Shortland et al. (2002) suggest that short spastic muscles are weak and need strengthening rather than being in need of reduction of spasticity with BoNT-A.

Daily management following injections

In the management of BoNT-A, Graham et al. (2000), Ubhi et al. (2000), and Eames et al. (1999) all recommend using BoNT-A together with physiotherapy and orthoses. The APCP (2008) have stated that one cannot be prescriptive, leaving decisions to individual physiotherapists based on their assessments. The National Institute for Health and Care Excellence (NICE 2012) consider that an adapted physical therapy programme, possibly including casting or an orthosis, is an essential component of management after BoNT-A.

Dumas et al. (2001) report a consensus of 62 paediatric physiotherapy experts in the USA and Canada, which included a ranked importance of various direct interventions following BoNT-A injection(s) for lower limb spasticity in cerebral palsy. These are similar to many of those used in the UK. It seems that BoNT-A does not change the goals and methods of paediatric physiotherapy but offers a transition phase of intensifying training of motor control and function. Some therapists increase sessions whereas others continue twice-a-week sessions just before injection (O'Neil et al. 2003).

Physiotherapy techniques and activities after BoNT-A result from an assessment of the individual's needs. The following are based on the guidelines of the APCP (2008).

1. Daily ROM with stretches and maintained stretch in day orthoses and night splints. Night splints immediately after injection worn for 6 hours or more (Tardieu et al. 1988). Orthoses may be increased initially and decreased from, say, AFO to hinged AFO to dynamic AFO to supportive shoe with insole. Increased activity of leg muscles is enhanced with such progressive decrease of support.
2. A sleeping system for prolonged stretch depends on each child.
3. Strengthening injected muscles which appear weak or very weak after injection, their antagonists, and postural control muscles.
4. Among many individual physiotherapy programmes are targeted motor training, constraint-induced movement therapy, developmental therapy, including getting in and out of chairs, walking, use of stairs and inclines. Tricycling, climbing, and swimming are recommended as well as enabling any other activities an individual has chosen. Combinations of techniques are usual (Dumas et al. 2001; O'Neil et al. 2003; APCP 2008).
5. Re-educating the gait pattern and gradually decreasing support during gait training with walking aids.
6. Checking that postural alignments in sitting, standing, and lying are maintained.
7. Training of daily living activities and functional locomotion is highly recommended by parents, for example getting in and out of cars, dressing, and walking at home, school, and in the community.
8. Home programmes and regular monitoring of parents, carers, and school staff for strengthening exercises and daily use of postural management equipment. Their comments are especially important for choice of methods and progress.
9. General weakness, discomfort or other unexpected symptoms should be immediately conveyed to the medical consultant or therapists.
10. Activities such as horse riding and gym clubs become beneficial once specific treatment regimes are established. Horse riding is frequently recommended later after BoNT-A for adductors.

Selection of strategies, frequency, and timing of therapy depends on the individual's response to BoNT-A. Decisions of therapists depend on their assessments of impairment and function following injections.

Outcome measures

Outcome measures from some of the many studies include measures of impairment, activity, and participation in daily life (Baird and Vargus-Adams 2010). Measures are usually used before injection and at 2 weeks, 6 weeks, and 3–4 months after injection. This varies in clinical settings.

Long-term outcome measures are also used once injections have worn off, which confirm that long-term improvements remain. (See section 'Current measures used in cerebral palsy' in Chapter 8.)

Review of dynamic deformities and therapy

See developmental training in Chapter 9 for examples of flexion and extension of legs in training of creeping, rolling, and rise to standing and return to sitting, Techniques in four-point kneeling for postural adjustments for using leg flexion and extension, including abduction and adduction, external rotation and internal rotation to midline (see Figs 9.37 and 9.38), and in standing (see Figs 9.141a,b and 9.149a,b).

Exercises are given in Figs 12.1–12.10 for the movement of both agonists and antagonists.

Remember that ROM and stretch of a child's hip flexors may rock the pelvis, increasing lordosis. Therefore, in assessment, positioning, and in exercises, stabilise the pelvis as shown in Figs 12.4–12.6. Correct hip flexion without excessive hyperextension of the thoraco-lumbar spine. This hyperextension is the compensation for hip flexion deformity.

Positioning. Use special chairs and standing frames to improve atypical postures and correct deformities (see Chapter 13). See correct carrying postures of young children (see Figs 9.200–9.205). Use tailor sitting, squatting, and crook sitting for predominately extended hips and legs.

Use prone lying on a wedge with straight knees or sitting with straight knees on the floor or in a floor seat. If the back rounds and pelvis tilts back with straight knees, use an inclined leg support with a raised floor seat or with a special chair. Postural equipment at night in lying, in prone standing, or in upright standing promotes correct postures.

Splintage. Knee gaiters, knee splints, soft knee night splints.

Plaster back slabs and thermoplastic back splints from hip to ankle may be useful for day or night.

Active movements for knee extensors and hip extensors and for knee flexors. See developmental training for hip and knee extension and exercises in Figs 12.1–12.10. Active sitting with pelvic and trunk positioning in postural control may prevent a need for a hamstring lengthening to correct a round back. Postoperative physiotherapy to strengthen hips and knee extensors and flexors, and development of balance is important. Re-educate walking and other functions.

Dynamic knee hyperextension deformity

This may be associated with hip flexion or secondary to plantarflexion and valgus. Therefore, combine therapy with procedures either for hip flexion or for plantarflexion or both based on assessment of the muscle, tendon, and soft tissue tightness.

Positioning. A standing frame needs to align knee posture and sometimes allow some flexion. If hip extension is present with knee hyperextension, then vary postures such as sitting on different sized boxes, on a chair, side-sitting, upright kneeling avoiding excessive lordosis, and crook-sitting in the corner of a sofa with back supported and weight on buttocks. If a child is standing already, stand with knee pieces preventing hyperextension; use shoes with a higher heel to throw the child's weight into knee flexion posture, *if* the child's plantar flexors are not shortened.

Splintage. Knee pieces which lock with the knee in midline, but allow knee flexion motion, may be necessary in some children during the day.

Plasters, orthoses for plantar flexors if the plantarflexion is the cause of hyperextended knees.

Passive stretch and movement. When hyperextension may be due to tight plantar flexors, maintain passive stretch of these muscles in orthoses or standing frames (see the technique for equinus).

Active movement of knee flexors and the dorsiflexors of ankles if tight plantar flexors are present. See Chapter 9 for active work for stabilisation of the pelvis, which is often the cause of hyperextended knees. This includes crawling development and standing development for pelvic stabilisation. Use upright supported kneeling. Train holding hips in bridging position in supine. Teach 'bear-walk' with knee control and flex knee in stepping (see Fig. 9.156).

Dynamic equinus and equinovarus deformity

Therapy and daily care

This may be toe-walk on its own or associated with hip and knee flexion. There is too early a heel raise after mid-stance and persistent plantarflexion on the swing phase of gait. Feet are not flat in sitting and make putting on of socks, tights, and shoes difficult.

Positioning. Prone lying with feet hanging relaxed over the edge of a wedge or pillows. Maintained stretch is used with standing frames and sitting with heels down. Train standing feet held flat on ground. Try standing in special boots with raised soles. Mild-to-moderate conditions may correct with special boots and insole straps to keep the child's heel down in the boot.

Splintage and orthoses. Use various AFOs, either solid, encouraging dorsiflexion, or dynamic orthoses. The strap should be wider and padded as it crosses the front of the ankle.

See Chapter 9 for a discussion of orthoses in section 'Development of standing and walking'.

Figures 12.11 and 12.12 show an inhibitory plaster cast and a removable post-plaster splint. These are used to stretch spastic hypertonic muscles below the knee. Thermoplastic splints are preferred by

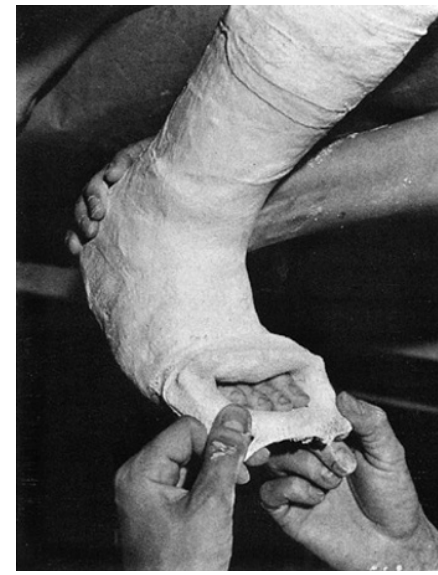


Figure 12.11. Inhibitory plaster cast for lower leg which includes toes.

Figure 12.12. Post-plaster splint (removable) (day or night splint).

Miller (2007), as parents and their child find these plaster casts very inconvenient in their daily life. See earlier in the chapter for a discussion on casting and BoNT-A for dynamic deformities.

Suggestions of exercises for passive stretch of plantar flexors, hamstrings, including active dorsiflexions

1. Child stands and leans forwards to wall to stretch plantar flexors and heel cords.
2. With child's legs apart, knees straight, and feet pointing forwards, help them to actively push both the feet into dorsiflexion. Control knee hyperextension (recurvatum) if it occurs.
3. Stand and lunge forwards keeping heel down and back knee as straight as possible; half-kneeling lunge forwards on front foot. Push balls under the front knee.
4. Sitting heels on small inclined footboard obtaining dorsiflexion; stand with heels down, child facing up on small inclined board during classroom/play activity. Knees straight or with gaiters.
5. Bear-walk with heels down; stand on hands and feet with toys on low table.
6. Standing on a tilting board or rocker, slowly tip back with child's heels held down (see Fig. 9.169).
7. Walk on heels if possible. Raise the soles of the child's shoes, or remove heels off the shoes (heels down in Figs 12.2, 12.6, 12.7, and 12.10).
8. Child is reminded to sit in a chair with heels down and to squat with heels down. Slow rise from sit/squat to stand with weight forwards.
9. Stimulate creeping patterns for dorsiflexion. Other leg flexion patterns may do this (see Fig. 9.37).
10. Brushing dorsiflexors following passive stretch to plantar flexors, and during backward tilt in point 6.
11. Striking heel of foot on surface stimulates dorsiflexion. Use in context of gait training.
12. Walk up inclined plane or ramps with heel down on the surface. Slow stair ascent and descent keeping heels down. Ascend two steps at a time to stretch hamstrings.
13. Draw faces on the child's feet, and ask him or her to dorsiflex or raise the feet to look at the face, or to touch a toy, use toe puppets, and create similar games of your own.
14. Child to practise heel strike in walking. Attach flat squeezable toys to the heels of child's shoes which create a sound on heel strike. There are trainers with lights in the heels on heel strike. These amuse a child and motivate the *heels down* action as a biofeedback during stance and step.
15. If the physiotherapist knows proprioceptive neuromuscular facilitation use the pattern of hip flexion–adduction–external rotation, knee extension, foot dorsiflexion. The child is in sitting over the edge of a bed or in supported standing. Use stretch, touch, pressure, and resistance to muscles in this pattern (see Fig. 9.149b).
16. Check dorsiflexion in postural management equipment.

Older children and adolescents can use these exercises on their own after supervision has been given by therapists.

Valgus feet (pronated)

Valgus may be secondary to plantarflexion, or tight peroneal muscles, and the forefeet may be everted with medial prominence of the talus.

Positioning. Have hips and knees turned out with weight on the outside of feet using supporting shoes, also during the round sit on the floor, with hips externally

rotated with feet in varus. Correct equinus in sit-and-stand if present as valgus is often overcompensation for this.

Splintage and bracing. Correct shoes or boots with inside raise, inside the shoe or outside on the sole or both; use moulded foot support to inner side of feet; below-knee orthosis; flare the heel or sole on the inner side so that it juts out slightly at the base. The position of the feet should be carefully monitored during the growing years.

Plasters (casting) or moulded orthoses if equinus needs therapy.

Prolonged passive stretch as for equinus, emphasising some inversion.

Activity. As for equinus, but emphasise inversion (Figs 12.13–12.16). Tap the bone at the heel and malleoli on one side to activate inversion, just before an active attempt by a child.

Varus feet (supinated)

Varus causes instability with a tendency to sprains and strains of the foot.

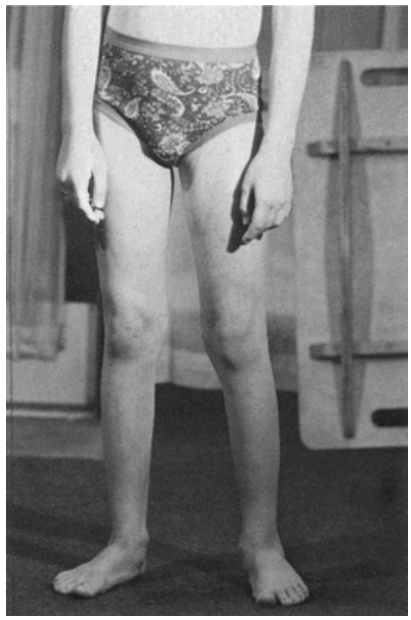


Figure 12.13. Child with valgus feet.

See equinus for treatment and Figs 12.14–12.16; tap bone at the heel and malleoli all to activate eversion before strengthening exercises. Plasters, splintage, and orthoses may be used with adjustment to the opposite side to that used for valgus. Train stand-and-walk with corrected feet.

Clenched toes or everted toes

These disappear with correct weight bearing and balance training. Heel must be on the ground and equinus treated. 'Flick' toes up as the child takes weight. Use sponge or felt to hold toes corrected while balance develops. Excessive toe flexion occurs if standing is developmentally too early for the child. Incorporate toes into plaster or thermoplastic splints and orthoses. This avoids clenching when a child is ready for standing.

Figure 12.14. Rotate the pelvis to stimulate the action of foot muscles to correct valgus. Rotate against your manual resistance at the hip in front and behind.

Figure 12.15. Stand, tip the child onto the outside of his foot to provoke the action of foot muscles to correct valgus. Child may move the pelvis laterally against your hand to obtain inversion of feet, backwards for dorsiflexion, forwards for plantarflexion.

Figure 12.16. Correction of excessive adduction, internal rotation, or valgus feet. Press child's knees outwards against your hands or the therapist turns the child's knees outwards for him. This may be done in sitting, in standing, or in squatting positions.

Dynamic arm deformity

Shoulder flexion–adduction–internal rotation, elbow flexion, wrist flexion and ulnar deviation, and hand and thumb deformities

See Chapter 9 on the developmental training of arm and hand function, which also corrects dynamic deformities (see Figs 9.99–9.104, 9.171–9.186).

For flexed elbows with dynamic deformity, elbow gaiters are used and need to be well padded in the forearm area. Do not force arms into a splint.

For wrists and hands. Many new splints and materials are regularly being designed.

Passive stretch and motion. The whole arm and hand need a gentle stretch as one pattern. Avoid any forced stretches of elbows as this is dangerous but use slow, very gentle passive ROMs of each joint to maintain existing mobility. The pronators are in particular need of gentle stretching together with activation of the weak supinators with elbow bent and with arm extended.

Deformities of trunk and neck

Trunk and neck deformities are associated with pelvis, legs, and arms, and are incorporated in positioning of the whole child in the day and during sleep. Windswept hips, pelvic asymmetry, and scoliosis are seen together but the primary cause may be unclear (see Fig. 9.68a–d). Figures 12.1–12.10 show the active strengthening of neck, trunk, and pelvis to counter deformities. See figures of equipment in all sections of Chapter 13, which correct head, trunk,

and pelvis. Twenty-four-hour postural management for the whole child includes minimising deformities of head, trunk, and pelvis. Special seating is essential for functional positions.

To minimise or correct scolioses, position a child in side lying, observing correction with either a straightening of scoliosis when lying on the side of convexity or on the side of concavity. Raise hips and legs to stretch concavity. Correct side flexion with rotation.

Passive stretch in side lying with arm elevated. Rotate hips and shoulders in opposite directions to stretch trunk muscles in young children using a slow rhythm (see Fig. 9.61).

Orthopaedic surgeons recommend special seating as well as trunk orthoses or body jackets, though in some cases breathing is difficult for a child and there may be skin breakdown. Body orthoses are for kyphosis, for scoliosis, and to give extra support for sitting in a child who cannot manage this (Terjesen et al. 2000; Miller 2007). Some experts have devised various operations as well, mainly in adolescence. Surgery is considered when scoliosis and other joint contractures interfere with comfortable seating. This is usually in adolescence and in people in GMFCS levels IV and V. This is major surgery, which is explained by the surgeon to the family and individual with cerebral palsy. A skilled, experienced surgeon with nurses and specialist therapists in the team is best. It may take up to 12 months for recovery and rehabilitation.

13

Assessment, prescription, and provision of equipment

Children with cerebral palsy in Gross Motor Function Classification System (GMFCS) levels III, IV, and V frequently need adaptive equipment to enable participation in their daily lives. Paediatric occupational therapists prescribe and provide equipment to assist children to overcome barriers to occupations (self-care, productivity such as school/work, and leisure) (Howard 2002; Isabelle et al. 2003; Rodger et al. 2005). Similarly, physiotherapists are involved in assessment and provision of postural management and mobility equipment. It is usually found that the more severe the impairment, the more equipment is required and the more it costs (Novak et al. 2012).

Children's wide range of equipment is now known as 'assistive technology', which is defined as any 'assistive product that is used to prevent activity limitations or participation restrictions' (Borgestig et al. 2016). Occupational therapists and physiotherapists select equipment within individuals' therapy programmes to minimise impairment as well in the wider situation of activity and participation.

It is essential to consider the views of individuals and their families, their environments, and personal and social experiences (Østensjø et al. 2008). This avoids their abandoning the devices. In addition, as described in Chapter 2, therapists need to provide interventions and equipment that parents and family can manage. Therapists plan use of time with parents/carers to maintain support (Kahjoogh et al. 2016). Therapists also aim to reduce the physical moving and handling and psychological stressors experienced by parents, carers, and family members (Whittingham et al. 2016).

It is beyond the scope of this book to detail all the equipment that exists for individuals. Designs of equipment also continue to be developed. The specialist equipment pictured in this chapter are examples of what is currently available on the market, but there are other manufacturers producing similar equipment that should be considered by therapists prior to clinical decisions of what will best meet the needs of a child, adolescent, or adult and their parents and family.

This book categorises equipment for a specific need, but equipment is not always solely prescribed to meet one explicit goal alone. For example, adaptive seating

Treatment of Cerebral Palsy and Motor Delay, Sixth Edition. Sophie Levitt and Anne Addison.
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systems provide postural support for activities such as feeding, play, or school-based tasks and as such target more than one of the World Health Organization's (WHO 2001) current *International Classification of Functioning, Disability and Health* (ICF) levels (Ryan 2012, 2016). Thus, although we may classify assistive technology by 'type', this is not to say that it cannot be used therapeutically by therapists to manage deformities and achieve other motor and functional goals. Each therapist uses their clinical reasoning based on available evidence and best practice guidelines. In addition, it is strongly recommended that in accordance with legislation (Lifting Operations and Lifting Equipment Regulations 1998 (LOLER) – Work Equipment and Machinery) equipment manufactured to enable a specific manual-handling task be used only for the purposes for which it was intended. For this reason, a section on manual handling, which covers transfers across environments, therapeutic interventions, and various occupations, is included.

Although cerebral palsy itself is not progressive, there are changes over time due to how children use their bodies and when there are secondary neuromuscular complexities. All equipment will therefore require regular review in response to growth, physical changes, developmental progress, and change in individual and family goals. Equipment may also need to be adapted, or additional equipment provided temporarily, if an individual undergoes surgical intervention that impacts on their motor abilities.

The use of specialised equipment does not substitute for therapy sessions and practice for training active development as much as is possible. Postural control, postural adjustment, and changing of positions can become more active in individuals in GMFCS level III.

Equipment for self-care tasks

Self-care involves everything that is taking care of oneself, from brushing teeth, washing and dressing, toileting, and feeding through to meal preparation and home maintenance. As young people grow into adulthood, additional occupations that can be categorised as self-care begin to emerge, from medication management to domestic household tasks (Dunn and Gardner 2013). Children often have difficulties with aspects of self-care because of problems in planning and motor control. Children in more severe Manual Ability Classification System (MACS) levels require more assistance in self-care tasks at home (Kuijper et al. 2010). Therapeutic intervention to support the acquisition of motor skills pertinent to specific self-care tasks is therefore required, as detailed in Chapter 10, but individual children require equipment to increase independence or to reduce safety risks.

Bathing and showering

Children with movement and balance difficulties find access to washing facilities risky due to inherent bathroom dangers. There are numerous pieces of equipment available for showering and bathing that support children who cannot sit independently, from bath seats through to custom-moulded shower chairs (Fig. 13.1). Equipment should be used to support an appropriate posture, with access to either a bath or shower determined through task analysis, completion of a manual-handling risk assessment, and the feasibility of an accessible bathroom environment, alongside personal and social factors. The question of whether a bath or shower is most appropriate is often a contentious issue in paediatric occupational therapy, with families requesting a specialist bath for their child to promote typical developmental

Figure 13.1. The SOS toilet and shower seat. (Printed with permission from Specialised Orthotic Services.)

experiences, include their child in meaningful everyday activities, and to comply with social norms. The manual-handling risks associated with bathing (owing to difficulties with transfers and hoisting) often lead to the recommendation of level access showers. However, every child must be assessed individually and subsequent equipment or adaptation prescription is based on clinical need.

The clinical reasoning utilised to prescribe or recommend a specific bath or shower chair reflects that used for seating and wheelchairs, unless there is a specific medical reason why the child needs to be positioned for washing in a certain way. Access to the toilet needs to be considered as children are likely to achieve independence later than their typically developing peers. Children in GMFCS levels IV and V may never gain full control of their bladder or bowel. There are also some children who may not be able to maintain a seated position on the toilet independently despite having been successfully toilet trained. Assessment for the most appropriate piece of equipment for a child will therefore need to include a child's ability to recognise and communicate their need to use the toilet as well as their physical skills. For some children, it may be possible to enable access to the toilet using a shower–commode chair which fits over the toilet itself, while those with greater physical ability may use smaller pieces of equipment such as foot stools, free-standing toilet frames, and toilet seat inserts or even stable potties for very young children with some balance.

Children and young people in GMFCS levels III–V will require more supportive equipment for posture in an upright position, especially if there are deformities, when prescribing either a bath or shower chair. It may be necessary to consider customised or even custom-moulded support systems for washing. In addition, voluntary movements of individuals in MACS levels II and III can be used for washing and drying. The section on seating systems provides more in-depth advice on aspects of assessment of the physical presentation.

Feeding

The development of feeding skills, as discussed in Chapter 10, is often affected by motor delay and/or motor dysfunction. Children with purposeful voluntary arm and hand movement may need specialist feeding equipment such as adaptive cutlery for reduced grip strength or dyskinetic movements. High-sided bowls are successfully used by individual children with unilateral cerebral palsy or tremor. Portable non-slip mats are useful when children visit family or friends and non-slip surfaces can support those who have difficulty

grading their movements or using their hands bilaterally. Specialist cups designed for children with reduced motor control enable some to drink without spilling, although for those who have difficulty combining upper limb and neck movements closed lidded cups or cartons with straws may provide the most effective solution.

Specialist seating supports are available for a child to enable the parent/carer to have their hands free for feeding. Seating can also provide localised head support to ensure a safe position for swallowing and preventing aspiration. There are many different types of headrest supports available but their utility will depend on the individual child's clinical presentation. It is important that the therapist takes an individualised approach because of the possibility that certain positions may exacerbate problems depending on the phase of swallowing that is affected (Snider et al. 2011).

Therapists show parents how to safely position children in special equipment. Consideration of reflux and discomfort is important. In addition therapists need to position children after surgery. When providing adaptive seating for this purpose, as with children who are orally fed, specific attention will need to be paid to the functionality of the seat in regards to backrest recline and tilt-in-space features.

Postural management equipment

The overlapping of occupational therapy and physiotherapy intervention is frequently encountered when working with children (Farley et al. 2003; Graham et al. 2015) as this provides an opportunity to develop both component physical and functional skills. This blurring of responsibilities has become particularly evident within the area of specialist or adaptive seating as there are multipurpose provision needs of such equipment (McDonald et al. 2015). While the two professions are distinct, we now share an understanding of the potential of equipment prescribed for optimal physical positioning to not only address access to occupations but also overcome barriers to participation. The primary goal of postural management is to enhance the child's ability to undertake daily activities and increase participation (Gough 2009).

When considering the biomechanical aspects at an impairment level, a 24-hour programme for children has been adopted by physiotherapists and occupational therapists. Aims are to prevent contractures and deformities, to reduce pain, and promote independence where possible. A consensus statement suggested that such programmes, encompassing 'all activities and interventions which impact on an individual's posture and function' should be individualised for every child (Gericke 2006). This statement acknowledged that limited evidence existed to support elements of such programmes. Clinical programmes include all, some, or a specific combination of specialist equipment and orthotics alongside therapy and surgical interventions. Research has since been carried out to evaluate standing equipment to maintain hip abduction in children with spastic diplegia (Macias-Merlo et al. 2015).

Although research into the use of children's equipment continues to be carried out, paediatric physiotherapists and occupational therapists need to acknowledge that measuring the effectiveness of equipment for children does not lend itself to the most rigorous level of evidence owing to ethical issues, methodological difficulties, and the impact of maturation or degenerative conditions. The result of this is that within the realm of equipment there exist very few empirical studies documenting the direct effect of specialist equipment on children with disabilities (Novak et al. 2013). In turn it remains difficult to establish the evidence to ascertain whether a

postural management approach in its purest form prevents or slows the rate of physical complications experienced by children and young people with cerebral palsy (Cloake and Gardner 2016). Practically, this means that clinicians will need to refer to future available evidence regarding the recommended individual pieces of equipment for postural management.

Adaptive seating systems

Seating interventions vary in complexity (Ryan 2016), and children in GMFCS levels I and II, and some in level III, may be able to use high chairs with minor modifications in early years or regular chairs and tables of the appropriate size and at their developmental level to achieve the following:

1. development of sitting balance and upright posture
2. development of hand function
3. develop transfers from sitting to standing and back to sitting using a variety of motor patterns from regular children's chairs.

More specialist, multiadjustable seating is required for children with a more severe motor disability in GMFCS levels III–V. Traditionally, more complex seating systems have been selected in accordance with a child's developmental stage.

The goals for improved positioning in seating are the following.

1. Correct postures used in very early typical development, but still present in older children as well as atypical postures caused by neurological symptoms of cerebral palsy or the neuromuscular deformities.
2. Prevent long-term complications caused by contracture and tertiary deformity (Picciolini et al. 2009).
3. Promote a child's visual, hearing, communication, and social abilities.
4. Provide a stable base from which hand function can be developed.
5. Provide a safe position for swallowing during eating and drinking.
6. Limit fatigue.

Assessment also needs to include possible integration of seating with other technologies (Ryan 2016). Seating systems are assessed in the context of home, school, and community, together with people who know the child well. The authors also suggest that, while two distinct aims of seating systems exist to 'serve an anatomical purpose' and 'enhance participation' (McDonald et al. 2004), these are not mutually exclusive or necessarily achievable to the same extent for every child. Finding one seating system that meets both goals may not always be possible.

Although it is encouraging that adaptive seating has been identified as a 'promising intervention' within a recent systematic review (Novak 2014), we need to strive towards ways of demonstrating its value. Using outcome measures to show achievement of participation goals, we can develop a bank of data to support seating interventions beyond the level of impairment.

Assessment: measurements

Chairs and seating systems need to be matched to the child in order that they do not obstruct development of sitting and hand function nor increase atypical postures (Fig. 13.2). Height of the chair is important to promote support of feet flat on the floor; dangling feet may disturb both sitting balance and increase foot plantarflexion. The width of a chair has an impact on weight distribution, resulting in lateral flexion to one side or the other and increased risk of scoliosis. Seat depth is equally important, as chairs that are too short in depth may impact on a child's ability to balance without assuming a posterior pelvic tilt position or curling their feet

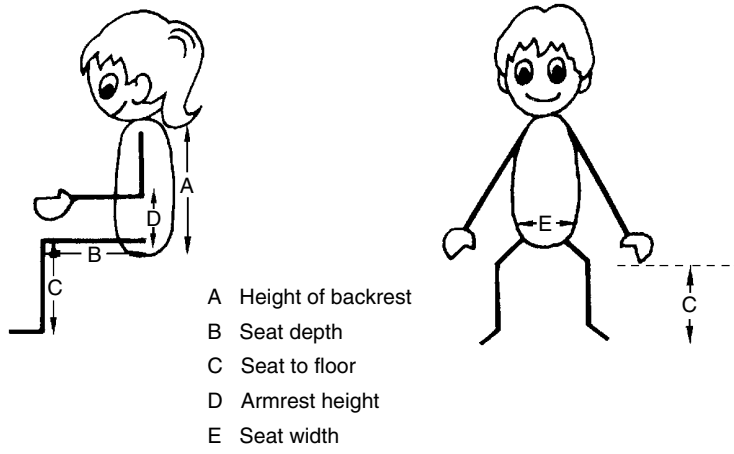


Figure 13.2. The measurements for a chair. See the modifications in the text on the evaluation of special chairs.

around the chair legs for balance, resulting in internal rotation and adduction of lower limbs. If the chair seat is too long the child may slump backwards and increase hip extension–adduction–internal rotation, knee extension or semiflexion, and foot plantarflexion. Kyphosis of the thoracic spine is promoted, which may have implications for hand function. Increased effort to maintain an upright sitting posture will impact on the child's concentration, engagement in activity, or social communication.

Evaluating the seating system

Knowledge of a child's overall physical abilities and type of cerebral palsy inform the assessment for seating for children. The increasingly consistent use of the GMFCS is providing a universal language through which clinicians can anticipate the level of postural support that a child will need. Although data on the prevalence of children classified using individual GMFCS levels are lacking in the UK, research from other countries suggests that 30–40% of children with cerebral palsy are classified as GMFCS IV or V (Himmelmann et al. 2007). Children whose mobility difficulties are best understood within the criteria for a level IV classification usually function in supported sitting with limited self-mobility. They require adaptive seating providing support at the pelvis and trunk and need physical assistance for transfers. Children functioning at level V are likely to have severe limitations in pelvis, trunk, and head control and therefore require a seating system that provides support at these key points. They are fully dependent on assistance for mobility. Some children between ages 2 and 12 and adolescents achieve self-mobility using powered wheelchairs with extensive adaptations. Dependency in self-care in seating relates to their MACS level.

Adaptive seating systems are an integral part of the postural management programme recommended in guidance for children in GMFCS levels IV and V (Angsupaisal et al. 2015), although there is research evidence that this equipment does not always improve children's posture or comfort (McDonald et al. 2004). Even when the seating is controlled as far as possible, children are likely to shift and adjust their body to assume their preferred position (Ryan 2016). However, research conducted by therapists and bioengineers has continued to look at whether elements

(a) (b)

Figure 13.3. (a) Child seated in a dynamic seating system (x:panda). (b) The same seating system on a wheelbase for outdoor mobility. (Printed with permission from R82 Ltd.)

or designs are indicated for specific problems. Stavness (2006) and McNamara and Casey (2007) both reviewed research and concluded that, in seat inclination, a neutral position or one in forward tilt was preferred to backward tilt. Cherng et al. (2009) concluded that anterior-inclined positions (forward tilt) improved postural stability and reaching efficiency. Forward tilt increases lumbar extension observed in typical development. Costigan and Light (2010, 2011) demonstrated that a seated position with a neutral pelvic position, appropriate weight-bearing surfaces, and vertical alignment of the upper body improved access to a computer-based augmentative and alternative communication (AAC) device. McDonald et al. (2015) established that ramped and contoured cushions are more effective in increasing stability and evenly distributing pressure than flat cushions. Despite this evidence, controversy still exists between therapists as they find the research inconclusive. It is therefore important that each child is assessed individually, with the goals for the seating system agreed prior to provision.

Potential seat elements

There is an increasing range of seating systems available from different manufacturers, all of which have the potential to be supplied with a myriad of accessories and adaptations to provide postural support. Certain products come with specific features that may or may not be required for an individual child, such as swing-away lateral supports to promote ease of transfers, dynamic back rests to maintain pelvic position for children with dyskinetic movements and extensor thrust, tilt-in space capacity, and elevated leg rests. The possibility of using a seating system on a wheelchair base is also provided by certain manufacturers (see section 'Wheelchairs'); Fig. 13.3a,b shows the potential for a seating system to be used on both an indoor and outdoor base. The importance of the availability of such accessories will be dependent on not only therapists' postural assessment but also the child's and family's goals for seating. McDonald et al. (2007) suggested how best to work with families to resolve potential disagreements about seating provision. Telfer et al. (2010) also

provide information on parental views of their child's seating system.

The following should be considered.

1. The child and parents find the chair aesthetically and culturally acceptable.
2. The chair should not result in the child experiencing pain; frequent changes in position may need to be considered.
3. The portability of the chair should enable engagement in activities throughout the home or school environment.
4. Height adjustment should be considered in order that age-appropriate activities carried out at different heights can be accessed.
5. While adaptive seating systems can serve more than one purpose, a child may need more than one chair to meet all goals. For example, a chair with reduced support provides the opportunity to promote motor control, but the child may require a more supportive seating system with the postural support necessary for daily living activities. Younger children may require a floor seat in addition to a seating system on a height-adjustable base (Fig. 13.4). A specialist armchair that provides support alongside the opportunity for relaxation also benefits many individuals (Fig. 13.5).

Figure 13.4. The Bee seating system by Jenx provides an introduction to supported seating for children aged 4 months to 5 years. (Printed with permission from Jenx Ltd.)

Figure 13.5. A Symmetrikit modular chair. (Printed with permission from Symmetrikit Postural Care, a division of the Helping Hand Company.)

Specific considerations (Fig. 13.6; see also Figs 9.93, 9.94, 9.106)

Pelvis, hips, and thighs. The position of a child's pelvis is the keystone for better alignment of their head and trunk. Children should be encouraged and supported to sit well back in the chair so that weight is taken equally throughout the hips, thighs, and feet. However, various adjustments to seating systems may also need to be made to promote a neutral pelvic position, and minimise or accommodate for obliquity or rotation. For example, a sacral pad may be required to support a younger child whose pelvis is smaller in girth than their trunk.

Figure 13.6. The Multiseat by Jenx is a modular seating system that can be individualised to meet the needs of the child. (Printed with permission from Jenx Ltd.)

This may later be replaced with a lumbar support, especially if the child usually adopts a position through posterior pelvic tilt; a lumbar support promotes typical lordosis. When a child is unable to achieve developmentally appropriate pelvic alignment, the following additional supports might be considered.

- Use of a four-point lap strap that includes diagonal straps across the front of the child's hips and is secured below the level of the seat. This will help the child to maintain a more aligned pelvic position, with their hips back against the sacral pad or backrest.
- Anterior incline increases the child's hip flexion while the thighs receive support and their buttocks rest on a flat contoured seat. This prevents the child from sliding forwards or sacral sitting and has been shown to promote increased hand function (Stavness 2006; McNamara and Casey 2007; Cherng et al. 2009). If a child experiences severe extensor thrust, a greater seat inclination, increasing hip flexion, may help to prevent this. If this adaptation also leads to increased flexion of the head and back, this may be corrected with a firm back rest with lumbar padding for extension. If not, try flexing the child's hips with their chest supported in a forward-leaning chair with a tray or table (see Fig. 9.106c).
- The use of 'tilt-in-space', whereby the whole seating system can be tilted backwards in relation to the seat base. This has the *advantage* that extensor thrusts out of the chair can be prevented. In this way, hip flexion may not have to be increased as much, as gravity is used to keep the child's pelvis back in the chair. Additional *advantages* of this alternative position are that it has the potential to provide pain relief for children with subluxed or dislocated hips. Increased recline can also promote spinal alignment for children who have spinal curvature that is not fixed, and can encourage passive hip and knee flexion in children with extensor tightness. However, there are *disadvantages* to increased recline in sitting, as it makes it more difficult for the child to visually explore and engage with their immediate environment and to make eye contact with others. The child's ability to use their hands for functional activities may also be reduced. The backward recline reduces the safety of a child during feeding, so needs to be avoided. Lastly, backward leaning does not provide the same proprioceptive input as upright sitting, which is essential for the development of postural stabilisation and hand use if supported by a table (Fig. 13.7a,b).
- Several dynamic chairs are available that have an adjustable (dynamic) back frame to allow movement through extensor patterns while maintaining a good pelvic position. Results from a small study by

(a) (b)

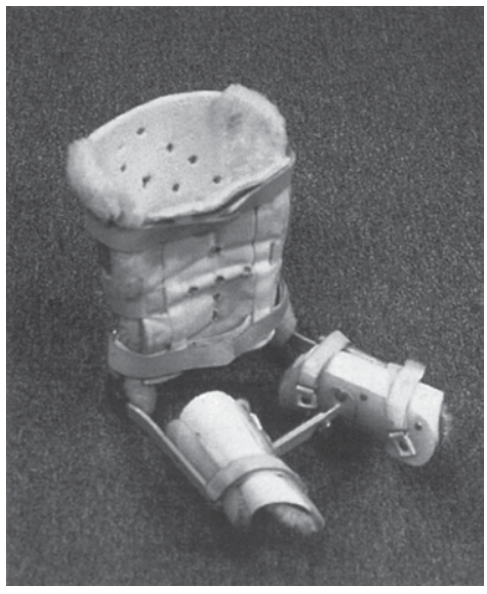
Figure 13.7. (a, b) Effect of backward tilt and upright position of a chair. Upright position with tray assists head control and arm function for daily activities, use of vision, and communication.

Cimolin et al. (2009) suggest that children with severe dyskinesia in a seating system with a dynamic back rest had improved head and trunk stability, but at the expense of more involuntary upper limb movements. However, head and trunk stability assist eye movements, or specific head motion for 'yes/no' communication.

- If a child experiences involuntary lower limb movements that lead to knee flexion greater than 90°, or dystonic posturing that presents the risk of their legs and feet becoming 'stuck' behind the foot plate stem, thigh pads may need to be provided, with care taken to avoid pressure behind the knees.
- Leg length discrepancies may be apparent. Check that this is not due to correctable pelvic rotation. If pelvic rotation is fixed or the child has one femur shorter than the other, this may need to be accommodated through a split seat to prevent increased posterior pelvic tilt; some seating systems allow for one side of the seat cushion to be shorter than the other.
- Pommels should be considered when a child has lower limb adduction–internal rotation and sits for long periods.

This avoids an increased risk of hip subluxation and dislocation. Pressure care must be considered if lower limbs are constantly in contact with a pommel or with knee blocks.

- Some children with cerebral palsy present with windswept hips, whereby both knees are angled to either the left or right. Therapists need to ensure a thorough assessment of the cause of this position before deciding how to address it through seating interventions. For example, it is possible for a child to appear windswept when this is due to forward pelvic rotation rather than the leg postures. Assess whether the position of the trunk is secondary to the legs and pelvis or vice versa. The position of the lower limbs in relation to the pelvis needs to be considered before attempting to correct this in sitting. Hip dislocation must be ascertained before it is decided what equipment is indicated, but some children will benefit from accessories to promote a neutral lower limb position. Others may require orthotics to correct asymmetrical postures of pelvis and hips, with or without symmetrical trunk support. This helps to prevent dislocation in sitting (Fig. 13.8). There is a simpler orthosis for milder cases. This consists of pelvic support and thigh cuffs and a hip joint. In addition, standing and lying equipment corrects adduction–internal rotation.
- If both hips are dislocated, the trunk and pelvis appear symmetrical, but hip flexion is reduced and sitting may be painful. Prevention is essential and this is discussed more fully in section 'Prevention of hip dislocation' in Chapter 12.



(a)

(b)

Figure 13.8. (a, b) Orthosis for trunk and hips.

- If pelvic obliquity is present, then additional support for the thigh on the lower side of the pelvis, or additional seat padding, may encourage symmetry and help to maintain a straight spine. Careful consideration as to whether this is a fixed deformity is required to prevent lateral trunk flexion.
- Some seating systems offer a 'pelvic cradle' to help stabilise the pelvis in a symmetrical posture.
- The use of thigh straps can be considered to further anchor the child's pelvis stability, although this may cause discomfort for children with strong involuntary movements.

Head and trunk. Once a child's pelvis and hips are aligned as far as possible, their head and trunk require further consideration. Add the following if necessary.

- An H harness or shoulder straps to maintain an upright position. Young girls reaching puberty may require special consideration to prevent applying too much pressure through the chest. It may also be necessary to consider the position of the strap buckles if the child enjoys playing with these, but easy access by an adult must be ensured, especially if the child has additional medical complications such as epilepsy.
- Lateral thoracic and pelvic supports can be used to support a child to maintain a midline position if they frequently assume a position through lateral trunk flexion. Placing one lateral (thoracic) support higher than the other can be useful for children with scoliosis.
- Shoulder supports may encourage shoulder protraction, although for children with dystonic movements it is important to ensure against entrapment of the upper limbs. Reducing retraction at the shoulder may enable more functional hand movements.
- For some children, having something in front of them to hold onto can promote postural alignment and reduce dyskinetic movements or dystonia. A tray for leaning on both forearms or grasp of a horizontal bar positioned on the tray may enable this. Release of one arm or hand may allow hand use.
- Optimally positioning the height of the tray can help to correct kyphosis and enable functional hand use.
- Children with correctable scoliosis may benefit from using trunk orthoses in conjunction with their seating system. Any accessories that limit the width of the chair will need to be adjusted accordingly.
- Supporting a child to achieve a head position in midline can be extremely difficult. A functional head position for feeding, social interaction, and access to technology can be promoted by optimal positioning of the rest of their body, but many children with cerebral palsy will continue to require a specialist headrest.
- Severely involved children may need seating custom made to the shape of their head and body, or their body only, as in the customised Matrix seating (Fig. 13.9a).
- Children with fixed contractures, structural scoliosis, or unfixed deformities who cannot be comfortably positioned in modular seating may require a moulded seating system cast for their body shape (Fig. 13.9b). This can be done not only for seating systems, but also for wheelchairs and bathing and shower chairs (Fig. 13.1).

Floor seats. A seat to be used at floor level may provide the most developmentally appropriate position for some children to participate in activities. This enables the child to play with toys on the floor or join other children playing on the floor in playgroups or nursery settings. Family outings,

(a) (b)

Figure 13.9. (a) Customised Matrix seating system on a MoJo wheelbase from SOS. (b) Foam Carve system on a MoJo wheelbase from SOS. (Printed with permission from Specialised Orthotic Services.)

such as picnics, can also be facilitated by giving a child support in an upright sitting position.

In conclusion, the postural complexities of children with cerebral palsy depend on positions at all key body points, each of which is affected by neurological symptoms and secondary contracture and deformity. The postural assessment considers all these aspects before decisions for seating interventions are made.

Standing frames

Individual children may use standing frames from an early age (Hughes and Campbell 2014) as part of management of body functions and structures. Bush et al. (2010) and Bush and Biggs (2011) reviewed studies of standing frames for motor function, hand use, neuromuscular benefits, deformities, physiological benefits, psychological and social factors, management of bone density, hip development, and especially views of the users of the frames. Studies had limited evidence and not always of adequate scientific design. The National Institute for Health and Care Excellence (NICE 2017) points out that medication is also needed for treatment of bone density. Goodwin et al. (2017), in what really is a health-related quality of life study, have focused more on the view of the users.

Non-ambulant children classified as GMFCS levels IV and V often continue to require supportive standers in the long term to prevent threatening deformities or contractures, especially of the hip. Hip dislocation is discussed in Chapter 12. Several clinical benefits of standing frames have been demonstrated through research, as follows.

1. Improved acetabular formation, promotion of hip integrity, and prevention of subluxation and dysplasia (Pountney et al. 2002; Gibson et al. 2009).
2. Improvements in lumbar spine and tibial bone density (Caulton et al. 2004), although the guidance from NICE (2017)

informs therapists that standing frames should not be provided solely to address low bone density. Medication and training of active standing and stepping must also contribute.
3. Maintenance of joint ranges at the hip (Macias-Merlo et al. 2015).
4. Gross motor development, including increased head and trunk control (Salem et al. 2010).

However, as with specialist seating, research carried out to demonstrate the clinical effectiveness of standing frames is limited by small sample sizes, non-blinded assessors, and difficulties extrapolating the effect of the equipment from the effects of maturation, alternate positions, and therapeutic approaches also used. However, physiotherapists with clinical experience cite additional benefits (Freeman et al. 2014), which include:

1. improved joint range of motion of hip, knee, and ankle
2. overall reduction of deformities of trunk, pelvis, and limbs through maintained stretch and improved alignments
3. pressure relief though the provision of an alternative position
4. development of hand function in standing position at a table
5. improved communication with peers and family in play or social activities
6. opportunity for new visual, proprioceptive, and perceptual experiences
7. improved access to school-based occupations
8. physiological benefits for bladder, bowel, circulation, and respiration by position change.

Paleg et al.'s (2013) systematic review suggests that for non-ambulatory children using a standing frame 5 days a week for 30–90 minutes a day can positively affect bone density, range of motion, hip stability, and spasticity. However, the authors acknowledge that only two of the studies directly addressed duration of use. Continued research limitations therefore mean that there is little guidance available regarding the frequency and duration of standing frame use in children with cerebral palsy, or on the type of frame that provides the most benefit for the child based on their physical presentation. In addition, while combining different therapeutic approaches and equipment may be considered a practical approach, there is a lack of evidence for the optimum combination and duration of each (Whittaker and Tomlinson 2015). The result is that therapists are required to decide on the most appropriate frame based on their clinical experience. The goal for use of a standing frame guides the decision.

Choice of standing equipment

In 2004 Daniels et al. provided details of different types of standing frames available in the UK. Since then, further research has demonstrated that compliance with standing programmes may play a key role in the effectiveness of the intervention (Pountney et al. 2009). The review by Bush et al. (2010) highlighted the importance of considering the views of the child, family, and carers on standing frames. This consisted of position, ease of access, support, time of toleration, aesthetics, multiple adjustability that parents, carers, or classroom assistants can manage, child feeling comfort, and in control of position and transportability.

Children can be more motivated to use a standing frame when it provides access to play, toys, or entertainment (such as television and touch-screen tablets). The psychological and social rewards of being at eye level with peers in a standing frame may result in tolerance of the frame as well as engagement in specific activities that benefit from an upright position. Individuals enjoy using a standing frame

Figure 13.10. Children mobilising in self-propelling Rabbit standing frames. (Printed with permission from R82 Ltd.)

that doubles as a mobility aid (Fig. 13.10), which also eliminates handling techniques.

Therapists need to check a child's comfort, avoid pain, take care with entrapment by involuntary movements/dystonia, and ensure there is space for the standing frame in the environments of child and family.

Therapists carry out the following assessments.

- Child's postures in supine versus prone stander, which stimulates head control and enables use of hands on a table.
- Manoeuvrability of the frame, which will become a larger issue the older the child gets and the larger the frame required.
- Moving and handling techniques required to assist the child to access the standing frame. Older children classified as GMFCS levels IV and V may require a supine stander or tilt table to allow for safe transfers. There are now seating systems that automatically transition the child or young person into a standing position to eliminate transfers (Fig. 13.11a,b).
- Adjustability of the child's trunk, pelvic tilt, or postural asymmetry and presence of any fixed deformities. Pads and straps promote alignment of the hips, knees, and feet. Leg length discrepancy may need to be accommodated.
- Check when to decrease levels of support by the frame to activate any of the child's own stability (Fig. 3.1).

Sleep systems

The aims of night-time positioning are for better sleep, to reduce deformities, especially of hips, to avoid or delay surgery, for pressure relief, for comfort and reduced need for repositioning a child at night, and to reduce pain. As night positioning is part of 24-hour postural management, it has the same consequences for a child's function in all areas in daily life.

Night-time positioning equipment or 'sleep systems' are available on the market. They include Symmetrisleep (Goldsmith 2000), Chailey lying equipment (Pountney et al. 2004), Dreama by Jenx (Hankinson and Morton 2002), and models by Moonlite (Collins 2007). In a survey of the value and design of the Night Time Postural Management equipment by Polak et al. (2008), Snoooooze (Peacocks Medical Group) and Sleepform (Leckey) were also added.

There is evidence to suggest that an asymmetrical lying posture may cause later development of spinal scoliosis, pelvic obliquity, and hip subluxation/dislocation (Porter et al. 2008). Clinicians should therefore be aware of the atypical postures in lying assumed by children and use specialist equipment (Goldsmith 2000; Clayton et al. 2016). However, a Cochrane review (Blake et al. 2015) of the evidence on the impact of sleep positioning systems on hip

(a) (b)

Figure 13.11. (a, b) The Baffin Automatic, which can be used as both an adaptive seating system and a standing frame. (Printed with permission from Baffin Technology Systems Limited.)

migration, sleep, and comfort found that only two studies met the criteria for inclusion, but these studies only considered pain and sleep quality, for which they found no significant differences. There were no randomised trials that evaluated hip migration (which may lead to subluxation/dislocation). Authors of the review have called for more rigorous research, but in the meantime clinicians will need to make decisions based on the best existing evidence.

Sleep systems consist of adaptations to the lying surface of the bed and may include cushions and rigid or foam-covered blocks/brackets, which are used to promote an optimal symmetrical lying position throughout the night. Sleep systems that can be moulded around the child while they are in a lying position have become available. Hankinson and Morton (2002) suggest that the main aims of sleep systems are to provide hip abduction and muscle stretch, as well as to discourage asymmetrical lying positions, to minimise the risk of hip dislocation. Sleep systems may be used in conjunction with specialised mattresses and height-adjustable and profiling beds, to help maintain a constant position during sleep (Fig. 13.12).

Figure 13.12. Example of sleeping or resting on an adjustable bed to correct persistent extension. Different lying positions can be used for other atypical postures. ('Dreama' reproduced with permission of Jenx, Sheffield.)

The adverse outcomes of any sleep system need to be thoroughly considered before deciding to use it. If a child finds the system too uncomfortable or it results in pressure sores or rubbing, a less restrictive approach to support should be considered. Regular cushions and pillows may provide

enough support to promote greater alignment or to accommodate fixed positions, although these will be more likely to move out of position, which increases demands on parents in relation to night-time care. Cushions designed to prevent frequently assumed atypical postures, such as lower limb adduction, may provide a practical compromise and increase comfort while requiring minimal adjustment.

Note. Select equipment for positioning during sleep, provided there is no contraindication such as seizures, vomiting from gastro-oesophageal reflux, threats of aspiration and breathing problems, opisthotonus, and nocturnal hypoxaemia (Martin et al. 1995). The bed needs to be correctly tilted for these problems without causing the child to slip down in bed.

Other equipment for positioning

Other positioning equipment may need to be considered if a child has a specific need to function in daily life. For example, children who experience pain and discomfort in sitting due to contracture, or dynamic deformity, may be unable to tolerate a seated position for the entire school day. They may need specialist equipment that supports them in side lying for hand use and is appropriate for the special needs school. There are several companies manufacturing equipment that enables positioning in different positions of lying or sitting. This may reduce the need for manual handling while taking up less space than two separate pieces of equipment (Fig. 13.13).

Mobility equipment

From an early age, moving from one place to another enables the baby to explore their environment and consequently learn through experience. Subsequent ability to move independently between positions continues to promote development of

Figure 13.13. The Acheeva adjustable learning station can support children and young people to access activities in a variety of positions. (Printed with permission from Symmetrikit Postural Care, a division of the Helping Hand Company.)

psychological skills (Anderson et al. 2013). Livingstone and Field's (2015) synthesis of qualitative evidence also serves to evidence the relationship between independent mobility and development, supporting the theory that autonomous mobility promotes engagement in meaningful activities and overall participation. Novak et al. (2012) found that approximately one-third of children with cerebral palsy are non-ambulatory. Mobility equipment should therefore be introduced as early as possible in line with a child's whole developmental profile. Butler (1986) showed that powered mobility enabled 2–3-year-old children, severely restricted in mobility, to gain changes in play, socialisation, communication, and exploration. This was achieved within weeks of using this equipment. Although parental views of wheelchair prescription may be negative initially, it is important

that parents are supported to understand that there is evidence that wheelchair provision does not prevent motor development (Rousseau-Harrison and Rochette 2013) and walking with or without aids.

Walking aids (sticks, frames, and wheeled walkers)

Children may need to use a hand-held walking aid when first learning to walk. After the age of 4, children with cerebral palsy classified as level I or II can walk independently without equipment. Children and young people in level III need a walking device to walk indoors but use wheeled mobility to access the community. For children and young people in levels IV and V, self-mobility is limited and they will be full-time wheelchair users.

When selecting, and using walking aids consider the following.

- Whether a posterior or anterior walker is most appropriate. A posterior walker may be more effective if a child already has an anterior weight shift and is ready to step with hip–trunk extension. Some physiotherapists prefer posterior walkers although this decision should be based on an individual assessment (see Figs 9.158 and 9.159a,b).
- Some children experience involuntary movements, tremors, poor grasp, or weakness, which interfere with maintenance of grasp needed for a walker. Children with cognitive difficulties, intellectual disability, or perceptual problems need more training after they gain motor control with an appropriate walker. A ladder walker (see Fig. 9.159c) or a ladder-back chair with skis may be used initially as they move slowly.
- Consider the stability of the walkers in relation to the child's abilities. Some children may not be able to manage walkers with castors or wheels, if these move too quickly.
- Do not use baby walkers that are mass produced as they may tip over easily and lead to accidents. The wheels on all four corners create atypical postures and prevent a child from taking weight within their own base and keeping their feet plantigrade. Development of independent and better patterns of walking are prevented as standing, and weight shift by the child, is disrupted by the wheels. The child will therefore sit into the canvas or hang onto the rim of the walker and clutch it with tense flexed arms and may stiffen and walk on toes.
- Older children may benefit from the additional support offered by a specialist walker with a seat element. This type of walker can also be used to promote lower limb abduction, thereby preventing scissoring and improving gait patterns. However, children should be discouraged from 'hanging' in walking aids as this will reduce the weight taken through the feet and discourage development of independent mobility.
- Use of a quadruped/tripod walking aid (see Fig. 9.167b) with each hand is usually a progression from using a walker holding on with two hands. Two aids correct weight atypically taken through one side more than the other, which leads to asymmetrical postures. Some children progress to grasping a quadruped aid or stick in the centre and in front of them, instead of using two aids.
- Observe the head, trunk, and leg postures assumed when using a walking aid. Find a walking aid that minimises or corrects atypical postures.
- The height of walking aids is extremely important. Aids that are too high will not provide enough support, while aids that are too low may increase rounding of the back and neck flexion and may lead to a kyphotic posture.
- Supported walking using a standing sling and hoist should only be used after

thorough, individualised assessment. The use of standing slings in conjunction with mobile or ceiling track hoists should be avoided as it is extremely difficult to move the hoist at the same pace as the child. Instead, therapeutic walking supported in this way should be done with 'H-frame' or 'X-Y' hoist where the transverse track moves manually with the individual.

- Continual reassessment is required to ensure that the equipment used is providing the optimal amount of support. Monitor the child's own ability to weight bear, step, control head, trunk, and pelvis, and to grasp. Avoid walkers which provide the individual with too much support. More support is often required in challenging environments within the community, such as longer distance, poor weather conditions, difficult terrain, or unfamiliar places.

A single piece of mobility equipment may not meet all of an individual's needs. A combination of crutches, tripods, sticks, or walker as well as a wheelchair may be required. The choice of equipment is based on the inherent demands of the activity or the environment in which this takes place. Stamina, fatigue, and fluctuations in motor ability may also result in the need for multiple pieces of equipment.

Wheelchairs

Young children may require a commercially available buggy for some time after their typically developing peers have learnt to walk. These buggies need to be within the weight limit and may also require minor modifications for postural needs. However, opportunities of regular training in active weight bearing, stepping, and eventually walking with or without aids is essential. The continued use of wheeled mobility depends on a child's developmental abilities to safely negotiate environmental obstacles and is influenced by their cognition alongside their motor skills.

Children with cerebral palsy in GMFCS level III may continue to require mobility equipment in the longer term, and those in GMFCS levels IV or V will be full-time wheelchair users with specialist seating for deformities and neurological difficulties. Recent NICE guidelines (NICE 2017) on the assessment and management of cerebral palsy in young people under 25 highlight the need to consider wheelchair provision to address participation in daily life.

Considerations for wheelchairs

- For very young children with postural requirements, specialist buggies can be provided that offer front- or rear-facing seating and can support medical equipment if needed.
- Measurement for the seating component of a wheelchair and accessories is fundamentally the same as that required when assessing for adaptive seating systems as described earlier in the chapter. However, specialist knowledge of available equipment is required to ensure that a child's goals for functional mobility can be met while postural management requirements are addressed.
- Development of independent mobility should be encouraged for those children who have the physical ability and cognitive understanding to do so. The ability to self-propel a manual wheelchair requires bilateral upper limb strength and control alongside cognitive and perceptual skills.
- As in the case for other equipment, aesthetics is important for acceptance.
- The accessibility of home and school environments, including toileting and changing facilities with turning spaces, should be considered.
- Horizontal and vertical circulation within these environments needs to

(a) (b)

Figure 13.14. (a, b) Use of an Action 3 self-propelling wheelchair promotes activity engagement and increased participation. (Printed with permission from Invacare.)

be considered, especially for older children using larger wheelchairs not able to access smaller through-floor lifts.

- Access to transportation is fundamental to support participation goals. School transport for children who are full-time wheelchair users is provided as standard. However, family vehicles may not be wheelchair accessible and a folding manual chair may be required to facilitate access to their community.
- Individuals with cerebral palsy have various needs and will require a wheelchair that interfaces with other technologies. For example, a clear mount point will enable a communication device to be mounted to the chair, while a headrest with integral switches may promote access to technology. It is important that the stability of the chair is considered to ensure that the weight and position of any mounted items does not increase the risk of the chair tipping (BHTA 2013).
- Collaborative working across health and social care may be required.

Wheelchair training

The reciprocal relationship between development, independent mobility, and participation in meaningful occupations (Livingstone and Field 2015) suggests that, for children with cerebral palsy, learning to use a wheelchair has the potential to facilitate positive outcomes across ICF levels (Fig. 13.14a,b). However, limited research exists in regards to teaching individuals with cerebral palsy to use either manual self-propelling wheelchairs or powered mobility. MacPhee et al. (2004) devised wheelchair skills training for adults with cerebral palsy, based on the Wheelchair Skills Test (Kirby et al. 2002). Specific projects for individuals with cognitive difficulties have been carried out (Nilsson et al. 2011), but, despite positive results in regards to the assessment reliability, in practice use of the strategies to facilitate competence did not result in independent driving. Current literature indicates the need to consider comorbidities that might influence independent driving ability

(a) (b)

Figure 13.15. (a, b) Spectra Blitz paediatric powered wheelchair with tilt-in-space functionality. (Printed with permission from Invacare.)

(Frank and De Souza 2017), but at present specific training programmes have not been evidenced.

Transitioning from manual to powered mobility

Rodby-Bousquet et al. (2016) demonstrated that 90% of children with cerebral palsy aged 10–11 years did not self-propel their manual wheelchairs regardless of age, gross motor function, or range of motion or manual abilities. In contrast, 75% of children who used powered mobility were independent. Ability to use a wheelchair independently correlated with GMFCS and MACS levels. The results from this study provide a compelling argument for the consideration of powered mobility for all children with cerebral palsy who are unable to walk or use a manual wheelchair. However, it is important to remember that, although independent mobility can be achieved with less active movement than is required to self-propel a manual chair if a reliable access point can be established, driving a powered wheelchair requires different cognitive and perceptual skills. Powered wheelchairs for use indoors have been designed for young children with restricted mobility and these are purported to support the development of the skills required for driving (see Fig. 13.15a for an example of a child-sized powered wheelchair). However, while the benefits of powered mobility for young children in relation to participation in various occupations have been documented over time (Frank and De Souza 2017), there is no concrete evidence to support the introduction of powered mobility at a specific age. Livingstone and Paleg (2014) argue that all children who have mobility difficulties should be considered for power mobility from the age of 12 months, regardless of their developmental level and physical abilities. However, although the authors agree that restrictive blanket policies for provision should not exist, caution needs to be exercised to ensure safety. Thorough, individualised assessment is recommended.

Considerations for assessment

- Use of a powered wheelchair to achieve successful participation in everyday life activities is dependent on a good match between the user, the power mobility device, and the environment (Gudgeon and Kirk 2015).
- Proportional hand joysticks are the most common type of control option for powered wheelchairs, and are provided as routine unless there is a specific reason that an individual requires an alternative (Dolan and Henderson 2017). However, children with spasticity, dystonia, involuntary movements, or reduced strength and dexterity may experience difficulties in using a joystick to safely control a powered chair. Alternatives include foot or chin joysticks, sip puff (pneumatic) switches, and single or multiple switches operated using an access point on the body. Access to powered wheelchair controls can therefore be achieved through a variety of methods, but successful driving is dependent on establishing a reliable and consistent access point. A thorough understanding of the child's physical abilities is therefore required in order that the most appropriate chair can be recommended to suit their needs.
- When considering powered mobility access options, a control system that enables computer access alongside wheelchair control can provide a means of communication as well as access to the curriculum and other environmental controls. However, this is a complex area for intervention and advice from several specialist services needs to be sought.
- As with all equipment used by children, regular review will be required to accommodate growth as well as potential changes in physical ability. This will be especially important for children who access their wheelchair indirectly (via switches) or who have additional physical or medical complications that may impact on independent use over time.
- Provision of additional, secondary controls on the back of the chair may be required while the child is learning to drive or if they experience fatigue that restricts use throughout the entire day.
- Research has shown that, compared with adults, children are more frequently provided with the additional wheelchair features of tilt-in-space (Fig. 13.15b), specialist seating, and complex controls (Frank and De Souza 2017). The tilt-in-space feature is not used for a powered chair.

Moving and handling

Moving and handling relates to the moving of items by lifting, lowering, carrying, pushing, or pulling (Health and Safety Executive (HSE) 2004). Bracher and Brooks (2006) explain that, within health and social care settings, supporting people to engage in activities of daily living frequently requires moving and handling practices that encompass risks, and there is a consensus in the wider literature that good practice requires the completion of a thorough risk assessment. The term *moving and handling equipment* is used to refer to any item used to support an individual to move from one position to another; as such, the term encompasses small items such as slide boards, slide sheets, and handling belts right through to larger pieces of equipment including standing aids, hoists, and slings. Other equipment provided to support an individual may also reduce handling manoeuvres and therefore play a part in the moving and handling process; for example, a height-adjustable seating system may enable the child to carry out independent transfers, thereby reducing the risk of musculoskeletal damage to carers who would otherwise provide physical support.

Working with children who are unable to carry out transfers independently may require repetitive moving and handling. While apparent risks should be minimised as much as possible, younger children require accommodations or adaptations to the way they are handled when developing their motor skills. Skilled handling by a physiotherapist or occupational therapist encourages typical movement patterns as much as possible, to enable a child to experience achieving tasks efficiently and effectively. A report by Capability Scotland (2012) acknowledges that, although those working with children with disabilities need to adopt a risk management approach to moving and handling, they must not fully constrain children's engagement in their desired activities. The therapist will therefore need to carefully consider their own postures and the child's unpredictable movements, while encouraging a variety of movements, but should not adopt blanket approaches to moving and handling.

As the child gets bigger, decisions regarding the use of moving and handling equipment will need to be made to ensure the safety of the child, their carers, and the professionals supporting them. While there is no legal limit in regards to the weight of a person that professionals can 'lift' or handle as part of their professional role, the law places duties on employers to manage or control risk. Health and Safety Executive (HSE 2016) guidance on the regulations suggest that, before carrying out any task that requires moving and handling, the individual should consider their own capabilities, the weight to be lifted and distance to be carried, the nature of the load, or the postures to be adopted, alongside the availability of equipment to facilitate the lift.

Choosing equipment

When working therapeutically with children with movement difficulties, the therapist should support the child to engage in transfers as much as possible. Specific moving and handling equipment, for example slide boards, can be used by a child to independently move from one sitting position to another. These are prescribed for children who have limited abilities in standing but have the trunk stability and the upper limb function to participate in the transfer. They may also be utilised on a short-term basis by children who have had specific surgery interventions for cerebral palsy such as selective dorsal rhizotomy or by those who are being provided with therapeutic intervention in the form of lower limb serial casting. Standing aids may be used to support children who can take some weight through their lower limbs. However, it is important to be realistic about a child's ability to actively engage in transfers, and children who have bilateral cerebral palsy (affecting trunk and all four limbs) may require hoisting in which active engagement is limited.

As children grow and their size and/or physical abilities change, so too does moving and handling advice. The recommendations for moving and handling equipment may therefore need to be altered, with children being prescribed more or less equipment over time. From a physiotherapy perspective, it is especially important that children are supported to engage in physical exercise (Verschuren et al. 2014). The support provided in this instance may be considered 'therapeutic handling', which is the use of physical assistance during targeted therapy that would not be provided during regular transfers on a day-to-day basis.

In recent years, there has been a move towards the concept of 'single-handed care' within social care services to ensure efficient provision (Phillips et al. 2014). This type of assistance is recommended for individuals who require just one person to assist them to transfer between positions. Many children with cerebral palsy do not

require any assistance to transfer, or can do so independently through the provision of moving and handling equipment as described above. However, owing to the varying abilities of those with cerebral palsy, those in GMFCS levels IV and V will require greater amounts of assistance, and the nature of the support may be determined by the equipment required to support the transfer, including the number of carers required to use equipment safely. This book recommends avoiding a blanket policy for manual handling, and suggests that it is only through assessment of a child's ability and needs that decisions regarding the most appropriate or safest transfer can be made.

Communication

Children with cerebral palsy frequently present with complex communication needs (Barty et al. 2016). Communication involves movements such as facial expressions, gestures, and later complicated oral–motor movements used for speech. Motor impairment can have significant consequences for communication but a child's expressive abilities are also linked to their level of understanding.

It is important for therapists to note that, while population-based cerebral palsy registers estimate that between 36% and 60% of children with cerebral palsy may have communication difficulties (Himmelmann et al. 2013), there are many children who despite their physical difficulties can develop understanding of language through very early interaction with their parents and using strategies taught by speech and language therapists. Subsequently they can communicate with others effectively using an AAC device given the appropriate access method. However, the means of using communication technology will depend upon the child's physical skills and therefore the role of the occupational therapist and physiotherapist, although frequently overlooked in the world of AAC, is in fact paramount. In accordance with the contemporary view that 'access' is not restricted to physical skills (Higginbotham et al. 2007), it must be acknowledged that, for a child to use communication systems, consideration must be paid to their linguistic ability, understanding, social communication skills, and the amount of support available from communication partners.

The methods for accessing a high-technology communication device are many and varied. However, unfortunately the available case evidence cannot yet demonstrate that one access method is more effective than another as efficacy will depend not upon the system per se but on the skills of the individual (Myrden et al. 2014). For example, while direct access via a touchscreen might appear to generate faster output, if the child's movement difficulties result in accidental selections, the initial time saved may be used in repairing communication breakdowns. Indirect access utilising switches may therefore be slower, but will be more accurate; efficiency versus accuracy must always be considered when deciding on a child's most reliable and effective access point.

The occupational therapist has an additional role to play in considering the child's occupational needs and relating this to the language required to engage in these specific tasks or activities. There has been some research into the language required to participate in specific occupations (Dark and Balandin 2007), and, although this is limited in regards to systematic analysis, it provides us with an option to consider our role within this field in a differential way. While decisions regarding software and vocabulary packages for children with AAC devices usually fall within the realm of the speech and language therapist, the understanding of which specific vocabulary is

required to complete certain functional tasks crosses over into the realm of occupational therapy.

In addition, positioning of the device to support the most effective access method requires consideration of mounting options. For example, the optimal position of eye gaze technology is approximately 60 cm in front of a child, with the eye gaze camera at a 45° angle to the eyes. The position of a touchscreen device will depend on the child's active range of movement and switches may need to be presented on a tray or integrally as part of a switch array. Various mounting solutions are available, all of which require additional assessment. Joint working within this field will have a positive impact on children and young people with complex communication needs.

Digital assistive technology

The *British Assistive Technology Association* defines assistive technology as any piece of equipment that 'maintains or improves the ability of individuals with disabilities or impairments to communicate, learn and live independent, fulfilling and productive lives' (BATA 2016).

Some equipment has a specific purpose and cannot necessarily be used during other activities such as the moving and handling equipment and bathing equipment. However, digital technology has the greatest potential to enable individuals to access occupations such as school, work, and leisure, especially since there is increased use of mobile electronic devices. The concept of *universal design*, which has been used in relation to the built environment for many years (Connell et al. 1997), is now increasingly used in relation to technology to achieve inclusion (Bauer and Elsaesser 2012). Individuals with physical disabilities or sensory impairments can frequently use mainstream devices without the need for additional software 'add-ons'.

Digital assistive technology is increasingly prescribed for children and others who have reduced hand function and need to exert control over their environment. From early cause-and-effect activities to recording written work in school, to environmental controls, there are increasing opportunities for people with disabilities to engage in activities they desire. However, do remember that, for whichever purpose the technology is used, the user must have the skills to control the devices. Therapists must therefore have a clear understanding of individuals' motor skills and their cognitive, linguistic, sensory, and communicative abilities (Gosnell et al. 2011; Costello et al. 2013). So it is necessary to enlist support from speech and language therapy, assistive technology, medical, and psychology colleagues in the multidisciplinary team.

There are numerous access methods available for children and young people with movement difficulties, from adapted keyboards, mice and joysticks through to switches, head pointers, and eye gaze technology. Thorough assessment and matching of the technology to the person (Costello et al. 2013) will continue to be important to speech and language therapists, occupational therapists, and physiotherapists.

Adaptations and the built environment

When working with individuals with physical disabilities, the built environment may need to be adapted to facilitate participation (AOTA 2015). Occasionally, within clinical settings there is discussion regarding what constitutes an adaptation and what is equipment, especially when the two are frequently used together to support task engagement. Debate can also occur since certain items such as ramps are equipment

if 'temporary' but considered an adaptation if permanent.

Minor adaptations such as handrails and stair rails are often used by children with more enhanced gross motor skills to increase their independence. However, there are children who function at an early developmental level, who are fully dependent on a carer. For these children, increasing engagement in meaningful occupations is likely to require more major environmental adaptations that allow for supported physical access. Perenboom and Chorus (2003) described participation as '…the involvement in life situations…even if one is not actually doing things themselves' (p. 578). Although the 'environment' is perceived as both a barrier to and an enabler of children's participation, it has received limited attention by many physiotherapists and occupational therapists within their wider assessment of a child's needs (Anaby et al. 2017). If participation is viewed as engagement in the task regardless of the level of support required, we need to ensure that all individuals with cerebral palsy are supported to participate in a wider range of meaningful activities.

Appendix 1

Developmental levels

Physical ability assessment guide

Grading of ability

0 No ability, no initiation
1 Initiates alone
2 Partial, laboured, unreliable, or infrequent
3 Completes alone reliably but very atypical performance
4 Completes reliably with near typical/typical performance

Maintains posture 10 seconds
Locomotion 10 steps
Stairs 4 steps

Prone

0–3 months	Can be placed, head turns Raises head up Maintains head up On forearms, head, chest up Rises onto knees and forearms
3–6 months	Reaches forwards with right arm (extended) Reaches forwards with left arm (extended) Rolls over to right Rolls over to left
6–9 months	Creeps on abdomen Maintains on hands, elbows straight Rises onto hands and knees Maintains hands and knees Reaches forwards with one hand, on hands posture
9–12 months	On hands and knees, lifts arm and opposite leg Pivots body using limbs to right Pivots body using limbs to left Crawls reciprocally Achieves sit from hands and knees Half-kneels with hand supports Rises to upright kneeling with hand supports Walks on hands and feet
12–24 months	Creeps onto table/couch Crawls upstairs Crawls downstairs backwards Kneels upright, hips straight, no support Half-kneels upright, no support Knee walks forwards Rises to stand, no support

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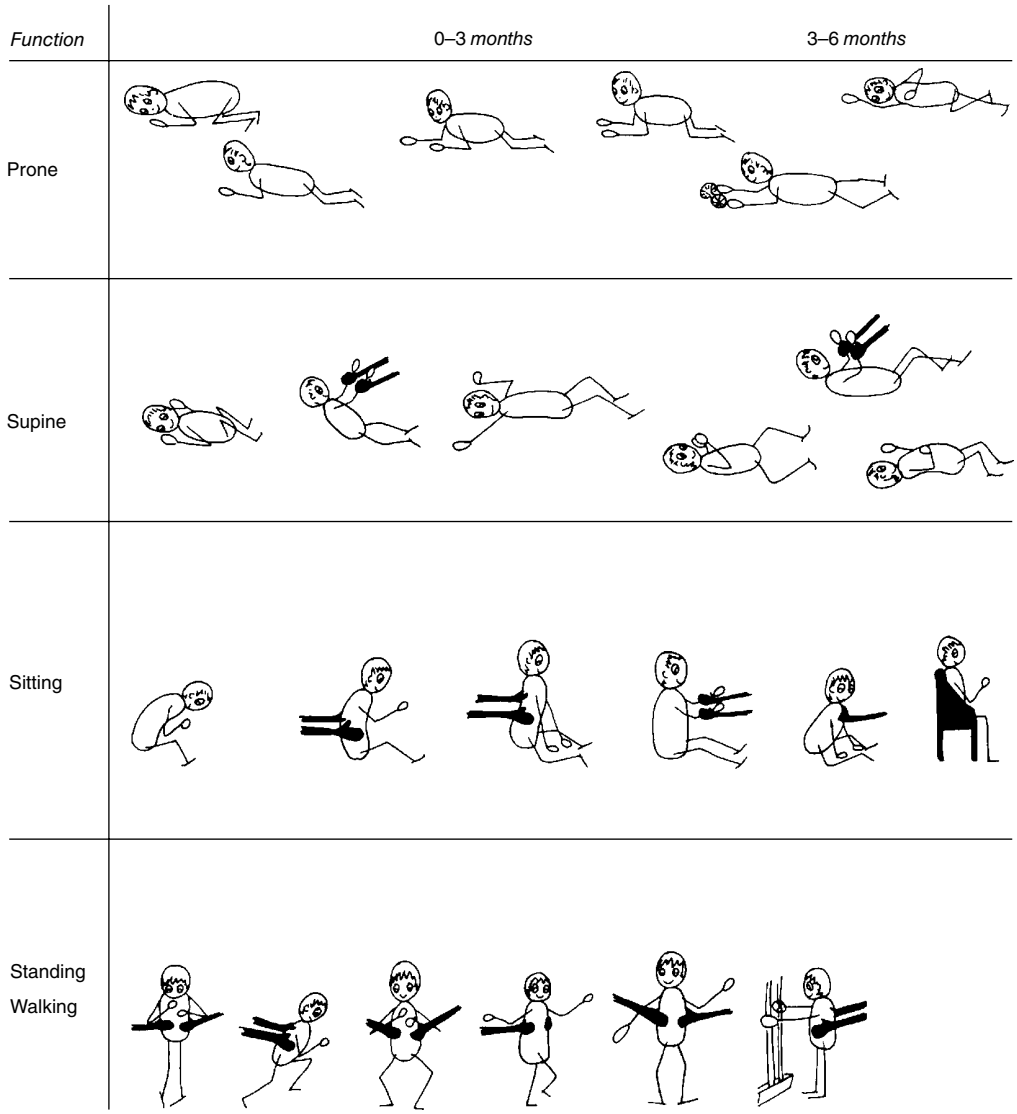
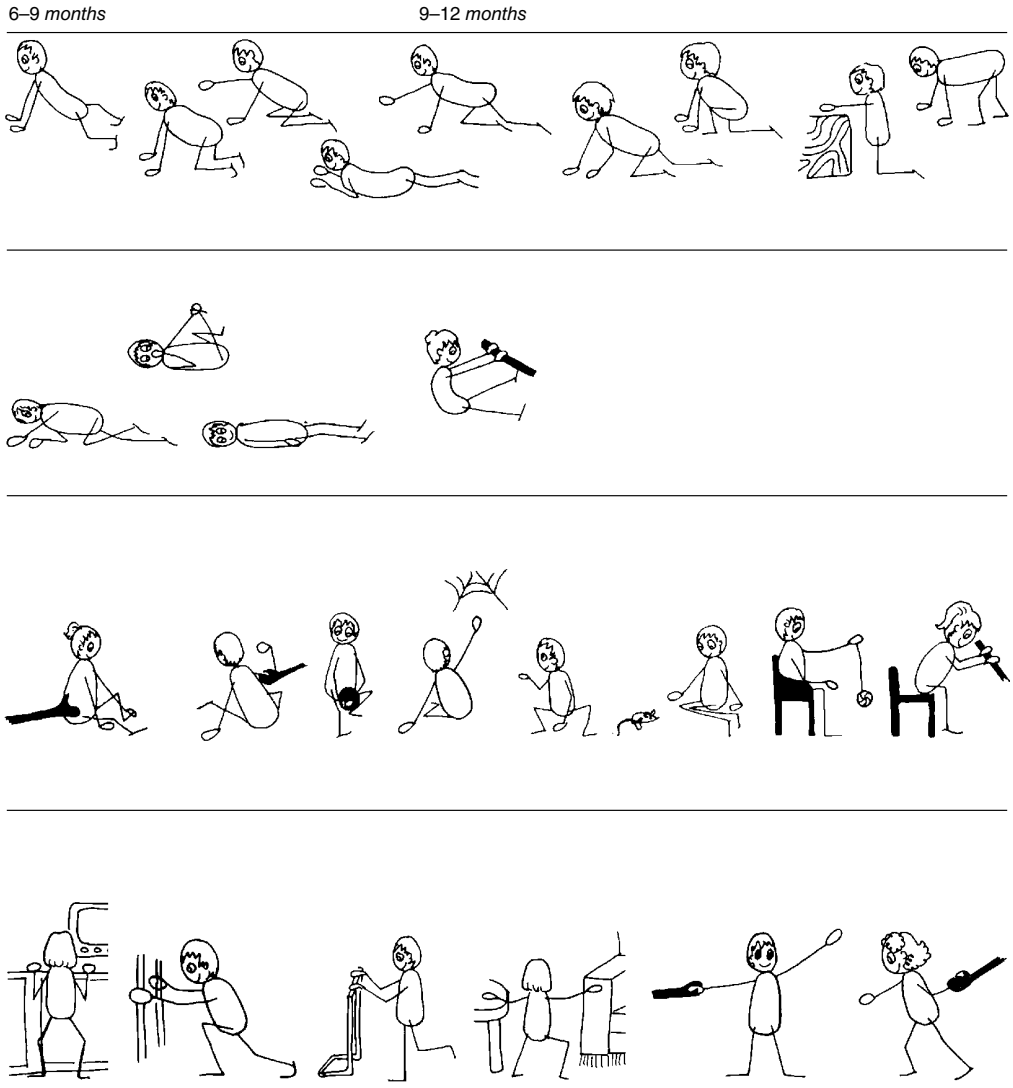


Supine

0–3 months	Can be placed, head turns Head lag overcome slightly Reaches out along floor, to side
3–6 months	Head maintained in midline, symmetrical weight bears Hands together, symmetry Head raises, head lag overcome Reaches up, across body Bridges hips into extension, feet flat
6–9 months	Rolls over to right Rolls over to left Reaches, grasps foot Lying straight, arms down, head midline, turns
9–12 months	Rises to sitting through right side lying, alone Rises to sitting through left side lying, alone Pulls self to sitting



Sitting

0–3 months	Can be placed, head, trunk supported, flexes hips Vertical head control, trunk supported Leans on forearms or hands, trunk supported
3–6 months	Sits leaning on hands, no support to upper then lower trunk Sits in chair with back, sides, or chest support
6–9 months	Sits with one hand support, uses other hand Saves self on hands forwards Sits arms free, alone Saves self to right side Saves self to left side Sits leaning forwards, re-erects alone
9–12 months	Sits, reaches across, to side, above head Sits and turns, reaches to right

	Sits and turns, reaches to left Side sits on right hip Side sits on left hip Changes to hands and knees Sits alone on regular chair Sits on chair, reaches in all directions Rises from sit to standing, holding on Sits and pivots on floor Sits and pivots on chair Bottom shuffles along floor Tilt reactions anterior–posterior Tilt reactions laterally
12–18 months	Seats self on low stool Rises from sit to stand, no holding Sits on high stool, legs dangling Squats at play Squat rises to stand and returns to squat Saves self if tipped backwards

Standing and walking

0–6 months	Weight bears, plantigrade feet, full then lower trunk support Steps, trunk supported
6–9 months	Stands, forearm leaning or holding on, pelvis supported Stands, holds on alone, hips may flex, feet flat
9–12 months	Pulls self to standing, holds on Stands, holds on, lifts right leg Stands, holds on, lifts left leg Cruises using two hands Stands, holds one hand, reaches in all directions
12–18 months	Stands alone Stands, stoop and recover Walks, two hands held or grasps walker Walks, one hand help Walks alone
	Walks, carrying object Rises to stand from all positions, no support Walks backwards Walks upstairs, holds both sides, two feet per step Protective stagger reaction if pushed sideways Protective stagger reaction if pushed forwards Protective stagger reaction if pushed backwards
18–24 months	Stands, kicks ball Throws ball overhead Runs Walks, stops, and turns (pivot) Walks upstairs, holding one rail, two feet per step Walks downstairs, both rails, two feet per step
2–3 years	Jumps in place Jumps off 15-cm (6-inch) step Pedals tricycle Broad jump (20 cm (8 inches)) Walks downstairs, on rail, alternate feet Walks upstairs, no hold, alternate feet Walks downstairs, no hold, alternate feet
3–4 years	Stands on preferred leg (5–10 seconds) Hops on preferred leg Heel-to-toe walk Catches bounced ball Uses large bat
4–5 years	Balances on one leg, 10 seconds Walks on narrow, straight line Walks between 20-cm (8-inch) parallels Walks on narrow plank/bench Steps over knee-high stick with right Steps over knee-high stick with left Backward, heel-to-toe walk

Note.

- Ages are in approximate sequence.
- Select items in each section (prone, supine, sitting, standing and walking) which have not yet been achieved as aims/objectives in a developmental therapy plan.
- Record items achieved with dates; use grading as outcomes/evaluations.

See Table 9.4 for development of hand function and eye–hand coordination (assessment guide).

Wheelchair use

Development of abilities – assessment outline

- Sits upright in wheelchair
- Finds and grasps wheel on right side
- Finds and grasps wheel on left side
- Grasps both wheels simultaneously
- Moves right wheel forward slightly (5 cm (2 inches))
- Moves left wheel forward slightly (5 cm (2 inches))
- Moves right wheel forward over 30 cm (1 foot)
- Moves left wheel forward over 30 cm (1 foot)
- Moves both wheels forward over 30 cm (1 foot)
- Moves right wheel backwards
- Moves left wheel backwards
- Moves both wheels backwards
- Travels forwards, brings wheelchair to a halt
- Travels backwards, brings wheelchair to a halt
- Starts from stationary, turns wheelchair to right, 180°
- Starts from stationary, turns wheelchair to left, 180°
- Propels wheelchair round obstacles
- Propels wheelchair between two objects forwards
- Propels wheelchair between two objects backwards
  - Increase distances and speed
  - Explore child's own strategies

Transfers

- Sitting, uses brake to halt wheelchair
- Sitting, lifts leg rests out of way
- Sit slides forwards in seat pushing on armrests
- Sit slides forwards in seat using semi-pivot pelvis
- Sit rises to stand on plantigrade feet, uses armrests

  or
- Sit rises to stand, uses arms forwards to grasp support
- Sit transfers laterally to bed, to toilet, to chair
- Sit slides along transfer board to new seat, uses hand
- Sit transfers out of seat downwards, to kneel or sit
- Sit rises to stand using armrests or grasping support
- Sit to stand, changes to new seat

  Repeat any of the above in safe return to wheelchair
  - Modify this list according to each child's own strategy and condition
  - Therapist uses physical guidance and support to teach
  - Demonstrate transfers to parents and carers so that they bend hips and knees correctly, and protect their own backs (see Fig. 9.165, rising)

See the study by Knox (2018) on manual and powered wheelchairs.

Appendix 2

Useful organisations

Equipment lists and related information may be obtained from various voluntary organisations, parents of disabled children, Departments of Health, Social Services and Education in local authorities or other government departments, and equipment lists from various medical equipment firms, toy manufacturers, and education suppliers.

Consult organisations such as:

Action on Hearing Loss (trading name of the Royal National Institute for Deaf People (RNID)), 1–3 Highbury Station Road, London N1 1SE. (www.actiononhearingloss.org.uk)

Association of Paediatric Chartered Physiotherapists, c/o Chartered Society of Physiotherapy, 14 Bedford Row, London WC1R 4ED. (apcp.csp.org.uk)

Capability Scotland, Osborne House, 1 Osborne Terrace, Edinburgh EH12 5HG. (www.capability-scotland.org.uk)

Cerebral Palsy Sport, Unit 5, Heathcoat Building, Nottingham Science and Technology Park, University Boulevard, Nottingham NG7 2QJ. (www.cpsport.org)

Children, Young People & Families, Specialist Section of the Royal College of Occupational Therapists, 106–114 Borough High Street, London SE1 1LB. (www.rcot.co.uk)

Disabled Living Foundation, Unit 1, 34 Chatfield Road, London SW11 3SE. (www.dlf.org.uk)

Halliwick Association of Swimming Therapy, c/o ADKC Centre, Whitstable House, Silchester Road, London W10 6SB. (www.halliwick.org.uk)

Headway – The Brain Injury Association, Bradbury House, 190 Bagnall Road, Old Basford, Nottingham NG6 8SF. (www.headway.org.uk)

KIDS – The Disabled Children's Charity, Head Office, 7–9 Elliott's Place, London N1 8HX. (www.kids.org.uk)

Mencap (Royal Mencap Society), 123 Golden Lane, London EC1Y 0RT. (www.mencap.org.uk)

MOVE Programme, www.enhamtrust.org.uk/our-services/children-and-young-adult-services/move/about-move

NASCH Swimming for People with Disabilities (National Association of Swimming Clubs for the Handicapped), The Willows, Mayles Lane, Wickham PO17 5ND. (www.nasch.org.uk)

RDA (Riding for the Disabled Association), Norfolk House, 1a Tournament Court, Edgehill Drive, Warwick CV34 6LG. (www.rda.org.uk)

Royal College of Speech and Language Therapists, 2 White Hart Yard, London SE1 1NX. (Enquire for centres offering communication aids and advice.) (www.rcslt.org)

Royal National Institute of Blind People (RNIB), 105 Judd Street, London WC1H 9NE. (www.rnib.org.uk)

Scope (for people with cerebral palsy), 6 Market Road, London N7 9PW. (www.scope.org.uk)

Sense (for deafblind people), 101 Pentonville Road, London N1 9LG. (www.sense.org.uk)

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