Concussive Events

Using the Evidence to Guide Physical Therapist Practice

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Concussion (also called mild traumatic brain injury) can occur across the lifespan. Concussion may be caused by sports or by falls, accidents, and acts of violence. Excessive force to the head, either through direct impact or force transmission through the body and neck, is a concussive event. After a concussive event, there can be injury not only to the brain, but also to other structures such as the cervical spine and vestibular system. The clinical practice guideline published in the April 2020 issue of *JOSPT* outlines the role of physical therapy examination and management after a concussive event.[2] Because the forces that cause concussion can also cause injury to the neck and/or disrupt normal vestibular function, we use the term *concussive event* to describe the injury.

WHAT WE KNEW

Although some people recover from a concussive event after a brief period of rest and gradual resumption of activity, others have persistent impairments that may respond well to physical therapy management. Headache, dizziness, or oculomotor disturbance can have multiple and sometimes overlapping causes, including brain injury, neck injury, vestibular system dysfunction, or other diagnoses. Accurate differential diagnosis followed by an appropriate treatment and referral to other clinicians, if indicated, are critical physical therapy competencies.

WHAT WE DID

Clinicians and researchers with expertise in different physical therapy specialties (orthopaedics, sports, neurology, pediatrics) collaborated to develop physical therapy–focused guidance for rehabilitation management after a concussive event (postacute phase). We searched for and evaluated the quality of the best available evidence, using standardized appraisal tools and guided by a methodologist and the American Physical Therapy Association Clinical Practice Guideline Process Manual.[1]

WHAT WE FOUND

Physical therapists have a role in the evaluation and treatment of 4 areas of impairment: (1) cervical musculoskeletal, (2) vestibulo-oculomotor, (3) autonomic dysfunction/exertional intolerance, and (4) motor function. Recommendations from this clinical practice guideline may be reasonably applied to patients aged 8 years and older. Evidence for specific physical therapy management of patients after a concussive event is limited. Evidence supports the use of progressive subsymptom-threshold aerobic exercise to improve exercise intolerance. Previously published clinical practice guidelines for common areas of impairment that present after a concussive event (neck pain, vestibular disorders) are also applicable.

This *JOSPT* Perspectives for Practice was written by Karen L. McCulloch, PT, PhD, FAPTA, with a team of *JOSPT*'s Special Features Editorial Board, including Alexander Scott, BSc(PT), PhD, led by Editor-in-Chief Clare L. Ardern, PT, PhD, and staff. The flow chart on the following page was produced by Kate Minick, PT, DPT, OCS, of Intermountain Healthcare, Rehabilitation Services, Salt Lake City, UT.

BOTTOM LINE FOR PRACTICE

Physical therapists should screen for potential red or yellow flags that might require timely referral to other physical therapists or disciplines with specialty diagnostic and treatment skills. We recommend screening for specific cervical, vestibulo-oculomotor, exertional, and functional mobility impairments that may respond to physical therapy intervention.

We also suggest sequencing the assessments to account for symptom irritability. For example, screen for cervical impairments and neck pain at the first visit, as some vestibulo-ocular system tests require cervical motion that may exacerbate existing neck pain. Symptom irritability guides treatment progression. Avoid extended periods (greater than 48 hours) of complete rest. Encourage gradual resumption of activities that do not cause significant symptom exacerbation. Teach self-management skills, and screen and refer appropriately if there are mental health concerns (eg, anxiety, depression, posttraumatic stress disorder).

For this and more topics, visit *JOSPT* Perspectives for Practice online at **www.jospt.org**.

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JOSPT PERSPECTIVES FOR PRACTICE

Clinical Practice Guideline: Physical Therapy After a Concussive Event

Diagnosis/Classification of Concussion: Evaluation of Clinical Findings

Screening and Differential Diagnosis – A
- All patients with a potential concussive event must be assessed for symptoms, impairments, functional limitations, signs of medical emergency, and severe pathology; referrals should be made as indicated
- Should screen for mental health, cognitive impairment, and differential diagnoses and refer for additional services as indicated

Examination
- Examine for impairments in the domains below – B
- Determine level of irritability. Sequence/delay examination procedures, if needed. Triage neck pain irritability first, then dizziness and/or headache – F

Cervical Musculoskeletal Impairments

Symptoms: neck pain, headache, dizziness, fatigue, balance problems, difficulty with visual focus– C
Test: range of motion, muscle strength and endurance, tenderness to palpation, joint position error– C

Vestibulo-oculomotor Impairments

If benign paroxysmal positional vertigo is suspected, assess using the Dix-Hallpike test or another suitable test – A
Symptoms: headache, dizziness, vertigo, nausea, fatigue, balance problems, visual motion sensitivity, blurred vision, difficulty focusing – B
Examine: vestibular and oculomotor function related to ocular alignment, smooth pursuits, saccades, vergence and accommodation, gaze stability, dynamic visual acuity, visual motion sensitivity, light-headedness, vertigo – B

Autonomic/Exertional Tolerance Impairments

Test: orthostatic hypotension and autonomic dysfunction by evaluating heart rate and blood pressure in supine, sitting, and standing – B
Conduct a symptom-guided, graded exertional tolerance test, optimizing safety and appropriateness – B
If vestibulo-oculomotor or cervical spine impairments/symptoms are present, use stationary bike for testing – C

Motor Function Impairments

Examine: static balance, motor coordination and control, dual/multitasking – B

Assessment

- When headache is a symptom, determine the type in accordance with the International Classification of Headache Disorders – B
- Establish the presence or absence of all impairments and their levels of irritability to support the selection of intervention strategies and priorities– E
- Elicit and evaluate factors related to self-efficacy, self-management, and potential psychological and sociological factors that may influence recovery, such as (1) coping strategies, (2) support systems, (3) risk factors, (4) attitude toward recovery, and (5) access to resources/equipment to support recovery – E
- Determine and document plan for outcome measurement – F

Intervention Strategies

Communication and Education
- Reassurance that most patients recover quickly – A
- Self-management of symptoms – B
- Importance of relative rest – B
- Benefits of progressive re-engagement in activities – B
- Importance of sleep – B
- Safe return-to-activity pacing strategies – B

Potential Signs/Symptoms of the Need for Follow-up Care – B
- Refer for consultation: persistent migraine or other chronic headaches; vision impairments, including ocular alignment; auditory impairments; sleep disturbances; mental health symptoms; and cognitive problems

Cervical Musculoskeletal Impairments

Exercises and manual therapy to address cervical and thoracic spine dysfunction, such as strength, range of motion, postural position, and/or sensorimotor function – B

Vestibulo-oculomotor Impairments

Benign paroxysmal positional vertigo: use canalith repositioning interventions – A
Individualized vestibular and oculomotor rehabilitation plan, visual-motion habituation program – B
Therapists without appropriate training in vestibular and oculomotor rehabilitation should refer patients with these impairments to a clinician with appropriate expertise – F

Autonomic/Exertional Tolerance Impairments

Symptom-guided, progressive aerobic exercise training program considering goals, comfort level, lifestyle, and equipment access, with moderate/low irritability – A

Motor Function Impairments

Target identified or suspected motor function impairments, including static balance, dynamic balance, motor coordination and control, and dual/multitasking – C

Based on the guidelines, the grades in this flow chart may be translated as follows: A, strong evidence; B, moderate evidence; C, weak evidence; D, conflicting evidence; E, theoretical/foundational evidence; F, expert opinion. Figure produced for *JOSPT* by Kate Minick, PT, DPT, OCS, of Intermountain Healthcare, Salt Lake City, UT.

[RESEARCH REPORT]

DIEGO DIULGEROGLO VICCO AMARAL, PT[1] • **GISELA CRISTIANE MIYAMOTO**, PhD[1,2] • **KATHERINNE FERRO MOURA FRANCO**, PhD[1]
YURI RAFAEL DOS SANTOS FRANCO, PhD[1] • **NAIANE TEIXEIRA BASTOS DE OLIVEIRA**, PhD[1] • **MARK JONATHAN HANCOCK**, PhD[3]
MAURITS W. VAN TULDER, PhD[2] • **CRISTINA MARIA NUNES CABRAL**, PhD[1]

Examination of a Subgroup of Patients With Chronic Low Back Pain Likely to Benefit More From Pilates-Based Exercises Compared to an Educational Booklet

Low back pain (LBP) is a common condition with a lifetime prevalence of 39%.[23,29] Low back pain is the primary cause of years lived with disability and absenteeism and results in high socioeconomic costs.[5,6,23,30,47] About 80% of patients have nonspecific LBP, when a known specific pathology is absent.[32,36] Clinical practice guidelines and systematic reviews recommend a range of interventions, including general exercise, tai chi, yoga, Pilates, and motor control exercise, to improve pain and disability in patients with chronic LBP.[1,18,45,56] However, there is good evidence that the average benefit of different types of exercise may be similar among patients with chronic LBP.[1,26,48] Furthermore, the magnitude of the treatment effect is typically small to moderate.[45]

OBJECTIVE: To investigate whether 2 previously published classification approaches, the updated treatment-based classification system and a Pilates subgroup defined by a preliminary clinical prediction rule, could identify patients with chronic low back pain who would benefit more from Pilates exercises compared to an educational booklet.

DESIGN: Secondary analysis of a randomized controlled trial.

METHODS: Two hundred twenty-two patients received advice and were randomly allocated to a group that received an educational booklet with no additional treatment (n = 74) or a group that received Pilates-based exercise treatment (n = 148) 2 or 3 times a week. At baseline, using a treatment-based classification system, patients were classified as having a good prognosis (positive movement control) or a poor prognosis. Similarly, using the Pilates clinical prediction rule, patients were classified as having a good prognosis (positive) or a poor prognosis (negative). The analysis was conducted using linear regression models to analyze the interaction between subgroup characteristics and treatment effect size, with changes in pain and disability from baseline to 6 weeks after randomization as dependent variables.

RESULTS: None of the interaction terms for pain and disability were statistically significant. The treatment effect of Pilates versus an educational booklet was similar in all subgroups.

CONCLUSION: The treatment-based classification system and the Pilates clinical prediction rule did not differentiate subgroups of patients with chronic low back pain who were more or less likely to benefit more from Pilates compared to an educational booklet. *J Orthop Sports Phys Ther 2020;50(4):189-197. Epub 23 Aug 2019. doi:10.2519/jospt.2019.8839*

KEY WORDS: *low back pain, Pilates, rehabilitation, subgroup*

Patients with nonspecific LBP present a diversity of characteristics (psychological, physical, clinical, and demographic) and a variable clinical course.[18,31] Thus, it is unlikely that a standardized intervention for this heterogeneous condition would be effective for all patients.[18,31] Classification and identification of patients with nonspecific chronic LBP into subgroups who respond best to specific interventions are important to optimize the treatment effect of existing interventions.[31] Clinical prediction rules (CPRs) have been used to identify patients who are likely to benefit from a specific intervention.[10,20,46] Recent studies have investigated whether specific exercise programs, such as the McKenzie method, motor control exercises, and Pilates, are

[1]Masters and Doctoral Programs in Physical Therapy, Universidade Cidade de São Paulo, São Paulo, Brazil. [2]Department of Health Sciences, Faculty of Science, Vrije Universiteit Amsterdam and Amsterdam Movement Sciences, Amsterdam, the Netherlands. [3]Department of Health Professions, Faculty of Medicine and Health Sciences, Macquarie University, Macquarie Park, Australia. The protocol of this study was approved by the Research Ethics Committee of Universidade Cidade de São Paulo, and the study was prospectively registered at www.ClinicalTrials.gov (NCT02241538). The São Paulo Research Foundation provided a scholarship to Dr Miyamoto and one to Diego Amaral (process numbers 2013/26321-8, 2015/18974-7, and 2016/07915-2). Dr Miyamoto was an instructor of NeoPilates courses at the time of data collection. NeoPilates is a type of exercise that integrates the principles of Pilates with characteristics of functional training and circus activities. Although NeoPilates has a similar name to the Pilates method, the exercises are performed with different approaches and with different equipment. The other authors certify that they have no affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article. Address correspondence to Dr Gisela Cristiane Miyamoto, Rua Cesário Galero, 448/475, Tatuapé, São Paulo, SP, Brazil 03071-000. E-mail: gfisio_miyamoto@hotmail.com

more effective in specific subgroups of patients with LBP.[22,46,50]

Pilates has been recommended for the treatment of patients with chronic LBP, though the effects are small to moderate.[56] Stolze et al[50] developed a preliminary CPR to identify a subgroup of patients with LBP who benefit from Pilates. This CPR suggested that patients with 3 or more variables, including left or right hip internal or external rotation range of motion of 25° or more, total trunk flexion range of motion of 70° or less, body mass index of 25 kg/m^2 or more, no leg symptoms in the last week, and duration of current symptoms of 6 months or less, have a 54% to 93% probability of improvement of symptoms after Pilates-based treatment. However, in a cohort study it is not possible to distinguish whether the CPR identified is prognostic or an effect modifier.[49] The study by Stolze et al[50] did not include a control group, and it is essential to test this CPR in a randomized controlled trial to determine whether the rule is an effect modifier for Pilates. Effect modifiers are characteristics indicative of subgroups of patients who respond differently to the same treatment.[25]

Another classification system that could identify patients who respond best to Pilates is the updated treatment-based classification system (TBCS).[2,18] The subgroups defined by this system include (1) a symptom modulation group, with recommendations of directional preference exercises, mobilization/manipulation, traction, and active rest; (2) a movement control group, with recommendations of sensorimotor, stabilization, and flexibility exercises; and (3) a functional optimization group, with recommendations of work- or sport-specific tasks, strengthening, conditioning, and aerobic and general fitness exercises.[2] The main aim of Pilates exercises is to improve muscle control, core stability, flexibility, strength, and posture.[53] Thus, the movement control subgroup would be expected to benefit most from Pilates. Because Pilates exercises also focus on strengthening, they could provide benefit for the functional optimization subgroup. However, that subgroup focuses on work- and sport-specific tasks, conditioning, and aerobic and general fitness exercises, in contrast to Pilates.

We are not aware of studies that have evaluated the reliability of the TBCS. Whether these subgroups act as effect modifiers for these interventions has yet to be tested in a randomized controlled trial. The aim of this study was to investigate whether 2 previously published classification approaches (the CPR and TBCS) could identify patients with nonspecific chronic LBP who are likely to benefit more from Pilates-based exercises compared to an educational booklet.

METHODS

Study Design and Setting

This study is a secondary analysis using data from a randomized controlled trial.[38] Details of the study design have been described elsewhere.[38,39] The study was conducted at a physical therapy clinic and a Pilates clinic in São Paulo, Brazil. The protocol of this study was approved by the Research Ethics Committee of Universidade Cidade de São Paulo, and the study was prospectively registered at www.ClinicalTrials.gov (NCT02241538).

The randomized controlled trial assessed the effectiveness and cost-effectiveness of the addition of different doses of Pilates exercises to advice in the treatment of patients with nonspecific chronic LBP.[38] Two hundred ninety-six patients, recruited from the community, were randomized to 1 of 4 groups (n = 74 per group) who received an educational booklet (educational booklet group), Pilates exercises for 1 session per week (Pilates group 1), Pilates exercises for 2 sessions per week (Pilates group 2), and Pilates exercises for 3 sessions per week (Pilates group 3). The main results of this randomized controlled trial showed that all of the Pilates groups were more effective than the educational booklet group at improving pain and disability at 6 weeks. However, only Pilates groups 2 and 3 were considered to have clinically important effect sizes compared to the educational booklet group for pain and disability at 6 weeks. At the 6-month assessment, only Pilates group 2 was more effective than the educational booklet group at improving pain and disability, but the effect was small. At the 12-month assessment, none of the Pilates groups provided additional effects compared to the educational booklet group. For this secondary analysis, we therefore prospectively decided to only include the educational booklet group (n = 74) and Pilates groups 2 and 3 combined (Pilates group, n = 148), and to analyze only the 6-week follow-up data, where main effects were larger.

Patients

Two hundred twenty-two patients, between 18 and 80 years of age, with nonspecific chronic LBP of more than 12 weeks in duration[32,52] were included in this study. Low back pain was defined as discomfort or pain localized below the costal margin and above the inferior gluteal folds, with or without referred lower extremity pain.[1] Patients with serious spinal pathologies (eg, tumors, fractures, and inflammatory diseases), previous or scheduled spinal surgery, nerve root compromise, pregnancy, Pilates treatment for LBP in the previous 3 months, and any contraindication to physical exercise (assessed by the Physical Activity Readiness Questionnaire)[17] were excluded. All patients provided written informed consent prior to their participation.

Assessment

Baseline assessment included demographic information and clinical characteristics of pain and physical examination findings. This assessment provided all the data required for the subgroup classifications investigated in this study. The physical examination included the positive prone instability test and goniometer measures of total trunk flexion range of motion, hip flexion range of motion, and hip internal and external rotation range of motion.[21,28,35,37]

TABLE 1 Subgroups of the Treatment-Based Classification System

Outcome	Symptom Modulation	Movement Control	Functional Optimization
Pain intensity	High to moderate (7-10 points)	Moderate to low (4-6 points)	Low to absent (0-3 points)
Disability	High (14-24 points)	Moderate (6-13 points)	Low (1-5 points)
Clinical status	Volatile (symptoms predominate) Means: the patient's clinical status can easily be aggravated, the patient is highly irritable (ie, minor lumbar spine movements easily provoke pain), and occasionally the patient's presentation does not permit physical examination Examination: the patient avoids specific postures (flexion or extension of the spine), range of motion is limited, spine movement is painful, and lower-limb pain and serious functional limitations (difficulty with standing more than 15 minutes, sitting more than 30 minutes, or walking more than 250 m) are present	Stable (movement impairments predominate) Means: the patient's clinical status can increase with certain movements, postures, or tests but returns to baseline level relatively quickly Examination: pain is worst during sudden movement, active movement is complete but can be abnormal/aberrant, and there are a flexibility deficit (hip flexion less than 70°), positive prone instability test, and moderate functional limitations (difficulty with housework, mowing grass, or lifting heavy objects)	Well controlled (performance deficits predominate) Means: the patient's clinical status is asymptomatic most of the time but can be aggravated when performance demands are increased Examination: without flexibility deficits (hip flexion more than 90°), negative prone instability test, and low functional limitations (difficulty with activities of great physical demand and long duration, such as handling heavy materials, participating in sports, or doing heavy housework)

Adapted with permission from Alrwaily et al.[2]

TABLE 2 Criteria of the Clinical Prediction Rule for Pilates[50]

Criterion	Definition of "Positive"
Leg symptoms	Not having symptoms in the last week
Body mass index	≥25 kg/m^2
Total trunk flexion range of motion	≤70°
Hip rotation range of motion	1 hip with ≥25° of internal or external rotation
Duration of symptoms	≤6 mo

Primary Outcomes

Patients completed the assessment of pain and disability at 6 weeks after randomization. Pain intensity was assessed using the 11-point numeric pain-rating scale, with 0 representing "no pain" and 10 representing "pain as bad as could be."[14] Patients were asked to rate their average pain during the last 7 days. The numeric pain-rating scale has good levels of reproducibility (intraclass correlation coefficient [ICC] = 0.85; 95% confidence interval [CI]: 0.77, 0.90), responsiveness (standardized effect size, 1.16), and construct validity.[14] Disability was assessed using the Roland-Morris Disability Questionnaire, which ranges from 0 to 24 points, with scores close to 24 indicating greater limitation.[14,15,42] The Roland-Morris Disability Questionnaire has good levels of reproducibility (ICC = 0.94; 95% CI: 0.91, 0.96), responsiveness (standardized effect size, 0.70), internal consistency (Cronbach α = .90), and construct validity.[14]

Subgroup Classification

Patients were classified into subgroups of the TBCS[2] and the Pilates subgroup by 2 independent assessors using the CPR[50] on the baseline data. Disagreements were resolved by discussion and then by a third assessor when a consensus could not be reached. A customized sheet was used to extract relevant information for each subgroup classification.

In the TBCS, patients were classified into 1 of 3 subgroups: symptom modulation, movement control, or functional optimization.[2] Criteria for classification were based on pain intensity (high to moderate, moderate to low, and low to absent), disability level (high, moderate, and low), and clinical status (volatile, stable, and well controlled). Details of the classification are presented in **TABLE 1**. We hypothesized that the movement control subgroup would respond best to Pilates compared with the symptom modulation and functional optimization subgroups. Pilates is considered a mind-body exercise, with focus on breathing, posture, muscle control, core stability, strength, and flexibility,[53] presenting some of the characteristics recommended in the intervention prescribed for the movement control subgroup.[2] Thus, we combined the symptom modulation and functional optimization subgroups into 1 subgroup, called the "negative movement control" subgroup (poor prognosis for response to Pilates), and compared it with the positive movement control subgroup (good prognosis for response to Pilates).

Using the Pilates CPR for patients with LBP, which consists of 5 predictors (**TABLE 2**),[50] patients were also classified into a positive Pilates subgroup (good prognosis for response to Pilates) and a negative Pilates subgroup (poor prognosis for response to Pilates). The inclusion criterion for the positive Pilates subgroup was the presence of 3 or more of the 5 predictor variables.

Intervention

Details of the intervention have been published elsewhere.[19,38] All patients received an educational booklet containing information about LBP, anatomy of the spine, and recommendations related to activities of daily living and posture.[8] The booklet group did not receive additional treatment. The Pilates group received an individual Pilates-based exercise program 2 or 3 times a week over 6 weeks.

In the first session of the Pilates group, patients received instructions on the Pilates principles and training for the activation of the deep abdominal muscles while exhaling during all exercises.[40,41] The Pilates-based exercise program consisted of 5 minutes of warm-up (breathing and mobility exercises), 50 minutes of Pilates-based exercises (stretching and strengthening exercises for muscles of the trunk and the lower and upper limbs), and 5 minutes of cool-down (relaxation exercises and massage with a ball). The Pilates-based exercises were performed in single series, with the number of repetitions varying from 8 to 12, and at 3 levels of difficulty (basic, intermediate, and advanced). The progression of the exercises was individualized with respect to the physical condition, comfort level, and postural compensations of each patient.[3,4]

Physical Therapists

The treatment of patients was performed by 5 physical therapists certified in Pilates. These physical therapists had a minimum of 3 years and a maximum of 8 years of experience in the treatment of patients with LBP using Pilates. As the physical therapists were certified at different Pilates schools, they received specific training on the Pilates-based exercise program used in this study.

Statistical Analysis

A subgroup analysis was conducted using linear regression models, considering change in pain intensity and disability from baseline to 6 weeks after randomization as dependent variables. The TBCS and the CPR were investigated in separate models. Each model included terms for treatment group, subgroup, and the interaction term (group by subgroup). As this was an exploratory secondary analysis and likely underpowered, we assessed both the statistical significance ($P<.05$) and the point estimates of the interaction term (the interaction between characteristics of the subgroup and the effect size of treatment). We considered interac-

TABLE 3 Baseline Characteristics of the Patients[a]

Variable	Booklet Group (n = 74)	Pilates Group (n = 148)
Age, y	48.6 ± 15.8	47.9 ± 15.5
Sex, n (%)		
Male	18 (24.3)	38 (25.7)
Female	56 (75.7)	110 (74.3)
Weight, kg	71.3 ± 15.1	71.6 ± 14.2
Height, m	1.6 ± 0.1	1.6 ± 0.1
Body mass index, kg/m^2	26.9 ± 5.3	26.4 ± 4.5
Family income, USD/mo	2413 ± 1700	2261 ± 1731
Duration of symptoms, mo[b]	48.0 (3-372)	48.0 (3-480)
Marital status, n (%)		
Single	23 (31.1)	40 (27.0)
Married	35 (47.3)	81 (54.7)
Divorced	12 (16.2)	17 (11.5)
Widower	4 (5.4)	10 (6.8)
Academic level, n (%)		
Primary education	17 (23.0)	30 (20.3)
Secondary education	24 (32.4)	45 (30.4)
Tertiary education	33 (44.6)	73 (49.3)
Smoking, n (%)		
No	70 (94.6)	137 (92.6)
Yes	4 (5.4)	11 (7.4)
Psychosocial status, n (%)[c]		
Negative	45 (60.8)	106 (71.6)
Positive	29 (39.2)	42 (28.4)
Disability at baseline (0-24 points)	12.3 ± 5.5	11.7 ± 4.8
Pain intensity at baseline (0-10 points)	6.3 (1.8)	6.2 (2.3)
Treatment-based classification system		
Negative movement control subgroup	48 (64.9)	86 (58.1)
Symptom modulation	41 (55.4)	73 (49.3)
Functional optimization	7 (9.5)	13 (8.8)
Positive movement control subgroup	26 (35.1)	62 (41.9)
Clinical prediction rule		
Negative Pilates subgroup	31 (41.9)	66 (44.6)
Positive Pilates subgroup	43 (58.1)	80 (54.1)

[a]*Values are mean ± SD unless otherwise indicated.*
[b]*Values are median (range).*
[c]*The patient was classified as positive psychosocial status when presenting with 2 or more of 3 psychological characteristics: 49 points or more on the Tampa Scale of Kinesiophobia (17-64 points), 30 points or more on the Pain Catastrophizing Scale (0-52 points), and feeling depressed during the last month (yes or no).*

tion terms of greater than 1 point on the numeric pain-rating scale and of greater than 3 points on the Roland-Morris Disability Questionnaire as clinically important at 6-week follow-up. Interaction terms represent how much more effective a treatment is, compared to a control, in the patients in a subgroup compared to those who are not in a subgroup. There is no consensus on what constitutes a clinically important interaction for pain or disability, as it depends on the main effect size and the cost and harm of an intervention.[25] We selected the values for the interaction term after considering these factors. The assumptions of normality, multicollinearity, and linearity were not violated in both models and were considered present in the occurrence of tolerance lower than 0.10. A test of normal distribution of the linear regression models was conducted by plotting both residuals and normal distribution.

RESULTS

TABLE 3 DESCRIBES THE PARTICIPANTS' characteristics. Most patients were women, married, overweight, with tertiary education, and nonsmokers. From the 222 patients assessed, 1 patient was excluded due to being diagnosed with cancer during the study, 13 patients did not answer the assessment of pain intensity and disability at 6-week follow-up (5 patients in the educational booklet group and 8 patients in the Pilates group), and 2 patients did not provide sufficient information for classification into the Pilates CPR subgroup. Thus, 208 patients were analyzed in the TBCS analysis and 206 patients in the Pilates CPR subgroup analysis. Considering the TBCS, 64.9% of patients in the educational booklet group and 58.1% in the Pilates group were classified into the negative movement control subgroup. According to the Pilates CPR, 58.1% of patients in the educational booklet group and 54.1% in the Pilates group were classified into the positive Pilates subgroup.

TABLES 4 and **5** present the results of subgroup analyses for pain intensity and disability, respectively. None of the interaction terms (the positive movement control subgroup or positive Pilates CPR subgroup) for pain intensity and disability were statistically significant, and point estimates did not exceed the threshold determined for clinical importance. **FIGURE 1A** and **FIGURE 2A** show means for pain intensity and disability, respectively, at baseline and 6-week follow-up for the Pilates and educational booklet groups, separated by the positive movement control subgroup and the negative movement control subgroup. The effect of treatment (Pilates group versus educational booklet group) was similar in participants in both the positive movement control subgroup and negative movement control subgroup (**FIGURES 1** and **2**). **FIGURE 1B** and **FIGURE 2B** show the mean pain intensity and disability, respectively, at baseline and 6-week follow-up for the Pilates and educational booklet groups, separated by the positive Pilates subgroup and the negative Pilates prognosis. The effect of treatment (Pilates group versus educational booklet group) was similar in participants in both the positive Pilates subgroup and negative Pilates subgroup (**FIGURES 1** and **2**).

TABLE 4 Results of the Linear Regression Model for Pain Intensity at 6-Week Follow-up

Variable	β[a]	*P* Value
TBCS: movement control subgroup		
Treatment	2.3 (1.3, 3.2)	<.001
Positive movement control subgroup	−0.9 (−2.2, 0.4)	.16
Interaction[b]: treatment versus movement control subgroup	−0.3 (−1.9, 1.3)	.73
CPR: Pilates subgroup		
Treatment	1.7 (0.5, 2.9)	<.001
Positive Pilates subgroup	−0.1 (−1.4, 1.1)	.82
Interaction[b]: treatment versus Pilates subgroup	0.6 (−0.9, 2.2)	.19

Abbreviations: CPR, clinical prediction rule; TBCS, treatment-based classification system.
[a]*Values in parentheses are 95% confidence interval.*
[b]*Interaction terms provide the critical information for assessing whether effect modification exists. Negative interactions mean that the effect was in the opposite direction to that hypothesized. Positive interactions mean that the direction of the effect was in favor of the hypothesis.*

TABLE 5 Results of the Linear Regression Model for Disability at 6-Week Follow-up

Variable	β[a]	*P* Value
TBCS: movement control subgroup		
Treatment	5.0 (3.0, 6.9)	<.001
Positive movement control subgroup	−0.5 (−3.2, 2.1)	.69
Interaction[b]: treatment versus movement control subgroup	−2.4 (−5.6, 0.9)	.15
CPR: Pilates subgroup		
Treatment	3.7 (1.2, 6.1)	<.001
Positive Pilates subgroup	0.3 (−2.6, 2.9)	.80
Interaction[b]: treatment versus Pilates subgroup	0.3 (−2.9, 3.4)	.87

Abbreviations: CPR, clinical prediction rule; TBCS, treatment-based classification system.
[a]*Values in parentheses are 95% confidence interval.*
[b]*Interaction terms provide the critical information for assessing whether effect modification exists. Negative interactions mean that the effect was in the opposite direction to that hypothesized. Positive interactions mean that the direction of the effect was in favor of the hypothesis.*

DISCUSSION

Principal Findings

THE PURPOSE OF THIS SECONDARY analysis of a randomized controlled trial was to investigate whether the movement control subgroup of the TBCS or the positive Pilates defined by a CPR could identify patients with nonspecific chronic LBP who would benefit more from Pilates-based exercises compared to an educational booklet. Based on our results, neither of the subgroups investigated was an effect modifier for response to Pilates. The results were consistent for the 2 assessed outcomes (change in pain intensity and change in disability). While the CIs for the interactions are somewhat wide, 2 of the 4 interaction terms were contradictory to the hypothesis. The limits of the CIs in the direction of the hypothesis were relatively small (less than 1.3 for pain and less than 3.4 for disability), suggesting that we did not miss important moderation effects.

Strengths and Weaknesses of the Study

A strength of this study was that the data were derived from a randomized controlled trial.[38] Furthermore, this study was designed before the beginning of the randomized controlled trial. Thus, the variables and clinical outcomes were collected prospectively, with the purpose of investigating effect modification.[51] This secondary analysis is the first study to investigate whether Pilates exercises provide more benefits in a specific TBCS subgroup of patients with nonspecific chronic LBP. Although, theoretically, Pilates may be a good approach for patients in the movement control subgroup of the TBCS, the TBCS was not specifically developed to identify patients who are likely to respond best to Pilates. In addition, this is the first hypothesis-testing study to validate the Pilates CPR in a randomized controlled trial. However, the randomized controlled trial was powered for the evaluation of differences in effect between the intervention groups. Consequently, a limitation of this study was the lack of statistical power for the subgroup analysis.[7] In secondary analysis with interaction tests, a randomized controlled trial with 80% power for overall effect has only 29% power to detect an interaction effect of the same magnitude.[7] However, the relatively tight CIs suggested that we did not miss an important interaction effect.

FIGURE 1. Means for pain intensity at baseline and 6-week follow-up for the (A) movement control subgroup of the treatment-based classification system and (B) Pilates subgroup defined by a clinical prediction rule.

FIGURE 2. Means for disability at baseline and 6-week follow-up for the (A) movement control subgroup of the treatment-based classification system and (B) Pilates subgroup defined by a clinical prediction rule.

Comparison With Other Studies

The main criteria used for the TBCS[2] are pain intensity and disability levels. A prospective cohort study[44] found that higher pain intensity and disability at baseline are associated with greater clinical improvement in patients with chronic LBP after 4 weeks of treatment, regardless of the intervention.[44] As the symptom modulation subgroup of the TBCS[2] is defined by high levels of pain intensity and disability, it may not be surprising that the effect of Pilates was greater in participants in the negative movement control subgroup than in those in the positive movement control subgroup. Furthermore, in our study, most patients presented significant symptoms and were classified into the symptom modulation subgroup (55.4% of patients in the educational booklet group and 49.3% in the Pilates group).

In our study, the Pilates subgroup based on a CPR did not respond best to Pilates. This Pilates subgroup was developed in a cohort study[50] without a control group, so it is not surprising that the CPR did not identify those who would respond best to Pilates when tested in a randomized controlled trial. Clinical prediction rules developed in cohort studies cannot distinguish whether predictors are simply prognostic factors regardless of treatment or are effect modifiers.[49] Previous studies have shown that lack of leg symptoms[24,43] and shorter duration of current symptoms[13,16] are general prognostic factors, regardless of treatment. Other CPRs developed in cohort studies[9,11,27] have failed to validate as effect modifiers when tested in randomized controlled trials.[10,12,46] This likely occurs because CPRs developed in cohort studies are prone to identifying prognostic factors rather than effect modifiers. Furthermore, patients in this hypothesis-testing study had similar characteristics compared to the CPR study (age, body mass index, moderate pain and disability at baseline). There were some differences in the patients included in the Stolze et al[50] study (patients with acute, subacute, and chronic LBP) and ours (patients with chronic LBP), and we cannot rule out that these may have contributed to the different results. However, although the CPR study included patients with acute, subacute, and chronic LBP, most patients experienced symptoms for more than 6 months.

Meaning of the Study and Future Research

Although the randomized controlled trial showed that Pilates is more effective than an educational booklet for patients with chronic LBP,[38] the present study was unable to identify effect modifiers for Pilates exercises. Pilates is an individualized exercise program adapted to individual patient characteristics.[33,34,40,41,54,55] It is possible that the Pilates approach had relatively consistent effects across the included population and that no important subgroups exist. Given the current evidence[26,48,56] that there is no specific exercise that produces greater effects than other forms of exercise, and the inability to identify clear effect modifiers for different types of exercise, the choice of exercise approach should be based on patient preference and clinician expertise. Future research can be conducted to investigate other potential effect modifiers for patients with nonspecific chronic LBP who are most likely to benefit from Pilates exercises. This could be conducted in a randomized controlled trial to identify new variables with a stronger biological rationale that have not been tested as effect modifiers (eg, hip flexion range of motion, positive prone instability test, aberrant movements).

CONCLUSION

The results of this study suggest that the TBCS movement control subgroup and CPR Pilates subgroup were not treatment effect modifiers for patients with nonspecific chronic LBP. Therefore, specific exercises did not produce greater effects than other types of exercise, thus the choice of exercise approach can be based on patient preference and clinician expertise. ◉

KEY POINTS

FINDINGS: The results of this study show the inability to identify Pilates exercises as clear effect modifiers.

IMPLICATIONS: The choice of exercise approach should be based on patient preference and clinician expertise.

CAUTION: A limitation of this study was a lack of statistical power for the subgroup analysis. However, the relatively tight confidence intervals suggested that we did not miss an important interaction effect.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: Dr Miyamoto was involved in setting the research question, trial design, protocol writing, data analysis, and manuscript preparation. Diego Amaral was involved in protocol writing and manuscript preparation, and was also the researcher responsible for patient subgroup classification and the blinded assessor for follow-up assessment. Dr Miyamoto, Katherinne Franco, Yuri Franco, and Naiane de Oliveira were the therapists of the study. Dr Cabral contributed to randomization schedule preparation, protocol writing, and manuscript preparation. Drs van Tulder and Hancock contributed to data interpretation and statistical analysis. All authors reviewed and approved the manuscript prior to submission.

DATA SHARING: All data used in this study are available on request and may be reused for individual patient data analysis. Dr Miyamoto is responsible for the data (gfisio_miyamoto@hotmail.com).

PATIENT/PUBLIC INVOLVEMENT: In this study, patients were not involved in the design, conduct, interpretation, and/or translation of the research.

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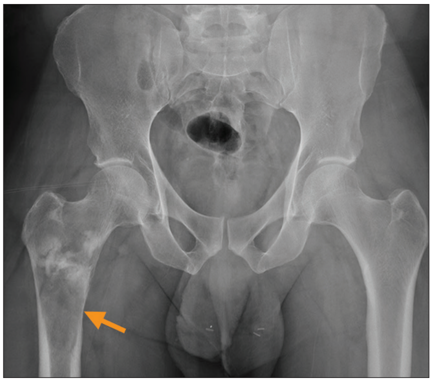

FIGURE 1. Anteroposterior radiograph of the pelvis showing a proximal femur osseous lesion (arrow).

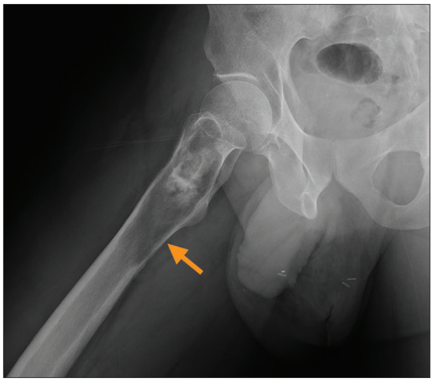

FIGURE 2. Frog-leg radiograph of the right femur showing a proximal femur osseous lesion (arrow).

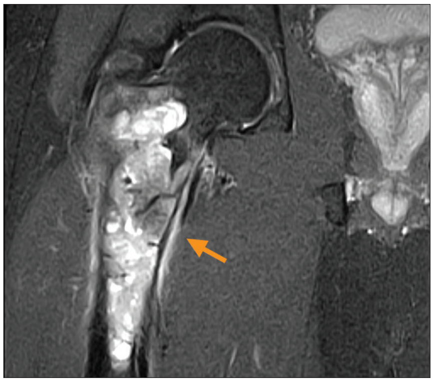

FIGURE 5. Coronal, contrast-enhanced, proton-density magnetic resonance image of the right hip demonstrating osteosarcoma of the proximal femur (arrow). The mass extends into the proximal metadiaphysis of the femur and into the base of the femoral neck, the lesser trochanter, and the base of the greater trochanter.

Osteosarcoma in a Man Referred for Lumbar Radiculopathy

APRIL J. BROWN, PT, DPT, OCS, MSCI, *Department of Rehabilitation Services, School of Allied Health Professions, Louisiana State University-Shreveport, Shreveport, LA.*
ASHLEY GONZALEZ, PT, DPT, *Department of Rehabilitation Services, School of Allied Health Professions, Louisiana State University-Shreveport, Shreveport, LA.*

A 48-YEAR-OLD MAN REPORTED right hip pain and low back pain, which started 2 months prior after a forceful hip flexion injury while freeing his foot from under his motorcycle. He was referred to physical therapy by an orthopaedic surgeon after magnetic resonance imaging revealed an L1-2 symmetrical disc bulge. His chief complaint was worsening right groin pain. He denied night pain, weight change, recent infection, fever, or chills.

Upon examination, he demonstrated reduced stance phase on the right leg during gait. Lumbar range of motion (ROM) was within normal limits; extension reproduced groin pain but not back pain. Neural tension tests from L1 to S1 were unremarkable. Passive hip ROM was comparable to that of the left side, but painful at end ranges in all planes, including combined flexion, adduction, and internal rotation (FADIR) and combined flexion, abduction, and external rotation (FABER). Right hip flexion during left single-leg stance reproduced significant groin pain. Right single-leg stance reproduced a minimal anterolateral hip ache. A severe hip flexor strain with labral involvement was suspected based on presentation and injury mechanism.[1]

The patient attended 3 treatment visits over 7 days, which consisted of grade I to II hip accessory mobilizations and pain-free hip active ROM. However, each visit exacerbated the patient's groin pain, so the physical therapist recommended the patient return to his surgeon for hip imaging.

Radiographs revealed a right proximal femur osseous lesion (**FIGURES 1** and **2**). Magnetic resonance imaging was subsequently performed (**FIGURES 3** and **4**, available at www.jospt.org, and **FIGURE 5**), and a biopsy established the diagnosis of osteosarcoma. Physical therapy ceased and the patient underwent further medical management. After tumor excision, chemotherapy, and megaprosthesis total hip replacement (**FIGURE 6**, available at www.jospt.org), he returned 6 months later to address hip ROM, gait instability, and strength deficits.

This case highlights the importance of differential diagnosis, regardless of referral diagnosis, and demonstrates the importance of timely referral back to a physician when physical therapy management is not effective. *J Orthop Sports Phys Ther 2020;50(4):214. doi:10.2519/jospt.2020.9131*

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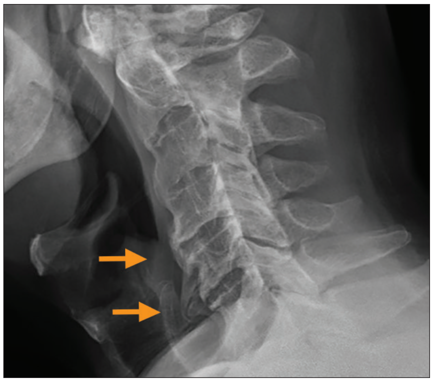

FIGURE 1. Lateral-view radiograph of the cervical spine, showing multilevel spondylosis with bridging osteophytes (arrows).

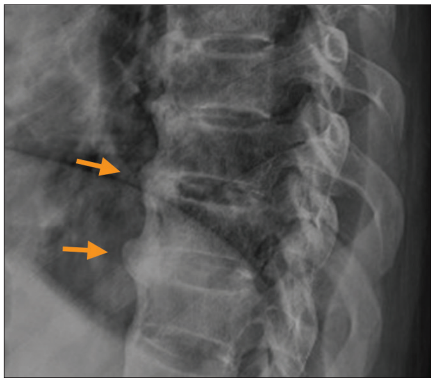

FIGURE 2. Lateral-view radiograph of the thoracic spine, showing characteristic flowing ossifications at the anterolateral aspect of the spine (arrows).

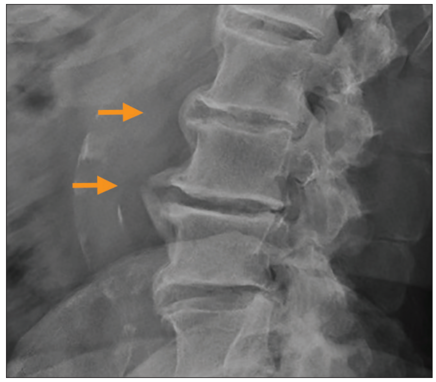

FIGURE 3. Lateral-view radiograph of the lumbar spine, showing anterior bridging osteophytes at multiple levels (arrows).

Diffuse Idiopathic Skeletal Hyperostosis in a Patient With Shoulder Pain

KYLE W. FELDMAN, PT, DPT, OCS, CSCS, FAAOMPT, *ReShape Physical Therapy, Winchester, VA.*
AARON J. HARTSTEIN, PT, DPT, OCS, FAAOMPT, *Doctoral Program in Physical Therapy, Shenandoah University, Winchester, VA.*

A 74-YEAR-OLD MAN WAS REFERRED to physical therapy by his primary care physician for insidious onset of right shoulder pain, which limited overhead range of motion (ROM). He had impaired sleeping tolerance for 5 months and also reported years of morning stiffness to his neck, left hip, and low back that lasted 1 to 2 hours but improved with exercise. Pertinent medical history included gout and type 2 diabetes mellitus.

Right shoulder assessment revealed ROM loss in a capsular pattern with symptom provocation. Despite clear mechanical shoulder impairments, his ROM and joint mobility loss were not typical of age-related degenerative changes and suggested systemic inflammatory disorder. Further examination revealed 75% loss in cervical, thoracic, and lumbar spine ROM in all directions.[1] Significant hypomobility was noted along the entire spine during accessory testing. Spinal radiographs and the human leukocyte antigen (HLA-B27) test, which is used to identify common autoimmune disorders, were completed.

The radiographs revealed multilevel changes consistent with diffuse idiopathic skeletal hyperostosis (DISH) (**FIGURES 1** through **3, FIGURE 4** available at www.jospt.org). The HLA-B27 test, positive in 8% of individuals with DISH, was positive. The primary care physician recommended changes to the patient's diet and changed his insulin dosage to be consistent with current recommendations for spondyloarthropathy.[3] Physical therapy intervention included education; activity modification; spine, shoulder joint, and soft tissue mobilizations; periscapular and trunk strengthening; and cardiovascular exercise. After 10 weeks, he reported improved tolerance to sleeping, yard work, and household tasks.

The prevalence of DISH increases between the ages of 70 and 79 years.[2] Further, the relationship between DISH and enthesopathy might have contributed to his impairments. Clinicians should be aware of systemic inflammatory presentations, their relationship to previous medical history or musculoskeletal complaints, and the appropriate testing. Appropriate referral and additional medical assessment assisted the identification of DISH, which enhanced management and improved this patient's function. *J Orthop Sports Phys Ther 2020;50(4):215. doi:10.2519/jospt.2020.9243*

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HEGE GRINDEM, PT, PhD[1,2] • GRETHE MYKLEBUST, PT, PhD[1]

Be a Champion for Your Athlete's Health

In a refreshingly honest account, Hammerseng-Edin[4] highlighted the dark side of elite sport culture and called for discussion about the balance between protecting the athlete's health and pursuing athletic greatness in elite sport. When a former athlete warns us that the load on athletes is too high, we should take it seriously. Many parties are involved in this issue, most of all managers, coaches, athletes, and members of the health team. As sports physical therapists, we offer our perspective.

Robust Systems Help Clinicians and Athletes Manage Health Risk

Some clubs have established systems that reduce the health risks for the athletes. These systems may include expert health teams in close contact with athletes, a well-functioning load-monitoring system, strict guidelines for return to sport after injury, and regular injury prevention training. Robust systems require resources,[4] and the investments of a club or federation will influence the health risk of the athlete. However, between the limits of what the club considers to be an unacceptable cost or demand of the athlete and what the club considers to be unacceptable health consequences, there is room for individual decisions that either increase or decrease the health risk for the athlete (**FIGURE**).

A one-sided focus on short-term athletic gain and a success-at-all-costs mentality may drive decisions toward the limit of unacceptable health consequences. Opposing forces push decisions toward the lower end of health risk: long-term athletic success depends on athletes being healthy enough to perform.[3] Public discussions, such as the one initiated by Hammerseng-Edin,[4] increase our awareness of the problem, and injury prevention campaigns successfully reduce sports injury incidence.[7]

The Sports Physical Therapist's Roles and Responsibilities

Deciding whether an athlete should play is important, and the sports physical therapist's role in this decision may vary in different contexts. The decision may be to return to play after an injury, to modify training due to an overuse problem, or to end an athletic career for health reasons. Sometimes, the sports physical therapist is the only member of the health team; at other times, we work in large teams with limited authority. Our roles and responsibilities must be clearly defined within the specific context in which we work. It is incontrovertible that there is a difference between coaching responsibilities and medical responsibilities—the manager does not make medical decisions and the sports physical therapist does not decide the team tactics. Like the athlete who faces tremendous pressure to compete when she should not, we are not immune to pressure from athletes, coaches, media, and sponsors. Protecting the athlete's health at the potential cost of short-term athletic success does not come without risks to our career.[8]

Duty of Care and Ethical Obligations The code of ethics of the International Federation of Sports Physical Therapy offers guidelines and key ethical principles[5] to guide practicing sports physical therapists: "The basis of the relationship with the athlete should be that of absolute confidence and mutual respect," and our advice and decisions should only be influenced by the health risk of the athlete, not by coaches or the outcome of the competition.[5] The sports physical therapist's role is to provide advice about whether an athlete should play, and the sports physical therapist should not delegate this advice.[5] Yet return-to-sport decisions are often made by the athlete.[4] We suspect the biggest problem is simply that the club has not allocated enough money

SYNOPSIS: Many athletes push themselves beyond their limits and sacrifice short-term well-being and long-term health for a chance at victory. Elite sport shapes a certain type of character: mentally and physically tough, and unrelenting in the pursuit of the marginal gains that separate champions from the second best. The difficult question, especially for elite sports, is, "How do managers, coaches, athletes, and members of the health team find the balance between protecting the athlete's health and pursuing athletic greatness?" In this Viewpoint, we offer 4 perspectives on the roles and responsibilities of sports physical therapists: (1) the care of, and ethical obligations to, the elite athlete, (2) decision making that is in the athlete's best interest, (3) building a working relationship with the athlete, and (4) supporting athletes who face end-of-career decisions.
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KEY WORDS: *athletic health, physical therapy, return to sport, sports injury, sports physical therapy*

[1]Oslo Sport Trauma Research Center, Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway. [2]Stockholm Sports Trauma Research Center, Department of Molecular Medicine and Surgery, Karolinska Institutet, Stockholm, Sweden. The authors certify that they have no affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article. Address correspondence to Dr Hege Grindem, Norwegian School of Sport Sciences, PO Box 4014, Ullevål Stadion, 0806 Oslo, Norway. E-mail: hege.grindem@nih.no

to health personnel. The sports physical therapist is therefore not always present when the decision is made.

Core ethical documents from other national and international professional organizations are also relevant. One fundamental principle endorsed by most organizations is that physical therapists should always act in the best interests of the patient.[5,9,10] Sports physical therapists who are employed by a club have a responsibility to help the club achieve its sporting goals. Although the interests of the athlete and the club often align, sometimes there might be disagreement. In these situations, the ethical guidelines for physical therapists clearly instruct us to act in the interests of the athlete.

What Is in the Athlete's Best Interest?

Decisions to play are too often left to the athlete, without adequate support to make an informed decision.[4] External pressure and internal motivation compel elite athletes to make decisions that are not in their best long-term interest. For return-to-sport decisions, strict criteria can help us decide. Norway's national handball team provides a good example: players with anterior cruciate ligament reconstructions must pass return-to-sport criteria and wait for 1 year after surgery before they can play matches.

For overuse injuries, regular monitoring with instruments like the Oslo Sports Trauma Research Center overuse injury questionnaire[2] can detect problems early and serve as a guide to manage load. But these decisions are complex, and, in most scenarios, it is the athlete who must determine whether the reward of playing is worth the risk. Even if health care professionals fully understand the health risks, determining what is in the athlete's best interest requires in-depth knowledge about how playing (and not playing) will affect the athlete's life in the short and long term. Most athletes will probably confirm that participating in the Olympics is worth the risk of a hamstring reinjury, but the health team cannot make that decision alone.[1] The athlete should have the final say about the level of risk that is acceptable and, therefore, must be involved in the decision.

Mutual Respect and Trust

Of all health care professionals, sports physical therapists are often in closest contact with the athlete. To protect the athlete's health, it is paramount to build a relationship of mutual respect and trust. We offer 4 suggestions to help sports physical therapists build that relationship.

1. Respect confidentiality. Do not reveal information to other people affiliated with the team or to the media unless the athlete consents. The athlete should feel free to discuss his or her problems honestly, without fear of consequences.
2. Give strong recommendations when it is obvious that playing carries a substantial health risk, and justify your recommendations to the athlete and the coach.
3. Provide consistent information to the athlete and the coach. Never downplay the severity of an injury when you talk to an athlete.
4. Build a relationship with the coach and get to understand his or her point of view. Mutual respect is needed if he or she is to follow our recommendations.

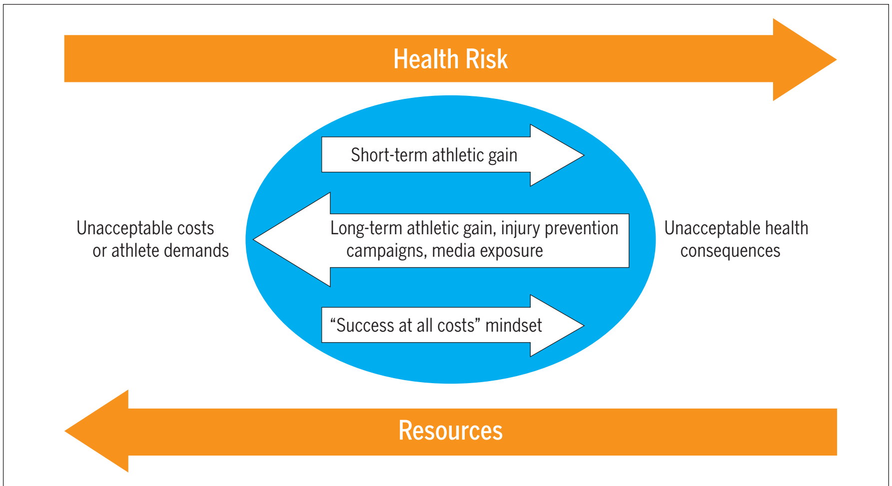

FIGURE. Model of the dynamic system within a club or federation that influences the health risk for athletes. The space for individual decisions is inside the blue circle. White arrows contain examples of forces that can drive the health risk up or down.

Is It Time for Life After Sports?

Sports physical therapists who work for the athlete's club can help the athlete decide when it is time to retire. During the athlete's career, we gain important insight into her medical and personal history. However, in situations where the interests of the club and athlete do not align, there is an inherent conflict of interest. Therefore, consulting a health care professional with no connections to the team may be appropriate for athletes who are considering retirement for health reasons. Although members of the club's health team assess and treat most injuries sustained by athletes, athlete contracts should never restrict the athlete's right to an assessment of risks to long-term health by someone who is unaffiliated with the club. If the discussion takes place with the club's health team, then an athlete-centered approach[6] can lay the necessary foundation to approach this difficult topic.

SUMMARY

Sports physical therapists play an important role in protecting the health of athletes while they push their limits to pursue athletic success. Our close connection with the athlete offers the opportunity to help her make good choices on a range of topics, including return to sport after injury, strategies to reduce the risk of injury, and when to retire. Working with ambitious athletes is rewarding, but we must remember that, first and foremost, we are health care professionals. In the jungle of advice and pressure from athletes, coaches, sponsors, parents, and media, we owe it to our athletes to base our practice on sound evidence and clinical experience.

Key Points

Building a relationship of mutual respect and trust between health care professionals, coaches, and athletes can be facilitated by

- Respecting confidentiality. Do not reveal information to other people affiliated with the team or to the media unless the athlete consents
- Delivering strong recommendations when it is obvious that playing carries a substantial health risk to the athlete
- Providing consistent and accurate information to the athlete and the coach
- Striving to understand the coach's point of view ◉

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GRO HAMMERSENG-EDIN[1]

The Alarm Bells Are Ringing: A Call to Action From a Newly Retired Professional Athlete

Alarm bells are ringing because the total load on elite athletes is too high. Many factors contribute to the total load, including the intensity and frequency of matches and practices, sponsor assignments, frequent traveling, and media pressure. Some athletes may handle it, but for the rest of us, being the best comes with a high price tag. There is no easy solution—athletes, coaches, and managers will not lower their ambitions. We in the elite sports community cannot wait until athletes start complaining, because elite athletes do not complain. We proudly push our bodies beyond their limits. This is our trademark.

Athletes who manage extreme training loads are idols. They set the bar. Who would dare to raise their head above the parapet and shout, "I can't take this. It is too much!"? Few will risk their position by admitting they can't deal with the load. Coming forward might not lead to severe consequences, but, in the mind of the athlete, the possibility of blowback is often enough. It is better to be silent. Those who have a rock-solid position on a team might be in a position to speak up, but even for them it is tough. I know—I have been one of them (**FIGURE**).

Some athletes go through surgery after surgery to continue to compete. They keep fighting until there are no reasonable treatment options left and pay a high price in retirement: knees, hips, shoulders, and other body parts worn out to the point where it is hard to sleep, to work, to function. I made my own decision about when to retire and kept playing handball until I was 37. Should I have retired sooner? Time will tell, but I have certainly had enough injuries to have an opinion on this topic.

Athletes Who Are Passionate About Their Sport Often Lose the Ability to Think Rationally About Load and Injuries

In this Viewpoint, I focus on the athletes who sometimes underreport or ignore their injuries and on those whose concerns are not taken seriously. I want to start a discussion about how to ensure that the total load is manageable over the athlete's career.

Team Culture Ambitious athletes who are part of a good team culture are rarely lazy. Many worry about not training enough, which leads to overtraining. I was a poor role model for my teammates in the last few years I played. I rarely skipped a training session and did not ask for adjustments, even though I was in pain from accumulated injuries. I used painkillers almost daily and saw others do the same. I took nonsteroidal anti-inflammatory drugs before practices and matches, and powered through. I loved to play and wanted to be a leader, yet I contributed to a culture that expected me to play with pain and injuries—to play at all costs.

As a team player, I always put my team first. If it was important for the team that I play, I pushed myself beyond my limits. When so many others were playing with injuries, it was easy to think that I should ignore mine. A vicious cycle.

Increasing Pressure on Today's Elite Athletes Today's elite athletes experience extreme pressure to perform at their highest level, both inside and outside the sports arena. I know several athletes who have said that they feel some relief when they sustain an injury. Finally, a chance to slow down—the injury being a valid reason to step out of the circus for a while. This happens at the top levels of profes-

SYNOPSIS: The total load on elite athletes is too high. There is no easy solution to this problem—athletes, coaches, and managers do not want to lower their ambitions. We cannot wait to address the problem until athletes start complaining, because elite athletes do not complain. We proudly push our bodies beyond the limits, and that is our trademark. Very few athletes will risk their position by admitting they can't deal with the load. What I need you to take seriously is that athletes who are passionate about their sport often lose the ability to think rationally about load and injuries. This Viewpoint is about athletes who sometimes underreport or ignore their injuries and whose concerns are not taken seriously. I want to start a discussion: how do we in the elite sports community ensure load is manageable across the athlete's career? *J Orthop Sports Phys Ther 2020;50(4):170-172. doi:10.2519/jospt.2020.0604*

KEY WORDS: *athlete perspective, athletic health, physical therapy, return to sport, sports injury, training load*

[1]Larvik Handball Club, Larvik, Norway. The author works as a presenter, expert sports commentator, and writer. She is the chairwoman of the International Handball Federation Athletes' Commission and is a board member of Larvik Handball Club. The author certifies that she has no other affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article. Address correspondence to Gro Hammerseng-Edin, Hølen Verft 35, 3260 Larvik, Norway. E-mail: grohammersengedin@gmail.com

sional sports. The same athletes have also accepted that being an elite athlete means they will have pain and often feel exhausted. The thrill of competing makes the sacrifice feel worth it.

Should the Athlete Make the Decision to Play? It is too often up to the injured athlete to decide when she is ready to train. Through most of my career, I appreciated being the one who made the decision. But looking back, I'm not sure I should have been. I understand that only the athlete can feel her pain and make decisions based on what she feels. The problem is, we will not always tell you what we feel. Many clubs do not have the resources to provide appropriate medical support. Therefore, coaches and players become responsible for decisions they are not qualified to make. It is too easy to be blinded by emotions and external factors, such as the important game next week.

I lost my head too many times. I was so hungry to play, to be part of the team. I valued the recognition and feedback my professional life brought. I feared falling behind, or not making the team. I was proud to be someone who rarely complained and was acknowledged for that ability. Not complaining became my trademark, and I had to live up to that image. I truly appreciate my ability to push myself to the limit, but I want to warn athletes that there is a fine line between being resilient and torturing your body so much that it will not function well for the rest of your life. I did not always consider the long-term consequences. Not until someone brutally explained the consequences to me, straight to my face. But even then, I sometimes chose to play.

FIGURE. Gro Hammerseng-Edin is a former national team handball player and captain for Norway. She was the International Handball Federation World Handball Player of the Year in 2007, is a 3-time European champion (2004, 2006, 2010), is an Olympic champion (2008), and is a 6-time champion of the Norwegian League, Playoff, and Cup. She also has silver medals from the European Championship (2002) and World Championship (2001, 2007). Photograph reprinted with permission from the Norwegian Handball Federation.

Physical Therapists Are Key Allies

I have been privileged to work with physical therapists who helped me make good decisions in my career. You are invaluable! When you are pressured to push your limits as a health care professional, remember, professional sport takes an extreme toll on the athlete's body. You might stand between the athlete pushing herself too far and finishing her career with her health intact.

I encourage coaches, club management, health teams, and all others who are responsible for the athlete's health to implement solid routines, including injury prevention strategies, close follow-up, and reasonable training loads. My recommendations for sports physical therapists are to:

1. Champion a culture that considers masking injuries to be unprofessional and taking competition breaks to be healthy and admirable.
2. Make it clear to athletes that they can, and are expected to, let you know when they are in pain before they feel completely worn out. Let the athlete be the one to decide how much information should be passed on to the coaching team.
3. Foster close and honest communication between athletes and the health team. Build trust and get to know the athletes so that they give honest answers to your questions and concerns.
4. Recognize that sometimes the athlete may be incapable of making the final decision. When it is obvious that the right decision is to sit on the bench, make the decision for the athlete.

Coach Responsibility

The coach will often listen to the opinions of the physician, the physical therapist, and the athlete, but still has a responsibility to protect the athlete's health. The coach knows that athletes will do everything they can to be in the starting lineup or to qualify for the national team and championships.

Coaches see the athlete in daily practice and know the training schedule. A good coach will (1) know when to pay closer attention to the athlete's total load; (2) protect the athlete when the number of training hours, matches, travel days, championships, sponsor assignments, media pressure, etc, is too high; and (3) respect and collaborate with the health team and not overrule decisions made to protect the athlete's health.

A Culture Shift in Professional Sports

A culture shift will only happen if athletes fight for it. Top athletes from leading nations in the sport must lead the culture change. There is a cost to fighting this battle, but it helps when influential athletes use their position to bring attention to important causes. These athletes are also often the ones who risk the least by confronting potentially unpopular topics.

To promote a culture shift in professional sports, athletes should do the following:

1. Think of recovery, sleep, nutrition, and injury prevention training as equally important as technical or physical training. We must educate athletes from an early age!
2. Recognize that they have a professional duty to work with the coach to regulate their load when it is too high. Athlete monitoring systems can help quantify loads of various kinds, but the athlete alone knows how she is actually feeling.
3. Applaud other athletes when they make choices that lead to a healthier life. The “athlete hero” should be the one who stands up for health, not the one who can endure the most pain.
4. Consider organizing for improved and enforced employee rights. It is easier to create change from a united front. A single voice is not effective in negotiating issues like match scheduling, tournament frequency, and vacation periods.

SUMMARY

TOO MANY ELITE ATHLETES SUFFER the consequences of pushing their bodies beyond the breaking point. The extreme pressure of professional sports and a culture that idolizes pain and personal sacrifice contribute to the problem. Physical therapists, coaches, and athletes can all play an important role in securing a healthy future for professional athletes. Let us stop telling the athletes, who have sacrificed their health for sport, that it was simply part of the game.

Key Points

Physical therapists can help athletes stay healthy by

- Championing a culture where masking injuries is considered unprofessional behavior
- Helping athletes understand that they can, and are expected to, report pain before they feel completely worn out
- Fostering close and honest communication between the athlete and the health team
- Recognizing that sometimes athletes are incapable of making the final decision about playing their sport ◉

LETTER TO THE EDITOR-IN-CHIEF

Letters to the Editor are reviewed and selected for publication based on the relevance, importance, appropriateness, and timeliness of the topic. Please see submission guidelines at www.jospt.org for further information. J Orthop Sports Phys Ther 2020;50(4):216-217. doi:10.2519/jospt.2020.0202

CAN "STRONG" RECOMMENDATIONS BE MADE FOR EXERCISE AND MANUAL THERAPY IN TREATING SUBACROMIAL SHOULDER PAIN?

In their recent review of systematic reviews on subacromial shoulder pain (SSP), Pieters et al[5] make several strong conclusions. We would like to comment on 2 of these. First, the authors claim that "evidence for exercise as an intervention for SSP is increasing and strengthening." Second, we discuss their decision to make a "strong recommendation" for the use of manual therapy in the initial treatment phase.

First, based on this review, it is not clear that the evidence for the use of exercise for SSP is increasing or strengthening. It might be accurate to say that the volume of research evidence is increasing, but this is not the same as suggesting that the evidence in favor of exercise for SSP is increasing and strengthening. To substantiate this recommendation would require clear evidence of increasingly consistent, clinically important effect sizes over time, which does not appear to be the case, or at least cannot be derived from the data provided in this review of systematic reviews. As the authors reflect, there is considerable uncertainty around the optimal type, dose, and duration of exercise for SSP, or, indeed, whether these characteristics of exercise programs matter greatly in terms of patient outcomes. Most of the included systematic reviews do not comment on effect size or the clinical importance of the between-group differences observed. In those that do, we would like to draw readers' attention to the wide confidence intervals (indicating uncertainty). We therefore believe it would be more accurate to conclude that, based on the rating system used in this review of systematic reviews, there is evidence for using exercise for SSP, but the clinical importance of the size of the differences observed is uncertain.

Second, their "strong recommendation" for the use of manual therapy in the short term needs further consideration to ensure accurate interpretation. Pieters et al[5] write that they have based this recommendation on the number of studies that report high-, moderate-, and low-quality evidence for each treatment. However, they seem to overstate the strength of the evidence described in these reviews. Of the 4 reviews underpinning their strong recommendation for manual therapy, it is true that both Page et al[4] and Haik et al[3] describe the level of evidence they found as "high." But Page et al[4] report high evidence for no clinically important differences between exercise and manual therapy versus placebo. Further, Desjardins-Charbonneau et al[2] describe the evidence as "low to moderate," and Steuri et al[6] as "very low quality," not moderate, as Pieters et al[5] report for both. If these studies were reclassified as low quality, then Pieters and team's[5] strong recommendation could not be made.

In addition to our concerns about the basis for this strong recommendation, we would like to add that the recommendation reflects the authors' conclusions about the quality of the evidence, but it does not represent the size or clinical importance of the effect of exercise or exercise combined with manual therapy. Statistical significance is not the same as clinical importance. In fact, the conclusions of these systematic reviews are far more tentative than the phrase "strong recommendation" might imply. Indeed, Desjardins-Charbonneau et al[2] write that the effect "may or may not be clinically important," and the study by Page et al,[4] a Cochrane systematic review, reports "no clinically important difference between groups in any outcome."

Hence, we believe it would be more accurate to conclude, based on the rating system used by Pieters et al,[5] that there is evidence for using exercise combined with manual therapy for SSP, but the clinical importance of any benefits observed is uncertain. Such a conclusion would be in keeping with the only sham-controlled trial on this topic, by Bennell et al,[1] which found that a standardized program of manual therapy and home exercise did not confer additional immediate benefits for pain and function compared with a realistic placebo treatment, but at 22 weeks there was a statistically significant difference between the treatment groups that did not meet the threshold for clinical importance.

We hope this letter helps readers to accurately interpret the findings of this recent review of systematic reviews of treatments for SSP.

Chris Littlewood, PhD
Tom Jesson, BSc
Nadine Foster, DPhil
School of Primary, Community and Social Care
Keele University
Staffordshire, UK

Dr Littlewood has recently collaborated and published with the lead author (Louise Pieters) and senior author (Filip Struyf) of the work under commentary. No financial support was received for writing this letter. The authors certify that they have no affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the letter.

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RESPONSE

We would like to thank Dr Littlewood and his colleagues for their interest in our paper,[5] and for taking the time to express their concerns.

We address 3 key points. First, Dr Littlewood and his colleagues note concern with the statement of increasing and strengthening evidence for the use of exercise as an intervention for SSP. We acknowledge that the volume of research evidence is increasing, and that this is not the same as suggesting that the evidence in favor of exercise for SSP is increasing or strengthening.

In order to support our statements, we need clear evidence of increasingly consistent, clinically important effect sizes over time. As not all included systematic reviews reported effect sizes, only the available ones were reported in our paper.[5] In Littlewood et al's[3] 2013 review, exercise therapy was mentioned as a possibly effective intervention for SSP. Since 2013, there have been more studies in favor of exercise therapy, which makes a stronger conclusion possible. We agree that there might be a risk of misinterpretation. We believe that the strengths of our systematic review far outweigh the weaknesses in accomplishing this goal.

Second, we agree that continued research is needed to better understand the uncertainty around the ideal type, dose, and duration of exercise for SSP, and to what extent these characteristics matter in terms of patient outcomes. The main goal of our review[5] was to provide an overview of conservative physical therapy interventions and their effectiveness. The key conclusion is that there is evidence supporting exercise for SSP. However, what constitutes the most appropriate exercise regime is unclear.

Third, Dr Littlewood and his colleagues have concerns about the "strong recommendation" for the use of manual therapy in the short term. Of the 4 reviews underpinning our strong recommendation, Haik et al[2] and Page et al[4] describe the level of evidence as "high." For Desjardins-Charbonneau et al,[1] the evidence is described as "low to moderate," but the addition of manual therapy to an exercise program was significantly effective for pain reduction. Steuri et al's[6] description is ambiguous, but they describe different moderate effects of manual therapy on both pain and function. The word "strong" can also be used in different ways. When describing the quality of the evidence to be included in a review, a system needs to be put in place to describe differences and similarities that will be included. Not following such a process would be counterintuitive to the purpose of systematically reviewing research. One way to reduce bias is to clearly define criteria before analysis, a process we followed. The term "strong" was defined at the protocol development stage, before the search was conducted and before the data were analyzed.

We emphasize that all possible effects of manual therapy for SSP are seen in the short term following treatment, in the initial phase of rehabilitation, and always when manual therapy is used in addition to an exercise program. No effects of manual therapy as a solitary treatment were described.

Louise Pieters, PT
Kevin Kuppens, PT
Jill Jochems, PT
Twan Bruijstens, PT
Laurence Joossens, PT
Filip Struyf, PT, PhD
Department of Rehabilitation Sciences and Physiotherapy
Faculty of Medicine and Health Sciences
University of Antwerp
Antwerp, Belgium

Jeremy Lewis, PT, PhD
School of Health and Social Work
University of Hertfordshire
Hatfield, United Kingdom

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ANNE E. MCCARTHY, BS[1] • ALLYN M. BOVE, PT, DPT, PhD[2] • SARA PIVA, PT, PhD[2]
LAUREL PERSON MECCA, MA[3] • MICHAEL J. SCHNEIDER, PhD, DC[2]

A Qualitative Study of Preparation for Lumbar Spinal Stenosis Surgery: Perceptions of Patients and Physical Therapists

Lumbar spine stenosis (LSS) is a highly prevalent chronic condition, marked by compression and narrowing of the lumbar spine canal and associated with decreased walking tolerance (neurogenic claudication), that currently affects around 30% of older adults.[10] In cases of more severe LSS, or for those who fail conservative management, surgery is the preferred method of treatment.[3] Lumbar spine stenosis surgery is one of the fastest-growing inpatient procedures among adults,[4] with annual Medicare costs exceeding $1 billion.[25]

Despite the rise in utilization of LSS surgery, the success rate is only around 60%.[6,9,16,17] Several factors may contribute to the variability in postoperative LSS surgery outcomes, specifically the high proportion of suboptimal outcomes. Some of these factors include psychological considerations, such as anxiety[26] and depression,[8,20] and patients' expectations regarding their physical function after surgery.[7] Another such factor may also be the preparation phase prior to surgery. A recent meta-analysis by Wallis and Taylor[24] found low to moderate evidence that preoperative exercise, in conjunction with education programs, is beneficial to patients' postoperative physical function and physical activity. However, that meta-analysis was performed in studies of patients awaiting hip or knee replacement surgery. Presently, the literature describing common preoperative LSS surgery protocols is lacking, and there are no standardized guidelines for preoperative care.

Data gathered via focus groups are beneficial for understanding patients' and physical therapists' views on preoperative rehabilitation and education. To our knowledge, no other qualitative study has evaluated perspectives on care before LSS surgery from focus group data of both patients and physical therapists.

OBJECTIVES: To gain the perspectives of patients who underwent lumbar spinal stenosis (LSS) surgery and physical therapists who treat spine-related disorders regarding rehabilitation and other care prior to LSS surgery.

DESIGN: Qualitative focus group study.

METHODS: Sixteen patients (4 female; average ± SD age, 64.3 ± 8.8 years; time since surgery, 9.9 ± 4.4 months) and 10 physical therapists (2 female; average ± SD age, 40.9 ± 6.6 years; time in practice, 17.2 ± 7.7 years) participated. Four groups were conducted: 2 with patients post LSS surgery and 2 with physical therapists who treat spine-related disorders. Participants were asked open-ended questions by a trained facilitator regarding their perceptions of preoperative LSS education and rehabilitation. Transcripts were coded and themes were identified.

RESULTS: Analyses revealed 4 themes within the discussions: (1) desire for helpful information, (2) benefits of preoperative rehabilitation, (3) downfalls of preoperative rehabilitation, and (4) desire for coordinated care. Varying opinions on preoperative physical therapy between patients and physical therapists were discussed, revealing that similar numbers of participants held positive and negative perceptions of preoperative physical therapy. A desire for more thorough preoperative education and care was expressed by both groups.

CONCLUSION: There is a clear need for standardized preoperative LSS care and education. This may decrease misunderstandings about LSS surgery and its treatments in the future as well as improve coordinated care between surgeons and physical therapists. *J Orthop Sports Phys Ther 2020;50(4):198-205. Epub 30 Oct 2019. doi:10.2519/jospt.2020.8887*

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[1]US Army-Baylor University Doctoral Program in Physical Therapy, Fort Sam Houston, TX. [2]Department of Physical Therapy, University of Pittsburgh, Pittsburgh, PA. [3]School of Nursing, McMaster University, Hamilton, Canada. This study was granted exempt status by the University of Pittsburgh Institutional Review Board (PRO17020245). This work was supported by a contract with the Patient-Centered Outcomes Research Institute (contract CER-1410-25056; Dr Schneider is the principal investigator). The authors certify that they have no affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article. Address correspondence to Dr Allyn Bove, Department of Physical Therapy, University of Pittsburgh, 100 Technology Drive, Suite 210, Pittsburgh, PA 15219. E-mail: allyn.bove@pitt.edu

The purpose of this study was to gain the perspectives and opinions of patients who underwent LSS surgery and the physical therapists who treat such patients through the collection of qualitative focus group data.

METHODS

Four focus groups were conducted: 2 groups consisting of patients post LSS surgery and 2 groups consisting of physical therapists who commonly treat patients before and after LSS surgery. Patients who underwent surgery for LSS within the past 2 years were recruited via letters sent directly from surgeons' offices. Physical therapists were recruited with the assistance of a physical therapist facility director from the University of Pittsburgh Medical Center (UPMC). The physical therapist facility director identified physical therapists who commonly treat spine-related disorders and invited them via letters to participate in a focus group. Both samples of participants were recruited via convenience sampling.

Focus groups were conducted by a trained facilitator from the Qualitative Data Analysis Program at the University of Pittsburgh. This facilitator had a masters degree and 18 years' experience in qualitative and survey research. She was unknown to all participants in focus groups, and participants were only given her name and job title. Participants were aware that the facilitator was not a physician, surgeon, or physical therapist. Focus groups were held around a large, round table in a conference room at the University of Pittsburgh. The trained facilitator introduced herself and reiterated the purpose of the study to the participants, once again informing them that their opinions and views may help guide the development of future LSS preoperative protocols. An interpretive description approach[21] was used, with the facilitator asking open-ended questions of the participants (see the **APPENDIX**, available at www.jospt.org, for the full list of questions asked to each group). Questions for patients focused on the information and treatment received prior to surgery. Physical therapists received a separate set of questions regarding their preoperative goals for the patients and challenges they face in treating these patients.

Responses from each focus group were audio-recorded in duplicate, with 2 recording devices present in case one of them proved faulty, and a trained note taker was also present. Each focus group session lasted between 75 and 105 minutes. At the end of each focus group session, the trained facilitator provided a verbal summary of the discussion and asked participants whether they would like to clarify any points or add anything to the discussion that hadn't already been covered. Sessions were then transcribed verbatim, with names replaced by ID numbers. Participants were not given copies of the transcripts.

Data management and analysis were performed using ATLAS.ti qualitative data analysis software (Version 7.5.11; ATLAS.ti Scientific Software Development GmbH, Berlin, Germany). Transcripts were simultaneously and independently coded by 2 coders.[22] A codebook was created and used by both coders. An interpretive description approach was used to iteratively develop the codebook. Two coders reviewed the focus group transcripts independently, each proposing code names and definitions based on themes emerging from the data. The coding team discussed the 2 versions to arrive at 1 initial codebook. Each coder then independently coded 1 of the patient transcripts and 1 of the physical therapist transcripts using ATLAS.ti. The coding team adjudicated discordant coding and revised the codebook. The coders used this final version of the codebook to code the remaining 2 transcripts. After comparing codes, discrepancies were resolved through discussion. Emergent themes were derived from the data. Quotations were extracted from the transcripts to highlight the themes, and certain quotations were flagged as "mentions" within a theme; however, the frequencies of these mentions did not relate to the development of the themes. Themes were very similar across both patient and physical therapist groups, and the 2 coders agreed that data saturation had been achieved.

Intercoder reliability was assessed after the coding of the transcripts by calculating kappa statistics after the first round of coding, using Eusebius (K. Christine Scarpinatto, Pittsburgh, PA). The kappa statistic is a measure of interobserver agreement, with values ranging from –1 to 1. A value of 1 indicates perfect agreement, a value of 0 indicates chance agreement, and a negative value indicates agreement that is lower than what would be expected by chance.[23] The Institutional Review Board at the University of Pittsburgh granted this study an exempt status (PRO17020245); therefore, participants were not required to sign a consent form.

RESULTS

Participants

Sixteen patients who had undergone LSS surgery (4 female; average ± SD age, 64.3 ± 8.8 years; time since surgery, 9.9 ± 4.4 months) participated in this study. Ten physical therapists (2 female; average ± SD age, 40.9 ± 6.6 years; time in practice, 17.2 ± 7.7 years) also participated in focus groups. There were 8 patients in each of the separate patient focus groups, and 5 physical therapists in each of the separate physical therapist focus groups. The identification markers for quotations cited from patients ("P") and physical therapists ("PT") denote which focus group the speaker participated in, with patient markers ranging from P1 to P16 and physical therapist markers from PT1 to PT10. All participants who agreed to participate arrived and completed the full focus group session.

Interrater Agreement

A kappa statistic of 0.50 was calculated, indicating moderate interrater agreement.[13]

Themes

Several major themes arose from the discussions in these focus groups. Analysis found similar themes between the patient and physical therapist groups. The major themes included (1) desire for helpful educational information, (2) benefits of preoperative rehabilitation, (3) downfalls of preoperative rehabilitation, and (4) desire for coordinated care. Theme 4 was the only theme that arose solely from the physical therapist focus groups; all other themes arose from discussion within both patient and physical therapist groups.

Theme 1: Desire for Helpful Educational Information Many patients described having received very little educational information prior to their surgery. A majority of patients reported that they received detailed information about rehabilitation and care following their surgery, but they stated that they would have liked to have received much more of this detailed information before their surgery. Some of the participants' comments suggested that more educational information would have improved their recovery.

Other responses focused more on the lack of knowing what to expect during the immediate postoperative period and what one ought to expect in terms of recovery over time. One participant shared this experience:

> *"I received virtually no information prior unless I specifically asked a question … I thought I was prepared very well for what to expect when I left. But as far as before it started? If I didn't think to ask it, I didn't find out what information I needed. And I didn't know what to ask. So I went in purely trusting my surgeon because I had no information." (P5)*

The desire for more thorough preoperative education came up 28 times in the coding analysis of the patient groups (14 mentions in each group). In terms of feeling prepared for LSS surgery, the number of times patients mentioned feeling unprepared, somewhat prepared, and well prepared totaled 16 (6 in patient group A and 10 in patient group B), 13 (9 in patient group A and 4 in patient group B), and 19 (9 in patient group A and 10 in patient group B), respectively.

Similarly, physical therapists frequently stated that surgeons provide inadequate preoperative education and information about the surgical procedures to patients preparing for LSS surgery (29 mentions; 11 in physical therapist group A and 18 in physical therapist group B). They also talked about the lack of setting realistic postoperative expectations when consulting with these patients before surgery.

More quotations related to helpful information prior to preoperative physical therapy are found in the **TABLE**.

Theme 2: Benefits of Preoperative Rehabilitation Many patients found value in preoperative physical therapy. Preoperative physical therapy typically aims to maximize patients' physical function and strength prior to surgery in order to offset atrophy and decreased activity and function after surgery. Patient education is typically a crucial element of preoperative physical therapy as well, so that

TABLE Supporting Quotations of Themes

Theme/Group		Illustrative Quotations
1. Desire for helpful information		
Patients	P5	"Next time, if there is a next time, I would want to know exactly what he's going to do, literally exactly how long it's going to take, and I'd probably feel better in my recovery because I would know at least what he did. I just think any information would have helped me"
	P14	"…but if I would have wished for anything, it would have been more specific [instructions]—not just, 'go for a walk or walk more frequently,' but just some real very specific, 'if you do these 5 things, these 3 times a week, you'll improve.' Or, 'You won't improve.' Or, 'You'll get used to not being able to tie your shoe the whole way down anymore.' Just to get that information would be really helpful to me"
	P15	"You need the surgery, then okay I need it. And you sign the paper and schedule it outside and you're out the door. I mean he didn't explain anything"
	P7	"I didn't know until I was being [discharged from the hospital] that I basically was going to be either walking or [lying] down because [for] 2.5 weeks I was only allowed to sit up for 3 times a day for 20 minutes"
Physical therapists	PT1	"A lot of patients have the misplaced notion that the surgery is going to fix all of their symptoms, including their back pain … and those are the times where you start to worry, 'Are we going in the right direction now? Is this really the best alternative for you to have this surgery?' Because again, we've got an expectation and a possible outcome here that aren't necessarily going to align themselves"
	PT6	"A lot of [patients] ask things like, 'What is the surgeon going to do?' You kind of just give them the basic idea about what the surgery entails and what you're hoping for and the fact that we're hoping to fix more of the leg pain. You know what the realistic expectations may be for afterwards and that you're trying to [help them] regain function. A lot of them come in and the doctors will give them a brief overview, but they really don't know what's going on"
	PT4	"I think they need to know what they're in for"
	PT6	"…them being able to access [educational information], whether it's online or with handouts, whichever way they decide to go, and then a visit with a therapist after they've reviewed that material, I think, is very helpful because they're still going to have questions. How many of your patients say, 'My doctor never told me that'? And so they love the fact that you're sitting there for hopefully 30 to 40 minutes, and if they've got a question, 'Oh, I've read this, what does that mean?' And we can say, well, that's just simply this"

Table continues on page 201.

a patient learns what to expect from the recovery process. One patient appreciated preoperative physical therapy as a way of confirming the need for surgical intervention. Overall, patients reported a positive perception of preoperative physical therapy more often than a negative perception. This indicates that patients had a more positive than negative experience with preoperative physical therapy. One patient shared:

> *"...the surgeon gave me a script for PT, and I did four sessions. But he said that was to strengthen my muscles around my back to help me afterwards. And I don't know if they helped or not at that point, but I could tell you afterwards I wouldn't be walking straight if I didn't have physical therapy." (P4)*

Similarly, physical therapists reported that they perceived high value in patients attending physical therapy prior to surgery.

TABLE SUPPORTING QUOTATIONS OF THEMES (CONTINUED)

Theme/Group		Illustrative Quotations
2. Benefits of preoperative rehabilitation		
Patients	P12	"...your physical therapist should have a protocol for you that you go through these exercises to do core strengthening. It won't cure you, but it strengthens the muscles around that area before you have the surgery so that they don't go into a deep atrophy. If you didn't have that therapy before you went for the surgery, then the changes to those muscles are going to take a lot longer to come back"
	P6	"I think the [physical therapy] before the surgery is good because when I found out that I really would need the surgery is when I went through some physical therapy and it didn't work. So I knew I needed to do something else"
Physical therapists	PT7	"There are other barriers to patients' outcomes that start to surface that were unknown to the surgeon or other folks in the medical community"
	PT8	"I think you're also, at that point, setting up a relationship with that patient preoperatively. So that if things do go wrong, you're going to know about them much earlier in [the] postoperative phase or they're going to feel much more comfortable with you, I guess, push—or moving them forward a little bit quicker than if they didn't have that sort of preoperative relationship with you"
	PT10	"I think [preoperative physical therapy] works well. I think [patients] appreciate the time we spend with them. Their fears are alleviated before the surgery, so I think that works well. That's the best model"
	PT7	"I think a lot of my goals [preoperatively] are from an educational standpoint for them and what their future may look like postoperatively. Trying to discuss things to think about in terms of body mechanics, ergonomics, what they're going back to occupationally, in the home as a parent or grandfather, who knows what their role may be in that period of time. And then sort of looking at the impairments they're coming in with. Is there presurgical weakness or other limitations, flexibility, motion? They also have to know we can educate them on what's happening, why this is going on. I think from a pathology standpoint and from the educational models that I'll show them what's happening and empower them, if you will, to make gains in those areas"
3. Downfalls of preoperative rehabilitation		
Patients	P2	"...when they put you on physical therapy, okay, they think it might help. You could take physical therapy for years, but as soon as you leave, one month later, let me tell you what's going to happen: you're back to square one. So physical therapy, in my opinion, doesn't work at all, not before [surgery]"
	P3	"...I believe [physical therapy] makes it worse prior to surgery"
	P16	"I had some therapy before my first surgery, and I don't think it helped me. I had just as much pain after that, so [from] then on I didn't have any therapy. I just went straight to the surgery"
Physical therapists	PT4	"I think the main [challenge in treating these patients] is their preconceived notions. 'I'm having surgery anyway, what's the point [of preoperative physical therapy]?' You know they've got barriers from the cost, you know, copays, time. A lot of them are getting up there in age, so transportation to or from therapy can be a thing. They want to save their money for rehab following surgery"
	PT2	"[Patients] have no notion that they can gain something from [preoperative physical therapy]. I think patients are kind of, like, 'This is just a waste of time to me, I'm not going to improve. I'm getting surgery. Why am I coming here? All because the insurance company made me'"
	PT2	"I think there's more anxiety coming into our clinic because [patients] have already been warned that, 'Hey, [preoperative physical therapy] isn't going to get you better.' They're so anxious coming to see us just to move a little bit because they think all we're going to do is make them worse"
4. Desire for coordinated care		
Physical therapists	PT6	"If the surgeon wants something done a specific way, he's the guy in there, [the surgeon] knows what the limitations are going to be coming out. So I definitely want that surgeon to say, 'Hey, yeah, green light on this or no bending, no lifting.' So I definitely want their input. Whether we want to set up a team to get together with a couple of them and say, 'Hey, this is what [physical therapy] does; do you agree?' and vice versa"
	PT7	"In speaking with a patient, having a conversation such as, 'What Mr [name] said is what Dr [name] said as well, and I'm also in the same message.' So it's not blurred, it's clear—in that situation, the patients continue to hear the same message over and over again, which I think for them can calm fears and certainly create more clarity into the future"
	PT9	"I think [surgeons] buy into the coordination of care. That both sides are on the same team. Where it's not adversarial. If it's a cooperation of, 'All right, you're going to have surgery; we need to get you prepared for this,' then I think this is better if we look at it along that line and the continuum of the care"

Other physical therapists mentioned how preoperative physical therapy is beneficial in terms of laying the foundation for an ongoing patient-therapist relationship that could continue after surgery. Another physical therapist mentioned how addressing psychosocial issues as part of preoperative physical therapy would serve the patient well. Further illustrative quotations regarding the positive aspects of preoperative rehabilitation are found in the **TABLE**.

Theme 3: Downfalls of Preoperative Rehabilitation A number of patients felt that preoperative physical therapy was simply not personally beneficial. Rather, it was seen as a hurdle one must jump over in order to have surgery. Most patients felt that their physical therapists presented physical therapy as a substitute treatment for surgery, instead of providing physical therapy in the preoperative phase to better prepare them for surgery.

The physical therapists largely felt that these patients generally did not buy into the idea of physical therapy being effective before LSS surgery. They found it challenging to engage patients who did not appear invested in trying to improve their physical function during preoperative physical therapy, and were simply there because the surgeon and/or insurance provider mandated them to attend. This may be related to some patients' view that their physical therapists presented physical therapy as a possible alternative to surgery instead of a helpful addition to their surgeon's plan of care. In addition, physical therapists often lamented that very few patients with LSS attended preoperative physical therapy more than once, if at all. One therapist described the mindset that he often saw in patients:

> *"I typically don't find that people [are] very open to [managing their pain conservatively]. They've already received the [message that] 'I'm getting surgery, so this is going to fix [the pain].'" (PT5)*

The physical therapists appeared to have a slightly more negative view of preoperative physical therapy (40 negative mentions: 17 in physical therapist group A and 23 in physical therapist group B and 34 positive mentions: 12 in physical therapist group A and 22 in physical therapist group B) than the patients. In the full analysis of both patient and physical therapist focus group transcripts, the topic of preoperative physical therapy was mentioned positively as often as it was mentioned negatively (50 and 51 mentions, respectively). Neutral perceptions were much less frequently observed (19 mentions; 10 from patients and 9 from physical therapists). Further quotations illustrating theme 3 are found in the **TABLE**.

Theme 4: Desire for Coordinated Care Although the topic of coordinated care did not come up within the patient focus groups, the physical therapists discussed it at length during their focus groups. They felt that their patients' outcomes could improve if the surgeons and physical therapists were working together as coordinating members of the health care team, rather than as separate entities with different agendas. A team-based model of health care delivery to patients, including bundled insurance payments (such as those for knee replacements), was seen as essential to producing better postsurgical patient outcomes. One physical therapist stated:

> *"And [the patients] would see … that, 'You know, my surgeon and my therapist actually are thinking the same thing and they wanted me to have this [therapy], so my outcome would be better.'" (PT9)*

More quotations illustrating coordinated care are found in the **TABLE**.

DISCUSSION

Based on the findings from these focus groups with patients and physical therapists, there is a need for greater standardization of pre–LSS surgery rehabilitation protocols. When combining the results of both patient and physical therapist groups, positive perceptions of preoperative physical therapy were mentioned as frequently as negative perceptions of physical therapy. Physical therapists appeared to have a slightly more negative view of preoperative physical therapy, while more patients saw preoperative physical therapy as slightly more positive. These varying experiences before LSS surgery further highlight the lack of standardization of physical therapy protocols before this surgery.

Along with greater standardization of preoperative rehabilitation protocols, the desire for more thorough preoperative education was also discussed at length by both patients and physical therapists. This demonstrates an overall lack of education in current preoperative information methods. Some patients reported receiving no preoperative education, while others reported dissatisfaction with the methods of delivery of preoperative information. This may lead to disillusionment and unrealistic expectations after LSS surgery. Patients may think that their pain will disappear and physical function will be completely restored. More thorough preoperative education, and perhaps more robust informed consent and shared-decision-making models, would help these patients to better understand what happens during LSS surgery, and what can be realistically expected while recovering from this procedure in terms of pain, quality of life, and physical function.

Currently, there are very limited qualitative data from patients with LSS regarding rehabilitation. One recent study involved focus groups with patients with LSS who had participated in a clinical trial of various nonoperative treatments. There was a common misunderstanding of the pathology of LSS and the mechanism of treatments designed to improve LSS symptoms.[14] Patients also expressed a mistrust of physicians and noted that they frequently turned to the Internet or television for educational information.[2,14] This may lead to high levels of misunderstanding of expectations for LSS treatments, as many patients received information from sources that lack credibility. Kennedy and colleagues[11] performed a qualitative study of individuals undergoing elective hip and knee replacement surgery and found that patients want more education, particularly with respect to pain management. Pain management was surprisingly not mentioned often during the focus group discussions in the present study. It is unclear whether this indicates that education regarding pain management is more thorough for patients in the present study, or whether the participants in this study simply did not have concerns about postoperative pain management. A qualitative study by Malley and Young[15] explored patients' perceptions of preoperative care for unspecified surgeries. This study revealed that patients felt there was a lack of preoperative education from the surgeons and, similar to the current study, did not feel like they knew what to expect after surgery.[15] Results of this study suggest that a general lack of education or knowledge about the surgery may be a common theme across many disciplines and types of surgeries.

Although not mentioned during the focus group discussions, there are several additional factors that may relate to the confusion experienced by patients post LSS surgery. Overall literacy and health literacy of patients were not assessed, and this may affect how patients understand the reasons they need LSS surgery and what to expect after surgery. Older adults (aged 65 years and older) have the lowest average literacy scores compared to all other adult age groups.[12] Due to low literacy, patients may not comprehend the medical terminology used by physicians to explain LSS pathology and its treatment outcomes, leading to a misunderstanding of what to expect after LSS surgery.

Surgeons must relay information to patients in a short time (physicians generally report spending around 13 to 16 minutes with each patient, according to the 2016 Medscape Physician Compensation Report).[18] While supplementary educational materials may be offered, it is also well documented that patient educational material provided by spine surgeons is often overcomplicated and too difficult for patients to understand.[1,5,19] Within the limited face-to-face time with the surgeon during an office visit, patients may not have sufficient time to grasp the material and generate meaningful questions for the surgeon. As one patient mentioned in theme 1, if patients had not thought to ask the question, then they may have never received an answer. The emotional state of patients must also be taken into account, as the environment of a hospital room or health care office may not offer much comfort when patients are told they need major lumbar surgery.

Physical therapists expressed dissatisfaction with their current role in the preoperative rehabilitation process. Both physical therapists and patients mentioned that some insurers require patients to trial physical therapy before qualifying for surgery. Consequently, physical therapists encounter resistance from some patients, who see the physical therapist as a barrier to undergoing surgery instead of as a provider who may improve their pain and function or better prepare them for postoperative recovery. Also, the time between consenting to and undergoing LSS surgery ranges from 4 to 6 weeks, which often is not sufficient time for the physical therapist to help reverse patients' impairments before surgery. According to the physical therapists, this short duration leads many patients to believe that preoperative physical therapy is unhelpful in both their rehabilitation and recovery. Overall, physical therapists dislike how they are viewed by patients attending physical therapy for pre–LSS surgery rehabilitation and desire improved coordination with surgeons. This coordination may help to ease patients' minds entering surgery and help to convince them that preoperative physical therapy will benefit their recovery. Surgeons, physical therapists, and other members of the health care team should consider developing more protocol-based "prehabilitation" programs to help ensure that patients receive comprehensive preoperative education and exercise interventions to prepare them for LSS surgery.

Limitations

This study was conducted within the UPMC system. All patients were treated by UPMC surgeons and physical therapists, and all physical therapists in the focus groups worked within UPMC rehabilitation clinics. It is possible that other local and nonlocal surgeons and hospital systems may have different preoperative education and rehabilitation protocols; the results of this study are not largely generalizable to the US health care system as a whole. Therefore, other health care systems may have established protocols prior to LSS surgery that were not assessed in this study. For the patient focus groups, the degree of compliance with and intensity of preoperative rehabilitation were not gathered for each participant; therefore, the patients might have differed according to their adherence to, as well as their values regarding, preoperative physical therapy. Also, there may be different characteristics between the participants (both patients and physical therapists) and those who were contacted but did not participate in the focus groups. Patients who participated might have experienced different postoperative outcomes compared to those who chose not to participate. Recall bias within the patient focus groups may have affected the results of this study, but on average, surgery was 10 months prior to these focus groups; therefore, the information recalled by the patients was relatively recent. Last, this study contained a small sample size of both patients and physical therapists, so the results may not be representative of the full range of opinions and experiences of patients who received LSS surgery and physical therapists who treat such patients.

CONCLUSION

Individuals who had received surgery for LSS and physical therapists who treat spine disorders both reported varying opinions on preoperative physical therapy and a strong desire for better educational information before surgery. The results of this study highlight the lack of standardization in preoperative rehabilitation and education protocols for individuals with LSS. Future studies should examine the role that standardized preoperative care may play in LSS surgical success rates. ◉

KEY POINTS

FINDINGS: The results of this qualitative study indicate that patients who undergo surgery for lumbar spinal stenosis desire more thorough preoperative patient education. Physical therapists who treat such patients would like greater coordination of care between all members of the health care team.
IMPLICATIONS: Physical therapists and surgeons should work together with all members of the health care team to ensure that patients receive all necessary information prior to undergoing surgery for lumbar spinal stenosis. Development of standardized preoperative protocols, perhaps including "prehabilitation," may aid in patient preparation and recovery.
CAUTION: This was a qualitative focus group study conducted at a single site, with a relatively small number of patients and physical therapists, so the results may not be generalizable to all patients with lumbar spinal stenosis or all physical therapists who treat spine disorders.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: Drs Schneider and Piva conceived of and designed the work. All authors were involved in the acquisition, analysis, and interpretation of data. All authors drafted and revised the manuscript and gave final approval of the version to be published, and all authors agreed to be accountable for all aspects of the work.
DATA SHARING: Data are available on request. Original deidentified data, deidentified focus group transcripts, and methods of qualitative analysis are available by contacting the corresponding author.
PATIENT AND PUBLIC INVOLVEMENT: Patients were not directly involved in the design or interpretation of this study. Study participants were patients recruited from local surgeons' offices.

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APPENDIX

PATIENT FOCUS GROUP QUESTIONS

1. In preparation for your surgery, what sort of information was provided to you about the surgical procedure itself **and** what to expect after surgery (eg, length of the recovery process, realistic pain expectation, appropriate physical activities after surgery, the need [versus not] to exercise or do physical therapy)? Follow-up questions:
   a. How was the information provided (from the surgeon, office staff, rehabilitation providers, online, pamphlet, video, etc)?
   b. How did the information help with the recovery process?
   c. What could have been done differently in terms of education to enhance surgical recovery?
2. Did the surgeon refer you to a physical therapist, chiropractor, or physical medicine and rehabilitation doctor **before** the surgery (ie, in the period between surgical consultation and the surgery)? Follow-up questions:
   a. Did you have to pay for that? What was the cost?
   b. What aspects of the physical therapist/chiropractor/physical medicine and rehabilitation doctor care did you find helpful before your surgery? Did they talk with you about what to expect after your surgery and goals for postoperative rehabilitation?
   c. What could have been done differently during presurgical physical therapist/chiropractor/physical medicine and rehabilitation doctor care to enhance your surgical recovery?
3. Some individuals who undergo surgery for lumbar spinal stenosis may be concerned that something could go wrong with their surgery, some may be overly cautious that physical activity after the surgery may be harmful, and others may not feel confident in their ability to actively participate in the recovery process. Did you experience some of these feelings before surgery? Follow-up questions:
   a. How do you think these feelings might have affected your recovery process?
   b. What could be done before surgery to decrease these feelings and promote confidence in your ability to exercise and more fully participate in your recovery process after surgery?

PHYSICAL THERAPIST FOCUS GROUP QUESTIONS

1. In the past year, approximately how many patients did you see who were referred to physical therapy prior to their lumbar spinal stenosis surgery (ie, after they see the surgeon but before they have the surgery)? On average, how many physical therapy sessions did each of these patients attend?
2. What are your main goals for physical therapy when providing care to these patients? What aspects of physical therapy do you find helpful to these patients' recovery?
3. How confident do you feel in preparing these patients (ie, do you feel well prepared or unprepared to provide presurgical care)? Why?
4. What are the challenges in treating these patients? Follow-up questions:
   a. Is the timeline for physical therapy appropriate (ie, the number of weeks available before surgery)?
   b. What goals or expectations have the surgeons given to the patients who they are referring to physical therapy before surgery?
   c. Are the patients motivated to attend physical therapy before surgery?
5. What else could be done differently during the care of these patients before surgery that you think would enhance their recovery?

CATHERINE C. QUATMAN-YATES, PT, DPT, PhD • **AIRELLE HUNTER-GIORDANO,** PT, DPT
KATHY K. SHIMAMURA, PT, DPT, NCS, OCS, CSCS, FAAOMPT • **ROB LANDEL,** PT, DPT, FAPTA
BARA A. ALSALAHEEN, PT, PhD • **TIMOTHY A. HANKE,** PT, PhD • **KAREN L. McCULLOCH,** PT, PhD, FAPTA

Physical Therapy Evaluation and Treatment After Concussion/ Mild Traumatic Brain Injury

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Academy of Orthopaedic Physical Therapy, American Academy of Sports Physical Therapy, Academy of Neurologic Physical Therapy, and Academy of Pediatric Physical Therapy of the American Physical Therapy Association

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REVIEWERS: Roy D. Altman, MD • Paul Beattie, PT, PhD • Kate E. Berz, DO • Bradley Bley, DO, FAAP, RMSK, CSCS
Amy Cecchini, DPT, MS • John Dewitt, DPT • Amanda Ferland, DPT • Isabelle Gagnon, PT, PhD • Kathleen Gill-Body, DPT, MS, NCS, FAPTA
Sandra Kaplan, PT, PhD • John J. Leddy, MD • Shana McGrath, MA, CCC-SLP • Geraldine L. Pagnotta, PT, MPT, MPH
Jennifer Reneker, PT, MSPT, PhD • Julie Schwertfeger, PT, DPT, MBA, CBIST • Noah Silverberg, PhD, RPsych, ABPP

 Address correspondence to Terri DeFlorian, ICF-Based Clinical Practice Guidelines Coordinator, Academy of Orthopaedic Physical Therapy, APTA, Inc, 2920 East Avenue South, Suite 200, La Crosse, WI 54601. E-mail: icf@orthopt.org

Summary of Recommendations*

SCREENING AND DIAGNOSIS

Diagnosis

A Physical therapists must screen all individuals who have experienced a potential concussive event and document the presence or absence of symptoms, impairments, and functional limitations that may relate to a concussive event.

Screening for Indicators of Emergency Conditions

A Physical therapists must screen patients who have experienced a recent potential concussive event for signs of medical emergency or severe pathology (eg, more serious brain injury, medical conditions, or cervical spine injury) that warrant further evaluation by other health care providers. Referral for further evaluation should be made as indicated (**FIGURE 1**).

Differential Diagnosis

A Physical therapists must evaluate for potential signs and symptoms of an undiagnosed concussion in patients who have experienced a concussive event but have not been diagnosed with concussion. Evaluation should include triangulation of information from patient/family/witness reports, the patient's past medical history, physical observation/examination, and the use of an age-appropriate symptom scale/checklist (see **FIGURE 1** for diagnostic criteria).

F For patients who have experienced a concussive event and do not report or demonstrate signs and symptoms consistent with a concussion diagnosis, physical therapists should evaluate for other potential diagnoses and follow standard-of-care procedures in accordance with their findings.

F For patients who have experienced a concussive event and report or demonstrate signs and symptoms consistent with a concussion diagnosis, physical therapists should determine whether a comprehensive physical therapy evaluation is appropriate using information from a comprehensive intake interview and clinical judgment (see **FIGURE 1** for potential considerations).

A Physical therapists should screen patients who have experienced a concussive event for mental health, cognitive impairment, and other potential coinciding diagnoses and refer for additional evaluation and services as indicated.

F For patients not deemed appropriate for a comprehensive physical therapy examination (ie, those who present with severe mental health concerns or health conditions that require medical clearance prior to comprehensive physical examination), physical therapists should provide education regarding concussion symptoms, prognosis, and self-management strategies and refer for consultation with other health care providers as indicated.

Comprehensive Intake Interview

A Physical therapists must conduct and document a comprehensive intake of past medical history, review of mental health history, injury-related mechanisms, injury-related symptoms, and early management strategies for patients who have experienced a concussive event.

EXAMINATION

Systems to Be Examined

B For patients identified as safe and appropriate for a comprehensive examination, physical therapists must determine and document a need for physical therapy to facilitate recovery from a concussive event, based on findings from a comprehensive multisystem physical therapy examination and evaluation. Examination procedures should include examination for impairments in the domains of cervical musculoskeletal function, vestibulo-oculomotor function, autonomic dysfunction/exertional tolerance, and motor function through foundational standard-of-care screening strategies (**FIGURE 2**).

Sequencing of Examination Based on Levels of Irritability

F Prior to initiating a comprehensive physical examination for patients who have experienced a concussive event, physical therapists should determine probable levels of irritability for movement-related symptoms and impairments and plan to strategically sequence and/or delay examination procedures as needed, based on patients' symptom types and probable levels of irritability. Physical therapists are encouraged to first triage for neck pain irritability and then for dizziness and/or headache (**FIGURE 2**).

F For patients who have experienced a concussive event and have high neck pain irritability but exhibit no signs of serious neck or systemic pathology, physical therapists should first examine the cervical and thoracic spines for sources of musculoskeletal dysfunction and address findings appropriately to promote symptom relief (eg, stretching, soft tissue mobilization, therapeutic exercise, modalities) and to support tolerance of examination of other body systems.

F For patients who have experienced a concussive event and report dizziness, vertigo, and/or headache, physical therapists should thoroughly examine for sources of cervical and thoracic spine dysfunction, vestibular and oculomotor dysfunction, and orthostatic hypotension/autonomic dysfunction that may contribute to the emergence or exacerbation of these symptoms (**FIGURE 2**). Physical therapists should start with the tests that are anticipated to be the least irritable and proceed with the tests anticipated to be the most irritable, based on patient tolerance.

F After triaging and screening for neck pain, dizziness, and headache, physical therapists should proceed with multisystem comprehensive examination of any untested domains of cervical musculoskeletal function, vestibulo-oculomotor function, autonomic dysfunction/exertional tolerance, and motor function by sequencing tests and measures based on clinical judgment as indicated (**FIGURE 2**).

Cervical Musculoskeletal Impairments

C Physical therapists should examine the cervical and thoracic spines for potential sources of musculoskeletal dysfunction for patients who have experienced a concussive event with reports of any of the following symptoms: neck pain, headache, dizziness, fatigue, balance problems, or difficulty with visually focusing on a target. Recommended cervical musculoskeletal tests and measures include range of motion, muscle strength and endurance, tenderness to palpation of cervical and scapulothoracic muscles, passive cervical and thoracic spine joint mobility, and joint position error testing.

F Physical therapists may examine the cervical spine, thoracic spine, and temporomandibular joint for potential sources of musculoskeletal dysfunction for patients who do not report the symptoms listed to determine whether subtle impairments are present and may be contributing to symptoms.

Vestibulo-oculomotor Impairments

B Physical therapists should examine vestibular and oculomotor function for patients who have experienced a concussive event with reports of any of the following symptoms: headache, dizziness, vertigo, nausea, fatigue, balance problems, visual motion sensitivity, blurred vision, or difficulty with focusing on stable or moving targets.

B Physical therapists should examine vestibular and oculomotor function related to the following: ocular alignment, smooth pursuits, saccades, vergence and accommodation, gaze stability, dynamic visual acuity, visual motion sensitivity, light-headedness caused by orthostatic hypotension, and vertigo caused by benign paroxysmal positional vertigo (BPPV).

A If BPPV is suspected, physical therapists should assess the patient using a Dix-Hallpike test or other appropriate positional test(s).

F Physical therapists may examine patients who have experienced a concussive event for vestibulo-oculomotor function, even if vestibulo-oculomotor symptoms are not reported, to identify potential subtle impairments that may be contributing to symptoms.

Autonomic/Exertional Tolerance Impairments

B Physical therapists should test for orthostatic hypotension and autonomic dysfunction (eg, resting and postural tachycardia or fast rise in heart rate with positional changes) by evaluating heart rate and blood pressure in supine, sitting, and standing positions.

B Physical therapists should conduct a symptom-guided, graded exertional tolerance test for patients who have experienced a concussive event and report exertional intolerance, dizziness, headache, and/or a desire to return to high-level exertional activities (ie, sports, active military duty, jobs that entail manual labor). Timing, modality, and protocol should be tailored to optimize safety and individual appropriateness. For patients who are highly symptomatic at rest, the symptom-guided, graded exertional tolerance test should be delayed until symptoms are stable and more tolerable at rest. Likewise, physical therapists may decide to postpone graded exertional testing until later in the course of care if the clinical judgment is that other symptoms and impairments are of higher priority. Testing modality (eg, treadmill versus stationary bicycle) and protocol selection should be based on clinical judgment, patient comfort, and the availability of necessary equipment. Heart rate and blood pressure should be monitored periodically throughout the test and afterward to identify any significant concerns for atypical responses to exercise testing.

C If vestibulo-oculomotor or cervical spine impairments or symptoms are present, physical therapists should use a stationary bicycle for testing to reduce the risk of exacerbating impairments or compromising the validity of the test results.

C Physical therapists may use assessments for orthostatic hypotension/autonomic dysfunction and symptom-guided, graded exertional tolerance tests for patients who do not report exertional intolerance to help determine the role that autonomic dysfunction, deconditioning, or general fitness may play in symptoms (eg, headache, fatigue, fogginess).

F Physical therapists may conduct exertional tests for patients who have experienced a concussive event and do not report symptoms indicative of exertional intolerance in order to rule out subtle autonomic dysfunction in response to exertion, establish initial postconcussion performance level, and identify exertional targets for aerobic exercise training that may be incorporated to promote brain health and healing.

Motor Function Impairments

B Physical therapists should examine patients who have experienced a concussive event for motor function impairments, including static balance, dynamic balance, motor coordination and control, and dual/multitasking (eg, having the patient perform motor tasks along with cognitive tasks or complex tasks with multiple subtasks involved). Selection and timing of motor performance assessments should be based on clinical judgment about which evaluation strategies are most appropriate for the patient's age and ability and will provide the most insight into current functional levels relative to goal levels.

Classification of Examination Findings Into Impairment Profiles

E Physical therapists should establish and document the presence or absence of all impairments and their levels of irritability to support the selection of treatment priorities and strategies for patients who have experienced a concussive event.

B For patients who have experienced a concussive event and report headache as a symptom, physical therapists should determine and document the potential headache type in accordance with the International Classification of Headache Disorders.

Psychological and Sociological Factors

E Physical therapists should elicit, evaluate, and document factors related to self-efficacy and self-management abilities, potential psychological and sociological factors that may significantly influence recovery processes and outcomes for physical therapy interventions. Examples of factors to consider include (1) the patient's expression and demonstration of good, healthy coping strategies in response to stressful situations, (2) the type of support system the patient has to enable self-management of her or his symptoms and impairments, (3) the number and type of potential risk factors that may contribute to delayed or complicated recovery (eg, history of mental health or substance use disorders), (4) the patient's understanding and attitude toward recovery (eg, the patient expresses a positive outlook for recovery versus a more negative mindset or high anxiety toward recovery), and (5) the patient's access to resources and equipment that may facilitate recovery (eg, access to athletic trainer or other health care providers to support recovery).

E When evaluating self-efficacy and self-management factors, physical therapists should explain and emphasize that most symptoms and impairments after concussion do improve.

Outcome Measure Selection

F Physical therapists should determine and document a plan for outcome measurement for patients who have experienced a concussive event for any impairment domains that will be targeted with physical therapy interventions and/or were previously untested due to poor tolerance.

INTERVENTIONS

Communication and Education

B Physical therapists must educate patients who have experienced a concussive event about self-management of symptoms, the importance of relative rest (rest as needed) instead of strict rest, the benefits of progressive re-engagement in activities, the importance of sleep, safe return-to-activity pacing strategies, and potential signs and symptoms of the need for follow-up care with a physician, physical therapist, or other health care provider.

A Physical therapists must educate patients who have experienced a concussive event and their families/caregivers about the various symptoms, impairments, and functional limitations that are associated with concussion, and stress that most patients with concussion recover relatively quickly. Providing this information can help avoid inadvertent reinforcement of poorer recovery expectations.

Movement-Related Impairments

F Physical therapists should use findings from the examination to triage patients who have experienced a concussive event into 1 of 2 categories: (1) patients with movement-related impairments and dysfunction who are good candidates for physical therapy interventions, or (2) patients with no identified movement-related impairments or dysfunction (**FIGURE 3**). Time since injury may influence level of irritability of symptoms, but should not be a primary determinant for decisions regarding when physical therapy interventions are appropriate. Evidence indicates that physical therapy early after concussion is safe, and that earlier initiation of physical therapy interventions may facilitate a faster recovery.

B Physical therapists should design a personalized intervention plan for patients who have experienced a concussive event and have movement-related impairments that aligns interventions with the patient's identified impairments, functional limitations, participation limitations, self-management capabilities, and levels of irritability.

B Physical therapists should refer patients who have experienced a concussive event for further consultation and follow-up with other health care providers as indicated. Of specific note, high-quality clinical practice guidelines recommend referral for specialty evaluation and treatment in cases of persistent migraine-type and other chronic headaches, vision impairments (including ocular alignment), auditory impairments, sleep disturbances, mental health symptoms, cognitive problems, or any other potential medical diagnosis that may present with concussion-like symptoms or coincide with concussion symptoms (eg, lesions/tumors or endocrine abnormalities such as posttraumatic diabetes insipidus).

Cervical Musculoskeletal

B Physical therapists should implement interventions aimed at addressing cervical and thoracic spine dysfunction, such as strength, range of motion, postural position, and/or sensorimotor function (eg, cervicocephalic kinesthesia, head position control, cervical muscle dysfunction) exercises and manual therapy to the cervical and thoracic spines, as indicated, for patients who have experienced a concussive event.

Vestibulo-oculomotor

A If BPPV is identified as a potential impairment, physical therapists should use canalith repositioning interventions.

B Physical therapists with appropriate expertise in vestibular and oculomotor rehabilitation should implement an individualized vestibular and oculomotor rehabilitation plan for patients who have experienced a concussive event and exhibit vestibular and/or oculomotor dysfunction. If visual vertigo/visual motion sensitivity (dizziness provoked by repetitive or moving visual environments) is identified, an individualized visual-motion habituation program may also be beneficial. Patients with neck pain or other cervical impairments may exhibit worsening of cervical impairments due to repetitive head movement as part of vestibular rehabilitation. Therefore, the implications of head-rotation interventions on the possible concomitant cervical impairments should also be considered and addressed.

F Physical therapists who lack appropriate training in vestibular and oculomotor rehabilitation should refer patients who exhibit vestibular and/or oculomotor impairments to a clinician with appropriate expertise.

Exertional Tolerance and Aerobic Exercise

A Physical therapists should implement a symptom-guided, progressive aerobic exercise training program for patients who have experienced a concussive event and exhibit exertional intolerance and/or are planning to return to vigorous physical activity levels. Selection of modality and protocol for training with a specific focus on the patient's goals, comfort level, lifestyle, and access to equipment is encouraged. Timing of the initiation of the aerobic exercise training program may vary by patient, but as soon as the patient's symptoms have stabilized to a moderate or lower level of irritability may be used as a guiding criterion.

E Physical therapists may implement progressive aerobic training for all patients who have experienced a concussive event, including those who do not exhibit exertional intolerance and those who do not intend to engage in vigorous physical activity, in order to reduce risk for deconditioning, promote functional brain healing, and provide a nonpharmaceutical option to improve mental health.

Motor Function

C Physical therapists should implement motor function interventions that address identified or suspected motor function impairments and help progress the patient toward higher-level functional performance goals. Motor function interventions that target the following impairments are strongly encouraged: static balance, dynamic balance, motor coordination and control, and dual/multitasking. Additionally, interventions that directly help improve motor function for work/recreation/activity-specific tasks are strongly encouraged.

Monitoring and Progressing Patients

F Physical therapists should regularly document symptoms, provide reassessments of movement-related impairments, and administer selected outcome measures as needed or indicated for patients with movement-related impairments post concussion.

*These recommendations and clinical practice guidelines are based on the scientific literature accepted for publication prior to January 2019.

List of Abbreviations

ADHD: attention-deficit hyperactivity disorder
AGREE II: Appraisal of Guidelines for Research and Evaluation II instrument
APTA: American Physical Therapy Association
BPPV: benign paroxysmal positional vertigo
CDC: Centers for Disease Control and Prevention
CPG: clinical practice guideline
CT: computed tomography
DHI: Dizziness Handicap Inventory
DVAT: dynamic visual acuity testing
ED: emergency department
GDG: Guideline Development Group
HiMAT: High-level Mobility Assessment Tool
ICD: International Classification of Diseases
ICF: International Classification of Functioning, Disability and Health
mTBI: mild traumatic brain injury
PECARN: Pediatric Emergency Care Applied Research Network
RCT: randomized controlled trial
VOMS: Vestibular/Ocular Motor Screening

Introduction

AIM AND PURPOSE OF THE GUIDELINE

The American Physical Therapy Association (APTA) and the various academies associated with the APTA encourage the creation of clinical practice guidelines (CPGs) for physical therapy management of patients with physical impairments and functional limitations described in the World Health Organization's International Classification of Functioning, Disability and Health (ICF).[224]

The purpose of this endeavor by the APTA and its associated academies is to produce clinical guidelines that

- Describe evidence-based physical therapy practice, including diagnosis, prognosis, intervention, and assessment of outcome approaches for disorders commonly managed by physical therapists
- Classify these conditions using World Health Organization terminology related to impairments of body structure and function, activity limitations, and participation restrictions
- Identify interventions supported by current best evidence to address impairments of body function and structure, activity limitations, and participation restrictions associated with common conditions
- Identify appropriate outcome measures to assess changes resulting from physical therapy interventions in body function and structure as well as in activity and participation of the individual
- Provide a description to policy makers, using internationally accepted terminology, of the practice of physical therapists
- Provide information for payers and claims reviewers regarding the practice of physical therapy for common neurologic and musculoskeletal conditions
- Create a reference publication for physical therapy clinicians, academic instructors, clinical instructors, students, interns, residents, and fellows regarding the best current practice of physical therapy

STATEMENT OF INTENT

This CPG is not intended to be construed or to serve as a standard of medical care. Standards of care are determined on the basis of all clinical data available for an individual patient and are subject to change as scientific knowledge and technology advance and patterns of care evolve. These parameters of practice should be considered as guidelines only. Adherence to them will not ensure a successful outcome in every patient, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgment regarding a particular clinical procedure or treatment plan must be made based on clinician experience and expertise in light of the clinical presentation of the patient; the available evidence; the available diagnostic and treatment options; and the patient's values, expectations, and preferences. However, we suggest that significant departures from strong recommendations should be documented in the patient's medical records at the time the relevant clinical decision is made.

SCOPE

For the purposes of this CPG, the term *concussion* is used synonymously with *mild traumatic brain injury* (mTBI) and is defined as a traumatic injury that affects the brain, induced by biomechanical forces transmitted to the head by a direct blow to, or forces exerted on, the body,[141,153,159] but that does not result in an extended period of unconsciousness, amnesia, or other significant neurological signs indicative of a more severe brain injury. Concussions occur via many different mechanisms and in a variety of contexts, including but not limited to falls, motor vehicle crashes, blast exposures, sporting and recreational injuries, or assault. The nature of such mechanisms and contexts constitutes a concussive event. Considering an injury of this nature as a *concussive* event is useful because the forces that induce concussion may result in damage to brain function (justifying the classification of the injury as a "mild traumatic brain injury") but also concomitant injury to other body structures and functions, especially areas in close proximity to the brain, such as the cervical spine and vestibular system. The Guideline Development Group (GDG) embraced the perspective that all concussions stem from a concussive event to ensure a broader consideration of the other structures, tissues, and body systems that may be involved when a physically traumatic incident occurs.

The intended scope of this CPG is to guide physical therapist clinical decision making for individuals who have experienced a concussive event resulting in movement-related symptoms, impairments, and functional limitations. It is important to acknowledge that there is potential for an individual to have experienced a concussive event but to have never been evaluated for a medical diagnosis of concussion prior to a physical therapy encounter. Therefore, the starting criterion for implementation of this CPG is a physical therapy encounter with a patient who has sustained a potential concussive event, regardless of whether or not the patient has a medical diagnosis of concussion. The CPG may be implemented whether the potential injury occurred recently or in the more distant past. Implementation adjustments for the CPG should not be based on time since injury (or acuity), but rather on clinical judgment of patient presentation, examination results, and response to interventions in alignment with the recommendations and decision trees provided.

Recommendations in this CPG are focused on the evaluation and treatment of individuals 8 years of age and older, with no more than mild cognitive impairment prior to or after the concussive event. Theoretically, the recommendation statements provided in this document may be able to be applied to children under the age of 8 years and individuals with more severe cognitive impairments. However, current management strategies for concussion rely heavily on reliable patient reports of their symptom responses to provocation tests and interventions. There are limited data available on symptom assessment in children under the age of 8 years,[70,141,142] which may limit the applicability of these recommendations for clinical decision making with young children.

It is not the intent of this CPG to address acute concussion screening or diagnosis (eg, sideline assessment), neurocognitive/neuropsychological management, or pharmacological management. These issues are well covered in consensus statements and CPGs that are published by various professional groups and associations (eg, the Ontario Neurotrauma Foundation,[153] Centers for Disease Control and Prevention [CDC],[141] US Department of Veterans Affairs and Department of Defense[149]). We encourage physical therapists to become familiar with other CPGs to enrich their understanding of postconcussion assessments and interventions that are often used but may fall outside the scope of physical therapy care.

CPG Framework

The complexity of concussion-related symptoms and impairments often necessitates the involvement of multidisciplinary teams that include a variety of medical and rehabilitation professionals.[34,107,108,159] The conventional approach to managing individuals with concussion was to encourage rest until symptom resolution.[34,192] One rationale in support of prescribing rest, especially in the first few days after a concussion, is that it may help alleviate symptoms and ease the discomfort individuals with concussion often experience.[66,166,167] It has also been hypothesized that rest may facilitate the brain's recovery by reducing energy demands and attenuating the acute neurometabolic and inflammatory responses to a concussive injury.[133,192] Moreover, concerns over potential risk for catastrophic injury from another head injury occurring prior to recovery from the first concussion have led to cultural and policy shifts designed to prevent individuals from returning to high-risk activities too soon.[159]

Recently, authors have questioned the value of rest until symptom resolution and suggest that an earlier, gradual return to activity may be beneficial.[34,192] Observational and experimental studies have demonstrated that both extremes of strict rest and intense bouts of cognitive or physical activity acutely after injury may be associated with delayed recovery trajectories.[23,33,36,39,45,50,62,63,69,73,76,88,98,117,127,132,145,146,157,158,167,168,175,192,194,197,204,208] Prolonged rest, specifically, may lead to development of secondary effects that are similar to common postconcussion symptoms (eg, deconditioning with exertional intolerance, anxiety or depression due to social isolation and/or reduced participation), making it difficult to discern whether the source of ongoing symptoms is the prescribed rest or the injury itself.[76,192]

Most recent CPGs and guidance documents include recommendations to encourage 24 to 48 hours of complete rest or "relative rest" (gradual reintegration of usual activity with the recommendation to "rest as needed"), followed by phased activity progressions based on symptom response to increasing activity.[141,153,159] While randomized controlled trials (RCTs) in this area are sparse, current clinical recommendations typically advocate for the resumption of low levels of activity in the presence of mild symptoms, as long as symptom exacerbation does not occur.[141,153,159,160]

Another emerging paradigm that contrasts with the rest-focused "wait-and-see" approach leverages active interventions, often referred to as "active rehabilitation." Many of these active intervention strategies incorporate skilled rehabilitation techniques within physical therapists' scope of practice.[4,5,9,18,34,38,47,51,53,54,62,98,117,125,132,133,137,145,152,178,191,192,194,220,225,226] Consequently, physical therapists are increasingly involved as key members in an interdisciplinary approach to caring for individuals with concussion.[53,159,192]

This CPG addresses active rehabilitation for management of patients who have experienced a concussive event using an overarching framework comprising 3 components: (1) a process for determining appropriateness of physical therapy concussive event examination, (2) physical therapy examination and evaluation processes for patients who have experienced a concussive event, and (3) developing and implementing a physical therapy plan of care for patients who have experienced a concussive event. Recommendations are broken down into sections that directly align with each component, and visual decision trees are provided to support implementation of the recommendations within the components. Within components 2 and 3, examination and treatment strategies are further broken down into primary impairment domains. Based on a synthesis of the literature, the GDG identified 4 overarching impairment domains that align with physical therapists' scope of practice: (1) cervical musculoskeletal impairments, (2) vestibulo-oculomotor impairments, (3) exertional tolerance impairments, and (4) motor function impairments. These impairment domains are described in a later section and serve as focal points for the examination and intervention recommendations provided in this CPG.

Examination and intervention strategies for movement-related impairments often require procedures that are intended to provoke symptoms to determine whether an impairment is present, and, in some cases, to treat the impairment. *Irritability* is a term used by rehabilitation practitioners to reflect the tissue or body system's ability to handle physical or physiological stress,[170] and is presumably related to physical status and the extent of injury and inflammatory activity. The GDG concluded that information gleaned during the intake interview can be used to help determine probable levels of irritability for the affected systems, which in turn can be used to help identify priorities and sequencing for examination procedures to allow for a greater number and accuracy of assessments. Determining probable levels of irritability may also help clinicians plan for modifications to examination procedures that would address safety concerns, patient comfort, and/or patient and family goals and preferences. Likewise, irritability levels for specific impairments can guide prioritization and selection of physical therapy interventions. Therefore, the concept of irritability is applied throughout this CPG to guide the sequence of screening, examination, and management of individuals who have experienced a concussive event. The GDG has also published a related clinical commentary article that provides more details on the rationale for and potential clinical approaches to using irritability to guide physical therapy treatments for individuals who have experienced a concussive event.[1]

CPG Rationale

Over the last decade, numerous concussion evidence-based CPGs, consensus statements, and clinical guidance documents have been published.[19,34,61,141,149,153,159,160] These documents have typically focused on the diagnosis of concussion and medical management of individuals post concussion, but provide little specific guidance for physical therapy management of concussion and its associated impairments. Further, many of these guidance documents have targeted specific populations (eg, athletes and military personnel) in specific care contexts (eg, sideline assessments and return-to-activity decision making).[34,159] The lack of guidance for management of a wider scope of patients is particularly problematic for physical therapists, as they may encounter patients with concussions from a variety of injury mechanisms and contexts (eg, children injured in recreational activities, military personnel in active-duty service, older adults after falls, or passengers in motor vehicle collisions). Practice settings also vary across the continuum of care, from acute inpatient settings to ambulatory outpatient clinics.

The growing body of evidence for using active rehabilitation strategies for postconcussion impairments[192] prompts the need for recommendations regarding how physical therapists should approach the management of individuals who have experienced a potential concussive event. Furthermore, a CPG for physical therapists may be useful in informing other health professionals and stakeholders about the expertise and services physical therapists can provide to patients diagnosed with a concussion. The primary purpose of this CPG is to provide a set of evidence-based recommendations for physical therapist management of the wide spectrum of patients who have experienced a concussive event.

Specific objectives of this CPG are to

- Systematically review the available scientific evidence pertaining to physical therapist management of patients who have experienced a concussive event
- Provide evidence-based recommendations to guide physical therapist treatment
- Educate all stakeholders regarding physical therapy strategies for management of patients who have experienced a concussive event

Secondary objectives are to

- Identify current gaps in knowledge related to physical therapist management of concussion
- Provide consensus-based recommendations for physical therapist management where evidence is lacking

Special Considerations for Physical Therapist Management of a Concussive Event

This CPG is the first to provide a comprehensive set of evidence-based recommendations for examination, evaluation, treatment, and outcome measurement strategies for physical therapist management of patients who have sustained a potential concussive event. Many of the symptoms, impairments, and functional limitations often reported after concussion are conditions and functional limitations that physical therapists are specifically trained to evaluate and treat (eg, vestibular impairments causing dizziness and imbalance; cervical impairments resulting in neck pain, headache, and cardiorespiratory deconditioning). However, the treatment for these conditions is supported, in large part, by CPGs derived from evidence that is not specific to concussion. The complex and multifactorial nature of concussion requires that physical therapists use clinical reasoning to apply CPGs and evidence for common complaints (eg, headache, dizziness, neck pain, and chronic pain management) that were developed without a specific focus on concussion. More research is needed to evaluate the appropriateness and feasibility of using guidelines that were developed for impairments common after a concussive event but have not been tested for use with people who have experienced a concussive event.

CPG Limitations

The recommendations provided in this CPG were based on a critical appraisal of the studies published and/or available as an electronic publication through December 31, 2018. The literature on concussion/mTBI is rapidly expanding. There have been many studies pertinent to the CPG since the end of 2018. Given the GDG's systematic search time frame, there are a number of 2019 articles that are highly relevant but were not integrated. Additionally, external reviewers raised a number of important suggestions for future topics that are relevant to physical therapy care but were outside the search processes and scope of the current CPG. Therefore, revision/updated versions of this CPG should begin critical appraisal from January 1, 2019 and consider inclusion of the following topics in the literature search: explicit headache management approaches, primary concussion prevention strategies, and self-management assessments and interventions.

Barriers and Facilitators to Implementation

A potential barrier to implementation of this CPG is that physical therapist management of patients who have experienced a concussive event may require evaluation and treatment strategies that are typically provided by physical therapy specialists. Therefore, effective physical therapist management of concussion may necessitate referral to physical therapy specialists or other health care providers with necessary expertise appropriate across the continuum of management. For example, an individual with complex neck pain or cervical spine dysfunction may normally be treated by a physical therapist with expertise in orthopaedic manual therapy techniques, while an individual with dizziness may typically be managed by physical therapists who specialize in vestibular rehabilitation. After a concussive event, however, a patient may need both types of interventions. These challenges are compounded by the practice of having patients with brain injuries managed by physical therapists who specialize in more severe neurologic conditions that may not commonly progress to a level where advancement in high physical performance is needed (eg, sports, military, tactical professions such as police, fire, or other emergency medical personnel). Therapists in outpatient orthopaedic and sports settings may be more familiar with progressing people to high performance levels, but have less expertise in managing patients with brain injuries. Therefore, it is important for physical therapists to be mindful of their clinical strengths and limitations and refer to and/or consult with other physical therapist colleagues as needed to help ensure their patients receive the necessary care. Physical therapists who plan to treat patients with concussion regularly are encouraged to seek specialized training and coursework that prepare them to manage the unique and multifactorial nature of postconcussive symptoms and impairments.

Additional barriers to implementation may include costs associated with training clinicians, lack of equipment, cultural barriers with local practice coordination or patterns that contrast with recommendations, and the additional time needed to examine, evaluate, and treat patients who have experienced a concussive event and have multiple impairments. Physical therapists are encouraged to use this CPG to support collaboration with the other care providers managing patients with concussion in their local practice settings. The contents of this CPG may also be useful to inform discussions with clinic managers and administrators on how to set up infrastructure to ensure adequate time and resources, and to ensure that referral sources are dedicated to provide optimal care for patients who have experienced a concussive event.

Facilitators to implementing this CPG may include a local practice culture that embraces evidence-based practice and physical therapists who are trained to specifically manage patients who have experienced a concussive event. Another facilitator to implementation may be access to a multidisciplinary clinic or network of health care providers who can work together to help manage patients who have experienced a concussive event. Last, the complexity of concussive injuries may lead to highly variable care-delivery processes. Clinical pathways that support optimal patient referral and treatment flows that align with the recommendations proposed in this CPG are encouraged to facilitate direct integration into local practice settings.

Methods

GUIDELINE DEVELOPMENT OVERVIEW

The composition of the GDG was strategically designed to ensure representation of diverse perspectives and experiences within the profession of physical therapy. Representatives from the APTA, Academy of Orthopaedic Physical Therapy, American Academy of Sports Physical Therapy, Academy of Neurologic Physical Therapy, and Academy of Pediatric Physical Therapy were recruited to ensure a GDG composed of people with sufficient and complementary clinical and research expertise to address the wide range of neurologic, orthopaedic, age-related, and functional impairments that are commonly present among individuals who have experienced a concussive event. The CPG development process was guided by a trained methodologist who was an integral part of the team, using standards consistent with the Institute of Medicine[101] and subsequently outlined in the 2018 edition of the APTA's Clinical Practice Guideline Process Manual.[6] In addition, the authors received methodological guidance and support from leading methodologists in the field. See the Affiliations and Contacts section at the end of the CPG for a full list of acknowledgments.

The authors declared relevant relationships and conflicts of interest and submitted a conflict-of-interest form to the Academy of Orthopaedic Physical Therapy. Articles identified for review that were authored by GDG members or volunteer reviewers were assigned to alternate reviewers. Throughout the CPG development process, the GDG received support through an APTA grant and sponsorship from the Academy of Orthopaedic Physical Therapy, the American Academy of Sports Physical Therapy, and the Academy of Neurologic Physical Therapy for training, travel, software, and librarian assistance. The funding bodies did not have any influence over the recommendations proposed.

Background Information Resources

Due to the large volume of background literature on concussion, the heterogeneity of the available literature, and the lack of specific relevance to physical therapy techniques and strategies, the GDG judged systematic review and critical appraisal to be outside the intended scope of this CPG for the following topics: incidence, risk, and clinical course. Therefore, these sections are provided as background information, using recent articles with the highest level of evidence as key informational sources.

Systematic Literature Searches

The recommendations provided in this CPG are based on the scientific literature published in print or as an electronic publication ahead of print prior to December 31, 2018. **APPENDICES A** through **H** (available at www.jospt.org) provide details about the search strategies, database search results, inclusion/exclusion criteria, critical appraisal tools, a flow chart of included articles, and appraisal syntheses. The review of the evidence for this CPG encompassed a range of physical impairments that may be relevant when making a differential diagnosis after a concussive event, with the goal of determining the underlying cause(s) of presenting signs and symptoms and matching them with intervention priorities. The GDG worked with a librarian from the University of North Carolina at Chapel Hill to engage in the 2 phases of the literature search process (preliminary searches and systematic searches), as recommended by the APTA Clinical Practice Guideline Process Manual.[6] EndNote X8 (Clarivate Analytics, Philadelphia, PA) and DistillerSR software (Evidence Partners, Ottawa, Canada) were used to manage the literature searches, coordinate evidence selection, carry out critical appraisals, and store notes and information about the evidence sources.

Evidence Selection

Title and Abstract Screening

Potential original research studies were initially screened independently by at least 2 GDG members by title and abstract. Screening criteria for this phase were that the document appeared to have potential relevance to inform physical therapists' examination or intervention processes. In cases where the screeners disagreed or the abstract was not clear enough to make a determination, the article was carried forward to the full-text-review stage.

Full-Text Review

Each article carried forward from the title and abstract screen was independently reviewed by 2 GDG members using previously established inclusion and exclusion criteria (**APPENDIX C**). Reviewers were given the option to identify and retain an article that was not in direct alignment with the inclusion/exclusion criteria if it might prove relevant for background information. The articles identified in this category could then be reviewed and considered level V (expert opinion) evidence to help inform the GDG's drafting of action statements and research recommendations when higher-level evidence was lacking. In cases of disagreement on inclusion, the reviewers were asked to resolve the conflict through discussion. If needed, a third reviewer was consulted to help make a final determination.

Critical Appraisals of Evidence

Each article was critically appraised by 2 independent, trained reviewers who were either GDG members or volunteers (Eugene Boeglin, Katherine Lynch), using a designated critical appraisal tool based on study type in accordance with the APTA Clinical Practice Guideline Process Manual.[6] All reviewers were trained in the use of the critical appraisal tools by appraising test articles to establish interrater reliability. When a study arose that was authored by a member of the GDG, the article was appraised by other GDG members. Each dyad compared scores for agreement and resolved conflicts through discussion, and submitted a single critical appraisal form for determination of the level of evidence. In cases where the appraisers were unable to agree, the GDG discussed the article as a group to achieve consensus. The final step entailed the GDG's assessment of the identified risks of bias and relative importance of those risks to the procedures or specific outcome of interest to designate the article into 1 of 4 quality ratings: (1) high quality, (2) acceptable quality, (3) low quality, and (4) unacceptable quality. If a study was deemed as unacceptable quality, it was removed from consideration for inclusion for recommendations related to that area.

Conceptual, Theoretical, and Expert Consensus Documents

Given the rapidly evolving practice standards and relatively new treatment paradigm of active concussion rehabilitation, a number of conceptual models, theory-focused commentaries, and expert consensus documents have emerged in the literature. Systematic critical appraisal for such types of documents is challenging and largely subjective in nature. However, several manuscripts and documents identified through the search process provided valuable strategies for framing how to approach physical therapy examination and intervention processes, for which evidence is currently lacking. Two GDG members independently reviewed conceptual, theoretical, and expert consensus documents identified during the systematic searches, and determined the appropriateness for inclusion in the CPG based on the criteria provided in **APPENDIX C**.

Strength of Evidence

Using the critical appraisal ratings, each article was assigned a level of evidence in accordance with the designations and procedures described in **APPENDIX F.** An abbreviated version of the level-of-evidence rating system is provided below. An individual article or recommendation statement from a previously published CPG could be assigned multiple levels of evidence if it was linked to more than 1 outcome of interest.

I	Evidence obtained from high-quality diagnostic studies, prospective studies, randomized controlled trials, or systematic reviews
II	Evidence obtained from lesser-quality diagnostic studies, prospective studies, systematic reviews, or randomized controlled trials (eg, weaker diagnostic criteria and reference standards, improper randomization, no blinding, less than 80% follow-up)
III	Case-control studies or retrospective studies
IV	Case series
V	Expert opinion

Development of Recommendations

The GDG developed recommendations based on the strength and limitations of the body of evidence, including how directly the studies addressed the clinical questions posed. Additionally, the authors considered potential health benefits, side effects, and risks of tests and interventions. The GDG used BRIDGE-Wiz Version 3.0 (Yale University, New Haven, CT) to write implementable and transparent recommendations that meet the Institute of Medicine CPG standards.[101] The GDG worked with the editors and staff of the target journal for publication and APTA CPG leaders to refine the recommendations and supporting documentation structure into a publishable format.

Selection and Adaptation of Recommendations From Previously Published CPGs

Numerous evidence-based CPGs and expert consensus guidance documents on concussion have been published. Likewise, several CPGs applicable to physical therapy examination and intervention strategies relevant to impairments and functional limitations common with concussive events have been developed and endorsed by the APTA and its associated academies. The GDG determined it was important to minimize redundancy in the literature and avoid replication of general practice recommendations by using a process of critical appraisal to adapt recommendations from previously published, high-quality CPGs relevant to general management of patients who have experienced a concussive event. As CPGs are often reviewed and updated, the group continued to monitor publication of updates and releases of new CPGs through December 31, 2018 for potential inclusion in this document. This ensured the inclusion of existing guidelines appropriate for endorsement and integration in this CPG.

Recommendations from previously published CPGs were eligible for inclusion if they met the following criteria: (1) published on January 1, 2015 or later, (2) included a multidisciplinary team for authorship, (3) based on a systematic review and appraisal of the literature, (4) included recommendations that pertained to movement-related impairments, and (5) rated as acceptable quality based on critical appraisal by 2 trained independent reviewers using the Appraisal of Guidelines for Research and Evaluation II (AGREE II) tool.[22] The AGREE II instrument consists of 23 items categorized under 6 domains, rated using a 7-point scale. A rating of 7 represents the highest possible score. Three CPGs were identified that met these criteria: (1) guidelines produced by a working group for the Ontario Neurotrauma Foundation in 2015,[153] (2) guidelines produced by a working group for the US Department of Veterans Affairs and Department of Defense in 2016,[149] and (3) guidelines for pediatric patients produced by a working group for the CDC in 2018.[141] Recommendations in this CPG that were developed based on an adaptation of previously published CPGs were assigned a level of evidence in accordance with the table below.

LEVEL	EVIDENCE LEVEL RATING FOR RECOMMENDATIONS ADAPTED FROM PREVIOUSLY PUBLISHED CPGS ON CONCUSSION MANAGEMENT
I	The recommendation being adapted was generated from level I evidence
II	The recommendation being adapted was generated from level II evidence
III	The recommendation being adapted was generated from level III evidence
IV	The recommendation being adapted was generated based on expert consensus of the authors of the published CPG

GRADES OF RECOMMENDATION

Grades for each recommendation were assigned through a consensus-generation process in accordance with the recommended grades and definitions provided below. The wording of the clinician level of obligation used in the recommendations was designed to align with the recommended language for linking evidence, grades of recommendation, and strength of obligation (Level of Obligation column). Unanimous agreement among all GDG members was required to include recommendations adapted from previously published CPGs. The GDG determined the grade of recommendation based on synthesis of the relevant recommendations.

AGREE II Review

To ensure the CPG was of high quality and implementable, the complete draft of the CPG was reviewed by members of the Academy of Neurologic Physical Therapy evidence-based Practice Committee, using the AGREE II instrument.[22] Domain scores for the CPG were strong overall, with individual ratings ranging from 5 to 7 on all domains. Scores and comments provided by the AGREE II reviewers were discussed by the GDG. When deemed feasible and appropriate, the GDG edited the CPG to address reviewer concerns and suggestions.

External Stakeholder Review Processes

Guideline development methods, policies, and implementation processes are reviewed at least yearly by the Academy of Orthopaedic Physical Therapy, APTA, Inc's ICF-based Clinical Practice Guideline Advisory Panel, which includes consumer/patient representatives, external stakeholders, and experts in physical therapy practice guideline methodology. This CPG underwent multiple formal reviews. The complete draft was reviewed by invited stakeholders representing CPG methodology and a variety of clinical perspectives, including physical therapists, physicians, athletic trainers, neuropsychologists, occupational therapists, and speech language pathologists. Acknowledgments for specific reviewers are provided at the end of the CPG. The draft was also posted for public comment in September 2019 on websites for the components of the APTA that supported the development process (the Academy of Orthopaedic Physical Therapy, the American Academy of Sports Physical Therapy, and the Academy of Neurologic Physical Therapy). Notices encouraging contributions to the request for public comment were sent via e-mail and electronic newsletter to members of APTA components

GRADES OF RECOMMENDATION		STRENGTH OF EVIDENCE	LEVEL OF OBLIGATION
A	Strong evidence	A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study	Must: benefits substantially outweigh harms Should: benefits moderately outweigh harms May: benefits minimally outweigh harms or benefit-harm ratio is value dependent Should not: harms minimally or moderately outweigh benefits or evidence of no effect Must not: harms largely outweigh benefits
B	Moderate evidence	A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation	Should: benefits substantially outweigh harms May: benefits moderately or minimally outweigh harms or benefit-harm ratio is value dependent Should not: evidence that harms outweigh benefits or evidence of no effect
C	Weak evidence	A single level II study or a preponderance of level III and IV studies, including statements of consensus by content experts, support the recommendation	Should: benefits substantially outweigh harms May: benefits moderately or minimally outweigh harms or benefit-harm ratio is value dependent Should not: harms minimally or moderately outweigh benefits
D	Conflicting evidence	Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting studies	May: conflicting evidence; the benefit-harm ratio is value dependent
E	Theoretical/ foundational evidence	A preponderance of evidence from animal or cadaver studies, from conceptual models/principles, or from basic sciences/bench research support this conclusion	May: in the absence of evidence from clinical studies, theoretical and/or foundational evidence supports benefit Should not: in the absence of evidence from clinical studies, theoretical and/or foundational evidence suggests risk of harms
F	Expert opinion	Best practice based on the clinical experience of the GDG	Must: strongly supported by consensus-based best practice/standard of care Should: moderately supported by best practice/standard of care May: supported by expert opinion in the absence of consensus Should not: best practice/standard of care indicates potential harms Must not: potential harms are strongly supported by consensus-based best practice/standard of care

for orthopaedics, sports, neurology, pediatrics, and geriatrics, as well as to individuals who inquired about the CPG during its development. Comments, concerns, and suggestions from each round of reviews were considered by the GDG with each successive draft of the document.

ORGANIZATION OF THE GUIDELINE

This CPG covers topics related to concussion incidence, risk factors for prolonged recovery, physical therapist examination strategies, and physical therapist intervention strategies. At the end of the document, decision trees are provided that align with the recommendations and address the flow of decisions for triage (process to help determine priorities) and sequencing of activities.

CLASSIFICATION

The primary International Classification of Diseases, 10th revision (ICD-10) code associated with concussion is **S06.0 Concussion**. Additional codes that may be directly associated with the brain injury aspect of concussive events include **S06.9X Unspecified intracranial injury**, **S06.2X Diffuse traumatic brain injury**, and **F07.81 Postconcussional syndrome**. Due to its complex nature, there are many ICD-10 codes related to physical impairments that may result from a concussive event. Studies have defined core sets of ICF indicators following concussion, spine trauma, or vestibular complaints.[61,75,206] Issues that would reasonably be addressed by physical therapy were identified from these sources, and consensus of the GDG confirmed their inclusion, resulting in the lists summarized in **TABLES 1** and **2**.

TABLE 1 ICD-10 Codes Related to Physical Impairments Associated With Concussive Events

Code	Description
G43	Migraines
G43.909	Headache, migraine
G44.209	Headache, tension type
G44.309	Headache, posttraumatic
G44.319	Headache, posttraumatic, acute
G44.329	Headache, posttraumatic, chronic
G44.84	Headache, exertional
G89.11	Pain, due to trauma
G89.21	Pain, chronic due to trauma
G89.29	Pain, chronic
G89.4	Pain, chronic pain syndrome
G96.9	Central nervous system disorder

Table continues in next column.

TABLE 1 ICD-10 Codes Related to Physical Impairments Associated With Concussive Events (continued)

Code	Description
H51.1	Convergence insufficiency and excess
H81.1	Benign positional vertigo
H81.3	Other peripheral vertigo
H81.39	Vertigo, peripheral
H81.4	Vertigo of central origin
H81.8	Unspecified disorder of vestibular function
H81.9	Vestibular function disorder
H82	Vertiginous syndromes
H83.2	Imbalance, labyrinth
M24.28	Vertebral ligament disorder
M25.60	Joint stiffness
M26.62	Pain, temporomandibular joint
M26.69	Derangement, temporomandibular joint
M46.01	Enthesopathy, spinal, occiput-atlas-axis
M46.02	Enthesopathy, spinal, cervical region
M50.90	Cervical disc disorder
M53.1	Pain, cervicobrachial; cervical root syndrome
M53.2	Instability, joint, posttraumatic, spine
M53.82	Dorsopathy, cervical region
M54.2	Cervicalgia
M79.1	Pain, myofascial
R26.8	Other abnormalities of gait and mobility
R29.3	Imbalance, postural
R42	Dizziness and giddiness
R51	Headaches
R52	Pain, acute
R53.83	Fatigue
S04.6	Injury, acoustic nerve
S06.06	Concussion
S06.2X	Diffuse traumatic brain injury
S06.9X	Unspecified intracranial injury
S09.31	Injury, blast, ear
S10	Superficial injury of neck
S10.9	Injury, superficial neck, unspecified part
S12.9	Fracture, cervical
S13.4	Sprain of ligaments of cervical spine
S13.4	Whiplash injury
S16	Injury of muscle, fascia, and tendon at neck level
S16.9	Injury, neck muscle, unspecified
S19.9	Injury, neck, unspecified

TABLE 2 ICF Codes for Physical Impairments Associated With Concussive Events

Code	Description
Body functions	
b130	Energy and drive functions
b134	Sleep functions
b140	Attention functions
b147	Psychomotor functions
b156	Perceptual functions
b210	Seeing functions
b215	Functions of structures adjoining the eye/oculomotor function
b235	Vestibular functions
b240	Sensations associated with hearing and vestibular function
b260	Proprioceptive functions
b280	Sensation of pain, headache, neck pain/other pain
b455	Exercise tolerance functions
b710	Mobility of joint functions
b730	Muscle power functions
b735	Muscle tone functions
b740	Muscle endurance
b760	Control of voluntary movement functions
b770	Gait pattern functions
Body structures	
s110	Structure of brain
s260	Structure of inner ear
s410	Structure of cardiovascular system
s710	Structure of head and neck region
Activities and participation	
d220	Undertaking multiple tasks
d410	Changing basic body positions
d415	Maintaining a body position
d430	Lift and carry objects
d450	Walking
d455	Moving around (includes running, jumping)
d460	Moving around in different locations
d469	Walking and moving, other specified and unspecified
d475	Driving
d640	Doing housework
d810-839	Education
d840-859	Work and employment
d910	Community life
d920	Recreation and leisure

Postconcussive Event Impairment Domains

The GDG identified 4 domains that are relevant to physical therapist examination and intervention processes and may be useful to identify specific patient needs and develop treatment plans. These domains should not be treated as mutually exclusive classifications, as patients may exhibit impairments that fall into more than 1 category. The 4 domains are presented below, with specific rationales about the associations between impairments and concussive events.

Cervical Musculoskeletal Impairments

Cervical musculoskeletal impairments can lead to a variety of symptoms that are also commonly reported by individuals with a diagnosis of concussion (eg, neck pain, headache with or without neck pain, dizziness, and diminished balance/postural control).[57,98,106,152,165,195] Currently, the incidence of cervical musculoskeletal impairment associated with concussive events has not been comprehensively studied or well reported. However, given the biomechanical mechanism of many concussive injuries, it is hypothesized that cervical musculoskeletal impairments may be present.[35,54,217] In patients with neck pain in the absence of concussion, there is strong evidence that impairments such as diminished range of motion, poor strength, and insufficient muscle endurance and control exist.[16] There is also evidence that sensorimotor control deficits may originate from alterations in cervical afferent input.[64,83,84,114,209-212] These deficits may include impaired cervical reflex responses and cervical proprioception that can affect the visual and vestibular systems and lead to dizziness, visual dysfunction, balance problems, and difficulties with head and eye movement control.[58,83] Therefore, even when neck pain is not present in a patient who has experienced a concussive event, cervical musculoskeletal impairments may serve as an underlying source driving other symptoms, particularly dizziness, imbalance, and headache. This overlapping of symptoms can make determining symptom origin difficult in patients after a concussive event.

Vestibulo-oculomotor Impairments

Numerous studies indicate that vestibular and oculomotor deficits are common after concussion.[165] Such deficits can contribute to many postconcussion symptoms, impairments, and functional limitations, including dizziness, balance problems, vertigo, blurred vision, headaches, nausea, sensitivity to light, sensitivity to sound, mental fogginess, difficulty reading, difficulty concentrating, anxiety, and fatigue.[82] Precise incidence rates for these impairments remain unclear, and they may be driven by different factors and/or multiple factors.[82,103,165,186,198] Physical therapy examination and intervention strategies for both the vestibular and oculomotor systems are linked, especially relative to the literature pertaining to concussions/mTBIs. Therefore, it is practical to view these as a single impairment domain for examination and treatment purposes. Regardless, it is important for physical therapists to consider the interplay and overlap between cervical and vestibular causes of dizziness, oculomotor dysfunction, and imbalance.

Autonomic Dysfunction and Exertional Intolerance

Mounting evidence indicates that reduced tolerance of physical exertion is common after concussion, with many individuals reporting an increase in a variety of concussion-related symptoms with physical exertion.[47,53,54,66,85,104,123,126,133,152,159,192] Poor tolerance of physical exertion may also be associated with higher reports of fatigue, as the effects of physical exertion may not occur during actual exercise but may emerge later.[47,118] The extent to which physical exertion intolerance is present among individuals with concussion has not been systematically studied, nor are the specific mechanisms that drive exertion intolerance fully understood. However, autonomic dysfunction resulting from the brain injury itself may be a contributing factor.[9,15,33,123,133] It has been hypothesized that concussions can lead to an uncoupling of the central autonomic nervous system and the heart, leading to a reduced ability to maintain and adjust cerebral blood flow, blood pressure, and/or heart rate in response to increases and decreases in physical exertion.[15,53,66,85,133] While confirmatory studies for these hypotheses are needed, preliminary work in this area suggests that concussions may be associated with altered autonomic regulation.[17,65,66,85] This autonomic dysregulation has been linked to higher perceived rates of exertion after concussion in comparison to individuals who have not recently sustained a concussion,[85] and may be captured by assessments for orthostatic hypotension.[187] Another potential source of poor tolerance of physical exertion is general deconditioning or secondary physical inactivity/lifestyle changes that may be recommended or occur as a result of the concussive injury.[191,192,204]

Motor Function Impairments

A variety of studies have reported that individuals who have experienced a concussive event may present with altered motor function abilities, including static and dynamic balance/postural control impairments, changes in dual/multitasking impairments, delayed motor reaction time, and increased difficulty with motor coordination (especially with more complex environments or tasks).[43,44,64,111] These motor function impairments may be relatively subtle and difficult to capture without laboratory equipment.[28-30,91,93,136] Studies also suggest that these underlying impairments may persist for months to years and may be present even when symptoms have seemingly resolved.[13,44] The extent to which such subtle motor function impairments may interfere with daily function and activity participation is unclear, and the prevalence of these impairments remains unknown. However, these types of impairments may lead to increased risk for future concussions and other injuries among athletes and those in high-activity/high-risk jobs (eg, active-duty military, firefighters, and police officers).[87,162,185]

DISSEMINATION AND IMPLEMENTATION PLANS AND TOOLS

In addition to the publication of this document, this CPG will be freely available on APTA Academy websites, including www.orthopt.org, and posted in a searchable CPG database hosted by the APTA. The initial presentation of the CPG draft was presented January 24, 2019 at the APTA Combined Sections Meeting in Washington, DC. Additional plans are in place for ongoing presentation of this CPG at educational conferences and webinars for clinicians. Planned implementation tools include a patient-oriented guideline summary, read-for-credit continuing education units, and suggestions for common data elements and minimal data sets for contribution to the Physical Therapy Outcomes Registry.

Plan for Updating the Guideline

The plans for updating this CPG include monitoring the evidence on a monthly basis and publishing a revision in approximately 5 years. If evidence of sufficient quality becomes available that directly contradicts or would result in substantial changes to the recommendations in this CPG prior to the planned 5 years, a revised CPG may be needed sooner.

CLINICAL PRACTICE GUIDELINES

Impairment/Function-Based Diagnosis

INCIDENCE

Evidence Summary

Concussion is increasingly recognized as a major public health concern due to high incidence rates and the potential for long-term effects.[4,107,108,141,159] Overall incidence rates for concussion have varied greatly across studies. The CDC estimates that 1.6 to 3.8 million concussions occur during sports and recreational activities annually.[121] For 2008, the Agency for Healthcare Research and Quality reported 43 802 emergency department (ED) visits for sports-related concussion, and more than 12 times as many reported non–sports-related concussions during the same period.[227] However, it may be that this ratio is different for non-ED contexts. Even so, it illustrates that while media reports have often focused on the high incidence and dangers of concussion in sports, it is important to recognize that the mechanisms and contexts of concussive events vary greatly, and frequently occur outside of sports contexts (ie, falls, motor vehicle crashes, and military injuries).[25,37,227] Furthermore, recent epidemiological reports indicate that incidence rates for concussions have been on the rise, likely as a direct result of the increases in research and media coverage indicating the substantial impact of concussive events and mild brain injuries.[25,41]

A commonly acknowledged limitation of incidence estimates is that not all individuals who experience a concussive event seek medical care.[41,46,55,56,107,120,121] Additionally, many concussive events go unrecognized or unreported,[41] and the symptoms, impairments, and functional limitations associated with concussion can be subtle, vary in presentation, and be easily confused with other common illnesses or injuries.[34,41,107] For example, headaches, fatigue, and dizziness commonly occur after a concussive event; however, they are also associated with other injuries and illnesses.[141,142,149,153] Collectively, these factors are significant challenges to providing accurate estimates of the incidence and prevalence of concussion.[34,107,142,159]

Gaps in Knowledge

Future research should investigate the prevalence of patients participating in physical therapy who do not have a medical diagnosis of concussion yet experienced a concussive event and exhibit signs and symptoms indicative of a concussion. Research in this regard would help provide estimates for undiagnosed concussion among individuals referred to physical therapy.

RISK FACTORS

Evidence Summary

There is growing recognition that concussion recovery trajectories are complex, highly variable, and influenced by a range of factors (eg, age, sex, prior history of concussion, premorbid diagnoses).[34,102,107,108] A recent systematic review highlighted preinjury factors, injury-related factors, and postinjury factors associated with prolonged recovery after a concussion.[102] It has been suggested that preinjury factors such as history of concussion, female sex, younger age, attention-deficit hyperactivity disorder (ADHD), history of migraine, and genetics may all be associated with prolonged recovery from concussion.[102] Injury-related factors associated with prolonged recovery include loss of consciousness, anterograde amnesia, retrograde amnesia, and delayed removal from sports participation.[102] Postinjury factors associated with prolonged recovery include symptoms of dizziness, headache, migraine, or depressive symptoms.[102] However, studies have also documented a lack of association between prolonged recovery and many of the aforementioned factors.[102] Consequently, definitive characterization of risk factors associated with poor concussion recovery remains unclear.[102,107,108]

Two emerging areas of research highlight additional factors that may influence recovery outcomes: (1) psychosocial factors (eg, perceived competence, tenacity, tolerance of negative affect, and positive acceptance of change)[107,119,138-140,176] and (2) early concussion management factors (eg, strict rest versus relative rest versus active rehabilitation).[34,107,137] Identification of risk factors and implementation of management approaches have continued to evolve quickly as new knowledge is gained and alternative strategies are proposed. This fast-paced evolution of evidence likely contributes to variation in care, which in turn adds to the difficulty in defining natural concussion recovery trajectories and the extent to which various strategies directly affect outcomes.[107,108]

Gaps in Knowledge

More research is needed to determine risk factors related to poor recovery from concussion and how timing and utilization of physical therapy services may affect recovery.

CLINICAL COURSE

Evidence Summary

Concussions are associated with a wide array of complaints, including headache, dizziness, balance problems, neck pain, sensitivity to light and sound, fatigue, disorientation, mental fogginess, sleep disturbances, and difficulty regulating emotions, among others.[41,107,142] Many studies report that most individuals who sustain a concussion "recover" within a relatively short period of time (approximately 7-14 days post injury).[34,41,102] However, definitions for concussion and the strategies to measure recovery have been inconsistent.[102,107] In recent years, the notion that most individuals recover fully from concussion within a few days or weeks has been increasingly challenged.[34,102,159] Studies have demonstrated that as many as 5% to 58%[96,107] of individuals who sustain a concussion have persistent symptoms, impairments, and/or limitations that affect daily function. The timing of these complaints ranges from a few days to a few weeks or longer.[96,144,151,196]

Although it is often reported that symptoms, impairments, and functional limitations follow a gradual pattern of improvement, the trajectory may not be linear.[197] Rather, many patients experience symptom exacerbations during their recovery period.[197] In some cases, these exacerbations may be an immediate reaction to a specific mechanism (eg, change of position or intense bout of physical or cognitive exertion),[47] or delayed reaction associated with activities over the preceding 24-hour period.[197] Some studies indicate that subtle, underlying impairments may continue to be present after concussion[43,44,144] and put individuals at risk for additional injuries[105,162] or more chronic/long-term sequelae (eg, chronic pain, persistent motor control deficits).[43,44,74,151]

Since approximately 2007, clinical commentaries and studies have supported postconcussion assessment, management, and skilled rehabilitation techniques that fall within physical therapists' scope of practice (eg, progressive aerobic exercise, vestibular and oculomotor interventions, manual therapy and exercises targeting the cervical spine, balance training).[4,5,9,18,34,38,47,51,53,54,62,98,125,132,133,145,152,178,191,192,194,220,225] Systematic reviews support active rehabilitation strategies for concussions under the direction of a physical therapist as a promising management approach for facilitating recovery.[178,192] Consequently, physical therapists have become key members in an interdisciplinary approach to caring for individuals with concussion.[53,159]

Gaps in Knowledge

Despite a growing body of evidence on the safety and primarily positive outcomes for physical therapy interventions, additional research is needed to provide more specific insight into factors that affect patient responsiveness to physical therapy for concussion-related symptoms, impairments, functional limitations, and participation restrictions. Additionally, studies evaluating the prevalence of the different types of movement-related impairments would be informative.

CLINICAL PRACTICE GUIDELINES

Screening and Diagnosis

DIAGNOSIS

I Two high-quality CPGs strongly emphasize the need to recognize and diagnose a concussion as soon as possible to promote positive health outcomes and mitigate poor health outcomes and secondary effects of concussion.[149,153]

Evidence Synthesis

High-quality concussion CPGs and consensus-based guidance documents consistently acknowledge (1) the importance of identifying and diagnosing a potential concussion as early as possible, (2) the importance of the involvement of a trained medical professional for determining the concussion diagnosis, and (3) common signs and symptoms that should be used to diagnose a concussion. Given the known problems of underreporting and underrecognition of concussions, physical therapists may encounter patients who have experienced a concussive event and exhibit concussion-related symptoms, impairments, and functional limitations, yet have not been diagnosed with a concussion. The benefits of identifying an undiagnosed concussion and associated impairments may outweigh the potential costs of time, resources, and overidentification that may occur with more expansive screening efforts.

Recommendation

A Physical therapists **must** screen all individuals who have experienced a potential concussive event and document the presence or absence of symptoms, impairments, and functional limitations that may relate to a concussive event.

SCREENING FOR INDICATORS OF EMERGENCY CONDITIONS

I Two high-quality CPGs included recommendations emphasizing the importance of screening for more serious neurological or musculoskeletal conditions that may require emergency evaluation and treatment.[141,153]

Evidence Synthesis

Although incidence is relatively low, there is potential for an individual with an initial presentation of mild brain injury to develop signs of decline that may be indicative of more moderate to severe brain pathology. In many cases, physical therapists are likely to encounter patients who are outside the most vulnerable period for signs of moderate to severe injury, so screening for indicators of emergency will align with standard-of-care practice patterns for general systems review. However, in some cases, physical therapists may be the patient's first health care providers (eg, through direct access, sideline coverage for certified sports specialists, providing coverage in an ED, or other contexts). In these cases, more in-depth screening procedures may be needed. Clinical practice guidelines for concussion/mTBI provide specific guidance on this type of screening.[141,153]

FIGURE 1 provides a synthesis of key signs and symptoms in screening to determine the need for emergency evaluation. The use of the Glasgow Coma Scale and the Canadian computed tomography (CT) head rule may be useful to support screening of individuals for brain injury of greater severity than concussion.[149,153] If patients demonstrate relatively normal mental status (alertness/behavior/cognition) at least 4 hours post injury, do not report severe headache, do not have signs of focal neurological deficit, and do not demonstrate high-risk factors for further imaging/scans (eg, Glasgow Coma Scale score of less than 13 two hours after injury, suspected open skull fracture or sign of base skull fracture, vomiting more than twice, and younger than 65 years of age), then concern for more severe brain injury requiring neurosurgical intervention is low. For patients aged 8 to 18 years presenting within the first 24 hours of head injury, the Pediatric Emergency Care Applied Research Network (PECARN) has developed a validated prediction rule to help identify children at very low risk of needing acute-care intervention, versus those who are showing signs of more moderate or severe brain injury.[116] Signs that CT imaging and other acute monitoring are not likely needed include normal mental status, no loss of consciousness, no vomiting, nonsevere injury mechanism, no signs of basilar skull fracture, and no severe headache.[116]

Additionally, given the mechanisms of a concussive event, screening for potential cervical spine pathology is also warranted, regardless of presence of neck pain. When screening for significant cervical spine pathology, signs indicative of infection, cancer, cardiac involvement, arterial insufficiency (ie, dizziness in combination with neurologic signs), upper cervical ligamentous insufficiency (ie, positive transverse or alar ligament testing), unexplained cranial nerve dysfunction, signs of central cord compression (ie, positive upper motor neuron tests), or fracture (ie, findings suggesting imaging is required based on the Canadian cervical spine rules and/or the National Emergency X-Radiography Utilization

Study criteria) warrant further assessment and referral for consultation with physicians or other members of the health care team (**FIGURE 1**).[10,16,201,202]

Recommendation

A Physical therapists **must** screen patients who have experienced a recent potential concussive event for signs of medical emergency or severe pathology (eg, more serious brain injury, medical conditions, or cervical spine injury) that warrant further evaluation by other health care providers. Referral for further evaluation should be made as indicated (**FIGURE 1**).

DIFFERENTIAL DIAGNOSIS

I Evidence and recommendations from a high-quality CPG emphasized a need to conduct a comprehensive intake on various aspects of the patient's past medical history, review of mental health history, injury-related mechanisms, injury-related symptoms, and early management strategies.[153]

I Evidence and recommendations from high-quality CPGs did not support the use of imaging for immediate diagnosis in the absence of more severe brain injury concerns.[141,149,153] The use of biomarkers and the consideration of helmet-based measurement devices for diagnosing concussion are not recommended outside the context of research studies.[141,149,153]

I Evidence and recommendation from 2 high-quality CPGs support using a symptom checklist or symptom rating scale to help evaluate/assess for concussion signs and symptoms and multisystem evaluations.[141,153] However, there are no clear evidence-based endorsements to support specific symptom scales or system measures.

I Evidence indicates that computerized neurocognitive assessments are an option to complement diagnostic evaluation for concussion, but the reliability, validity, and utility across patient populations remain unclear.[2,3,149]

II Evidence from a high-quality CPG further supports that multiple tools should be used to assess children with concussion, but does not provide endorsement of any specific tools.[141]

II Evidence from the CDC CPG, providing recommendations specific to children, indicates that age-appropriateness may be an important consideration for selection of concussion symptom scales, as there are different scales developed for specific age ranges.[141]

II Evidence and recommendations from 1 high-quality CPG support evaluation for cognitive difficulties through focused clinical interviews and symptom checklists.[153] Evidence and recommendations from a high-quality CPG recommend against the use of comprehensive and focused neurocognitive assessments in the first 30 days, instead encouraging general screening until symptoms appear to be persistent.[149]

IV Evidence from expert consensus documents and case studies provides further support for a comprehensive intake for factors that may affect or be affected by recovery from concussion.[61,159,160]

Evidence Synthesis

Available guidance documents indicate the multidimensional factors that should be considered and that triangulation of information sources should be used to identify concussion as the likely cause of the presenting signs and symptoms (**FIGURE 1**). As recognized by high-quality CPGs and numerous epidemiological studies, memory problems and confusion are common symptoms associated with concussion. Reports from individuals who know a patient well can be used to help verify and expand upon information the patient provides. Symptom scales or checklists are commonly used and cited. However, there is no clear gold standard for the most appropriate diagnostic tools based on previously published guidelines, and comparative studies between tools are limited.

A comprehensive systematic review of all potential diagnostic tools for concussion was outside the scope of the GDG goals for this CPG. Based on the evidence that was identified within the searches that were performed, the GDG determined that there is insufficient evidence to specifically endorse any of these assessments due to uncertain reliability, validity, and utility for the wide array of types of patients physical therapists may encounter.

Recommendations

A Physical therapists **must** evaluate for potential signs and symptoms of an undiagnosed concussion for patients who have experienced a concussive event but have not been diagnosed with concussion. Evaluation should include triangulation of information from patient/family/witness reports, the patient's past medical history, physical observation/examination, and the use of an age-appropriate symptom scale/checklist (see **FIGURE 1** for diagnostic criteria).

F For patients who have experienced a concussive event and do not report or demonstrate signs and symptoms consistent with a concussion diagnosis, physical therapists **should** evaluate for other potential diagnoses and follow standard-of-care procedures in accordance with their findings.

F For patients who have experienced a concussive event and report or demonstrate signs and symptoms consistent with a concussion diagnosis, physical therapists **should** determine whether a comprehensive physical therapy evaluation is appropriate using information from a comprehensive intake interview and clinical judgment (see **FIGURE 1** for potential considerations).

A Physical therapists **should** screen patients who have experienced a concussive event for mental health, cognitive impairment, and other potential coinciding diagnoses and refer for additional evaluation and services as indicated.

F For patients not deemed appropriate for a comprehensive physical therapy examination (ie, they present with severe mental health concerns or health conditions that require medical clearance prior to comprehensive physical examination), physical therapists **should** provide education regarding concussion symptoms, prognosis, and self-management strategies and refer for consultation with other health care providers as indicated.

COMPREHENSIVE INTAKE INTERVIEW

I Evidence and recommendations from a high-quality CPG emphasized the need to conduct a comprehensive intake on various aspects of the patient's past medical history, reviewing mental health history, injury-related mechanisms, injury-related symptoms, and early management strategies.[153]

II Evidence from a high-quality CPG further supports that multiple tools should be used to assess children with concussion, but does not provide endorsement of any specific tools.[141]

IV Evidence from expert consensus documents and case studies provides further support for a comprehensive intake for factors that may affect or be affected by recovery from concussion.[61,159,160]

Recommendation

A Physical therapists **must** conduct and document a comprehensive intake of past medical history, reviewing mental health history, injury-related mechanisms, injury-related symptoms, and early management strategies for patients who have experienced a concussive event.

CLINICAL PRACTICE GUIDELINES

Examination

SYSTEMS TO BE EXAMINED

II Evidence and recommendations from a high-quality CPG[153] and moderate-quality systematic review[147] consistently emphasize the importance of a multisystem physical examination to help discern specific impairments that may need to be monitored or targeted with rehabilitation strategies. Systems to be evaluated included neurological (including specific screens for vision, auditory, sensory processing, cognition, and motor control and coordination impairments), cardiovascular/autonomic, musculoskeletal, and vestibular systems.

IV Four recent expert consensus statements provide robust evaluation of potential physical examination techniques and domains, with varying strengths of recommendation based on clinical expertise.[19,61,159,160] Recommendations for examination approaches most relevant to this CPG included assessments for musculoskeletal function (especially in the cervical spine), vestibular and oculomotor function, exertional tolerance, gait, balance, and dual/multitasking.

Evidence Synthesis

There is strong evidence to support high risk for concussive events to result in multiple system impairments that affect and are affected by movement. There are no well-validated, evidence-based approaches or tools to guide how the multiple systems should be evaluated. Recent expert consensus statements provide insight into what may be considered best practice at this time.[19,61] However, it should be acknowledged that these recommendations were meant for more global management of concussion and are not specific to physical therapy management of concussion. Recent evidence offers some potential screening options that include screening for movement-related impairments (eg, Buffalo Concussion Physical Examination[77,124]). There is also insufficient evidence to support the validity, reliability, and utility of these screening tools for physical therapy purposes. Therefore, while there is moderate to strong evidence to suggest that it is important to assess the domains identified, the recommendations in this CPG are intentionally vague with regard to which assessments should be used. As previously mentioned in the Clinical Course section, the GDG identified 4 overarching system domains that align with movement-related impairments pertinent to physical therapists' scope of practice: (1) cervical musculoskeletal impairments, (2) vestibulo-oculomotor impairments, (3) autonomic dysfunction/exertional tolerance impairments, and (4) motor function impairments. Identifying impairments in each of these domains will help in the development of treatment plans tailored to the needs of each patient.[31]

Gaps in Knowledge

Future research to develop, test, and optimize a specific battery of physical therapy examination strategies for individuals who have sustained a concussive event is needed.

Recommendation

B For patients identified as safe and appropriate for a comprehensive examination, physical therapists **must** determine and document a need for physical therapy to facilitate recovery from a concussive event, based on findings from a comprehensive multisystem physical therapy examination and evaluation. Examination procedures should include examination for impairments in the following domains: cervical musculoskeletal function, vestibulo-oculomotor function, autonomic dysfunction/exertional tolerance, and motor function, through foundational standard-of-care screening strategies (**FIGURE 2**).

SEQUENCING OF EXAMINATION BASED ON LEVELS OF IRRITABILITY

Evidence Synthesis

No evidence was identified to address sequencing of physical therapy examination of patients who have experienced a concussive event. However, screening and examination for movement-related impairments often require procedures that are intended to provoke symptoms to determine whether an impairment is present. The consensus of the GDG was that transient increases in symptoms are expected in response to physical therapy examination processes. Because of the multisystem effects, it is possible that examination procedures for one system may increase symptoms to a level that may make it difficult to proceed or could compromise the validity of additional tests for other systems. The extent to which symptoms are provoked, and their duration, can be assessed and a level of irritability assigned.

FIGURE 2 provides a triage system (a process to help determine priorities) to guide examination sequencing that is based solely on the GDG's consensus of expert opinion. The focus is on using anticipated levels of irritability to strategically sequence exam procedures. Recommended irritability considerations with regard to symptom reports and examination procedures include (1) frequency of symptom provocation, (2) vigor of movement required to reproduce symptom(s),

(3) severity of symptoms once provoked, (4) how easily symptoms are provoked, (5) which factors ease the symptoms, and (6) how much, how quickly, and how completely the symptoms resolve (**FIGURE 2**).

Gaps in Knowledge

Future research is needed to test the utility and value of this triage strategy.

Recommendations

F Prior to initiating a comprehensive physical examination for patients who have experienced a concussive event, physical therapists **should** determine probable levels of irritability for movement-related symptoms and impairments and plan to strategically sequence and/or delay examination procedures as needed, based on patients' symptom types and probable level of irritability. Physical therapists are encouraged to first triage for neck pain irritability and then for dizziness and/or headache (**FIGURE 2**).

F For patients who have experienced a concussive event and have high neck pain irritability but exhibit no signs of serious neck or systemic pathology, physical therapists **should** first examine the cervical and thoracic spines for sources of musculoskeletal dysfunction and address findings appropriately to promote symptom relief (eg, stretching, soft tissue mobilization, therapeutic exercise, modalities) and to support tolerance of examination of other body systems.

F For patients who have experienced a concussive event and report dizziness, vertigo, and/or headache, physical therapists **should** thoroughly examine for sources of cervical and thoracic spine dysfunction, vestibular and oculomotor dysfunction, and orthostatic hypotension/autonomic dysfunction that may contribute to the emergence or exacerbation of these symptoms (**FIGURE 2**). Therapists should start with the tests that are anticipated to be the least irritable and proceed with the tests anticipated to be the most irritable, based on patient tolerance.

F After triaging and screening for neck pain, dizziness, and headache, physical therapists **should** proceed with multisystem comprehensive examination of any untested domains of cervical musculoskeletal function, vestibulo-oculomotor function, autonomic dysfunction/exertional tolerance, and motor function by sequencing tests and measures based on clinical judgment as indicated (**FIGURE 2**).

EXAMINATION FOR CERVICAL MUSCULOSKELETAL IMPAIRMENTS

IV Multiple consensus documents and lower-level studies emphasize that cervical musculoskeletal dysfunction is complex and may contribute to variable types of symptoms.[115,152,186,188,217] However, evidence and consensus statements encourage attempts to differentiate between the sources that may be causing the symptoms when possible.[186,188,217] When there is a report of neck pain with concussion, the potential for cervical spine musculoskeletal dysfunction is high. However, the potential for dizziness to be caused by cervical dysfunction post concussion is less clear.[188] Low-level evidence indicates that examination of cervical musculoskeletal, vestibulo-oculomotor, and autonomic functions may help clinicians differentiate between dizziness caused by cervical spine dysfunction and other sources.[188]

IV Several level IV studies, including a Delphi study, provide examples of cervical musculoskeletal assessments that may be useful to identify impairments that may contribute to neck dysfunction and cervicogenic dizziness.[106,187,188] Proposed examination techniques include active range of motion of the neck, testing for the presence of pain during active range of motion, manual passive joint mobility assessment, active trigger point assessment and tenderness to palpation, the cranial cervical flexion test, cervical flexion-rotation test, smooth pursuit neck torsion test, head-neck differentiation test, vibration tests, and motor control assessment of deep cervical flexors and extensors. Results of a Delphi study indicated a consensus of strong clinical utility for the following tests in patients with sports-related concussion: the Dix-Hallpike test, orthostatic hypotension testing, spontaneous nystagmus, head impulse test, roll test, gaze-hold nystagmus, saccade testing, vestibulo-ocular reflex cancellation, head-shake test, and smooth pursuit testing.[188] The authors noted that these tests identify dizziness originating from the vestibular or central nervous system. This Delphi study also achieved consensus categorizing the following tests as having weak clinical utility: the cervical flexion-rotation test, neck torsion test, vibration tests, head-neck differentiation test, and motor control assessments of deep cervical flexors and extensors. There was no clear consensus on the clinical utility of static and dynamic balance tests, convergence assessment, dynamic visual acuity testing (DVAT), reproduction of dizziness through manual passive joint mobility, the joint position error test, neck pain and related dizziness, or reproduction of dizziness through palpation of cervical musculature.

V A number of expert opinions, narrative reviews, and theoretical/conceptual papers have provided rationales and theoretical support for the potential role and relatively high prevalence of cervical musculoskeletal impairments that may coincide with symptom reports of dizziness and headache with proposed assessment strategies.[31,54,152,165]

Evidence Synthesis

There is clear evidence to suggest that the cervical spine should be examined after a concussive event, but there is limited evidence on examination procedures for cervical musculoskeletal dysfunction specific to patients who have experienced a concussive event. Low-level evidence suggests that a concussive event can cause cervical injury, and that cervical musculoskeletal impairments can cause symptoms that are often reported after a concussive event. Given the postulated connection between cervical musculoskeletal impairments and concussive events, the GDG consensus was that examination to detect impairments is useful for patients who have experienced a concussive event. Recommended tests and measures include passive and active range of motion of the neck, muscle strength and endurance for cervical and scapulothoracic muscles, tenderness to palpation of cervical and scapulothoracic muscles, passive cervical and thoracic spine joint mobility, and cervical joint position error. When dizziness is reported, the cervical spine should be examined to determine the potential for musculoskeletal dysfunction as a source of the dizziness. The GDG also agreed that the 2017 revision of the Academy of Orthopaedic Physical Therapy neck pain CPG[16] may be used as a resource for guiding physical therapist examination procedures. Musculoskeletal evaluations are part of all physical therapy curricula and are standard-of-care procedures for patients with suspected musculoskeletal dysfunction. Therefore, the GDG decided to set the level of obligation as "should" instead of "may," despite the relatively weak state of the evidence.

Gaps in Knowledge

Future research is needed to test the direct utility and implementability of the neck pain CPG[16] for patients who have experienced a potential concussive event. Although the scope of the systematic search process did not specifically cover the role of neck strength in mitigating subsequent concussion risk, numerous studies and expert opinion reports have hypothesized and demonstrated a potential link between concussion risk and neck strength and control.[152] Given the theoretical and hypothesized linkages between concussion risk, the potential dangers of subsequent concussions, and the expertise of physical therapists to address cervical spine dysfunction, the benefit of identifying potential cervical spine musculoskeletal impairments outweighs the potential costs and burden of examining the spine, even among those patients who do not report neck pain, headache, or dizziness. Future research to evaluate the value of examining neck strength and control among individuals in physical therapy when headache, neck pain, and dizziness are not reported would be beneficial.

Recommendations

C Physical therapists **should** examine the cervical and thoracic spines for potential sources of musculoskeletal dysfunction for patients who have experienced a concussive event with reports of any of the following symptoms: neck pain, headache, dizziness, fatigue, balance problems, or difficulty with visually focusing on a target. Recommended cervical musculoskeletal tests and measures include range of motion, muscle strength and endurance, tenderness to palpation of cervical and scapulothoracic muscles, passive cervical and thoracic spine joint mobility, and joint position error testing.

F Physical therapists **may** examine the cervical spine, thoracic spine, and temporomandibular joint for potential sources of musculoskeletal dysfunction for patients who do not report the symptoms listed to determine whether subtle impairments are present and may be contributing to symptoms.

EXAMINATION FOR VESTIBULO-OCULOMOTOR IMPAIRMENTS

I One CPG specific to concussion and a CPG not directly addressing individuals who have experienced a concussive event indicate that benign paroxysmal positional vertigo (BPPV) may be present and support the use of the Dix-Hallpike test/positional tests to assess for BPPV.[14,153]

II Evidence from a CPG specific to concussion provides strong support for examination to detect vestibular and oculomotor dysfunction that may contribute to postconcussive symptoms.[153] A moderate-quality systematic review reported the following as examination techniques that have been used in research to detect postconcussive oculomotor impairments: saccadic eye movement, smooth pursuits, vergence, and accommodation.[99]

II A prospective cohort study comparing preinjury baseline data and postinjury scores for 63 athletes indicated that both total and change scores on the Vestibular/Ocular Motor Screening (VOMS) may help identify vestibular and oculomotor impairments in athletes who have experienced a concussive event.[52]

II A cross-sectional study comparing 64 athletes with concussion and 78 healthy controls provided preliminary support for adequate internal consistency, sensitivity, and utility of the VOMS assessment.[169]

III Evidence from CPGs and systematic reviews using level III studies, as well as additional level III studies, further supports the use of vestibular and oculomotor evaluations to identify potential sources of postconcussive symptoms.[26,32,82,103,141,149,155,173,198]

IV A retrospective chart review of 167 youth patient records indicated that poorer scores on the VOMS in any of the domains except for near-point convergence may be predictive of delayed recovery after sport-related concussion.[8]

IV Expert consensus from 2 Delphi studies and preliminary evidence from other studies indicate that the following tests may have clinical utility for investigating various sources of dizziness after a concussive event, including dizziness of vestibular or oculomotor origin: ocular alignment, the Dix-Hallpike test, orthostatic hypotension testing, spontaneous nystagmus, head impulse test, roll test, gaze-hold nystagmus, saccade testing, vestibulo-ocular reflex testing, vestibulo-ocular cancellation testing, headshake test, smooth pursuit testing, motion sensitivity, optokinetic stimulation, and DVAT.[27,71,161,187,188,228]

IV A retrospective chart review indicated that pediatric patients who showed signs of vestibular abnormality on initial clinical examination at a sports medicine clinic took a significantly longer time to return to school or be fully cleared for return to sport.[38]

IV Multiple descriptive cohort studies indicate that dizziness, which is often tied to vestibulo-oculomotor dysfunction, is likely multifactorial and that it may be difficult to differentiate the specific impairments leading to the reports of dizziness.[38,82,152,186-188]

V A number of expert opinions, narrative reviews, and theoretical/conceptual papers have provided rationales and theoretical support for the potential role and relatively high prevalence of vestibular and oculomotor impairments that may coincide with symptom reports of dizziness and headache and proposed assessment strategies.[31,54,135,152,156,219]

Evidence Synthesis

Although evidence is available regarding evaluation for vestibular and oculomotor dysfunction, there is limited evidence specifically derived from patients who have experienced a concussive event. Various strategies to assess for impairments in vestibular and oculomotor function have been proposed. The VOMS is a vestibular and oculomotor functional screening tool that is commonly cited in the literature and was developed and has been tested for use specifically in athletes with concussion. Preliminary study of the VOMS supports its use for diagnosing sport-related concussions and predicting prolonged recovery. The VOMS captures self-reported symptom provocation with assessment of 5 areas: smooth pursuit, horizontal and vertical saccades, convergence, horizontal and vertical vestibular-oculomotor reflex, and visual motion sensitivity. The VOMS has demonstrated strong internal consistency and significant correlation with the Post-Concussion Symptom Scale, and has potential to help differentiate individuals with concussion from healthy controls. However, it is important to emphasize that the VOMS was not designed as a comprehensive tool for vestibular and oculomotor function and may not encompass all of the screening strategies necessary to examine all aspects of vestibular and oculomotor dysfunction. Therefore, it may be useful as a screening tool, but is not appropriate as a replacement for a comprehensive vestibular and oculomotor assessment.

The GDG determined that the following examination strategies may be useful for patients who have experienced a concussion: ocular alignment, head impulse testing, smooth pursuits, saccades, vergence and accommodation, gaze stability, dynamic visual acuity, and visual motion sensitivity. When symptoms indicate it, the use of positional tests (eg, the Dix-Hallpike test) may help to identify BPPV. Additionally, the CPGs for vestibular hypofunction[80] and BPPV[14] and their associated implementation tools may be useful to help guide examination and evaluation procedures.

Gaps in Knowledge

Various strategies to examine vestibular and oculomotor function have been proposed. At this time, there is limited evidence to support one strategy over others for examining patients who have experienced a concussive event. More research is needed to determine the utility and implementability of the CPGs for vestibular hypofunction[80] and BPPV[14] and other oculomotor-vestibular assessment protocols for use in individuals who have experienced a concussive event.

Recommendations

B Physical therapists **should** examine vestibular and oculomotor function for patients who have experienced a concussive event with reports of any of the following symptoms: headache, dizziness, vertigo, nausea, fatigue, balance problems, visual motion sensitivity, blurred vision, or difficulty with focusing on stable or moving targets.

B Physical therapists **should** examine vestibular and oculomotor function related to the following: ocular alignment, smooth pursuits, saccades, vergence and accommodation, gaze stability, dynamic visual acuity, visual motion sensitivity, light-headedness caused by orthostatic hypotension, and vertigo caused by BPPV.

A If BPPV is suspected, then physical therapists **should** assess the patient using the Dix-Hallpike test or other appropriate positional test(s).

F Physical therapists **may** examine patients who have experienced a concussive event for vestibulo-oculomotor function, even if vestibulo-oculomotor symptoms are not reported, to identify potential subtle impairments that may be contributing to symptoms.

EXAMINATION FOR AUTONOMIC/EXERTIONAL TOLERANCE IMPAIRMENTS

I A high-quality systematic review appraised the evidence on strategies for evaluating responses to physical exertion after mTBI/concussion for clinical and research purposes.[177] Findings indicate that testing may identify impairments that would not otherwise be detected based on symptom reports or physiologic measures taken with the patient at rest. Additionally, patient responses to exertional tests may result in a slight, short-term exacerbation of symptoms.

I Evidence from an RCT indicates that evaluation of exercise tolerance testing for adolescents within 1 week of sports-related concussion did not affect recovery, and that the extent of early exercise intolerance may be strongly associated with prolonged recovery time.[131]

II Evidence from a scoping review of the literature for postconcussion assessment strategies indicates that graded exercise tests are becoming more prominent in research and clinical practice, and they may provide valuable insight into concussion recovery trajectories and potential impairments.[78]

II Two cohort studies indicate that treadmill and stationary bicycle graded exercise testing could be useful tools for capturing impairment after concussion and while monitoring recovery.[47,174]

III A mildly blunted heart rate response, altered heart rate variability, and higher ratings of perceived exertion have been observed among individuals who have experienced a concussive event during graded exercise testing, suggesting potential autonomic dysfunction.[65,66,85,174] Findings indicated that exertional testing may identify impairments that would not otherwise be detected based on symptom reports or physiologic measures taken with the patient at rest,[65,85] and that results may be predictive of recovery trajectory.[79,174]

IV A variety of case series and other lower-level study designs indicate that graded exertional tests are safe, tolerable, and can be clinically valuable for assessing individuals who have experienced a concussive event.[36,42,112] Additionally, graded exertional tests have become recognized as an option for assessment via expert consensus documents and workgroups.[19,159]

V The use of graded exertional tests is further supported by numerous theoretical papers, clinical commentaries, and narrative review papers describing the potential value of postconcussive exertional tests.[53,54,123,126,128,133,134,156]

Evidence Synthesis

Collectively, the evidence suggests that evaluating symptoms and physiological metrics at rest (eg, heart rate, respiration rate, and blood pressure) is not sufficient to effectively detect lingering postconcussion exertional intolerance. Strong evidence indicates that (1) exertional assessments using symptom thresholds can provide important insights into recovery, and (2) exertional tolerance tests are a key assessment strategy for individuals with concussion with persistent symptoms and who desire to return to high-exertion activities (eg, sports, active military duty). Common outcome measures used with exertional tests include self-reported symptom exacerbation, heart rate, and blood pressure. Potential risks, harms, and implementation considerations related to exertional intolerance examinations include (1) exacerbation of concussion-related symptoms, (2) varying comfort levels and preferences of patients for exercise in general or with certain exercise modalities,[150,163,177] (3) a general lack of fitness that may limit the utility of an exertional assessment for identifying specific injury-related impairment, and (4) for some patients with cardiovascular, orthopaedic, or vestibular conditions or impairments, inability to tolerate certain types of exertional modalities or protocols. Emerging evidence suggests that exertional tests are safe and may be beneficial for athletes to help make return-to-play decisions, and may be administered within the first week of injury. Additionally, given the growing body of evidence supporting aerobic exercise training for promoting brain healing and health after concussion (evidence reported in the Interventions section), the GDG group consensus was that exertional tests may be useful for providing initial postconcussion measures and setting target exertion levels for promoting brain healing and health, regardless of whether exertional intolerance is suspected.

Gaps in Knowledge

Additional studies are needed to help clarify optimal testing modes, protocols, and interpretation for exertional tests with individuals who have experienced a concussive event. Another important knowledge gap is that a majority of the exertion testing studies for individuals who have experienced a concussive event have been conducted with athletes and/or individuals diagnosed with sport-related concussion. More research is needed to determine whether there is the same type of need for testing and whether the same type of testing protocols are appropriate for individuals who are not athletes.

Recommendations

B Physical therapists **should** test for orthostatic hypotension and autonomic dysfunction (eg, resting and postural tachycardia or rapidly accelerating heart rate with positional changes) by evaluating heart rate and blood pressure in supine, sitting, and standing positions.

B Physical therapists **should** conduct a symptom-guided, graded exertional tolerance test for patients who have experienced a concussive event and report exertional intolerance, dizziness, headache, and/or a desire to return to high-level exertional activities (ie, sports, active military duty, jobs that entail manual labor). Timing, modality, and protocol should be tailored to optimize safety and individual appropriateness. For patients who are highly symptomatic at rest, the symptom-guided, graded exertional tolerance test should be delayed until symptoms are stable and more tolerable at rest. Likewise, physical therapists may decide to postpone graded exertional testing until later in the course of care if clinical judgment deems that other symptoms and impairments are of higher priority. Testing modality (eg, treadmill versus stationary bicycle) and protocol selection should be based on clinical judgment, patient comfort, and the availability of necessary equipment. Heart rate and blood pressure should be monitored periodically throughout the test and afterward to identify any significant concerns for atypical responses to exercise testing.

C If vestibulo-oculomotor or cervical spine impairments or symptoms are present, physical therapists **should** use a stationary bicycle for testing to reduce risk for exacerbating impairments or compromising the validity of the test results.

C Physical therapists **may** use assessments for orthostatic hypotension/autonomic dysfunction and symptom-guided, graded exertional tolerance tests for patients who do not report exertional intolerance to help determine the role that autonomic dysfunction, deconditioning, or general fitness may play in symptoms (eg, headache, fatigue, fogginess).

F Physical therapists **may** conduct exertional tests for patients who have experienced a concussive event and do not report symptoms indicative of exertional intolerance in order to rule out subtle autonomic dysfunction in response to exertion, establish initial postconcussion performance level, and identify exertional targets for aerobic exercise training that may be incorporated to promote brain health and healing.

EXAMINATION FOR MOTOR FUNCTION IMPAIRMENTS

I A high-quality cohort study demonstrated that concussion may affect postural control during gait as far as 2 months post injury and that a dual-task assessment may help capture these deficits.[92]

III A low-quality systematic review provided foundational evidence that response times and postural control deficits are greater and gait strategies are less efficient under divided-attention tasks among individuals who have experienced a concussion.[183]

III Multiple cohort and case-control studies and systematic reviews of moderate-quality evidence found potential motor function impairments that may be present after a concussive event, including impairments in static and dynamic balance, dual-task/multitasking gait activities, and motor coordination with complex movement tasks, which may or may not correlate with symptom reports.[11,13,20,21,44,49,58,59,68,86,89,90,93-95,100,144,154,183,190,195,218,221,223]

III Studies indicate that the measurement properties for evaluation of motor tasks are uncertain, with numerous potential limitations in the reliability, validity, utility, and interpretability of the various measures currently in the literature, especially with regard to age and complexity of task used for assessments.[11,12,24,40,172,182,183] Several studies indicate that examination techniques most sensitive for detecting concussion-related motor function impairments may necessitate special equipment (eg, force plates or accelerometers) and/or advanced analyses (eg, entropy analyses or complexity metric analyses), thus limiting clinical implementability and practicality.[93,172,173,180,199]

IV Additional case series and case-control studies indicate that age/developmental factors and the presence of headache (versus no headache) may influence motor function assessment scores for individuals with concussion.[97,179,184]

IV Multiple case series and retrospective analyses indicate that subtle, subclinical motor function impairments (eg, postural control/sway metrics or sensory integration ability) may persist beyond the presence of easily observable and detectable impairments (eg, balance tests).[28,180,200,207,221]

IV Multiple evidence-based expert consensus documents based on lower-level study designs encourage the use of motor function assessments for motor function abilities such as dual task/multitask, balance, and motor coordination for individuals who have experienced a concussive event.[19,60,94,109,141,159,160,181,190]

Evidence Synthesis

A variety of tools and assessment strategies for motor function impairments related to concussion are available, some of which are cited more often than others. However, most have been designed for sideline and clinical evaluation for symptoms and impairments that may indicate a probable concussion. Many studies pertaining to this topic did not meet the relevance or inclusion/exclusion criteria set forth by the GDG. Consequently, at this time, there is insufficient evidence to support a clear set of motor function measures for individuals who have experienced a concussive event. For patients with lower-level function, the CPG titled "A Core Set of Outcome Measures for Adults With Neurologic Conditions Undergoing Rehabilitation"[164] may be useful. However, for patients with higher motor function abilities, the recommended measures are likely to have limited clinical utility, as their motor impairments may be too subtle. There is a growing set of evidence looking into dual/multitask assessments to identify subtle motor impairments after concussion. However, these studies have primarily used laboratory-grade motion-analysis equipment and more complex protocols that are not easily implemented in clinical contexts. There are inherent challenges in determining how useful, valid, and reliable a given test is when used by a physical therapist to inform plan of care, monitor progress, and determine episode-of-care end points for discharge from physical therapy. These challenges are compounded by an ever-growing body of new technologies or approaches that have only been tested in laboratory conditions and/or with healthy participants. In fact, the US Food and Drug Administration recently released a safety communication in March 2019 warning that products marketed for the assessment, diagnosis, or management of head injuries often lack validity and are not appropriately validated or vetted for accuracy and safety.[216] Current research suggests that more advanced and sophisticated assessment and analytic techniques (eg, complex analyses of postural sway, accelerometry, or other technologically advanced instrumentation) may improve the capacity to detect subtle motor function impairments in the future.

Gaps in Knowledge

Due to insufficient evidence to inform selection of motor function assessments specific to physical therapy needs and purposes for individuals who have suffered a concussive event, GDG consensus for motor function assessments is to use standard-of-care practices for testing these hypothesized motor function impairments. More research is needed to identify specific tests and measures that would inform clinical decision making and physical therapy intervention selection for individuals who have experienced a concussive event.

Recommendation

B Physical therapists **should** examine patients who have experienced a concussive event for motor function impairments, including static balance, dynamic balance, motor coordination and control, and dual/multitasking (eg, motor tasks along with cognitive tasks or complex tasks with multiple subtasks involved). Selection and timing of motor performance assessments should be based on clinical judgment about which evaluation strategies are most appropriate for the patient's age and ability and will provide the most insight into current functional levels relative to goal levels.

CLASSIFICATION OF EXAMINATION FINDINGS INTO IMPAIRMENT PROFILES

III Recommendations from 2 CPGs for patients who have experienced a concussion and report headache encourage clinicians to align evaluation and treatment planning based on headache phenotype (International Classification of Headache Disorders).[149,153]

IV A cross-sectional study of athletes between the ages of 10 and 23 years with a diagnosis of concussion found that many of the patients with a complaint of dizziness post concussion demonstrated deficits in a variety of tests that indicate that dizziness was not attributable to one main type of dysfunction, but rather was multifactorial in nature.[187]

IV An expert consensus document indicated that there was strong agreement among participating experts that "matching targeted and active treatments to clinical profiles may improve recovery trajectories after concussion," and that "[t]here is growing empirical support for the heterogeneity of this injury and clinical profiles, but additional research in these areas is warranted.[34]

V Several conceptual schemas promote the idea that although patients who experience concussions have variable clinical presentations and recovery trajectories, it may be possible to identify specific clinical profiles of diagnoses associated with concussion that can be targeted with specific rehabilitation techniques.[35,53,54,143]

Evidence Synthesis

Historically, individuals who experienced a concussion were conceptualized as a homogeneous patient population with similar responses to the trauma and relatively parallel recovery experiences and trajectories. There are several clinical commentaries and expert opinion documents that propose new conceptual schemas suggesting that individuals with concussion should be viewed in a more heterogeneous way through clustering or characterizing patients into phenotypic profiles. The current proposed schemas vary in the specific profile groups they suggest and the methods for determining which profile or profiles a patient fits best. However, these classification models have also not been thoroughly validated and tested. Additionally, there is growing expert consensus that patients may not directly fit any one classification but rather exhibit a profile that incorporates patterns consistent with multiple classifications.

Gaps in Knowledge

Although clinically important and conceptually compelling, current classification models have not been thoroughly validated and tested. At this time, there is insufficient evidence to support the endorsement of one classification system over others. The GDG consensus was to encourage physical therapists to identify all potential impairments that could be addressed with physical therapy interventions, as well as their levels of irritability, to formulate a treatment plan that is individualized to each patient. A comprehensive description of the GDG consensus and rationale for the profile is outside the scope of this CPG. However, the GDG team published a manuscript detailing this perspective and its collective opinions on this topic that clinicians may refer to for further clarification and context.[1] Future research is needed to identify an optimal classification or profiling system for patients who have experienced a concussive event and are experiencing movement-related impairments and symptoms.

Recommendations

E Physical therapists **should** establish and document the presence or absence of all impairments and their levels of irritability to support the selection of treatment priorities and strategies for patients who have experienced a concussive event.

B For patients who have experienced a concussive event and report headache as a symptom, physical therapists **should** determine and document the potential headache type in accordance with the International Classification of Headache Disorders.

PSYCHOLOGICAL AND SOCIOLOGICAL FACTORS

Evidence Synthesis

No studies directly related to physical therapy and psychological and sociological implications were identified. However, there is theoretical and foundational epidemiological evidence indicating that psychological and sociological resilience (personal qualities and social factors that enable one to thrive in the face of adversity) and psychological and social vulnerabilities (psychological and social factors that may put one at risk for poor recovery) may play important roles in recovery.[107,119,138-140,205] These theoretical and foundational studies also suggest that various preinjury and postinjury psychological and sociological variables may contribute to who recovers well naturally as well as to who may respond well to specific interventions. For example, positive, healthy coping skills and a good social support system may facilitate recovery, whereas an absence of these factors may be detrimental to recovery (eg, increased use of alcohol or other substances to cope with stress and symptoms). These studies are further supported by a number of theoretical and conceptual expert opinion documents highlighting the likelihood of psychological and sociological factors as important considerations for prognosis and intervention selection.[107,176] Specific assessments and evaluative decisions based on these factors have not been thoroughly tested.

Gaps in Knowledge

More research is needed to help apply available measures and/or develop specific evaluation measures for identifying potential psychological and sociological factors that may influence optimal physical therapy intervention and dosing selection.

Recommendations

E Physical therapists **should** elicit, evaluate, and document factors related to self-efficacy and self-management abilities, potential psychological and sociological factors that may significantly influence recovery processes and outcomes for physical therapy interventions. Examples of factors to consider include (1) the patient's expression and demonstration of good, healthy coping strategies in response to stressful situations; (2) the type of support system the patient has to enable self-management of symptoms and impairments; (3) the number and type of potential risk factors that may contribute to delayed or complicated recovery (eg, history of mental health or substance use disorders); (4) the patient's understanding and attitude toward recovery (eg, expressing a positive outlook on recovery versus a more negative mindset or high anxiety toward recovery); and (5) the patient's access to resources and equipment that may facilitate recovery (eg, access to an athletic trainer or other health care providers to support recovery).

E When evaluating self-efficacy and self-management factors, physical therapists **should** explain and emphasize that most symptoms and impairments after concussion do improve.

OUTCOME MEASURE SELECTION

II Evidence from high-quality CPGs informed by moderate-level evidence indicates that postconcussion symptom assessments/checklists should be used to monitor recovery, with perhaps more comprehensive outcome measures to specifically evaluate certain symptoms (eg, dizziness, headache, fatigue, and neck pain).[141,142,149,153]

III Evidence from a moderate-quality cohort study indicates that the Dizziness Handicap Inventory (DHI) and DVAT may be useful as outcome measures for individuals who have experienced a concussion and exhibit vestibular impairments.[72]

III A moderate-quality diagnostic study provided preliminary reliability, validity, and responsiveness of the High-level Mobility Assessment Tool (HiMAT) for individuals who have experienced a concussive event and reported balance problems 3 months post injury.[110]

IV Two recent expert consensus documents provide recommendations for a variety of outcome measures that may be useful for monitoring postconcussion recovery.[19,61]

Evidence Synthesis

Systematic and repeated outcome assessments provide a mechanism to evaluate the end results of care at the patient and population levels. Many outcome measures have been proposed for use with patients who have experienced a concussive event. However, the utility and appropriateness of these measures for physical therapy purposes are unclear. Many comparative studies related to postconcussion outcome measurement had insufficient quality and uncertain relevance for use in physical therapy contexts. Moderate-level evidence was available to support the ongoing use of symptom checklists or scales; however, there was no consensus on the most appropriate symptom assessment method for outcome measurement. There is weak evidence to support the use of the HiMAT; however, there is a large ceiling effect, and it may not be useful for detecting outcomes related to more subtle movement-related impairments. Expert consensus recommendations have proposed a variety of data elements that would be worth collecting, but the clinical utility and implementability for physical therapy purposes have not been tested. There was also weak evidence to support the DHI and DVAT; however, additional research is needed to evaluate the validity and reliability of these measures for patients diagnosed with concussion.

The GDG did not find sufficient evidence to endorse any specific outcome measures for use with patients with concussions. Ongoing measurement of symptoms using an age-appropriate scale or checklist may be valuable to help monitor for progress in postconcussion symptom presentation. Measures recommended in the Academy of Neurologic Physical Therapy's core set CPG,[164] the Academy of Orthopaedic Physical Therapy's neck pain CPG,[16] and the Academy of Neurologic Physical Therapy's peripheral vestibular hypofunction CPG[80] may be useful for some patients. Additionally, given the challenge of making sure interventions meet the individual needs and goals of younger and older patients, goal attainment scaling may be an option to help individualize outcome tracking while still retaining the ability to compare achievement levels across patients.[81,113,148,213-215,229] However, the utility and implementability for patients who have experienced a concussive event also remain untested. The GDG consensus at this time is that selection of specific outcome measure use should be based on clinician judgment of best fit for the patient's functional status, age, goals, needs, and prognosis.

Gaps in Knowledge

Future studies are strongly encouraged to develop, test, and optimize a battery of outcome measures that may include self-report measures, observation/performance-based measures, and clinically useful technology for patients who have experienced a concussive event. Self-management may be a key element for concussion recovery. Research into specific outcome measures for self-management and concussion for use as part of physical therapy examination and monitoring would be beneficial. Additionally, decision tools for selection of appropriate outcome measures given various impairment profiles may also be investigated.

Recommendation

F Physical therapists **should** determine and document a plan for outcome measurement for patients who have experienced a concussive event for any impairment domains that will be targeted with physical therapy interventions and/or were previously untested due to poor tolerance.

CLINICAL PRACTICE GUIDELINES

Interventions

COMMUNICATION AND EDUCATION

I Evidence from high-quality CPGs highlights the importance of educating and providing assurance to patients who have experienced a concussion that most people recover well and typically do not have significant difficulties that last more than 1 to 3 months post injury.[141,153]

III High-quality CPGs based on moderate-level evidence and other studies indicate that after an initial period of rest for the first 24 to 48 hours, patients with concussion should be encouraged to avoid activities that have a high risk for another concussion but gradually resume normal activity, based on their tolerance.[141,142,153,159,192]

IV Consensus-based recommendations from a panel of experts indicate that patients with concussion can benefit from education on lifestyle and self-management of symptoms to decrease the impact of symptoms on quality of life and to facilitate recovery.[160]

Evidence Synthesis

Several guidance documents stressed the importance of how the diagnosis of concussion is communicated to patients and their families. The rationale for clear communication and education about concussion diagnosis and prognosis is to establish an expectation for recovery and to avoid unintentional reinforcement of insecurities, fears, or a trajectory of catastrophizing about the injury. Published guidelines for concussion management also consistently emphasize the importance of patient education regarding the risks for subsequent injury during high-risk activities, management strategies, and return-to-activity progressions.

Recommendations

B Physical therapists **must** educate patients who have experienced a concussive event about self-management of symptoms, the importance of relative rest (rest as needed) instead of strict rest, the benefits of progressive re-engagement in activities, the importance of sleep, safe return-to-activity pacing strategies, and potential signs and symptoms of the need for follow-up care with a physician, physical therapist, or other health care providers.

A Physical therapists **must** educate patients who have experienced a concussive event and their families/caregivers about the various symptoms, impairments, and functional limitations that are associated with concussion, and stress that most patients with concussion recover relatively quickly. Providing this information can help physical therapists avoid inadvertent reinforcement of poorer recovery expectations.

INTERVENTIONS FOR MOVEMENT-RELATED IMPAIRMENTS

II Two systematic reviews of moderate-quality study designs indicate that personalized physical therapy interventions targeting movement-related impairments (eg, therapeutic exercises for cervical spine impairments, vestibulo-oculomotor impairments, and aerobic exercise training) are safe and result in clinical improvement (ie, reduced symptoms, improved ability to return to preinjury activities) after an initial period of relative rest, and potentially biological and physiological improvement.[178,192]

II A randomized controlled feasibility study that compared a group of adolescents with concussion and dizziness up to 14 days after injury who received early personalized physical therapy to a control group demonstrated a shorter recovery time in the experimental group.[189] The median number of days to medical clearance for the experimental group was 15.5 (versus 26 for the controls), and the median number of days to symptomatic recovery was 13.5 for the experimental group (versus 17 for the controls).

II Recommendations from high-quality CPGs based on moderate-quality evidence indicate that in addition to movement-related impairments, patients may also experience a range of other persistent postconcussion symptoms and impairments that may require treatment from other health care professionals.[141,142,149,153]

IV Numerous retrospective cohort studies and case series provide further support for the potential for multimodal physical therapy approaches to safely facilitate recovery after concussion.[48,62,63,73,98,137] Further, several of these studies indicate that these interventions can be safely introduced within a few days to weeks post injury, with earlier initiation potentially resulting in better outcomes for patients.[48,122,137]

Evidence Synthesis

Timing of initiation of physical therapy services is highly variable, with many earlier studies and guidelines focusing on individuals who experienced persistent symptoms lasting 2 or more weeks. Recent studies support considering the initiation of physical therapy interventions as early as the first week of injury. Studies have not found that early physical therapy contributes to significant safety concerns or worse outcomes. This is not surprising, as study designs and clinical practice patterns are often guided by theoretical and clinical judgments that are based on minimizing the potential for adverse events. Collectively, these studies suggest that time since injury should not independently drive decisions about the appropriateness and potential benefit of physical therapy for individuals who have experienced a concussive event. Additionally, some impairments may require specialized treatment that is not within physical therapists' scope of practice, including auditory impairments, vision impairments (including impairments of ocular alignment), cognitive impairments, sleep problems, and migraine and other chronic headache symptoms.

Gaps in Knowledge

Despite evidence of safety and positive outcomes for physical therapy interventions targeting postconcussion symptoms, impairments, functional limitations, and participation restrictions, there are limited data regarding specific patient and injury characteristics impacting responsiveness to physical therapy interventions. Given the large volume of patients who recover naturally or with general education about activity progression, there are presumably some individuals who may be able to self-manage mild movement-related impairments with education and a home exercise program. We propose a triaging plan in **FIGURE 3** to help differentiate patients who may be able to self-manage their symptoms and impairments from those who would benefit from skilled physical therapy care. Research investigating the proposed triaging system would be beneficial. Additionally, more research is needed to develop a system for identifying those patients who can optimally benefit from physical therapy interventions to facilitate recovery after experiencing a concussive event.

Recommendations

F Physical therapists **should** use findings from the examination to triage patients who have experienced a concussive event into 1 of 2 categories: (1) patients with movement-related impairments and dysfunction who are good candidates for physical therapy interventions, or (2) patients with no identified movement-related impairments or dysfunction (**FIGURE 3**). Time since injury may influence level of irritability of symptoms, but should not be a primary determinant for decisions regarding when physical therapy interventions are appropriate. Evidence indicates that physical therapy early after concussion is safe, and that earlier initiation of physical therapy interventions may facilitate a faster recovery.

B Physical therapists **should** design a personalized intervention plan for patients who have experienced a concussive event and have movement-related impairments that aligns interventions with the patient's identified impairments, functional limitations, participation restrictions, self-management capabilities, and levels of irritability.

B Physical therapists **should** refer patients who have experienced a concussive event for further consultation and follow-up with other health care providers as indicated. Of specific note, high-quality CPGs recommend referral for specialty evaluation and treatment in cases of persistent migraine-type and other chronic headaches, vision impairments (including ocular alignment), auditory impairments, sleep disturbances, mental health symptoms, cognitive problems, or other potential medical diagnoses that may present with concussion-like symptoms or coincide with concussion symptoms (eg, lesions/tumors or endocrine abnormalities such as posttraumatic diabetes insipidus).

CERVICAL MUSCULOSKELETAL INTERVENTIONS

II Evidence from RCTs indicates that physical therapy interventions that address the cervical spine can independently, and in combination with other therapies (eg, vestibular interventions), lead to improvement in symptoms, function, and return to activity after concussion.[189,194] Individuals receiving a combined cervical and vestibular intervention were 3.91 times more likely to be medically cleared for return to sport by 8 weeks than those in the control group.[194]

IV Retrospective chart reviews and case series provide further support for cervical musculoskeletal interventions to improve symptoms and function for individuals who have experienced a concussive event.[73,98,106,152,193]

V A narrative systematic review of studies related to the cervical spine and concussion highlighted several low-quality studies and theoretical papers emphasizing the potential for stronger neck muscles and anticipatory cervical muscle activation to reduce risk for future concussions.[165]

Evidence Synthesis

Few studies have been dedicated specifically to the study of physical therapy interventions for cervical musculoskeletal impairments in patients who have experienced a concussive event or been diagnosed with a concussion. The treatment studies identified typically incorporated interventions to address cervical musculoskeletal impairments in combination with other types of interventions (eg, aerobic exercise training and/or oculomotor-vestibular interventions). Regardless of the underlying mechanisms leading to these symptoms, several studies indicate that patients with concussion who exhibit signs of cervical musculoskeletal impairment may respond well to physical therapy interventions for cervical spine dysfunction alone and in combination with other active rehabilitation strategies. Additionally, neck strength and muscle strength imbalances have been shown to be associated with concussion risk. Therefore, even when cervical spine impairments are not present as a result of concussion, it may be valuable for physical therapists to provide cervical spine musculoskeletal interventions, with the goal of decreasing a patient's risk for subsequent concussive injuries. Evidence guiding specific postconcussion cervical spine interventions for patients who have experienced a concussive event is limited at this time. The consensus of the GDG is to use best-practice standards for selecting and implementing cervical musculoskeletal interventions. The neck pain CPG[16] guiding general management of cervical spine dysfunction may be useful to inform intervention strategies.

Gaps in Knowledge

Future research is needed to determine, test, and optimize cervical musculoskeletal interventions for individuals who have experienced a concussive event and exhibit cervical musculoskeletal impairments.

Recommendation

B Physical therapists **should** implement interventions aimed at addressing cervical and thoracic spine dysfunction, such as strength, range of motion, postural position, and/or sensorimotor function (eg, cervicocephalic kinesthesia, head position control, cervical muscle dysfunction) exercises and manual therapy to the cervical and thoracic spine, as indicated, for patients who have experienced a concussive event.

VESTIBULO-OCULOMOTOR INTERVENTIONS

I A CPG supported by level I evidence recommended that if BPPV is identified as a potential source of dizziness, then canalith repositioning maneuvers should be used.[153]

II A systematic review including 2 RCTs provided weak-to-moderate evidence that vestibulo-oculomotor rehabilitation improved outcomes.[171] Evidence from a moderate-quality RCT indicates that rehabilitation strategies targeting vestibulo-oculomotor impairments, independently and in combination with other physical therapy interventions, may be feasible even within the first 10 days after a concussive injury and can be effective in reducing symptoms, reducing time to recovery, and improving function.[189] For 1 RCT, individuals in the treatment group who received cervical and vestibular rehabilitation were 3.91 times more likely to be medically cleared for return to sport by 8 weeks.[194]

IV Multiple clinician survey studies, case series, and retrospective cohort studies without comparators indicate that vestibular rehabilitation, including canalith repositioning maneuvers for BPPV, is commonly used by physical therapists to treat individuals who have experienced a concussive event[5] and may help reduce dizziness and improve gait and balance dysfunction for these patients.[4,103,163,193,203]

Evidence Synthesis

Studies suggest that physical therapists commonly integrate vestibular and oculomotor rehabilitation strategies when working with patients who have experienced a concussive event. Vestibulo-oculomotor rehabilitation, when prescribed in isolation or in conjunction with other rehabilitation interventions, is associated with reduced dizziness, improved balance, and faster return to sport. It is expected that vestibulo-oculomotor rehabilitation exercises cause a mild transient increase in symptoms. The American Academy of Otolaryngology–Head and Neck Surgery recommends that patients with posterior and lateral canal BPPV should be treated with canalith repositioning procedures (a series of head maneuvers that can help correct BPPV).[14] Although repositioning maneuvers can be effective in treating BPPV, a patient may require additional interventions in the presence of concomitant vestibular hypofunction.[14]

Evidence guiding specific vestibulo-oculomotor intervention protocols for patients who have experienced a concussive event is limited at this time. However, the Academy of Neurologic Physical Therapy's peripheral vestibular hypofunction CPG[80] may provide some guidance for treatment strategies. Additionally, the American Academy of Otolaryngology–Head and Neck Surgery's CPG for BPPV may also be a useful resource for physical therapists.[14]

Gaps in Knowledge

More research is needed to evaluate the implementation of these guidelines in patients who have experienced a concussive event.

Recommendations

A If BPPV is identified as a potential impairment, then physical therapists **should** use canalith repositioning interventions.

B Physical therapists with appropriate expertise in vestibular and oculomotor rehabilitation **should** implement an individualized vestibular and oculomotor rehabilitation plan for patients who have experienced a concussive event and exhibit vestibular and/or oculomotor dysfunction. If visual vertigo/visual motion sensitivity (dizziness provoked by repetitive or moving visual environments) is identified, an individualized visual-motion habituation program may also be beneficial. Patients with neck pain or other cervical impairments may exhibit worsening of cervical impairments due to repetitive head movement as part of vestibular rehabilitation. Therefore, the implications of head-rotation interventions on the possible concomitant cervical impairments should also be considered and addressed.

F Physical therapists who lack appropriate training in vestibular and oculomotor rehabilitation **should** refer patients who exhibit vestibular and/or oculomotor impairments to a clinician with appropriate expertise.

EXERTIONAL TOLERANCE AND AEROBIC EXERCISE INTERVENTIONS

I A high-quality systematic review that included 5 RCTs provides strong evidence that monitored, progressive, symptom-guided aerobic exercise training is feasible, safe, and may accelerate symptom resolution and neurologic recovery after a concussive event.[118] The exertion training protocols varied by exercise mode, exertion protocols, and dosage of training. Despite these discrepancies in the studies, the meta-analysis results indicated that exercise resulted in significant decreases in symptom scores as measured by Post-Concussion Symptom Scale score (mean difference, –13.06; 95% confidence interval: –16.57, –9.55; $P \leq .001$), reaction time score among RCTs that used the Immediate Post-Concussion Assessment and Cognitive Testing (mean difference, –0.43; 95% confidence interval: –0.90, –0.06; $P = .02$), number of days off work (17.7 days versus 32.2 days, $P < .05$), and percent of patients with full function at the end of the study period (72% versus 17%, $P = .02$).

I A high-quality RCT comparing adolescent athletes who followed an aerobic exercise program in the first 10 days after a sports-related concussion to a group that followed a progressive stretching program found that early aerobic exercise may help speed recovery (interquartile ranges, 10-18.5 days for the aerobic group versus 13 to 23 days for the stretching group).[129]

II A quasi-experimental study provided evidence indicating that aerobic exercise training among males with sport-related concussion initiated within the first few days after injury may reduce total time to recovery compared to relative rest.[130] A second quasi-experimental study provided evidence of improved quality of life and less anger among youths who are slow to recover after concussion and who follow an exercise-based active rehabilitation intervention.[67]

IV Numerous case series and small pilot studies provide further support for the safety, feasibility, and potential benefits of aerobic training among individuals who have experienced a concussive event.[7,48,73,98,112,132,137] Additionally, a recent retrospective case series with propensity scoring analysis indicated that earlier time to aerobic exercise training may facilitate faster recovery for athletes and help mitigate prolonged recovery from concussion for athletes and nonathletes.[137]

Evidence Synthesis

Both alone and coupled with other impairment-specific active rehabilitation interventions, aerobic exercise training has been linked to faster symptom resolution and rate of return to sport and enhanced neurologic recovery. Many of the efficacy studies have been performed with patients who were 4 to 6 weeks post injury. However, preliminary evidence from case series with propensity scoring analysis provides some initial support that introducing physical exertion activities earlier after injury may be safe, feasible, and potentially advantageous. An RCT with adolescent athletes indicated that implementation of an aerobic training protocol early after injury may result in faster recovery.[129]

There is limited evidence for the best mode, protocol, progression parameters, dosing, and timing of initiation for aerobic exercise training after concussion. Currently available studies have utilized multiple modes, including treadmill training, bicycling, elliptical training, and multimodal training (eg, resistance training coupled with cardiovascular training and/or sport-specific training). However, there are no studies directly comparing modes or protocols. Additionally, protocols across studies have varied in terms of progression parameters. Some studies used systematic progressions guided by heart rate or ratings of perceived exertion. Others were time based, with more generic specifications about intensity. A common assertion from experts in consensus statements and commentaries has been that aerobic training interventions should be guided by symptoms, in that significant exacerbation of symptoms beyond a mild degree should result in exercise termination for the session, and an absence of symptom exacerbation can provide support for progressing exercise intensity and duration.[159,192] Symptom exacerbations may occur with aerobic activity, but they should be mild and temporary in nature.[9,47]

Gaps in Knowledge

Research is needed to determine optimal protocols for timing, progressing, and dosing strategies for exertion and aerobic exercise interventions for individuals who have experienced a concussive event.

Recommendations

A Physical therapists **should** implement a symptom-guided, progressive aerobic exercise training program for patients who have experienced a concussive event and exhibit exertional intolerance and/or are planning to return to vigorous physical activity levels. Selection of modality and protocol for training with a specific focus on the patient's goals, comfort level, lifestyle, and access to equipment is encouraged. Timing of the initiation of the aerobic exercise training program may vary by patient, but the stabilization of the patient's symptoms to a moderate or lower level of irritability may be a guiding criterion.

E Physical therapists **may** implement progressive aerobic training for all patients who have experienced a concussive event, including those who do not exhibit exertional intolerance and those who do not intend to engage in vigorous physical activity in order to reduce risk for deconditioning, promote functional brain healing, and provide a nonpharmaceutical option to improve mental health.

MOTOR FUNCTION INTERVENTIONS

IV Expert consensus from CPGs based on weak evidence from case series studies and expert opinion consensus documents suggest that interventions that target motor function impairments after concussion may be beneficial.[34,98,149,153,160]

V An expert opinion article provides guidance for physical therapy interventions for armed service members with mTBI that includes suggestions for balance and dual-task activities.[222]

Evidence Synthesis

At this time, there is limited evidence regarding the efficacy and effectiveness of interventions to target motor function impairments. Given the volume of evidence indicating the potential for motor function impairments, the GDG consensus was that motor function interventions are likely to be beneficial, even if the impairments are subclinical and difficult to identify as part of the clinical examination process. Expert consensus and low-level studies indicate that gradual, progressive return to higher-level motor function tasks and challenges, including return to work and return to physical activity/sport, could be supported through physical therapy interventions and progressions directly targeting motor function.

Gaps in Knowledge

Research is needed to evaluate the outcomes and value of interventions that target motor function.

Recommendation

C Physical therapists **should** implement motor function interventions that address identified or suspected motor function impairments and help progress the patient toward higher-level functional performance goals. Motor function interventions that target the following impairments are strongly encouraged: static balance, dynamic balance, motor coordination and control, and dual/multitasking. Additionally, interventions that directly help improve motor function for work/recreation/activity-specific tasks are strongly encouraged.

MONITORING AND PROGRESSING PATIENTS

Evidence Synthesis

The systematic search did not yield any evidence to specifically inform recommendations for how to make decisions regarding monitoring and progressing physical therapy interventions for patients who have experienced a concussive event. Studies that informed the Clinical Course section of this CPG indicate that it is important for clinicians to understand that patients' symptoms, impairments, and functional limitations may change and/or become more apparent during episodes of care. Thus, continual monitoring and re-evaluation of patients' responses to treatment and emerging clinical presentation are critical for providing an optimal match of interventions throughout each patient's episode of care. It is important to appreciate that patients may present differently at various points in the recovery process and may experience exacerbations and setbacks as they reintegrate and introduce new activities into their daily routines. Follow-up with physical therapy and referrals for follow-up with other health care providers should be encouraged as needed or indicated.

Gaps in Knowledge

Studies specifically designed to help inform intervention dosing parameters, monitoring and reassessment strategies, and criteria for progressions and discharge would be beneficial.

Recommendation

F Physical therapists **should** regularly document symptoms, provide reassessments of movement-related impairments, and administer selected outcome measures as needed or indicated for patients with movement-related impairments post concussion. The following data elements and monitoring frequencies are recommended.

Symptoms

- Age-appropriate symptom scale/checklist at least weekly until discharge

Cervical Spine Musculoskeletal Impairments

- Active neck range of motion, pain with active neck range of motion, and other cervical spine measures as determined by the physical therapist at the initial visit and at least every

2 weeks until discharge

- Cervical flexor and extensor strength and endurance at the initial visit and approximately every 4 weeks until impairments are resolved
- Joint position error or cervical proprioception assessments at the initial visit and approximately every 4 weeks until discharge
- Self-report outcome scales/measures (eg, Neck Disability Index, Headache Disability Inventory) as indicated at the initial visit and at least every 2 weeks until discharge

Vestibulo-oculomotor Impairments

- If BPPV is present, the Dix-Hallpike test should be performed at the initial visit and at least weekly until BPPV is resolved
- Vestibular and oculomotor tests and measures as indicated at the initial visit and at least every 2 weeks until impairments are resolved
- Self-report outcome scales/measures (eg, DHI) as indicated at the initial visit and at least every 2 weeks until discharge

Exertional Test

- Graded exertion test completed during at least 1 visit for individuals reporting symptoms related to exertional intolerance
- Graded exertion test completed during at least 1 visit and as needed to determine readiness to return to play or work for athletes and/or individuals with high-exertion activity needs

Motor Function

- Age- and functional-level tests and measures as indicated at the initial visit and at least every 2 weeks until impairments are resolved

Self-management

- Qualitative assessment of the patient's ability to self-manage symptoms and adhere to physical therapy recommendations at the initial visit and every visit until discharge

Physical Therapy Management Decision Trees

Visual decision tree models can provide valuable guidance for how physical therapists plan and make decisions during a patient's episode of care after a concussive event. The proposed decision tree model is depicted in **FIGURES 1** through **3** and broken down into the following components: (1) process for determining the appropriateness of physical therapy concussive-event examination, (2) physical therapy examination and evaluation processes for patients who have experienced a concussive event, and (3) developing and implementing a physical therapy plan of care for patients who have experienced a concussive event. Recommendations are broken down into sections that directly align with each component, such that clinicians can use the component narrative overviews below, the figures, and the recommendations together to inform their decision-making processes. The ovals in the decision trees indicate start and end points in that component. Rectangular boxes indicate a process or procedure to be implemented. Diamonds indicate a decision point that will lead to one pathway (versus another pathway).

COMPONENT 1: PROCESS FOR DETERMINING APPROPRIATENESS OF PHYSICAL THERAPY CONCUSSIVE-EVENT EXAMINATION

A triaging process may help determine whether a patient who has experienced a concussive event is appropriate for a more comprehensive examination to identify potential movement-related symptoms and impairments related to that event (**FIGURE 1**). The starting point for component 1 is a physical therapy encounter with a patient who has experienced a potential concussive event. Physical therapists should screen all patients who have experienced a potential concussive event for the possibility of a concussion, regardless of previous screening for a diagnosis of concussion related to that event. The first step in this component is observation and interview to evaluate for indicators of potential medical emergency and need for referral (**FIGURE 1**). Next, the physical therapist will determine whether the patient is presenting with signs and symptoms that align with the diagnostic criteria for a concussion (**FIGURE 1**). This screening may be useful even if the concussive event was not recent, as residual symptoms could be the result of an undiagnosed concussion injury. If the patient's history and presenting criteria are consistent with a diagnosis of concussion, the physical therapist will then decide whether the patient is appropriate for a comprehensive physical therapy examination, based on a multifaceted interview (**FIGURE 1**).

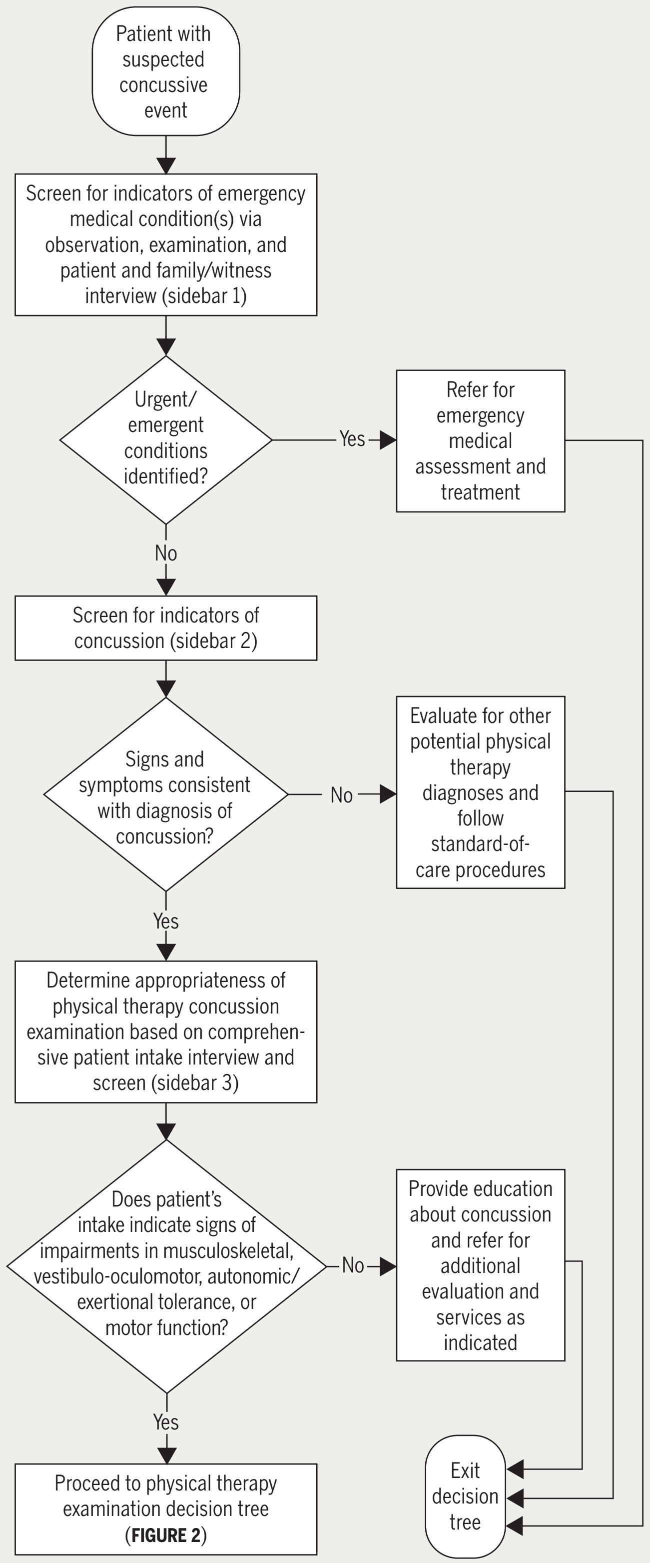
COMPONENT 2: PHYSICAL THERAPY EXAMINATION AND EVALUATION PROCESSES FOR PATIENTS WHO HAVE EXPERIENCED A CONCUSSIVE EVENT

Differential evaluation of clinical findings from patient interviews and physical examination can help determine the most relevant and key physical impairments associated with the diagnosis of concussion and also identify existing functional limitations. Determining probable movement-related impairments and levels of irritability (**FIGURE 2**) may help clinicians plan the examination, including the selection, sequencing, and modification needs to address safety concerns, patient comfort, and/or patient and family goals and preferences. Targeted follow-up questions from findings obtained during the intake can help clinicians determine which examination tests and measures are most appropriate for a patient. Neck pain is the first priority for sequencing, as neck pain irritated by movement limits the feasibility and accuracy of other tests, particularly vestibulo-oculomotor tests. If neck pain is present, pain relief interventions could be provided to potentially support tolerability and accuracy for additional tests. Dizziness and headache are symptoms that require more complex assessments and clinical reasoning to identify potential sources of impairment that may contribute to complaints. When dizziness and/or headache are reported, physical therapists are encouraged to conduct tests that are expected to be the least irritable for the patient first, then progress to tests expected to be most irritable per patient tolerance. Sequencing in this way should help increase the likelihood of patient tolerance for testing of all domains and improve the utility of the results obtained. If no specific reports of neck pain, dizziness, or headache are identified, clinical judgment should be used to determine optimal sequencing based on reported levels of irritability and disability, patient needs and preferences, and patient ability to tolerate tests. Therapists are encouraged to identify and document a complete set of impairments that physical therapy interventions could potentially address. Identification and consideration of psychological and sociological facilitators and vulnerabilities and the potential need for follow-up testing are also encouraged. As part of the examination process, the physical therapist should determine and document a plan for follow-up testing and outcome measure administration.

COMPONENT 3: DEVELOPING AND IMPLEMENTING A PHYSICAL THERAPY PLAN OF CARE FOR PATIENTS WHO HAVE EXPERIENCED A CONCUSSIVE EVENT

Development and implementation of a plan of care should be based on findings from the physical therapy clinical examination, in combination with patient and family needs and preferences (**FIGURE 3**). Education regarding the risks and prognosis for patients, self-management, and activity-related recommendations and potential signs of the need for follow-up care are important for patients who have experienced a concussive event. Movement-related impairments may not be identified for patients who have experienced a concussive event. In these cases, educate patients about potential signs and symptoms that may emerge and encourage them to follow up for further physical therapy evaluation and treatment as indicated. Intervention strategies for patients may vary depending on their impairment diagnosis profiles and level of irritability. Dosing parameters (frequency, intensity, timing, and type of intervention) for each impairment domain should be adjusted in accordance with the patient's level of irritability. Additionally, it is important for clinicians to understand that patients' symptoms, impairments, and functional limitations often change and/or become more apparent during an episode of care. Thus, continual monitoring and re-evaluation of the patient's response to treatment and emerging clinical presentation are critical for providing optimal matching of interventions throughout a patient's episode of care.

Process for Determining Appropriateness of Physical Therapy Concussive Event Examination



Sidebar 1

Indicators for immediate emergency medical evaluation

- Declining level or loss of consciousness, cognition, or orientation (Glasgow Coma Scale score of less than 13)
- New onset of pupillary asymmetry, seizures, repeated vomiting, or other focal neurologic signs
- Severe or rapidly worsening headache or neurologic deficits
- Signs/symptoms indicating undiagnosed skull fracture
- Serious cervical spine fracture, dysfunction, or pathology (eg, vertebrobasilar artery insufficiency, cervical ligamentous instability, signs of central cord compression)

Sidebar 2

Concussion diagnosis criteria

A direct blow to the head, face, or neck, or an impulsive force elsewhere on the body that is transmitted to the head, followed by any of the following:

- Any period of decreased orientation or loss of consciousness
- Posttraumatic amnesia
- Any alteration in cognition or mental state immediately related to the concussive event: confusion, disorientation, slowed thinking/processing, problems with attention/concentration, forgetfulness, decreased executive control
- Physical symptoms: headache, dizziness, balance disorders, nausea, vomiting, fatigue, sleep disturbance, blurred vision, sensitivity to light, hearing difficulties, tinnitus, sensitivity to noise, seizure, transient neurological abnormalities, numbness, tingling, neck pain, exertional intolerance
- Emotional/behavioral symptoms: depression, anxiety, agitation, irritability, impulsivity, aggression
- Glasgow Coma Scale (best available score in first 24 hours) of 13-15
- Brain imaging (if available) is normal
- Signs/symptoms not otherwise explained by drug, alcohol, or medication
- Symptoms are present that cannot be explained by preinjury history of medical diagnoses. If preinjury diagnoses were present, the patient reports or is observed to demonstrate an exacerbated state of symptoms

Sidebar 3

Patient intake process and interview

- Type, severity, frequency, and irritability of concussion-related symptoms
- Preinjury medical history with emphasis on previous concussions or brain injuries, medical conditions that could result in/present with symptoms similar to concussion-related symptoms (eg, learning challenges or disabilities, mood or emotional disorders, depression, frequent headaches), history of personal or familial migraine, sleep quality/history
- Any conditions or diseases that would limit or serve as a contraindication to comprehensive physical therapy evaluation or interventions
- Details regarding injury, including mechanism of injury and early signs and symptoms associated with the injury
- Medical/pharmacologic strategies implemented since the injury; reflection on things that seem to result in worsening or improvement of symptoms
- Physical function goals, priorities, and perceived limitations
- Mental health and substance use screens for referral needs

FIGURE 1. Process for determining appropriateness of physical therapy concussive-event examination.

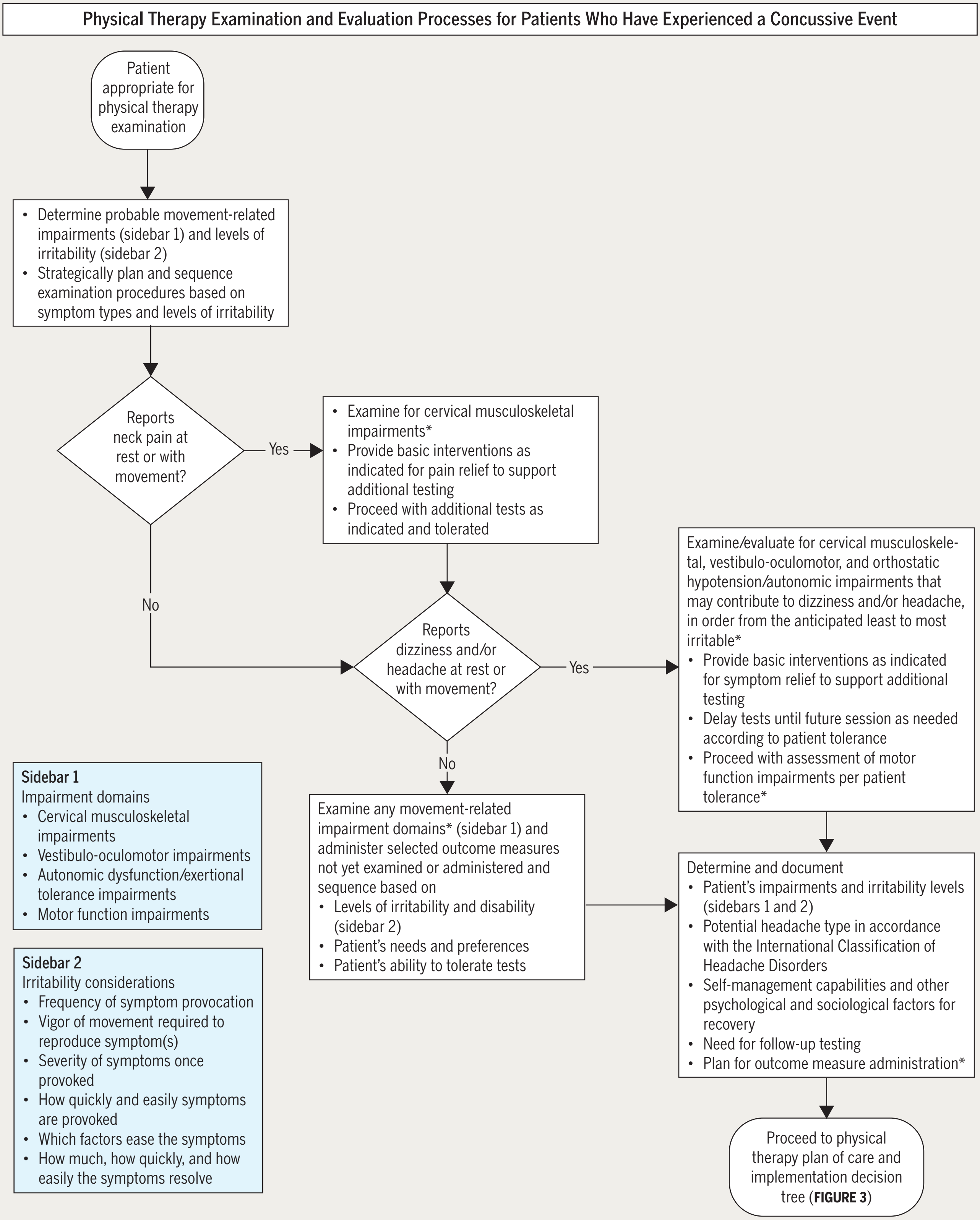


FIGURE 2. Physical therapy examination and evaluation processes for patients who have experienced a concussive event. *The vagueness regarding specific examination/assessment procedures is intentional, as evidence is lacking to endorse specific tests and measures in some cases and too complex to describe in others. Readers are encouraged to review the body of the text for examination/assessment strategies and the degree of evidence supporting them.

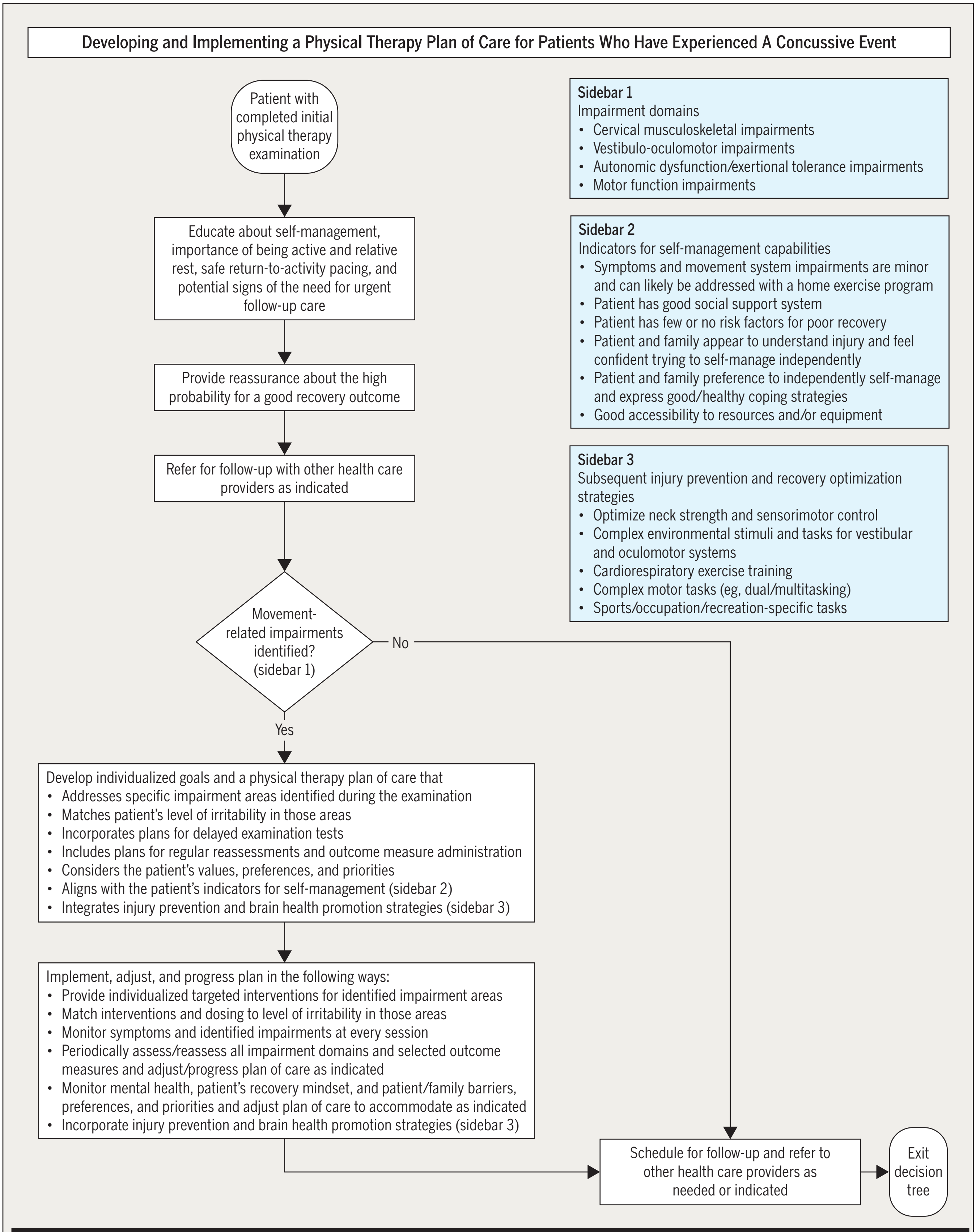


FIGURE 3. Developing and implementing a physical therapy plan of care for patients who have experienced a concussive event.

AFFILIATIONS AND CONTACTS

AUTHORS

Catherine C. Quatman-Yates, PT, DPT, PhD
Assistant Professor
Department of Physical Therapy
Sports Medicine Research Institute
Chronic Brain Injury Program
The Ohio State University
Columbus, OH
and
Physical Therapist III
Division of Occupational Therapy and Physical Therapy
Cincinnati Children's Hospital Medical Center
Cincinnati, OH
catherine.quatman@osumc.edu

Airelle Hunter-Giordano, PT, DPT
Assistant Professor of Practice
Physical Therapist
Associate Director of Clinical Services
Director of Sports and Orthopedic Physical Therapy Residencies
University of Delaware
Newark, DE
aohunter@udel.edu

Kathy K. Shimamura, DPT, NCS, OCS, CSCS, FAAOMPT
Professor
Department of Physical Therapy
Azusa Pacific University
and
Academic Coordinator and Clinical Faculty
Movement Science Fellowship
Azusa Pacific University
and
Clinical Faculty
Kaiser Permanente Spine Fellowship and Pain Fellowship
Azusa, CA
kkumagaishimamura@apu.edu

Rob Landel, PT, DPT, FAPTA
Professor of Clinical Physical Therapy
Division of Biokinesiology and Physical Therapy
Herman Ostrow School of Dentistry
University of Southern California
and
Physical Therapist
USC Physical Therapy Associates
Los Angeles, CA
and
President
Skill Works, Inc
Long Beach, CA
rlandel@usc.edu

Bara A. Alsalaheen, PT, PhD
Associate Professor of Physical Therapy
University of Michigan-Flint
Flint, MI
and
Research Assistant Professor of Neurology
University of Michigan-Ann Arbor
and
Physical Therapist
Michigan NeuroSport
Michigan Medicine
University of Michigan-Ann Arbor
Ann Arbor, MI
alsalahe@umich.edu

Timothy A. Hanke, PT, PhD
Professor
Physical Therapy Program
College of Health Sciences
Midwestern University
Downers Grove, IL
THANKE@midwestern.edu

Karen L. McCulloch, PT, PhD, FAPTA
Clinical Professor
Division of Physical Therapy
Department of Allied Health Sciences
School of Medicine
and
Adjunct Faculty
Department of Exercise and Sports Science
University of North Carolina at Chapel-Hill
Chapel Hill, NC
kmac@med.unc.edu

REVIEWERS

Roy D. Altman, MD
Professor of Medicine
Division of Rheumatology and Immunology
David Geffen School of Medicine
University of California at Los Angeles
Los Angeles, CA
journals@royaltman.com

Paul Beattie, PT, PhD
Clinical Professor
Doctoral Program in Physical Therapy
Department of Exercise Science
Arnold School of Public Health
University of South Carolina
Columbia, SC
pbeattie@mailbox.sc.edu3

Kate E. Berz, DO
Assistant Professor
Department of Pediatrics
University of Cincinnati
and
Assistant Program Director
Pediatric Sports Medicine Fellowship
Cincinnati Children's Hospital Medical Center
and
Physician
Division of Sports Medicine and Division of Emergency Medicine
Cincinnati Children's Hospital Medical Center
Cincinnati, OH
kate.berz@cchmc.org

Bradley Bley, DO, FAAP, RMSK, CSCS
Clinical Assistant Professor of Medicine and Pediatrics
Delaware Orthopaedic Specialists
Newark, DE
bradcbley@gmail.com

Amy Cecchini, DPT, MS
Research Physical Therapist
The Geneva Foundation
Fayetteville, NC
and
Intrepid Spirit Center
Defense and Veterans Brain Injury Center
Womack Army Medical Center
Fort Bragg, NC
amy.s.cecchini.ctr@mail.mil

John Dewitt, DPT
Director
Physical Therapy Sports and Orthopaedic Residencies
The Ohio State University
Columbus, Ohio
john.dewitt@osumc.edu

Amanda Ferland, DPT
Clinical Faculty
Tongji University/USC Division of Biokinesiology and Physical Therapy
Orthopaedic Physical Therapy Residency and Spine Fellowship
Shanghai, China
AmandaFerland@incarehab.com

Isabelle Gagnon, PT, PhD
Associate Professor
School of Physical and Occupational Therapy
McGill University
and
Clinician Scientist
Trauma Center/Child Development
Montreal Children's Hospital
Montreal, Canada
isabelle.gagnon8@mcgill.ca

Kathleen Gill-Body, DPT, MS, NCS, FAPTA
Physical Therapist and Neurologic Clinical Specialist
Rehabilitation Services
Newton-Wellesley Hospital
Newton, MA
kgillbody@mghihp.edu

Sandra Kaplan, PT, PhD
Clinical Practice Guidelines Coordinator
Academy of Pediatric Physical Therapy, APTA, Inc
Alexandria, VA
and
Professor
Doctoral Programs in Physical Therapy
Rutgers University
Newark, NJ
kaplansa@shp.rutgers.edu

John J. Leddy, MD
Professor of Rehabilitation Sciences
Director of Outcomes Research
Clinical Professor of Orthopaedics
Medical Director of Concussion Management Clinic
University of Buffalo
Buffalo, NY
leddy@buffalo.edu

Shana McGrath, MA, CCC-SLP
Rehab Team Lead/Speech Language Pathologist
Outpatient Rehabilitation
The Ohio State University Wexner Medical Center
Columbus, OH
shana.mcgrath@osumc.edu

Geraldine L. Pagnotta, PT, MPT, MPH
Director of Strategic Initiatives
Concussion Center
New York University Langone Medical Center
New York, NY
Geraldine.pagnotta@nyulangone.org

Jennifer Reneker, PT, MSPT, PhD
Associate Professor
The University of Mississippi Medical Center
Jackson, MS
jreneker@umc.edu

AFFILIATIONS AND CONTACTS

Julie Schwertfeger, PT, DPT, MBA, CBIST
Assistant Professor
College of Health Professions
Rosalind Franklin University of Medicine and Science
Chicago, IL
Julie.schwertfeger@rosalindfranklin.edu

Noah Silverberg, PhD, RPsych, ABPP
Clinical Associate Professor
Physical Medicine and Rehabilitation Medicine and Neurology
University of British Columbia
and
Board-Certified Neuropsychologist
G.F. Strong Rehabilitation Centre
Vancouver, Canada
noah.silverberg@vch.ca

GUIDELINES EDITORS

Christine M. McDonough, PT, PhD
Editor
ICF-Based Clinical Practice Guidelines
Academy of Orthopaedic Physical Therapy, APTA, Inc
La Crosse, WI
and
Assistant Professor of Physical Therapy
School of Health and Rehabilitation Sciences
University of Pittsburgh
Pittsburgh, PA
cmm295@pitt.edu

Robroy L. Martin, PT, PhD
Editor
ICF-Based Clinical Practice Guidelines
Academy of Orthopaedic Physical Therapy, APTA, Inc
La Crosse, WI
and
Professor
Department of Physical Therapy
Duquesne University
Pittsburgh, PA
and
Staff Physical Therapist
UPMC Center for Sports Medicine
Pittsburgh, PA
martinr280@duq.edu

Guy G. Simoneau, PT, PhD, FAPTA
Editor
ICF-Based Clinical Practice Guidelines
Academy of Orthopaedic Physical Therapy, APTA, Inc
La Crosse, WI
and
Professor
Physical Therapy Department
Marquette University
Milwaukee, WI
guy.simoneau@marquette.edu

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APPENDIX A

LITERATURE SEARCH DETAILS

The review of the evidence for this clinical practice guideline (CPG) encompassed a consideration of the range of physical impairments that may be relevant when making a differential diagnosis after a concussive event, with the goal of determining the underlying cause(s) of presenting signs and symptoms and matching them with intervention priorities. The Guideline Development Group (GDG) worked with a librarian from the University of North Carolina at Chapel Hill to engage in the 2 phases of the literature search process (preliminary searches and systematic searches), as recommended by the American Physical Therapy Association's Clinical Practice Guideline Process Manual.[6] EndNote X8 (Clarivate Analytics, Philadelphia, PA) and DistillerSR software (Evidence Partners, Ottawa, Canada) were used to manage the literature searches, coordinate evidence selection, carry out critical appraisals, and store notes and information about the evidence sources.

The first phase of the literature search process was conducted in October 2014 and entailed preliminary searches to help determine the extent to which a reasonable body of evidence was present to support the development of a guideline, and to identify existing guidelines and systematic reviews available at the time on concussion management. The preliminary searches explored the use of the following key words separately and in various combinations: "concussion," "mild traumatic brain injury," "mild closed head injury," "rehabilitation," "physical therapy," "physiotherapy," and "exercise." Databases searched included PubMed, SPORTDiscus, and PsycINFO. The preliminary searches helped identify previously published CPGs, systematic reviews, and meta-analyses pertaining to the topic of concussion. From these preliminary searches, the GDG refined the scope and plan for the CPG and developed a formal strategy for the second phase.

The second phase entailed iterative systematic searches performed for studies through April 30, 2015; May 1, 2015 to October 31, 2015; November 1, 2016 to March 31, 2017; April 1, 2017 to December 31, 2018. The second-phase searches entailed the high-level key word searches from phase 1 and added the following additional search terms, separately and in combination, to ensure a wide breadth and comprehensive search process to capture impairments in vestibular, cervical, physical exertion, and functional mobility. The electronic systematic searches were supplemented through manual searching of journals and bibliographies, Google and Google Scholar searches, and word of mouth.

Search Strategies for All Databases Searched

Database	Search Terms
MEDLINE, CINAHL, Embase	("Brain Injuries"[MeSH] AND (mild[tiab] OR moderate[tiab] OR minor[tiab] OR concussion[tiab] OR concussions[tiab] OR concussive[tiab] OR mtbi[tiab] OR "posttraumatic"[tiab] OR posttraumatic[tiab] OR postconcussion[tiab] OR postconcussive[tiab] OR "postconcussion"[tiab] OR "postconcussive"[tiab] OR "postconcussional"[tiab] OR postconcussional[tiab])) AND ("Physical Therapy Modalities"[mesh] OR "Rehabilitation"[mesh] OR "Physical and Rehabilitation Medicine"[mesh] OR "Exercise"[mesh] OR "Disability Evaluation"[mesh] OR "Recovery of Function"[mesh] OR "physical therapy"[all fields] OR ("rehabilitation"[Subheading] OR "rehabilitation"[All Fields] OR "rehabilitation"[MeSH Terms]) OR physiotherapy[tiab] OR "rehabilitation"[Subheading] OR neurorehabilitation[all fields] OR "neuro-rehabilitation"[all fields]) AND (Randomized Controlled Trial[ptyp] OR ("Meta-analysis"[pt] OR "Practice Guideline"[pt] OR "Randomized Controlled Trial"[pt] OR "Longitudinal Studies"[MeSH] OR systematic[ti] or "Follow-up Studies"[mh] OR "Retrospective Studies"[mh] OR "Clinical Trial"[pt])AND ("2000/01/01"[PDAT]: "2018/12/31"[PDAT]) AND English[lang]) ("Brain Injuries"[MeSH] OR brain[ti]) AND (mild[tiab] OR moderate[tiab] OR minor[tiab] OR concussion[tiab] OR concussions[tiab] OR concussive[tiab] OR mtbi[tiab] OR "posttraumatic"[tiab] OR postconcussion[tiab] OR postconcussive[tiab] OR "postconcussion"[tiab] OR "postconcussive"[tiab]) AND ("Physical Therapy Modalities"[mesh] OR "Rehabilitation"[mesh] OR "Physical and Rehabilitation Medicine"[mesh] OR "Exercise"[mesh] OR "Disability Evaluation"[mesh] OR "Recovery of Function"[mesh] OR "physical therapy"[tiab] OR rehabilitation[tiab] OR physiotherapy[tiab] OR "rehabilitation"[Subheading] OR ("neurological rehabilitation"[MeSH Terms] OR ("neurological"[All Fields] AND "rehabilitation"[All Fields]) OR "neurological rehabilitation"[All Fields] OR "neurorehabilitation"[All Fields])) AND ("2000/12/01"[PDAT]: "2018/12/31"[PDAT])

Table continues on page CPG51.

APPENDIX A

Database	Search Terms
SPORTDiscus, PsycINFO	Cervical and dizziness, cervical and concussion, cervical and mTBI, cervicogenic dizziness and concussion, cervicogenic and mTBI Balance and concussion, balance and mTBI, balance and cervical Dizziness and concussion, dizziness and mTBI, vertigo and concussion, vertigo and mTBI Concussion and fatigue, concussion and mTBI, concussion and exertion, exertion and mTBI Dual task and concussion, dual task and mTBI Vision and concussion, vision and mTBI, ocular motor and concussion, ocular motor and mTBI Cervical complications: ("Brain Concussion"[mh] OR concussion[tw] OR concussions[tw] OR mtbi[tw] OR "mild traumatic brain"[tw] OR concussive[tw] OR "postconcussion"[tw] OR "postconcussive"[tw] OR postconcussion[tw]) AND ("Neck"[mh] OR "Neck Pain"[mh] OR "Cervical Vertebrae"[mh] OR "neck"[tw] OR "cervical"[tw] OR cervicogenic[tw]) AND English[lang] AND ("2000/01/01"[PDAT]: "2016/12/31"[PDAT]) NOT (Case Reports[ptyp] OR "case report"[ti]) Balance: ("Brain Concussion"[mh] OR concussion[tw] OR concussions[tw] OR mtbi[tw] OR "mild traumatic brain"[tw] OR concussive[tw] OR "postconcussion"[tw] OR "postconcussive"[tw] OR postconcussion[tw]) AND ("Postural Balance"[Mesh] OR "Proprioception"[Mesh] OR "Gait"[mh] OR balance[ti] OR equilibrium[ti]) AND English[lang] AND ("2000/01/01"[PDAT]: "2016/12/31"[PDAT]) NOT (Case Reports[ptyp] OR "case report"[ti]) Dizziness/vertigo: ("Brain Concussion"[mh] OR concussion[tw] OR concussions[tw] OR mtbi[tw] OR "mild traumatic brain"[tw] OR concussive[tw] OR "postconcussion"[tw] OR "postconcussive"[tw] OR postconcussion[tw]) AND ("Dizziness"[Mesh] OR "Vertigo"[Mesh] OR dizzy[ti] OR dizziness[ti] OR vertigo[ti]) AND English[lang] AND ("2000/01/01"[PDAT]: "2016/12/31"[PDAT]) NOT (Case Reports[ptyp] OR "case report"[ti]) Fatigue/exertion: ("Brain Concussion"[mh] OR concussion[tw] OR concussions[tw] OR mtbi[tw] OR "mild traumatic brain"[tw] OR concussive[tw] OR "postconcussion"[tw] OR "postconcussive"[tw] OR postconcussion[tw]) AND ("Fatigue"[Mesh] OR "Physical Exertion"[Mesh] OR "Exercise"[Mesh] OR fatigue[ti] OR fatigued[ti] OR exertion[ti] OR exercise[ti]) AND English[lang] AND ("2000/01/01"[PDAT]: "2016/12/31"[PDAT]) NOT (Case Reports[ptyp] OR "case report"[ti]) Dual task: ("Brain Concussion"[mh] OR concussion[tw] OR concussions[tw] OR mtbi[tw] OR "mild traumatic brain"[tw] OR concussive[tw] OR "postconcussion"[tw] OR "postconcussive"[tw] OR postconcussion[tw]) AND ("dual task" OR "divided attention" OR "Stroop Test"[mh] OR Stroop[tw]) AND English[lang] AND ("2000/01/01"[PDAT]: "2016/12/31"[PDAT]) NOT (Case Reports[ptyp] OR "case report"[ti]) Vision/ ocular motor: ("Brain Concussion"[mh] OR concussion[tw] OR concussions[tw] OR mtbi[tw] OR "mild traumatic brain"[tw] OR concussive[tw] OR "postconcussion"[tw] OR "postconcussive"[tw] OR postconcussion[tw]) AND ("Vision, Ocular"[Mesh] OR "Visual Perception"[Mesh] OR vision[ti] OR visual[ti] OR "ocular motor"[ti] OR oculomotor[ti]) AND English[lang] AND ("2000/01/01"[PDAT]: "2016/12/31"[PDAT]) NOT (Case Reports[ptyp] OR "case report"[ti])

APPENDIX B

SEARCH RESULTS

Search	Result
April 30, 2015	210
October 31, 2015	823
March 31, 2017	103
December 31, 2018	1136
Hand searches	76
Total[a]	2348

[a]*All databases and hand searches combined, with duplicates removed.*

APPENDIX C

ARTICLE INCLUSION AND EXCLUSION CRITERIA

Inclusion Criteria

CPGs

- Published on January 1, 2015 or later
- Included a multidisciplinary team for authorship
- Recommendations based on a systematic review and appraisal of the literature
- Included recommendations that pertained to movement-related impairments
- Determined to be acceptable based on critical appraisal by 2 trained, independent reviewers using criteria on the AGREE II tool

Original Studies and Systematic Reviews

- Included human participants with clear designation of a concussion or history of concussive event
- Two trained, independent reviewers appraised the study as relevant to the scope of the CPG
- Critical review of the document by 2 trained, independent reviewers appraised it as having an acceptable level of quality for inclusion

Expert Consensus Documents

- Two trained, independent reviewers appraised the document as relevant to the scope of the CPG
- Based on a systematic search of the literature OR a Delphi study methodology
- Described sound methods for consensus generation
- Adequate evidence of applicable expertise of participants/authors was provided
- Critical review of the document by 2 trained, independent reviewers appraised it as having an acceptable level of quality for inclusion

Conceptual and Theoretical Documents

- Two trained, independent reviewers appraised the document as relevant to the scope of the CPG
- Source was perceived as trustworthy
- Critical review of the document by 2 trained, independent reviewers appraised it as having an acceptable level of quality for inclusion

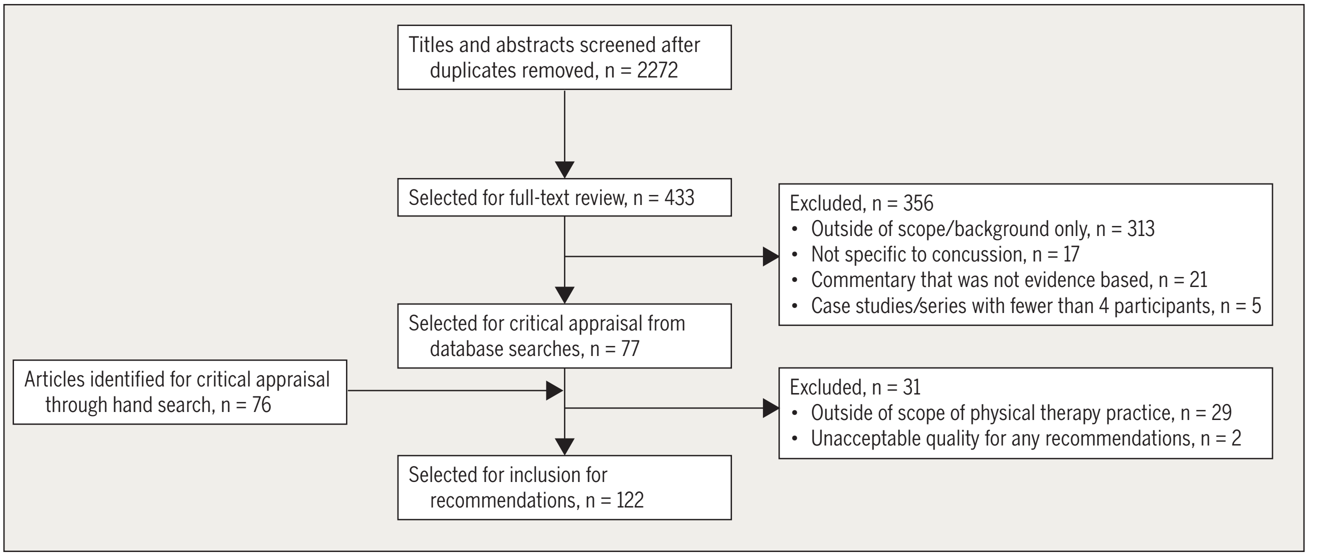
Exclusion Criteria

- Not available in English
- Determined to not be relevant to the CPG scope by 2 independent reviewers
- Inclusion of only healthy participants (no participants with history of concussive event)
- No clear delineation of outcomes specific to individuals with concussion/mild traumatic brain injury when the study also included participants with more severe brain injury
- Participant or target population mean age was younger than 8 years
- Case study/series with fewer than 4 participants
- Commentary that was not evidence based
- Critical appraisal that resulted in a rating of unacceptable quality

Abbreviations: AGREE II, Appraisal of Guidelines for Research and Evaluation II instrument; CPG, clinical practice guideline.

APPENDIX D

FLOW CHART OF ARTICLES



APPENDIX E

ARTICLES INCLUDED IN RECOMMENDATIONS BY TOPIC

Component 1: Process for Determining Appropriateness of Physical Therapy Concussive-Event Examination

Diagnosis

Management of Concussion-mild Traumatic Brain Injury Working Group. VA/DoD Clinical Practice Guideline for the Management of Concussion-Mild Traumatic Brain Injury. Washington, DC: US Department of Veterans Affairs/Department of Defense; 2016.

Marshall S, Bayley M, McCullagh S, et al. Updated clinical practice guidelines for concussion/mild traumatic brain injury and persistent symptoms. *Brain Inj*. 2015;29:688-700. https://doi.org/10.3109/02699052.2015.1004755

Screening for Indicators of Emergency Conditions

Lumba-Brown A, Yeates KO, Sarmiento K, et al. Centers for Disease Control and Prevention guideline on the diagnosis and management of mild traumatic brain injury among children. *JAMA Pediatr*. 2018;172:e182853. https://doi.org/10.1001/jamapediatrics.2018.2853

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Differential Diagnosis

Alsalaheen B, Stockdale K, Pechumer D, Broglio SP. Measurement error in the Immediate Postconcussion Assessment and Cognitive Testing (ImPACT): systematic review. *J Head Trauma Rehabil*. 2016;31:242-251. https://doi.org/10.1097/HTR.0000000000000175

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McCrory P, Meeuwisse W, Dvorak J, et al. Consensus statement on concussion in sport—the 5th International Conference on Concussion in Sport held in Berlin, October 2016. *Br J Sports Med*. 2017;51:838-847. https://doi.org/10.1136/bjsports-2017-097699

McCulloch KL, Goldman S, Lowe L, et al. Development of clinical recommendations for progressive return to activity after military mild traumatic brain injury: guidance for rehabilitation providers. *J Head Trauma Rehabil*. 2015;30:56-67. https://doi.org/10.1097/HTR.0000000000000104

Comprehensive Intake Interview

Gagnon I, Friedman D, Beauchamp MH, et al. The Canadian Pediatric Mild Traumatic Brain Injury Common Data Elements project: harmonizing outcomes to increase understanding of pediatric concussion. *J Neurotrauma*. 2018;35:1849-1857. https://doi.org/10.1089/neu.2018.5887

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Component 2: Physical Therapy Examination and Evaluation Processes for Patients Who Have Experienced a Concussive Event

Systems to Be Examined

Broglio SP, Kontos AP, Levin H, et al. National Institute of Neurological Disorders and Stroke and Department of Defense Sport-Related Concussion Common Data Elements version 1.0 recommendations. *J Neurotrauma*. 2018;35:2776-2783. https://doi.org/10.1089/neu.2018.5643

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Examination for Cervical Musculoskeletal Impairments

Cheever K, Kawata K, Tierney R, Galgon A. Cervical injury assessments for concussion evaluation: a review. *J Athl Train*. 2016;51:1037-1044. https://doi.org/10.4085/1062-6050-51.12.15

Ellis MJ, Leddy JJ, Willer B. Physiological, vestibulo-ocular and cervicogenic post-concussion disorders: an evidence-based classification system with directions for treatment. *Brain Inj*. 2015;29:238-248. https://doi.org/10.3109/02699052.2014.965207

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Reneker JC, Clay Moughiman M, Cook CE. The diagnostic utility of clinical tests for differentiating between cervicogenic and other causes of dizziness after a sports-related concussion: an international Delphi study. *J Sci Med Sport*. 2015;18:366-372. https://doi.org/10.1016/j.jsams.2014.05.002

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Examination for Autonomic/Exertional Tolerance Impairments

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Examination for Motor Function Impairments

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Component 3: Developing and Implementing a Physical Therapy Plan of Care for Patients Who Have Experienced a Concussive Event

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APPENDIX F

LEVELS OF EVIDENCE TABLE[a]

Level	Intervention/Prevention	Pathoanatomic/Risk/ Clinical Course/Prognosis/ Differential Diagnosis	Diagnosis/Diagnostic Accuracy	Prevalence of Condition/ Disorder	Exam/Outcomes
I	Systematic review of high-quality RCTs High-quality RCT[b]	Systematic review of prospective cohort studies High-quality prospective cohort study[c]	Systematic review of high-quality diagnostic studies High-quality diagnostic study[d] with validation	Systematic review, high-quality cross-sectional studies High-quality cross-sectional study[e]	Systematic review of prospective cohort studies High-quality prospective cohort study
II	Systematic review of high-quality cohort studies High-quality cohort study[c] Outcomes study or ecological study Lower-quality RCT[f]	Systematic review of retrospective cohort study Lower-quality prospective cohort study High-quality retrospective cohort study Consecutive cohort Outcomes study or ecological study	Systematic review of exploratory diagnostic studies or consecutive cohort studies High-quality exploratory diagnostic studies Consecutive retrospective cohort	Systematic review of studies that allows relevant estimate Lower-quality cross-sectional study	Systematic review of lower-quality prospective cohort studies Lower-quality prospective cohort study
III	Systematic reviews of case-control studies High-quality case-control study Lower-quality cohort study	Lower-quality retrospective cohort study High-quality cross-sectional study Case-control study	Lower-quality exploratory diagnostic studies Nonconsecutive retrospective cohort	Local nonrandom study	High-quality cross-sectional study
IV	Case series	Case series	Case-control study		Lower-quality cross-sectional study
V	Expert opinion	Expert opinion	Expert opinion	Expert opinion	Expert opinion

Abbreviation: RCT, randomized clinical trial.
[a]*Adapted from Phillips B, Ball C, Sackett D, et al. Oxford Centre for Evidence-based Medicine - Levels of Evidence (March 2009). Available at: http://www.cebm.net/index.aspx?o=1025. Accessed August 4, 2009. See also* **APPENDIX G.**
[b]*High quality includes RCTs with greater than 80% follow-up, blinding, and appropriate randomization procedures.*
[c]*High-quality cohort study includes greater than 80% follow-up.*
[d]*High-quality diagnostic study includes consistently applied reference standard and blinding.*
[e]*High-quality prevalence study is a cross-sectional study that uses a local and current random sample or censuses.*
[f]*Weaker diagnostic criteria and reference standards, improper randomization, no blinding, and less than 80% follow-up may add bias and threats to validity.*

APPENDIX G

PROCEDURES FOR ASSIGNING LEVELS OF EVIDENCE

- Level of evidence is assigned based on the study design using the Levels of Evidence table (**APPENDIX F**), assuming high quality (eg, for intervention, randomized clinical trial starts at level I)
- Study quality is assessed using the critical appraisal tool, and the study is assigned 1 of 4 overall quality ratings based on the critical appraisal results
- Level of evidence assignment is adjusted based on the overall quality rating:
  - High quality (high confidence in the estimate/results): study remains at assigned level of evidence (eg, if the randomized clinical trial is rated high quality, its final assignment is level I). High quality should include:
    - Randomized clinical trial with greater than 80% follow-up, blinding, and appropriate randomization procedures
    - Cohort study includes greater than 80% follow-up
    - Diagnostic study includes consistently applied reference standard and blinding
    - Prevalence study is a cross-sectional study that uses a local and current random sample or censuses
  - Acceptable quality (the study does not meet requirements for high quality and weaknesses limit the confidence in the accuracy of the estimate): downgrade 1 level
    - Based on critical appraisal results
  - Low quality: the study has significant limitations that substantially limit confidence in the estimate: downgrade 2 levels
    - Based on critical appraisal results
  - Unacceptable quality: serious limitations—exclude from consideration in the guideline
    - Based on critical appraisal results

APPENDIX H

APPRAISALS

AGREE II Appraisal Scores

Study	Domain[a] 1	2	3	4	5	6	Overall Score[b]
Marshall et al[153]	92%	92%	84%	69%	77%	50%	5
Lumba-Brown et al[141]	94%	69%	79%	86%	42%	84%	5
MCMTBIWG[149]	92%	75%	69%	92%	44%	50%	5

Abbreviations: AGREE II, Appraisal of Guidelines for Research and Evaluation II instrument; MCMTBIWG, Management of Concussion-mild Traumatic Brain Injury Working Group.
[a]Domains: (1) scope and purpose, (2) stakeholder involvement, (3) rigor of development, (4) clarity of presentation, (5) applicability, (6) editorial independence.
[b]A quality judgment based on the average of the 2 Guideline Development Group members who performed the appraisal using a range of 1 to 7, where 1 represents the lowest rating and 7 represents the highest rating.

AMSTAR[a] Scores for Systematic Reviews

Study	Item[b] 1	2	3	4	5	6	7	8	9	10	11	Quality[c]
Alsalaheen et al[2]	Y	Y	Y	Y	N	Y	Y	Y	NA	N	N	Acceptable
Alsalaheen et al[3]	Y	Y	Y	Y	N	Y	Y	Y	N	N	Y	High
Bell et al[11]	Y	N	Y	N	Y	Y	N	N	N	N	N	Low
Broglio and Puetz[20]	Y	Y	Y	Y	N	Y	N	N	Y	Y	Y	High
Fino et al[59]	Y	Y	Y	N	Y	N	Y	Y	N	N	N	Acceptable
Haider et al[78]	Y	Y	Y	Y	N	Y	Y	Y	NA	N	N	Acceptable
Hunt et al[99]	Y	Y	Y	N	N	Y	NA	Y	NA	N	Y	Acceptable
Lal et al[118]	Y	Y	Y	N	N	Y	Y	Y	Y	N	N	Acceptable
Lumba-Brown et al[142]	Y	Y	Y	N	N	N	Y	Y	N	N	Y	Acceptable
Makdissi et al[147]	Y	Y	Y	N	N	Y	Y	Y	NA	N	N	Acceptable
Murray et al[171]	Y	N	Y	Y	N	Y	Y	Y	N	N	N	Acceptable
Quatman-Yates et al[178]	Y	Y	Y	Y	N	Y	Y	Y	N	Y	N	High
Quatman-Yates et al[177]	Y	Y	Y	Y	N	Y	Y	Y	NA	N	N	Acceptable
Register-Mihalik et al[183]	Y	Y	Y	N	N	Y	N	N	N	N	N	Low
Schneider et al[192]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	N	High

Abbreviations: AMSTAR, A MeaSurement Tool to Assess systematic Reviews; N, no; NA, not applicable; Y, yes.
[a]Criteria from Shea BJ, Grimshaw JM, Wells GA, et al. Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. BMC Med Res Methodol. 2007;7:10. https://doi.org/10.1186/1471-2288-7-10
[b]Yes/no. Items: 1, Was an a priori design provided? 2, Was there duplicate study selection and data extraction? 3, Was a comprehensive literature search performed? 4, Was the status of publication (ie, gray literature) used as an inclusion criterion? 5, Was a list of studies (included and excluded) provided? 6, Were the characteristics of the included studies provided? 7, Was the scientific quality of the included studies assessed and documented? 8, Was the scientific quality of the included studies used appropriately in formulating conclusions? 9, Were the methods used to combine the findings of studies appropriate? 10, Was the likelihood of publication bias assessed? 11, Was the conflict of interest included?
[c]Scores of 8 or greater were considered high, 6 or 7 acceptable, 4 or 5 low, and 3 or below very low.

Diagnosis: Clinical Practice Guidelines

Study	Appraisal Level[a]	Quality[b]
Marshall et al[153]	I	Acceptable
Management of Concussion-mild Traumatic Brain Injury Working Group[149]	I	Acceptable

[a]Based on the critical appraisal tool and review results.
[b]Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).

APPENDIX H

Screening for Indicators of Emergency Conditions: Clinical Practice Guidelines

Study	Appraisal Level[a]	Quality[b]
Marshall et al[153]	I	Acceptable
Lumba-Brown et al[141]	I	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

Differential Diagnosis

Study	Study Type	Appraisal Level[a]	Quality[b]
Alsalaheen et al[2]	Systematic review	I	Acceptable
Alsalaheen et al[3]	Systematic review	I	High
Gagnon et al[61]	Expert opinion	IV	Acceptable
Lumba-Brown et al[141]	Clinical practice guideline	I-II	Acceptable
Marshall et al[153]	Clinical practice guideline	I	Acceptable
McCrory et al[159]	Expert opinion	IV	Acceptable
McCulloch et al[160]	Expert opinion	IV	Acceptable
Management of Concussion-mild Traumatic Brain Injury Working Group[149]	Clinical practice guideline	I-II	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

Comprehensive Intake Interview

Study	Study Type	Appraisal Level[a]	Quality[b]
Gagnon et al[61]	Expert opinion	IV	Acceptable
Lumba-Brown et al[141]	Clinical practice guideline	II	Acceptable
Marshall et al[153]	Clinical practice guideline	I	Acceptable
McCulloch et al[160]	Expert opinion	IV	Acceptable
McCrory et al[159]	Expert opinion	IV	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

Systems to Be Examined

Study	Study Type	Appraisal Level[a]	Quality[b]
Broglio et al[19]	Expert opinion	IV	Acceptable
Gagnon et al[61]	Expert opinion	IV	Acceptable
Makdissi et al[147]	Systematic review	II	Acceptable
Marshall et al[153]	Clinical practice guideline	II	Acceptable
McCrory et al[159]	Expert opinion	IV	Acceptable
McCulloch et al[160]	Expert opinion	V	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

APPENDIX H

Examination for Cervical Musculoskeletal Impairments

Study	Study Type	Appraisal Level[a]	Quality[b]
Cheever et al[31]	Expert opinion	V	Acceptable
Ellis et al[54]	Expert opinion	V	Acceptable
Kennedy et al[106]	Case series	IV	Low
Kuczynski et al[115]	Case series	IV	Acceptable
Marshall et al[152]	Case series	IV	Acceptable
Morin et al[165]	Expert opinion	V	Acceptable
Reneker et al[186]	Case series	IV	Acceptable
Reneker et al[187]	Cohort study	IV	Acceptable
Reneker et al[188]	Expert opinion	IV	Acceptable
van der Walt et al[217]	Case series	IV	Acceptable
Leddy et al[c]	Cohort study	...	Unacceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*
[c]*Leddy JJ, Baker JG, Merchant A, et al. Brain or strain? Symptoms alone do not distinguish physiologic concussion from cervical/vestibular injury. Clin J Sport Med. 2015;25:237-242. https://doi.org/10.1097/JSM.0000000000000128*

Examination for Vestibulo-oculomotor Impairments

Study	Study Type	Appraisal Level[a]	Quality[b]
Anzalone et al[8]	Case series	IV	Acceptable
Capó-Aponte et al[26]	Case-control study	III	Acceptable
Capó-Aponte et al[27]	Case-control study	IV	Acceptable
Corwin et al[38]	Case series	IV	Acceptable
Cheever et al[31]	Expert opinion	V	Acceptable
Cheever et al[32]	Cohort study	III	Acceptable
Elbin et al[52]	Cohort study	II	Acceptable
Ellis et al[54]	Expert opinion	V	Acceptable
Goodrich et al[71]	Expert opinion	IV	Acceptable
Heyer et al[82]	Cohort study	III-IV	Acceptable
Hunt et al[99]	Systematic review	II	Acceptable
Józefowicz-Korczyńska et al[103]	Cohort study	III	Acceptable
Lei-Rivera et al[135]	Expert opinion	V	Acceptable
Lumba-Brown et al[141]	Clinical practice guideline	III	Acceptable
Marshall et al[153]	Clinical practice guideline	I	Acceptable
Marshall et al[152]	Case series	IV	Acceptable
Master et al[155]	Cross-sectional study	III	Acceptable
Matuszak et al[156]	Expert opinion	V	Acceptable
McDevitt et al[161]	Case-control study	IV	Acceptable
Mucha et al[169]	Cross-sectional study	II	Acceptable
Murray et al[173]	Cohort study	III	Acceptable
Reneker et al[186]	Case series	IV	Acceptable
Reneker et al[187]	Cohort study	IV	Acceptable
Reneker et al[188]	Expert opinion	IV	Acceptable
Skóra et al[198]	Cohort study	III	Acceptable
Management of Concussion-mild Traumatic Brain Injury Working Group[149]	Clinical practice guideline	III	Acceptable
Ventura et al[219]	Clinical practice guideline	V	Acceptable
Zhou and Brodsky[228]	Case series	IV	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

APPENDIX H

Examination for Autonomic/Exertional Tolerance Impairments

Study	Study Type	Appraisal Level[a]	Quality[b]
Broglio et al[19]	Expert opinion	IV	Acceptable
Cordingley et al[36]	Case series	IV	Acceptable
Darling et al[42]	Case series	IV	Acceptable
Dematteo et al[47]	Cohort study	II	Acceptable
Ellis et al[54]	Expert opinion	V	Acceptable
Ellis et al[53]	Expert opinion	V	Acceptable
Gall et al[66]	Case-control study	III	Acceptable
Gall et al[65]	Case-control study	III	Acceptable
Haider et al[78]	Systematic review	II	Acceptable
Haider et al[79]	Case-control study	III	Acceptable
Hinds et al[85]	Cohort study	III	Acceptable
Kozlowski et al[112]	Case-control study	IV	Acceptable
Leddy et al[133]	Expert opinion	V	Acceptable
Leddy et al[123]	Expert opinion	V	Acceptable
Leddy et al[126]	Expert opinion	V	Acceptable
Leddy et al[129]	Randomized controlled trial	I	High
Leddy et al[128]	Expert opinion	V	Acceptable
Leddy et al[134]	Expert opinion	V	Acceptable
Matuszak et al[156]	Expert opinion	V	Acceptable
McCrory et al[159]	Expert opinion	IV	Acceptable
Orr et al[174]	Cohort study	II	Acceptable
Quatman-Yates et al[177]	Systematic review	I	High

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

APPENDIX H

Examination for Motor Function Impairments

Study	Study Type	Appraisal Level[a]	Quality[b]
Bell et al[11]	Systematic review	III	Low
Benedict et al[12]	Cross-sectional study	III	Acceptable
Berkner et al[13]	Case-control study	III	Acceptable
Broglio et al[19]	Expert opinion	IV	Acceptable
Broglio and Puetz[20]	Systematic review	III	High
Broglio et al[21]	Cohort study	III	Acceptable
Buckley et al[24]	Cohort study	III	Acceptable
Cavanaugh et al[28]	Case series	IV	Acceptable
Cossette et al[40]	Case-control study	III	Acceptable
De Beaumont et al[44]	Case-control study	III	Acceptable
Dorman et al[49]	Case-control study	III	Acceptable
Findling et al[58]	Cohort study	III	Acceptable
Fino et al[59]	Systematic review	III	Acceptable
Furman et al[60]	Case-control study	IV	Acceptable
Gera et al[68]	Case-control study	III	Acceptable
Howell et al[93]	Cohort study	III	Acceptable
Howell et al[92]	Cohort study	I	High
Howell et al[95]	Cohort study	III	Acceptable
Howell et al[86]	Cohort study	III	Acceptable
Howell et al[89]	Case-control study	III	Acceptable
Howell et al[94]	Case-control study	IV	Acceptable
Hugentobler et al[97]	Cross-sectional study	IV	Acceptable
Inness et al[100]	Cross-sectional study	III	Acceptable
King et al[109]	Case series	IV	Acceptable
Lumba-Brown et al[141]	Clinical practice guideline	IV	Acceptable
Lynall et al[144]	Cross-sectional study	III	Acceptable
Massingale et al[154]	Case-control study	III	Acceptable
McCrory et al[159]	Expert opinion	IV	Acceptable
McCulloch et al[160]	Expert opinion	IV	Acceptable
Murray et al[173]	Case-control study	III	Acceptable
Murray et al[172]	Systematic review	III	Acceptable
Quatman-Yates et al[180]	Case-control study	III	Acceptable
Quatman-Yates et al[179]	Case-control study	IV	Acceptable
Radomski et al[181]	Case-control study	IV	Acceptable
Register-Mihalik et al[183]	Systematic review	III	Low
Register-Mihalik et al[184]	Case series	IV	Acceptable
Sambasivan et al[190]	Cross-sectional study	III-IV	Acceptable
Schneider et al[195]	Cohort study	III	Acceptable
Solomito et al[199]	Case-control study	III	Acceptable
Sosnoff et al[200]	Case series	IV	Low
Teel et al[207]	Case-control study	IV	Acceptable
Vartiainen et al[218]	Case-control study	III	Acceptable
Walker et al[221]	Cross-sectional study	III-IV	Acceptable
Wilkerson et al[223]	Cohort study	III	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

APPENDIX H

Classification

Study	Study Type	Appraisal Level[a]	Quality[b]
Collins et al[34]	Expert opinion	IV	Acceptable
Collins et al[35]	Expert opinion	V	Acceptable
Ellis et al[53]	Expert opinion	V	Acceptable
Ellis et al[54]	Expert opinion	V	Acceptable
Lundblad[143]	Expert opinion	V	Acceptable
Marshall et al[153]	Clinical practice guideline	III	Acceptable
Reneker et al[187]	Cohort study	IV	Acceptable
Management of Concussion-mild Traumatic Brain Injury Working Group[149]	Clinical practice guideline	III	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

Outcome Measure Selection

Study	Study Type	Appraisal Level[a]	Quality[b]
Broglio et al[19]	Expert opinion	IV	Acceptable
Gagnon et al[61]	Expert opinion	IV	Acceptable
Gottshall et al[72]	Cohort study	III	Acceptable
Kleffelgaard et al[110]	Cohort study	III	Acceptable
Lumba-Brown et al[141]	Clinical practice guideline	II	Acceptable
Lumba-Brown et al[142]	Systematic review	II	Acceptable
Marshall et al[153]	Clinical practice guideline	II	Acceptable
Management of Concussion-mild Traumatic Brain Injury Working Group[149]	Clinical practice guideline	II	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

Communication and Education

Study	Study Type	Appraisal Level[a]	Quality[b]
Lumba-Brown et al[141]	Clinical practice guideline	I-III	Acceptable
Lumba-Brown et al[142]	Systematic review	III	Acceptable
Marshall et al[153]	Clinical practice guideline	I-III	Acceptable
McCulloch et al[160]	Expert opinion	IV	Acceptable
McCrory et al[159]	Expert opinion	IV	Acceptable
Schneider et al[192]	Systematic review	III	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

APPENDIX H

Physical Therapy Interventions for Movement-Related Impairments

Study	Study Type	Appraisal Level[a]	Quality[b]
Dobney et al[48]	Case series	IV	Acceptable
Hugentobler et al[98]	Case series	IV	Acceptable
Grabowski et al[73]	Case series	IV	Acceptable
Gagnon et al[62]	Case series	IV	Acceptable
Gagnon et al[63]	Case series	IV	Acceptable
Lawrence et al[122]	Case series	IV	Acceptable
Lennon et al[137]	Case series	IV	Acceptable
Lumba-Brown et al[141]	Clinical practice guideline	II	Acceptable
Lumba-Brown et al[142]	Systematic review	II	Acceptable
Marshall et al[153]	Clinical practice guideline	II	Acceptable
Quatman-Yates et al[178]	Systematic review	II	Acceptable
Reneker et al[189]	Randomized controlled trial	II	Acceptable
Schneider et al[192]	Systematic review	II	Acceptable
Management of Concussion-mild Traumatic Brain Injury Working Group[149]	Clinical practice guideline	II	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

Cervical Musculoskeletal Interventions

Study	Study Type	Appraisal Level[a]	Quality[b]
Grabowski et al[73]	Case series	IV	Acceptable
Hugentobler et al[98]	Case series	IV	Acceptable
Kennedy et al[106]	Case series	IV	Acceptable
Marshall et al[152]	Case series	IV	Acceptable
Morin et al[165]	Expert opinion	V	Acceptable
Reneker et al[189]	Randomized controlled trial	II	Acceptable
Schneider et al[194]	Randomized controlled trial	II	Acceptable
Schneider et al[193]	Case series	IV	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

Vestibulo-oculomotor Interventions

Study	Study Type	Appraisal Level[a]	Quality[b]
Alsalaheen et al[4]	Case series	IV	Acceptable
Alsalaheen et al[5]	Expert opinion	IV	Acceptable
Józefowicz-Korczyńska et al[103]	Cohort study	IV	Acceptable
Marshall et al[153]	Clinical practice guideline	I	Acceptable
Moore et al[163]	Cohort study	IV	Low
Murray et al[171]	Systematic review	II	Acceptable
Reneker et al[189]	Randomized controlled trial	II	Acceptable
Schneider et al[194]	Randomized controlled trial	II	Acceptable
Schneider et al[193]	Case series	IV	Acceptable
Storey et al[203]	Cohort study	IV	Acceptable
Gottshall and Hoffer[c]	Cohort study	...	Unacceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*
[c]*Gottshall KR, Hoffer ME. Tracking recovery of vestibular function in individuals with blast-induced head trauma using vestibular-visual-cognitive interaction tests. J Neurol Phys Ther. 2010;34:94-97. https://doi.org/10.1097/NPT.0b013e3181dead12*

APPENDIX H

Exertional Tolerance and Aerobic Exercise Interventions

Study	Study Type	Appraisal Level[a]	Quality[b]
Anderson et al[7]	Case-control study	IV	Acceptable
Dobney et al[48]	Case series	IV	Acceptable
Gauvin-Lepage et al[67]	Case-control study	II	Acceptable
Grabowski et al[73]	Case series	IV	Acceptable
Hugentobler et al[98]	Case series	IV	Acceptable
Kozlowski et al[112]	Case-control study	IV	Acceptable
Lal et al[118]	Systematic review	I	High
Leddy et al[132]	Case series	IV	Acceptable
Leddy et al[129]	Randomized controlled trial	I	High
Leddy et al[130]	Cohort study	II	Acceptable
Lennon et al[137]	Case series	IV	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

Motor Function Interventions

Study	Study Type	Appraisal Level[a]	Quality[b]
Collins et al[34]	Expert opinion	IV	Acceptable
Hugentobler et al[98]	Case series	IV	Acceptable
Marshall et al[153]	Clinical practice guideline	IV	Acceptable
McCulloch et al[160]	Expert opinion	IV	Acceptable
Management of Concussion-mild Traumatic Brain Injury Working Group[149]	Clinical practice guideline	IV	Acceptable
Weightman et al[222]	Expert opinion	V	Acceptable

[a]*Based on the critical appraisal tool and review results.*
[b]*Overall assessment of the methodological quality of the study (high, acceptable, low, unacceptable).*

NÛNO TROLLE, PT, MHSc[1] • **THOMAS MARIBO,** PT, PhD[2,3]
LONE DONBÆK JENSEN, MD, PhD[4] • **DAVID HØYRUP CHRISTIANSEN,** PT, PhD[1,5]

Task-Specific Sensitivity in Physical Function Testing Predicts Outcome in Patients With Low Back Pain

OBJECTIVE: To investigate the prognostic value of task-specific sensitivity in patients with low back pain by exploring whether task-specific sensitivity during physical function testing was associated with self-reported change in pain and disability.

DESIGN: Prospective cohort study nested in a randomized controlled trial.

METHODS: The study included 260 patients with low back pain, referred for evaluation in a secondary care setting. All patients completed questionnaires and underwent clinical examination by a physical therapist. Patients rated their pain intensity before and after completing a test battery measuring physical function and were classified into 4 categories—worse, unchanged, better, or no pain—depending on their pain response. At 3-month follow-up, outcomes were obtained by a postal questionnaire.

RESULTS: Task-specific sensitivity significantly predicted pain, after adjusting for known prognostic factors. Patients in the no pain, better, and unchanged groups improved their pain score significantly more than patients in the worse pain group. Patients in the no pain group also improved their disability score significantly more compared to patients in the worse pain group, after adjusting for known prognostic factors.

CONCLUSION: Task-specific sensitivity predicted pain intensity after 3 months in patients with low back pain. The prognostic value appears limited with respect to disability. *J Orthop Sports Phys Ther 2020;50(4):206-213. Epub 30 Oct 2019. doi:10.2519/jospt.2020.8953*

KEY WORDS: *musculoskeletal pain, pain sensitivity, prognosis, sensitivity to physical activity*

Low back pain (LBP) is one of the most common health problems globally[11,22] and is the leading cause of disability and loss of or limitations at work.[12,21] Low back pain is a recurrent problem, and it has been estimated that 65% of patients still experience pain after 12 months.[24] However, a specific cause for most cases of LBP has not been identified, and LBP is not fully explained by tissue pathology or damage alone.[3,12,16] Due to this discrepancy, there is increasing attention on prognosis studies in LBP.[16] Identifying prognostic factors is a high priority in research and clinical practice, as understanding factors related to future outcomes could improve treatment and inform lifestyle decisions.[15,18] A number of prognostic factors for poor outcome in patients with LBP have been identified[16]; however, few of these factors are consistent across studies.[15] Previous LBP episodes, greater disability, the presence of sciatica, and psychological factors such as fear-avoidance beliefs, depressive mood, and pain behavior have been shown to be useful predictors,[14,28,36,40] whereas the clinical findings of physical examination seem to hold limited prognostic value.[13] The prognostic value of more general physical task performance measures such as physical fitness level, muscle strength, or walking distance among patients with LBP has been more sparsely evaluated. Although some studies indicate that physical task performance levels alone do not predict outcomes in patients with LBP,[4,33] measuring sensitivity to such task performance tests could be of value.[41,42] Sensitivity to task performance, also called task-specific sensitivity, is measured by assessing pain before and after a physical function test. Studies of patients with knee osteoarthritis have found that increasing discomfort during physical function tests was associated with pain and disability scores.[41,42] Comparable findings have been reported by Sullivan et al,[39] who found physical activity of low to moderate intensity produced similar sensitized pain responses among patients with LBP, whereas other studies have found exercise to reduce pain sensitivity, measured by pressure pain

[1]Danish Ramazzini Center, Department of Occupational Medicine, Regional Hospital West Jutland-University Research Clinic, Herning, Denmark. [2]Department of Public Health, Center for Rehabilitation Research, Aarhus University, Aarhus, Denmark. [3]DEFACTUM, Central Denmark Region, Aarhus, Denmark. [4]Danish Ramazzini Center, Department of Occupational Medicine, Aarhus University Hospital, Aarhus, Denmark. [5]Department of Clinical Medicine, HEALTH, Aarhus University, Aarhus, Denmark. The study was approved by the Danish Data Protection Agency (number 2006-41-6190) and registered with the Central Denmark Region Committees on Biomedical Research Ethics. This study is part of a randomized clinical trial funded by the Danish Working Environment Research Fund (grant number 10-2005-09). The authors certify that they have no affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article. Address correspondence to Dr David Høyrup Christiansen, Danish Ramazzini Center, Department of Occupational Medicine, Regional Hospital West Jutland-University Research Clinic, Gl Landevej 61, 7400 Herning, Denmark. E-mail: david.christiansen@vest.rm.dk

thresholds.[20] Although the underlying mechanisms of task-specific sensitivity are not fully understood, sensitivity to physical activity has been linked to sensitization of the central nervous system,[42] fear of movement due to pain,[30,39,42] and work disability[31] in persistent musculoskeletal pain conditions, including whiplash-associated disorder, chronic LBP, and knee osteoarthritis. Thus, addressing pain response in relation to physical activity may be important when trying to predict responses to different interventions for LBP. The cross-sectional nature of previous studies does not allow any firm conclusions to be drawn with respect to the ability of task-specific sensitivity to predict outcome over time, and further research is needed to explore its usefulness as a prospective predictor.

Thus, the objective was to investigate the prognostic value of task-specific sensitivity in patients with LBP, by exploring whether task-specific sensitivity during physical function testing is associated with self-reported change in pain and disability after 3 months.

METHODS

Design and Populations

The study was conducted as a prospective cohort study with 3 months' follow-up nested in a previously published randomized controlled trial (RCT).[25] The aim of the RCT was to explore the effect of counseling by an occupational physician that addressed workplace barriers to and enhancement of physical activity as part of outpatient treatment of pain, disability, and sick leave. The RCT included 360 patients referred for specialized evaluation at rheumatologic clinics due to LBP. The inclusion criteria were LBP with or without sciatica, aged 18 to 63 years, paid work employment, willingness to accept a workplace visit if needed, concerns about ability to maintain current job, and spoken Danish. Exclusion criteria were referral for low back surgery, pregnancy, or serious comorbidities causing disability (eg, severe heart disease, cancer) or hindrance to the planned testing and intervention. A flow chart is shown in **FIGURE 1**. Of the 360 patients included in the RCT, 60 patients were allocated to another study, while 40 patients did not complete the baseline physical function test. Informed consent was obtained from all participants. The study was approved by the Danish Data Protection Agency (number 2006-41-6190) and registered with the Central Denmark Region Committees on Biomedical Research Ethics.

Procedures

Data were collected between November 2006 and July 2009. All patients attended a baseline session to provide demographic information and complete a questionnaire. Demographic information included sex, age, job, and workers' compensation status. The questionnaire included questions on pain, disability, and psychosocial factors. The patients underwent a clinical examination by a rheumatologist and were classified according to the Quebec Task Force classification system.[37] Subsequently, patients' physical function was tested by 1 of 3 experienced physical therapists. At 3-month follow-up, a questionnaire was sent to patients.

Outcome

Primary explanatory outcomes for the present study were changes in back-specific measures of pain and disability from baseline to 3-month follow-up, as recommended.[6] Average LBP intensity during the previous 3 months was scored on an 11-point numeric rating scale (NRS) from 0 (no pain) to 10 (worst imaginable pain).[9] The NRS has acceptable test-retest reliability, construct validity, and responsiveness,[8] but with measurement error being slightly higher than the recommended minimal important change (MIC) of 2 points.[35] Although the content validity of single-item pain scales has been questioned,[8] the NRS remains the most preferred measure of pain intensity among researchers, clinicians, and patients.[5] The Roland-Morris Disability Questionnaire (RMDQ) was used to assess back-specific disability. The ag-

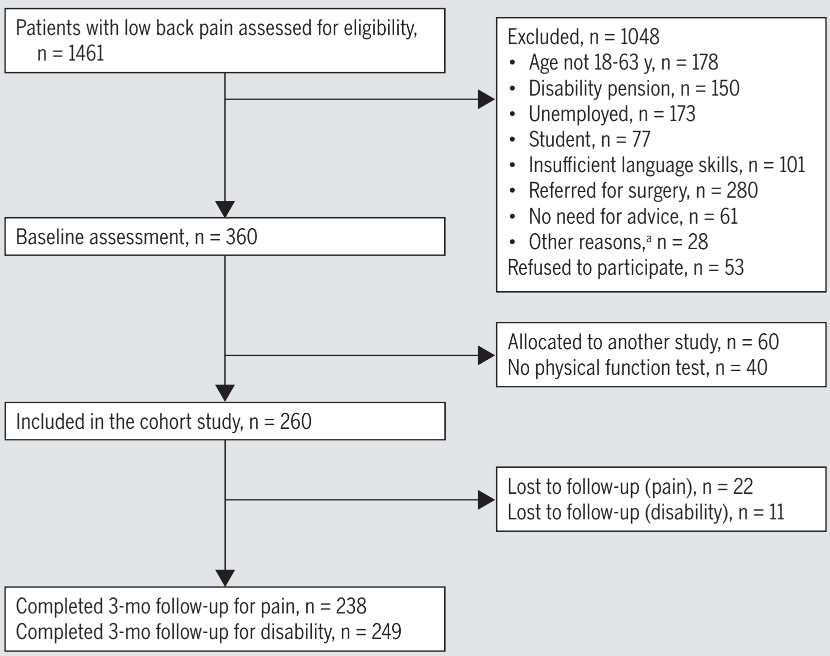

FIGURE 1. Flow chart of participants in the cohort study. [a]Did not want to inform employer about health problems; in the process of changing job; other illnesses; pregnancy; inhabitant from other region/country; workplace visit not possible (offshore installation).

gregated score ranges form 0 (no disability) to 23 (severely disabled). The RMDQ has been translated and cross-culturally adapted to the Danish population among patients with LBP.[1] The RMDQ has satisfactory measurement properties with respect to test-retest reliability, construct validity, and responsiveness, with measurement error being equal to or slightly lower than the estimated MIC of 5 points.[7,35]

Task-Specific Sensitivity

Task-specific sensitivity was measured during the test session with a physical therapist. Patients rated their current pain intensity using an 11-point NRS immediately before and after completing a test battery of physical function. Task-specific sensitivity was calculated as a pain response, by subtracting patients' posttest pain score from their pretest pain score, of at least a 1-point change. Task-specific sensitivity was divided into 4 categories: worse, unchanged, better, or no pain, depending on pain response. Worse was defined as patients who had a negative pain response (experienced more pain) to physical testing, unchanged was defined as patients who had no pain response (experienced unchanged pain), and better was defined as patients who had a positive pain response (experienced less pain) to physical testing. Patients who rated their pain as 0 before testing were classified as no pain, regardless of whether they experienced a negative pain response or had no pain response. The test battery consisted of a balance test (1-leg stance), the Biering-Sorensen test to assess the endurance of the trunk extensor muscles,[26] the modified Kraus-Weber test to assess the endurance of the abdominal muscles,[23] and the Åstrand cycle ergometer test to estimate maximum oxygen uptake (mL 0_2/min/kg).[2]

Other Prognostic Factors

To control for the potential influence of other factors, we included 5 additional available variables—age, sex, ongoing workers' compensation, sciatica, and fear-avoidance beliefs—thought to be associated with physical activity task performance[31,39,41,42] and predictive of poor outcomes in patients with LBP.[15,40] This information was obtained from the baseline questionnaire and clinical examination. Fear-avoidance beliefs were measured with the Fear-Avoidance Beliefs Questionnaire physical activity subscale (FABQ-PA), which has been cross-culturally validated in Danish.[32] Information on the presence of sciatica was assessed by a rheumatologist during the clinical examination at baseline, using the Quebec Task Force classification system.[37] The Quebec Task Force classification has demonstrated good predictive ability and can discriminate between those with and without radiating pain.[29]

Statistical Analysis

Descriptive statistics were calculated for all variables for the study population, categorical variables were cross-tabulated, and normality of distribution for continuous variables was checked using normal quantile plots. Numbers of patients with missing data for each variable and follow-up rate were estimated. Differences in baseline characteristics between the study population and those who were lost to follow-up were tested using Student's *t* test for normally distributed continuous data, the Mann-Whitney *U* test for nonnormal distribution, and the chi-square test for categorical data. Data that were absent or unclear were treated as missing. Associations between task-specific sensitivity and changes in pain and disability were estimated using linear regression. One model was fitted for each of the outcome measures (changes in pain and disability). To control for the potential influence of other factors, multivariate analysis was then performed for each outcome, including a priori–selected baseline variables (ie, factors related to the individual, clinical findings, psychosocial factors, and intervention group) and respective baseline values of the outcome. Regression coefficients are reported with 95% confidence intervals (CIs). The associations were tested using tests for trends, and a significance level of .05 was selected. Underlying assumptions for linear regression were checked for each model by residual scatter plots and residuals versus fitted-values plots. For the statistical analysis, Stata Version 15 (StataCorp LLC, College Station, TX) was used.

RESULTS

Participants

Of the 260 patients who completed baseline testing, 22 (8.5%) and 11 (4.2%) patients were lost to follow-up due to missing pain and disability scores, respectively. The final study population included 238 and 249 patients with complete follow-up data on pain and disability, respectively. A flow chart illustrating the course of the study is available in **FIGURE 1**.

Baseline Characteristics

Baseline characteristics of the study sample, classified by task-specific sensitivity groups, are available in **TABLE 1**. Of 260 included patients, 54 (20.8%) were classified by task-specific sensitivity as no pain, 117 (45.0%) as better, 56 (21.5%) as unchanged, and 33 (12.7%) as worse. At baseline, 6.5% and 20.0% of patients did not answer the NRS and FABQ-PA questionnaire, respectively. Questions about ongoing workers' compensation were unanswered by 8.9%. Missing responses for other baseline variables did not exceed 3%. There were no differences in baseline characteristics between the patients who were included and those who were lost to follow-up (**TABLE 2**). The mean follow-up time was 103 days.

Main Results

Pain intensity improved significantly for all 4 task-specific sensitivity groups at 3-month follow-up (**FIGURE 2**), with an overall mean difference of 2.3 points (95% CI: 1.9, 2.6). The between-group differences in the nonadjusted analysis were small and not statistically significant (**TABLE 3**), though an association between task-specific sensitivity and changes in pain was found (P = .05). After adjusting for factors related to the individual, clinical findings, psychosocial factors, and intervention group, we found that between-group differences increased significantly (P<.01) in favor of the better, unchanged, and no-pain groups. The largest mean difference, 2.2 points (95% CI: 1.0, 3.5), was between the worse group and the no-pain group. Disability improved significantly for all groups (mean difference, 2.7 points; 95% CI: 2.1, 3.3) (**FIGURE 2**), but there was no statistically significant difference between groups in the nonadjusted analysis (**TABLE 4**). In the adjusted analysis, the mean difference in disability scores between the worse and no-pain groups reached statistical significance (2.5 points; 95% CI: 0.2, 4.7) (**TABLE 4**).

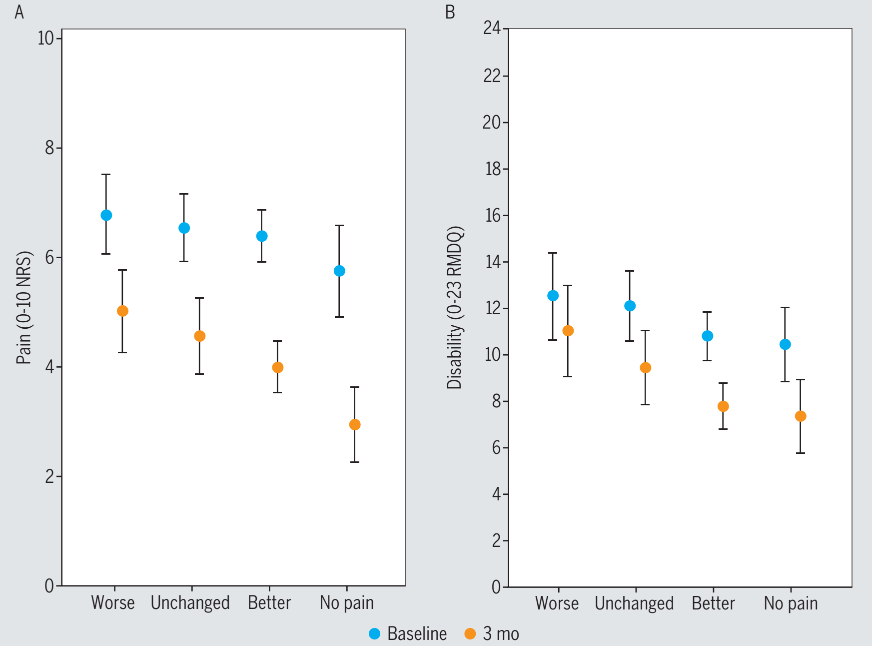

FIGURE 2. Mean (95% confidence interval) scores for (A) pain and (B) disability at baseline and 3-month follow-up, according to task-specific sensitivity classification. Abbreviations: NRS, numeric rating scale; RMDQ, Roland-Morris Disability Questionnaire.

TABLE 1 Baseline Characteristics of the Study Population, Divided Based on Task-Specific Sensitivity Group[a]

	No Pain (n = 54)	Better (n = 117)	Unchanged (n = 56)	Worse (n = 33)	Total (n = 260)
Age, y	44.3 ± 9.2	45.3 ± 10.2	44.4 ± 11.4	44.4 ± 10.3	44.8 ± 10.2
Sex (female), n (%)	26 (48.2)	65 (55.6)	34 (60.7)	19 (57.6)	144 (55.4)
Body mass index, kg/m^2	25.9 ± 4.8	26.9 ± 4.5[b]	25.4 ± 4.7	27.0 ± 4.6	26.4 ± 4.7[c]
Current job, n (%)					
Professionals, highly educated	19 (35.2)	37 (31.6)	13 (23.2)	6 (18.2)	75 (28.9)
Office, teaching, and nursing	23 (42.6)	59 (50.4)	27 (48.2)	22 (66.7)	131 (50.4)
Blue collar	12 (22.2)	21 (18.0)	16 (28.6)	5 (15.2)	54 (20.8)
Quebec Task Force classification, n (%)					
Without radiating pain	6 (11.1)	32 (27.4)	20 (35.7)	8 (24.2)	66 (25.4)
With radiating pain above knee level	16 (29.6)	31 (26.5)	17 (30.4)	4 (12.1)	68 (26.2)
With radiating pain below knee level	32 (59.3)	54 (46.2)	19 (33.9)	21 (63.6)	126 (48.5)
Ongoing workers' compensation, n (%)[d]	7 (14.0)	11 (10.4)	8 (15.4)	9 (31.0)	35 (14.8)
FABQ-physical activity (0-24)[e,f]	12 (6)	9 (8)	11 (7)	11.5 (6)	11 (7)
Numeric rating scale (0-10)[e,g]	6 (3)	6 (3)	6 (3)	6 (2)	6 (3)
RMDQ (0-23)[e,h]	11 (10)	11 (9)	13 (9)	13 (9)	11 (9)

Abbreviations: FABQ, Fear-Avoidance Beliefs Questionnaire; RMDQ, Roland-Morris Disability Questionnaire.
[a]*Values are mean ± SD unless otherwise indicated. The variation in n is due to missing values.*
[b]*n = 116.*
[c]*n = 259.*
[d]*Group values: no pain, n = 50; better, n = 106; unchanged, n = 52; worse, n = 29; total, n = 237.*
[e]*Values are median (interquartile range).*
[f]*Group values: no pain, n = 46; better, n = 84; unchanged, n = 48; worse, n = 30; total, n = 208.*
[g]*Group values: no pain, n = 51; better, n = 110; unchanged, n = 54; worse, n = 28; total, n = 243.*
[h]*Group values: no pain, n = 52; better, n = 114; unchanged, n = 56; worse, n = 31; total, n = 253.*

DISCUSSION

This study explored the predictive value of task-specific sensitivity among patients with LBP for changes in pain and disability. The principal finding was a significant association between task-specific sensitivity and change in pain and disability, when taking into account other known prognostic factors. The change in pain for patients classified as better, unchanged, and no pain, compared to patients classified as worse, showed significant improvement; the change in disability, however, only reached statistical significance for the no-pain group.

An important strength of this study is its prospective design with a 3-month follow-up, which ensured that the predictive value of task-specific sensitivity could be evaluated over time, when taking into account other prognostic variables. The prospective design also prevented selection bias in participation, as the outcomes were unknown at the point of selection. However, loss to follow-up might be differentially related to task-specific sensitivity and outcomes. Follow-up rates at 3 months were high (greater than 90%), and there were no differences in baseline characteristics or task-specific sensitivity classification between the patients who completed the study and those who were lost to follow-up. Thus, the risk of bias due to study attrition may be regarded as low. Because LBP is a fluctuating condition,[27] its intensity can vary over time, for example, between days or even within the same day. This means that task-specific sensitivity classification could vary from day to day, which is a limitation of the current study. However, such fluctuation in pain often occurs between neighboring groups[27] (eg, from worse to unchanged or from unchanged to better), and misclassification would likely be nondifferential and would not explain the observed differences between groups. The use of at least a 1-point cutoff level for classification of task-specific sensitivity was a pragmatic choice. It could be debated whether we should have used at least a 2-point cutoff, which has been suggested as the MIC threshold for pain assessment on an 11-point NRS.[35] However, assessment of recalled pain or spontaneous pain that does not involve physical activity may be quite different from assessment of pain related to physical activity (ie, movement-evoked pain),[10] and it is unknown whether measurement properties (eg, measurement error and MIC values) are transferable. Because fewer than half of the patients in the worse category who provided follow-up data exceeded a 2-point threshold, we could not explore a higher cutoff value. Information on outcomes was collected using valid and reliable outcome measures, but the lack of blinding of patients could nonetheless have resulted in differential misclassification of the outcomes, because patients were aware of the exposure. However, it seems very unlikely that pain and disability reported at the 3-month follow-up would be differentially related to task-specific sensitivity groups. We adjusted for a priori–selected prognostic factors known to be associated with poor outcome in patients with LBP.[14,40] However, other prognostic variables could have been included, such as pain catastrophizing and previous LBP episodes. It is unknown how these variables would have affected our results. In addition, the relatively large number of missing responses observed in the FABQ-PA prevented full adjust-

TABLE 2 Baseline Characteristics of the Study Population and Patients Lost to Follow-up[a]

	Study Population (n = 238)	Lost to Follow-up (n = 22)
Age, y	44.5 ± 10.2	48.0 ± 9.8
Sex (female), n (%)	135 (56.7)	9 (40.9)
Body mass index, kg/m^2	26.2 ± 4.6[b]	28.0 ± 5.0
Current job, n (%)		
Professionals, highly educated	69 (29.0)	6 (27.3)
Office, teaching, and nursing	122 (51.3)	9 (40.9)
Blue collar	47 (19.8)	7 (31.8)
Quebec Task Force classification, n (%)		
Without radiating pain	62 (26.1)	4 (18.2)
With radiating pain above knee level	60 (25.2)	8 (36.4)
With radiating pain below knee level	116 (48.7)	10 (45.5)
Ongoing workers' compensation, n (%)[c]	34 (15.4)	1 (6.3)
FABQ-physical activity (0-24)[de]	11 (7)	12 (8)
Task-specific sensitivity, n (%)		
Worse	28 (11.8)	5 (22.7)
Unchanged	53 (22.3)	3 (13.6)
Better	107 (45.0)	10 (45.5)
No pain	50 (21.0)	4 (18.2)
Numeric rating scale (0-10)[d]	6 (3)	6 (1)[f]
RMDQ (0-23)[dg]	11 (9)	12 (10)

Abbreviations: FABQ, Fear-Avoidance Beliefs Questionnaire; RMDQ, Roland-Morris Disability Questionnaire.
[a]*Values are mean ± SD unless otherwise indicated. The variation in n is due to missing values.*
[b]*n = 237.*
[c]*Group values: study population, n = 221; lost to follow-up, n = 16.*
[d]*Values are median (interquartile range).*
[e]*Group values: study population, n = 189; lost to follow-up, n = 19.*
[f]*n = 5.*
[g]*Group values: study population, n = 236; lost to follow-up, n = 17.*

ment of that variable in multivariable analyses. Dividing patients into 4 task-specific sensitivity groups based on their pain response to physical testing yielded different patterns across outcomes. A lack of difference between the better and unchanged groups suggests that task-specific sensitivity may hold the same predictive value. Absence of LBP at baseline is predictive of continued absence of LBP, and patients with LBP at baseline consistently report LBP.[27] This indicates that pain status at baseline is predictive of the future course, and that patients with and without LBP at baseline have different outcomes. In our study, patients who had no pain prior to physical testing had the most favorable outcome at 3 months, which adds to these previous findings.

The present study shows that some patients with LBP experience worsening pain after physical function tests. This is in agreement with findings by Sullivan et al,[39] who found that certain patients with chronic LBP experience an increase in pain following physical activity of low to moderate intensity. In another study, Wideman et al[42] found that patients with knee osteoarthritis also experienced worsening discomfort following a test of physical function, and that this sensitized response predicted both pain and disability. The present study somewhat confirms these results by demonstrating that task-specific sensitivity significantly predicted pain but was more limited in regard to disability. The differences in the findings of these studies could be due to design differences or different populations. The total group in the present study exceeded the MIC for pain, with an overall mean improvement of 2.3 points (95% CI: 1.9, 2.6), but not for disability (2.7 points; 95% CI: 2.1, 3.3). That NRS pain but not RMDQ disability scores exceeded the MIC may explain the difference in the prognostic value of task-specific sensitivity. Another reason could also be that the measure of task-specific sensitivity is directly related to pain, but not to disability, and therefore is a better predictor for pain-related outcomes. Previous research has reported limited prognostic value of physical task performance tests.[4,33]

In contrast, our results suggest that measuring patients' pain response to such performance tests may hold prognostic value. Prognostic research is essential for clinical decision making; it may help to inform patients about their possible course, as well as help clinicians to make decisions regarding stratified management.[17,19,38] The findings of the present study show that patients with LBP respond differently to exercise, which is in line with previous research suggesting that sensitization may be

TABLE 3 Linear Regression Analysis With the NRS as the Outcome

Task-Specific Sensitivity	Mean Difference[a]	*P* Value
Nonadjusted (n = 238)[b]		
Worse	Reference	
Unchanged	0.6 (–0.7, 1.9)	.36
Better	1.0 (–0.2, 2.1)	.11
No pain	1.3 (–0.1, 2.6)	.06
Test for trend		.05
Adjusted (n = 175)[bc]		
Worse	Reference	
Unchanged	1.3 (0.1, 2.6)	.04
Better	1.4 (0.2, 2.5)	.02
No pain	2.2 (1.0, 3.5)	<.01
Test for trend		<.01

Abbreviation: NRS, numeric rating scale.
[a]*Values in parentheses are 95% confidence interval.*
[b]*The variation in n is due to missing values.*
[c]*Adjusted for age, sex, radiating pain, intervention group, workers' compensation, fear-avoidance beliefs, and baseline NRS score.*

TABLE 4 Linear Regression Analysis With the RMDQ as the Outcome

Task-Specific Sensitivity	Mean Difference[a]	*P* Value
Nonadjusted (n = 249)[b]		
Worse	Reference	
Unchanged	0.8 (–1.4, 3.0)	.46
Better	1.4 (–0.6, 3.3)	.17
No pain	1.6 (–0.6, 3.8)	.16
Test for trend		.12
Adjusted (n = 184)[bc]		
Worse	Reference	
Unchanged	1.8 (–0.5, 4.0)	.12
Better	2.0 (–0.2, 4.1)	.07
No pain	2.5 (0.2, 4.7)	.03
Test for trend		.05

Abbreviation: RMDQ, Roland-Morris Disability Questionnaire.
[a]*Values in parentheses are 95% confidence interval.*
[b]*The variation in n is due to missing values.*
[c]*Adjusted for age, sex, radiating pain, intervention group, workers' compensation, fear-avoidance beliefs, and baseline RMDQ score.*

present only in certain patients with LBP.[34] It could be argued that the differences observed, when comparing the worse group to the unchanged and better groups, were below clinical relevance, as the differences did not exceed the proposed MIC values for pain. On the other hand, as the magnitude of these differences increased when adjusted for other existing prognostic factors, assessment of task-specific sensitivity seems to provide additional prognostic information, which contributes to the overall understanding and improvement of treatment pathways in LBP. These findings are in line with contemporary pain models, suggesting assessment of pain in relation to physical activity to be particularly important to understanding the underlying mechanisms of persistent musculoskeletal conditions.[10] Task-specific sensitivity may be a useful clinical test and easy to implement. However, future research will need to evaluate the reliability and measurement error of task-specific sensitivity classification for pain before and after testing. Furthermore, the test battery of physical function used in the present study lasted about 45 minutes and we do not, therefore, know whether a shorter session might have yielded the same pain response results. As the study population was an unselected population, the findings can be generalized to patients with LBP who are not referred for surgery and have a connection to the workplace. However, caution is warranted when generalizing to populations not similar to the population of the present study.

CONCLUSION

Patients with LBP experienced different pain responses during physical function testing. Task-specific sensitivity was predictive of self-reported pain intensity after 3 months in patients with LBP with moderate to severe symptoms. Patients who had a decrease in pain or stable pain response during physical function testing had a more favorable prognosis, as compared to those in whom pain increased. The predictive value of task-specific sensitivity was more limited in respect to self-reported disability among patients with LBP. ◉

KEY POINTS

FINDINGS: Task-specific sensitivity during physical function testing predicted short-term self-reported pain intensity, but yielded limited prognostic value in regard to disability, among patients with low back pain referred for evaluation in secondary care and with moderate to severe symptoms.

IMPLICATIONS: Measuring task-specific sensitivity to physical function testing may help clinicians evaluate patients' treatment potential and provide more accurate prediction of outcomes.

CAUTION: Because of a 3-month follow-up period, only the short-term prediction value of task-specific sensitivity was assessed. Also, the generalization of the findings may be limited to patients with low back pain who are seen in outpatient clinics and have moderate to severe symptoms.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: Nûno Trolle and Drs Maribo and Christiansen planned and designed the study. Nûno Trolle performed the statistical analyses and drafted the manuscript. All authors contributed to the interpretation of the results and critical revision of the manuscript. All authors read and approved the final manuscript.

DATA SHARING: The data set from the current study cannot be made publicly available according to Danish regulations. However, an anonymous version of the data sets used and analyzed during the current study is available from the corresponding author on reasonable request.

PATIENT AND PUBLIC INVOLVEMENT: No patients or public partners were involved in the design, conduct, interpretation, and/or translation of the research.

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