"EFFECT OF PASSIVE NEURODYNAMIC SLIDER ON GAIT PARAMETERS IN SUBJECT WITH LUMBAR CANAL STENOSIS RELATED TO NEUROPATHIC PAIN"

A SHAM RANDOMIZED TRIAL

Dissertation Submitted to the

UTKAL UNIVERSITY, Bhubaneswar, Odisha

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In Partial fulfilment of the requirements for the degree of

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In

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Under the guidance of

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Bhubaneswar, Odisha

2022-2024

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I hereby declare that this dissertation entitled **EFFECT OF PASSIVE NEURODYNAMIC SLIDER ON GAIT PARAMETERS IN SUBJECT WITH LUMBAR CANAL STENOSIS RELATED TO NEUROPATHIC PAIN- A SHAM RANDOMIZED TRIAL** is a bonafide and genuine research work carried out by me under the guidance of DR. Deepak Kumar Pradhan Assistant Professor, Abhinav Bindra Sports Medicine and Research Institute, Odisha.

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Dr. A. Joseph Oliver Raj

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LIST OF ABBREVIATIONS

1. **ABSMARI –** Abhinav Bindra Sports Medicine and Research Institute
2. **DN4-** Douleur Neuropathique 4
3. **L/E-** lower extremity
4. **10MWT-** 10 meter Walk Test
5. **SAUL-** Segmental Acceleration Upper Limb
6. **SALL-** Segmental Acceleration Lower Limb
7. **SAF-** Segmental Acceleration Foot
8. **SPSS –** Statistical package for social science
9. **Hip F/E Angle**- Hip Flexion/Extension angle
10. **Knee F/E Angle**- Knee Flexion/extension angle
11. **Ankle PF/DF Angle**- Ankle Flexion/extension angle
12. **MD-** Mean Difference
13. **SD-** Standard Deviation

LIST OF TABLES

LIST OF CONTENTS

LIST OF FIGURES

ABSTRACT

"EFFECT OF PASSIVE NEURODYNAMIC SLIDER ON GAIT PARAMETERS IN SUBJECT WITH LUMBAR CANAL STENOSIS RELATED TO NEUROPATHIC PAIN": A SHAM RANDOMIZED TRIAL.

Background- Neuropathic pain associated with lumbar spinal stenosis is a prevalent disorder that affects older adults caused by narrowing of lumbar spinal canal and nerve root canal thus leading to compression of the neural and vascular structures with the spaces. Having the symptoms individuals experience a difficulty in walking and standing. Due to this unexpected discomfort or neuropathic pain, there is a disruption in their normal gait patterns thus having increased gait variability. Neurodynamic sliders reinstate the dynamic balance between relative movement of neural tissues and surrounding mechanical interfaces, hence promote optimal physiological function thus resulting in reducing gait variability.

Objective: - To investigate the effect of passive neurodynamic slider technique on gait parameters in subject with lumbar spinal stenosis associated with neuropathic pain.

Methods-20 lumbar spinal stenosis diagnosed by MRI related with neuropathic pain of aged between 40-65 years were randomly assigned to Experimental group (n=10) and Sham group (n=10). Intervention was given for 12 sessions; each session consists of 30 repetitions with 2 seconds period rest between each repetition on affected extremity. Primary outcome measures include XSENS Awinda and 10 MWT, and secondary outcome measure includes ODI. All the outcome measures were calculated before and after the 4 weeks.

Results –The results within the group showed significant difference ($p<0.05$) in experimental group, whereas in sham group knee flexion/extension angle and ODI showed significant difference ($p<0.05$). The between group analysis showed significant difference ($p<0.05$) in segmental acceleration, 10MWT, ODI.

Conclusion-The study concluded that Passive neurodynamic slider is an effective therapeutic technique for reducing Gait variability and reducing disability of individuals hence improving the quality of life in lumbar spinal stenosis subjects related to neuropathic pain.

Key Word- **lumbar canal stenosis, neurodynamic sliders, neuropathic pain, gait parameters, randomized controlled trial (RCT)**

Introduction

Lumbar spinal stenosis (LSS) was initially described by Sachs and Frankel in their 1900 publication. However, it wasn't until 1954 that Dutch neurosurgeon Henk Verbiest provided a definitive clinical description of LSS. Following this, LSS was identified as a clinical condition associated with physical impairment. Later, Porter and colleagues established a connection between back pain, weakness, and the narrowing of the spinal canal. Today, the US Social Security Act recognizes spinal stenosis as a disabling condition. (1)

Lumbar spinal stenosis (LSS) is characterized by the narrowing of the spinal canal, nerve root canals, or intervertebral foramina. It can be classified according to its cause—either congenital or acquired—or based on its anatomical location, which includes central, foraminal, or lateral stenosis. Central stenosis occurs when the spinal canal and dural sac are narrowed. Foraminal stenosis involves the narrowing of the spinal foramina, while lateral stenosis affects the lateral recesses. Central stenosis may lead to some degree of lateral stenosis, although lateral stenosis can also develop independently. (1)

Central canal spinal stenosis can occur either under the facet joints or within the neural foramina. The most prevalent type of lumbar spinal stenosis is acquired degenerative spinal stenosis. This condition typically results from a combination of factors, including disc bulging or herniation, hypertrophy or folding of the ligamentum flavum, and hypertrophy of osteoarthritic facet joints. The changes in biomechanics between these affected spinal structures play a crucial role in the development of stenosis over time. (1)

Acquired lumbar spinal stenosis (LSS) is frequently linked to aging and the progressive degenerative changes in the spine. The severity of stenosis is categorized based on the degree of narrowing of the central canal's cross-sectional area: mild stenosis is defined as a reduction of one-third or less, moderate stenosis as a narrowing between one-third and two-thirds, and severe stenosis as a reduction greater than two-thirds. A previous study found that among individuals aged 55 years and older, 21%-30% had mild stenosis, 6% had moderate stenosis, and 7% had severe stenosis. (1)

The narrowing of the lumbar spinal canal and nerve root canals leads to compression of the neural and vascular structures within these spaces. This compression can result in neurologic symptoms that are often intermittent. These symptoms are typically triggered by activities such as standing and are usually aggravated by walking. They are generally relieved by bending forward or flexing the trunk. (2)

While having a narrow lumbar spinal canal is necessary for the condition, it is not sufficient on its own to cause the disorder. The condition only manifests when the narrowing is severe enough to compress the contents of the canal, including sensory and motor nerves, leading to functional impairment. (2)

Lumbar spinal stenosis (LSS) is often diagnosed through a multifaceted approach due to the lack of universal diagnostic criteria. The definitive diagnosis typically involves a combination of the patient's medical history, a thorough physical examination, and imaging studies. Magnetic resonance imaging (MRI) is the preferred method to demonstrate canal narrowing, which is characteristic of LSS. If MRI is contraindicated, computed tomography (CT)

may be used as an alternative to visualize the spinal canal and assess the degree of stenosis. (3)

Computed tomography (CT) is the best imaging option for visualizing bony anatomy and can be effective in diagnosing conditions such as disc herniation and spinal stenosis. However, CT has limitations, including its inability to reliably depict nerve root impingement and the associated exposure to radiation. As a result, CT is not typically the first choice for imaging spinal stenosis. An alternative to standard CT is the CT myelogram, which involves the injection of contrast medium into the subarachnoid space. This enhances the visibility of neural structures, making CT myelography comparable to magnetic resonance imaging (MRI) for detecting neural impingement and stenosis. Despite these advantages, the procedure still exposes the patient to radiation, requires a lumbar puncture, and necessitates the use of contrast medium. (1)

Magnetic resonance imaging (MRI) is frequently employed to evaluate radiological signs of lumbar spinal stenosis (LSS). MRI provides detailed information on the presence and extent of degenerative changes in the lumbar spine, the size of the spinal canal, and any compression of neural structures. This makes MRI a valuable tool in the diagnosis and assessment of LSS. (4)

Various grading systems have been developed to assess the degree of spinal compression on MRI, with grades 3 and 4, as defined by the system proposed by Jeong et al., being indicative of severe compression that may warrant surgical intervention. When conservative treatments fail to manage symptoms

effectively in patients with these grades of compression, lumbar decompression surgery, with or without fusion of the affected levels, is typically considered as the next step in treatment. (3)

In a previous study, it was noted that a decreased anterior-posterior diameter of the vertebral canal, as observed on magnetic resonance imaging (MRI), was strongly associated with the symptoms of lumbar spinal stenosis (LSS). This anterior-posterior diameter, also referred to as the mid-sagittal diameter of the spinal canal, is measured as the distance between the middle of the posterior edge of the vertebral body and the lamina posteriorly in the midline. A reduced mid-sagittal diameter is a key radiological indicator of LSS. (5)

Lumbar spinal stenosis can be categorized based on the degree of narrowing of the spinal canal. When the cross-sectional diameter of the spinal canal measures less than 12mm, it is referred to as relative stenosis. If the diameter is less than 10mm, it is classified as absolute stenosis. These measurements are critical thresholds for assessing the severity of spinal canal narrowing and guiding treatment decisions. (1)

The overall prevalence of lumbar spinal stenosis (LSS) was found to be 47% in a study population with a mean age of 64 years, ranging from 20 to 96 years. This indicates that nearly half of the individuals within this broad age range were affected by LSS. (1)

The prevalence of lumbar spinal stenosis (LSS) increases with age because the condition is primarily degenerative and is rarely seen in individuals under 50 years old. In some cases, however, abnormalities in postnatal development can result in congenital stenosis, leading to an earlier onset of

symptoms. Nevertheless, congenital stenosis remains an uncommon condition. (4)

In a study, the prevalence rates of lumbar spinal stenosis (LSS) were found to be 4.7% for relative LSS and 2.6% for absolute LSS in the congenital group. In contrast, the acquired LSS group had higher prevalence rates, with 22.5% for relative LSS and 7.3% for absolute LSS. The study also observed that prevalence rates increased with age; for individuals in the 60–69 age range, the prevalence rates were 47.2% for relative LSS and 19.4% for absolute LSS. (1)

In a population-based study conducted in Japan involving 2,666 patients, it was found that the prevalence of lumbar spinal stenosis (LSS) increased with age. For individuals aged 40–49, the prevalence was estimated at 1.7% for females and 2.2% for males. In contrast, for those in the 70–79 age group, the prevalence was significantly higher, estimated at 11.2% for females and 10.3% for males. (1)

With the increasing elderly dependency ratio, the number of individuals experiencing pain and disability due to lumbar spinal stenosis (LSS) is anticipated to rise, which will contribute to higher healthcare costs. Moreover, severe radiological signs of LSS are less common compared to moderate or mild forms of the condition. (4)

Lumbar spinal stenosis (LSS) is a degenerative condition that significantly impacts daily living and quality of life. The primary complaint associated with LSS is neuropathic pain. (6)

A study found that there is a higher prevalence (36%) of neuropathic pain components in patients with lumbar spinal stenosis (LSS). (7)

A previous study using the Pain DETECT questionnaire, which screens for neuropathic pain, reported that 17.6% of patients with lumbar spinal stenosis (LSS) were classified as having neuropathic pain. (6)

Neuropathic pain is defined by the International Association for the Study of Pain (IASP) as "pain initiated or caused by a primary lesion or dysfunction of the nervous system". (8) It may arise as a consequence of a lesion or disease affecting the somatosensory system. (7)

Neuropathic pain associated with spinal disorders includes pain resulting from compression or damage to the spinal cord or nerve roots. (9)

In lumbar spinal stenosis, nerve root deformation can be associated with clinical symptoms such as pain and neurological deficits in the lower extremities. (10) Neuropathic pain is significant in leg pain (radicular pain) and contributes to the overall severity of the pain. (7)

According to Turner et al 1992, Leg pain is reported in approximately 90% of cases of lumbar spinal stenosis, and it may be unilateral or bilateral. (11)

Neuropathic pain is characterized by painful symptoms in areas with altered sensations, such as numbness or increased sensitivity. The key features of this type of pain include spontaneous pain (pain occurring without any external trigger) and unusual responses to both non-painful and painful stimuli (such as allodynia and hyperalgesia). Patients might describe experiencing paroxysmal pain (including shooting, stabbing, or electric shock-like pain),

dysesthesias (abnormal sensations like skin crawling or tingling), and abnormal thermal sensations (such as burning or feeling ice cold). (12,13)

While these characteristics are not always present or definitively diagnostic of neuropathic pain, their presence strongly suggests a likely diagnosis of neuropathic pain. Therefore, it is essential to obtain a thorough patient history and conduct a comprehensive clinical examination to confirm the diagnosis of neuropathic pain. (13)

Pain is fundamentally a subjective experience that is expressed through symptoms unique to each patient. To classify neuropathic pain, standardized screening tools such as the Neuropathic Pain Questionnaire, PainDETECT, ID-Pain, and DN4 have been created. These tools rely on patient-reported descriptions of the quality of their pain (13).

The LANSS pain scale was the initial tool created and introduced for identifying neuropathic pain. It includes five symptom items and two clinical examination items. (7)

In lumbar spinal stenosis, symptoms are aggravated by lumbar extension, which narrows the cross-sectional area of the lumbar spinal canal. Consequently, standing upright and walking tend to worsen symptoms, leading to notable functional impairment, especially in mobility. Conversely, lumbar flexion, which enlarges the cross-sectional area of the lumbar spinal canal, tends to relieve symptoms. As a result, patients often find relief when sitting and may walk with a forward stoop and slightly flexed hips and knees to reduce pain and improve walking tolerance. (3).

During spinal extension, the edges of the laminae from adjacent vertebrae overlap, causing the ligamentum flavum to relax and buckle inward. Additionally, the superior facets move in a rostral-anterior direction. Symptoms might be worsened by walking, as the increased oxygen demand in the spinal nerve roots may outstrip the available blood flow. (1)

Lumbar extension and walking elevate epidural pressure, which in turn increases the compression on neural and vascular structures within the central spinal canal and the intervertebral foramen. (14)

Human walking patterns vary among individuals. While gait kinematics and kinetics are generally considered to be either periodic (Perry 1992, Cappozzo et al. 1975) or pseudo periodic (Pecoraro 2006), these patterns are influenced by individual body characteristics and the ability to control gait. Neuromuscular and musculoskeletal pathologies or injuries can disrupt these periodic patterns, leading to greater gait instability. (11)

The prevailing hypothesis is that individuals with gait-affecting pathologies will show disruptions in their normal gait patterns when faced with unexpected discomfort or pain. Other studies on gait variability suggest that an inability to sense painful or uncomfortable stimuli might lead to fewer corrections and, consequently, reduced gait variability. If the pain is unexpected—since in typical gait patterns acute pain is unforeseen and individuals often develop strategies to avoid it—the gait's periodicity may be altered. Given that literature indicates LSS patients experience acute pain, the paper hypothesizes that LSS patients demonstrated different patterns of gait variability. (11)

Consequently, patients with Lumbar Spinal Stenosis (LSS) often find walking uphill more comfortable than downhill and can walk longer distances when they bend forward while walking. (15)

Gait irregularities in patients with Lumbar Spinal Stenosis (LSS) are largely due to low walking tolerance and radicular pain, which are common clinical symptoms (Stucki et al., 1994; Turner et al., 1992; Katz et al., 1994, 1995; Rausching, 1993; Amundsen et al., 1995). Specifically, these symptoms force individuals to adjust their gait pattern as a compensatory mechanism, resulting in increased gait variability. (11)

The response to LSS-induced pain results in irregular and unpredictable movements, thereby increasing gait variability. (11)

It has been reported that as age increases—and with it the loss of neuromuscular control—gait variability also increases. (11)

Neuropathic pain (NP) significantly impairs patients' quality of life, and its treatment is challenging. Gait and postural balance are essential for maintaining independence in daily activities. Impaired proprioception caused by NP, along with asymmetrical loading of the lower extremities, dysfunctional muscle activation timing, sequencing issues, and asymmetry in plantar pressure, can lead to alterations in gait and balance control, thereby increasing the risk of falls. (16)

We believe that the narrower the space in the spinal canal, the greater the perception of pain and the reduction in functional capacity during walking. (17)

Deviations in gait parameters in Lumbar Spinal Stenosis patients include changes in spatio-temporal variables and gait kinematics compared to healthy individuals. (18)

Previously study shown that patients with Lumbar Spinal Stenosis exhibit greater gait irregularity compared to healthy subjects. (11)

Kinematic angular parameters describe the changes in joint angles within a single anatomical plane throughout the gait cycle. Kinematic gait parameters reflect the angular changes between two sets of axes, typically within a joint. Since angles and motion vectors within a joint dynamically change throughout the gait cycle, describing and interpreting kinematic gait parameters can be challenging. (18)

Neurodynamics, a concept introduced by Michael Shacklock, refers to the integrated biomechanical, physiological, and mechanical functions of the nervous system. Clinical neurodynamics applies these principles to explore the connection between the nervous system and musculoskeletal function. This manual technique involves applying force to nerve structures through specific postures and multi-joint movements. Grounded in the principle that the nervous system must be appropriately stretched and contracted to maintain normal muscle tension and range of motion, neurodynamics is employed to improve soft tissue mobility. (19)

If a nerve cannot move, glide, and stretch, its fundamental function of conduction becomes compromised 8. For a peripheral nerve to function properly, the nervous system must be able to move and slide, as well as withstand stretch and compression. These features are interdependent, so the

Peripheral Nervous System must adapt to body movement and dissipate mechanical forces by adjusting to elongation and compression, allowing for independent movement relative to surrounding tissues. (19)

This technique encourages the opening of the neural canal and enables nerve excursion of 6–7 mm during hip and knee extension, as shown in early cadaveric studies. Consequently, exercises or treatment methods incorporating these movements may help alleviate venous congestion and reduce endoneurial pressure. (14,20)

When neural mobilization is used to treat adverse neurodynamics, the primary theoretical goal is to try to reinstate the dynamic balance between the relative movement of neural tissues and surrounding mechanical interfaces. This aims to reduce intrinsic pressures on the neural tissue and hence promote optimal physiological function. (21)

A credible sham neural sliding intervention is designed to reduce the range of motion (ROM) at each joint and incorporate movement parameters that lower neural stress, thereby minimizing stress on the mobilized nerves. Such sham interventions have proven effective in blinding patients to group allocation, helping to reduce bias. A well-chosen sham neural mobilization comparator can effectively blind patients with low back pain (LBP) and reduce bias by mitigating the confounding effects of participant expectations (Maddocks et al., 2016). (22)

Research Gap

- According to previous literatures, LSS gives rise to neuropathic pain resulting in radiating pain, paresthesia, cramping of bilateral lower extremities ultimately deviating the normal gait pattern & decreasing the overall quality of life.
- Various conservative techniques like neural mobilization, static stretching, strengthening of lower extremities, TENS etc. have been effective in reducing the pain & reducing the need for surgery.
- However, there is no present literature which have focused on the gait deviations after application of these above techniques.

Need of the study

- Gait deviations like decreased gait velocity, decreased step length, decreased cadence, variation changes in the kinematic parameters are persistent in subjects with LSS which affects their QoL & mobility.
- Studies in literature have mostly focused on the neuropathic pain component in LSS & their gait pattern is often left uncorrected.
- Neural mobilisation techniques so far have been given in combination & specific slider technique have not yet been examined. Therefore, this study will see the effect of Passive Neurodynamic slider on gait deviations in lumbar spinal stenosis associated with neuropathic pain.

Aims and Objectives

- To see the effect of passive neurodynamic slider technique on gait parameter in Lumber spinal stenosis associated with neuropathic pain.
- To check the effect of passive neurodynamic slider on Kinematics parameters of gait in subject with LSS associated with neuropathic pain.
- To check the effect of passive neurodynamic slider on radiating pain in subject with LSS associated with neuropathic pain.
- To check the effect of passive neurodynamic slider on Quality of Life (QoL) in subject with LSS associated with neuropathic pain.

Hypothesis

Alternating hypothesis

There will be significant effect of Passive Neurodynamic slider on gait parameter in LSS associated with neuropathic pain.

Null Hypothesis

There will be no significant effect of Passive Neurodynamic slider on gait parameter in LSS associated with neuropathic pain.

Review of Literature

1. Reid Gehring et.al (2021) in the journal international journal of sports and exercise medicine: - conducted a study “A neural mobilization Treatment strategy for patients with neurogenic claudication related to Degenerative Lumbar Spinal Stenosis”. It is a prospective Case Series that shows significant improvement in pain and functional outcome measures that were noted after the application of a standard neural mobilization treatment strategy.
2. Jordan Perring et. al (2020) World neurosurgery: -Conducted a study “Analysis of Patterns of Gait Deterioration in patients with Lumbar Spinal Stenosis” in which 15 subjects with Lumbar Spinal Stenosis and 15 healthy subjects performed a 30m long walk and Gait was assessed by video recording. The study concluded that there is significant difference (reduced SL, GV, cadence and increased step duration) in Gait Parameters in subject with Lumbar Spinal Stenosis and Healthy Subjects.
3. Si Young Park et.al (2015) YMJ: - conducted a study “Neuropathic pain components in patients with lumbar spinal stenosis”. They found a higher prevalence of Neuropathic pain components in patients with lumbar spinal stenosis and they showed radicular pain is more strongly related to a neuropathic pain component.
4. Pragadesh Natarajan et. al (2022) Journal of spine surgery: - Conducted aa study on “Analysing Gait Patterns in Degenerative Lumbar spinal Disease: A Literature Review. The article reviews gait patterns in individuals with degenerative lumbar spine diseases like

lumbar spinal stenosis (LSS), lumbar disc herniation (LDH), and chronic low back pain (LBP). These conditions often lead to specific biomechanical impairments, resulting in inefficient walking. The study collated spatial and temporal gait data from 17 relevant studies, highlighting unique patterns of deterioration across the diseases.LSS was characterized by reduced gait velocity, gait asymmetry and gait variability, LDH by increased gait variability and reduced cadence, while LBP showed milder gait abnormalities. The article stresses the potential of gait analysis, especially using wearable devices, to diagnose these spine conditions effectively.

5. Timothy Deer MD et. al (2019) Pain Medicine: - conducted a study “A Review of Lumbar Spinal Stenosis with Intermittent Neurogenic Claudication: Disease and Diagnosis”. They show that LSS is characterized by the narrowing of the spinal canal, leading to symptoms such as neurogenic claudication, which manifests as pain in the lower extremities that worsens with walking and improves with sitting. They highlight the importance of distinguishing between neurogenic and vascular claudication for effective management. Surgical intervention is recommended for patients with moderate to severe LSS who do not respond to conservative treatments, as evidenced by the SPORT trial's findings of significant pain and functional improvements post-surgery. Additionally, a grading system proposed by Schizas et al. helps predict treatment outcomes based on dural sac morphology. The review underscores the need for a

multidisciplinary approach to optimize patient care and emphasizes the complexity of managing LSS.

6. Alvaro Cunado Gonzalez et. al (2021) Musculoskeletal Science and Practice 53 (2021) 102378: - conducted a study “Validation of a sham novel neural mobilization technique in patients with non-specific low back pain: A randomized, placebo-controlled trial”. They evaluate a novel sham neural mobilization (NM) technique for patients with non-specific low back pain (LBP). The study aimed to assess the believability of the sham intervention and its effectiveness in blinding participants. Results showed no significant differences in pain and straight leg raise (SLR) outcomes between the experimental and sham groups, indicating that the sham was effective in maintaining blinding. Additionally, patient expectations regarding treatment were similar across both groups. The findings suggest that the sham NM technique is a valid placebo for future clinical trials. The study highlights the need for further research on the effectiveness of NM techniques in LBP management. Overall, the sham NM demonstrated reliability in evaluating treatment effects without bias from patient expectations.
7. Tatsuya Igawa et. al (2018) PLOSONE: - conducted a study “Kinetic and kinematic variables affecting trunk flexion during level walking in patients with lumbar spinal stenosis”.They investigate the effects of kinetic and kinematic variables on trunk flexion during level walking in patients with lumbar spinal stenosis (LSS). LSS leads to cauda equina and nerve root compression, causing neurological symptoms. The study involved 111 patients, with gait recorded using a three-

dimensional motion capture system and force plates. Key variables measured included walking velocity, step length, trunk flexion angle, and hip joint angles. The analysis revealed that maximum hip extension angle, maximum hip flexion moment, and step length significantly influenced trunk flexion. The findings suggest that patients adopt one of two strategies while walking: either a trunk flexion posture to enhance step length and hip extension or an upright posture that reduces these parameters. The study highlights the importance of understanding gait mechanics in managing symptoms of LSS and suggests potential therapeutic approaches to improve patient mobility and comfort during walking. Understanding gait mechanics in managing symptoms of LSS and suggests potential therapeutic approaches to improve patient mobility and comfort during walking.

8. Jan Lodin et. al (2022) Sensors: - conducted a study “Quantitative Gait Analysis of Patients with Severe Symptomatic Spinal Stenosis Utilizing the Gait Profile Score: An Observational Clinical Study”They investigated gait patterns in patients with severe lumbar spinal stenosis (LSS) using the Gait Profile Score (GPS) for objective kinematic analysis. The study included 15 patients who underwent 3D motion analysis before surgical decompression. Key findings revealed that patients exhibited shorter steps and strides, increased step width, longer step times, and decreased cadence, resulting in slower gait speeds compared to healthy controls. Kinematic analysis focused on the pelvis, hip, and ankle, showing significant alterations in joint movements. The study emphasizes the importance of understanding

these kinematic changes for clinical assessment and treatment planning. Limitations included a small sample size and variability in claudication intervals. Overall, this research provides valuable insights into the gait pathophysiology of LSS and sets the stage for future studies on surgical outcomes and joint dynamics.

9. NC Papadakis et. al (2009) Physiol. Meas. 30 (2009) 1171–1186: - conducted a study “Gait variability measurements in lumbar spinal stenosis patients: part A. Comparison with healthy subjects” The study investigates gait variability in patients with lumbar spinal stenosis (LSS) compared to healthy individuals using accelerometry. A tri-axial accelerometer was employed to measure vertical gait acceleration at a sampling rate of 128 Hz during a 40 m walking test. The subjects included diagnosed LSS patients and healthy controls, with assessments conducted using the Oswestry Disability Questionnaire (ODQ) to evaluate health status. The research aimed to analyze differences in gait patterns through entropic analysis of the acceleration signals. Results indicated that LSS patients exhibited distinct gait variability compared to healthy subjects, suggesting altered motor strategies. The methodology allowed for objective, non-invasive measurements, minimizing stress on participants. Limitations included a small sample size and the use of a 40 m walkway, which could affect gait velocity standardization. The findings have implications for evaluating treatment responses in LSS patients. Overall, the study highlights the potential of accelerometry in clinical gait analysis.

10. R. Sethi et. al (2018) Journal of the Anatomical Society of India 67S (2018) S25–S28: - conducted a study “Spinal canal diameter in degenerative lumbar spinal stenosis” The study investigates the relationship between age and the morphometry of the lumbar spine, specifically focusing on spinal canal diameter. The study involved MRI scans of individuals aged 20 to 80, categorized into asymptomatic (Group I) and symptomatic (Group II) groups based on low back pain questionnaires. Significant findings indicated that the antero-posterior diameter of the spinal canal decreased with age, particularly in symptomatic individuals, suggesting a correlation between age-related degeneration and spinal canal narrowing. The research highlights the importance of understanding these morphological changes to better categorize degenerative lumbar spinal stenosis and its implications for treatment. Overall, the study emphasizes the need for further exploration of age-related changes in spinal canal dimensions to inform clinical practices.
11. Kalinath Chaudhary et. al (2022) Indian Journal of Physiotherapy and Occupational Therapy: - conducted a study “Effect of Neurodynamic Slider Technique Combined with Conventional Therapy and Conventional Therapy Alone in Sciatica: A Comparative Study”. The Study investigates the effectiveness of the Neurodynamic Slider Technique (NST) combined with conventional therapy (CT) compared to CT alone in treating sciatica. The study involved 40 patients, divided into two groups, with outcomes measured using the Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI). NST involves manual

techniques that apply force to nerve structures through specific postures and movements, promoting the nervous system's ability to glide, stretch, and adapt to mechanical forces. The results indicated significant improvements in functional ability and pain reduction for the group receiving NST alongside CT. The findings suggest that NST enhances rehabilitation outcomes for sciatica patients, making it a valuable addition to conventional treatment methods. Overall, the study supports the integration of neurodynamic techniques in clinical practice for better management of sciatica.

Methodology

- STUDY DESIGN – Sham Randomized trial.
- STUDY POPULTION – Subjects with Lumbar Spinal Stenosis associated with neuropathic pain
- SAMPLE SIZE – 20
- The sample size was calculated by using G power
- SAMPLING TECHNIQUE – Purposive Sampling.
- STUDY SETTING –Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha.
- STUDY DURATION – 6 months

Selection Criteria

Inclusion criteria

- Age: 40-65 years. (23)
- Gender- Male and female
- L/E or L/E Predominant radiating pain to Lower extremity.
- DN4 Questionnaire (>4).(16)
- Previous Magnetic Resonance Imaging (MRI) confirming lumbar spinal stenosis.(15)

Exclusion criteria

- Participants with history of any previous lumbar surgery that included fusion, spinal injection in the last 6 weeks,
- Participants with impaired walking due to any other comorbid conditions.
- Participants with inability to follow the instructions.
- Participants with having any medical contraindication for hip movement or any current medico-legal issues.

Sample size calculation

- Sample size was calculated in G-Power software using mean (84.28, 101.2) and standard deviation (10.89, 8.72), effect size (1.71), alpha (0.05), power (0.95).

Materials used:

Computer

Chair

Pen

Paper

Ruler

Measuring Tape.

Outcome Measures

PRIMARY OUTCOME MEASURE

X Sens- Aiwnda

10-meter Walk test

SECONDARY OUTCOME MEASURE

Oswestry Disability Index low back Pain Index Scale.

Variables

Independent Variables

Passive Neurodynamic slider

Sham Neurodynamic Slider

Dependent variables

Sagittal Kinematic parameter (segmental angle, segmental acceleration)

10-meter Walk test

Oswestry Disability Index low back Pain Index Scale

Protocol

A sample of 20 subjects, who met the inclusion and exclusion criteria, were recruited. A written informed consent was obtained from the subjects. Demographic data was taken and detailedexamination was done. The subjects were then randomly allocated into following two groups by Purposive sampling.

- Group 1 (Experimental group) was given passive neurodynamic slider technique
- Group 2 (Control group) was given sham neurodynamic slider.

Procedure

- The study was approved by the institutional research review committee and the institutional ethical committee of.A sample of 20 subjects with lumbar canal stenosis was taken. All subjects were given a detailed explanation of the procedurein respective groups and a written informed consent was obtained. Demographic data of the subjects was collected and baseline assessment was performed. The subjects were then randomly allocated into following two groups:
- Group 1 (Experimental group) was given passive Neurodynamic slider to affected side/symptomatic side.
- Group 2 (Sham group) was given Sham Neurodynamic slider to non-affected side/less symptomatic side.
- Both the groups continued the intervention program throughout the study. Intervention was given for 3 days a week / 4 weeks= 12

sessions. Each session will consist of 30 repetitions with 2 second period rest between each repetition on affected extremity.

Procedure for passive neurodynamic slider technique (22)

- The subject is positioned on their side-lying, with their gaze in a horizontal plane. The upper leg is kept steady at 0 degrees of hip flexion, with the knee extended and resting on a cushion in contact with the plinth. The therapist positions the lower leg at 20 degrees of hip flexion and 0 degrees of hip abduction, with the knee extended. The therapist then passively moves the patient's leg into 70-80 degrees of hip flexion while maintaining 0 degrees of hip abduction. During this movement, the patient is instructed to actively extend their upper cervical spine by "looking up."

Procedure for Sham Neurodynamic slider technique (22)

- The patients were positioned on the border of the plinth, lying on the side opposite to their most symptomatic side. In this side-lying position, the patient’s gaze remained in a horizontal plane, and the upper leg was kept steady at 0 degrees of hip flexion, with the knee extended, resting on a cushion in contact with the plinth. The mobilization was performed on the less symptomatic side, starting with 15 degrees of hip flexion, 20 degrees of abduction, and full knee extension, while the patient maintained a horizontal gaze. The therapist then passively moved the patient’s leg to 30 degrees of hip flexion, ensuring the abduction was maintained throughout the technique, while the patient was instructed to actively extend the upper cervical spine.

OSWESTRY DISABILITY INDEX (ODI) (16)

The ODI is a self-administered questionnaire designed to provide a subjective percentage score representing the level of functional disability in individuals recovering from low back pain. It comprises 10 sections, each rated on a scale from 0 to 5, with 5 indicating the highest level of disability. The index is calculated by summing the scores, dividing by the total possible score, and then multiplying by 100 to express the result as a percentage. Higher scores correspond to lower levels of functionality.

10 METER WALK TEST (10MWT) (24,25).

The 10-Meter Walk Test (10MWT) was utilized to assess gait velocity, although the actual measurement was taken over a distance of 6 meters. The test was conducted in a corridor marked with adhesive tape at both ends of a 10-meter walkway, with additional marks at the 2-meter and 8-meter points. Participants were given specific verbal instructions prior to the test: "I will say: ready, set, go. When I say 'go,' walk as normally and safely as you can until I say 'stop.'" Participants then walked the entire 10 meters at their self-selected pace, with the time for the intermediate 6 meters being recorded. Timing began when the toes of the leading foot crossed the 2-meter mark and ended when the toes crossed the 8-meter mark. Gait velocity was subsequently calculated from this timing.

XSENS MOTION CAPTURE (26)

Kinematic data from the hip, knee, and ankle joints of the affected extremity were collected during walking using the MVN Awinda motion capture system

(Xsens Technologies). This system utilizes wireless data collection through 17 inertial motion sensors attached to the specified body parts.

Figure:1.1 : Placement of X-SENS sensors in lower extremity

Figure:1.2: Walking with X-SENS sensors

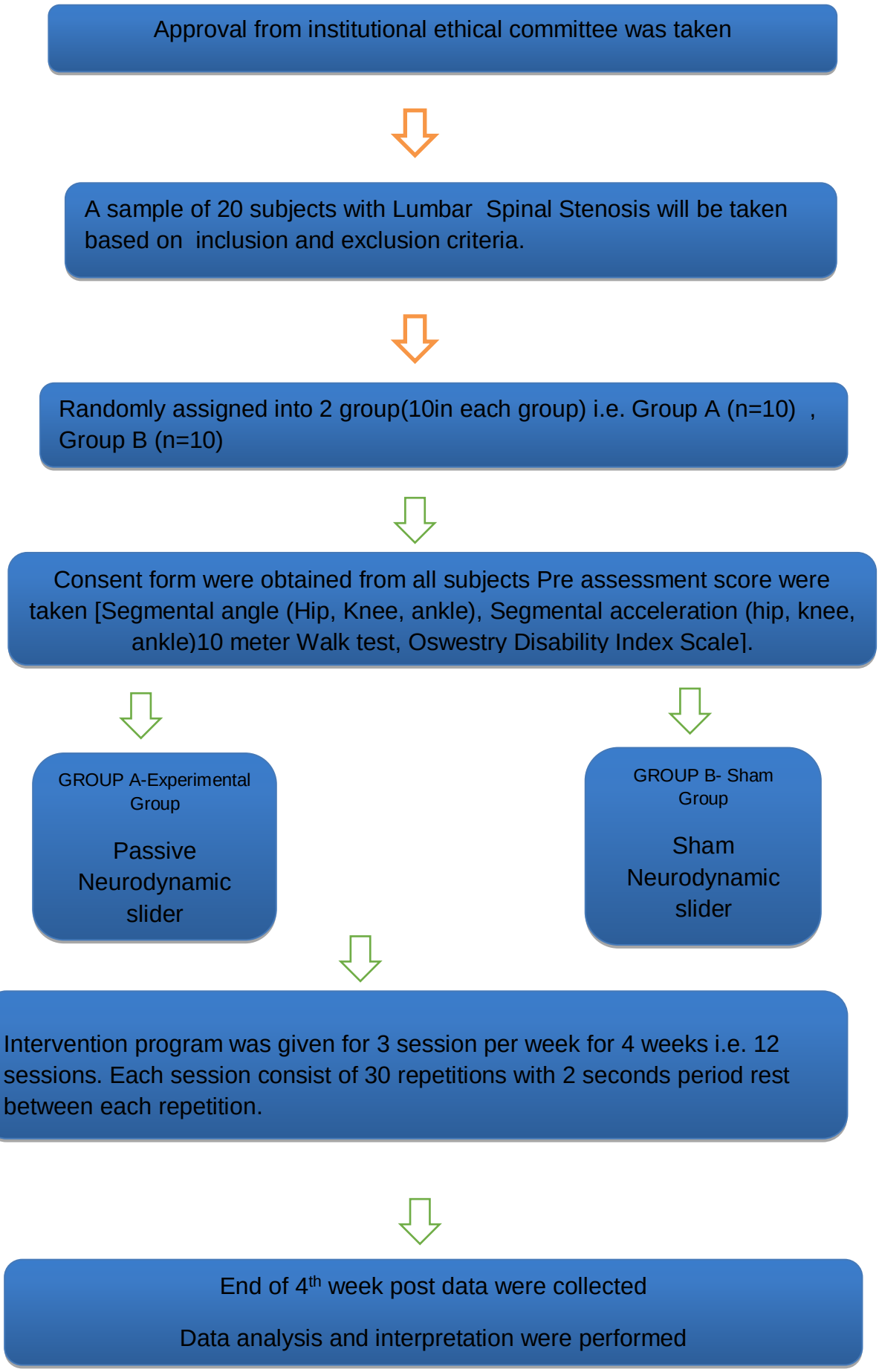
Figure:1.3: Experimental group sequence: Initial position

Figure: 1.4: - Experimental group sequence: Final position

Figure:1.5:- Sham group sequence: Initial position

Figure:1.6: Sham group sequence: Final position

Figure:1.7: 10m Walk Test


Approval from institutional ethical committee was taken
A sample of 20 subjects with Lumbar Spinal Stenosis will be taken based on inclusion and exclusion criteria.
Randomly assigned into 2 group(10in each group) i.e. Group A (n=10) , Group B (n=10)
Consent form were obtained from all subjects Pre assessment score were taken [Segmental angle (Hip, Knee, ankle), Segmental acceleration (hip, knee, ankle)10 meter Walk test, Oswestry Disability Index Scale].
GROUP A-Experimental Group
Passive Neurodynamic slider
GROUP B- Sham Group
Sham Neurodynamic slider
Intervention program was given for 3 session per week for 4 weeks i.e. 12 sessions. Each session consist of 30 repetitions with 2 seconds period rest between each repetition.
End of 4th week post data were collected
Data analysis and interpretation were performed

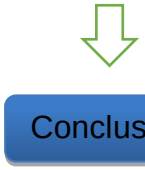


Fig 1.8: Flow chart of study procedure

Statistical Analysis

Data was analysed using the statistical package **SPSS 22.0**, and the level of significance was set at **p<0.05 Descriptive statistics** was performed to assess the mean and standard deviation of specific groups. The normality of the data was assessed using **Shapiro Wilk Test. Interferential statistics** to find out the within-group difference was done using **paired t-test**and between the group, analysis was done using an **independent t-test.**

Results

In the present study 20 LSS subjects were recruited. All the participants completed the study protocol and data were analysed for 20 participants with LSS.

Demographic details of Group 1

The Experimental group consisted of 10 LSS subjects with mean age (54.4± 3.92) years.

Demographic details of Group 2

The Sham group consisted of 10 LSS subjects with mean age (52.36±5.58) years.

Comparison of Pre- intervention scores of Group 1 and Group 2

The comparison of pre intervention scores of hip flexion /extension angle in sagittal plane between Group 1 (mean= 26.60, SD= 4.48) and Group 2 (mean= 29.82, SD= 2.31) showed no significant difference (t=-2.01, p= 0.06) (Table 1.2).

The comparison of pre intervention scores of knee flexion /extension angle in sagittal plane between Group 1 (mean=51.28, SD= 7.25) and Group 2 (mean= 50.97, SD=3.35) showed no significant difference (t= 0.12, p= 0.90) (Table 1.2).

The comparison of pre intervention scores of Ankle Plantar flexion/dorsiflexion angle in sagittal plane between Group 1 (mean=16.64, SD=3.32) and Group 2

(mean=17.02, SD=2.06) showed no significant difference (t= -0.30, p= 0.76) (Table 1.2).

The comparison of pre intervention scores of segmental acceleration of upper leg in between Group 1 (mean=9.85, SD= 4.68) and Group 2 (mean=9.79, SD=3.69) showed no significant difference (t= 0.03, p= 0.97) (Table 1.2).

The comparison of pre intervention scores of Segmental acceleration of Lower Leg in between Group 1 (mean=11.01, SD= 3.94) and Group 2 (mean= 9.52, SD=3.34) showed no significant difference (t= 0.91, p= 0.37) (Table 1.2).

The comparison of pre intervention scores of Segmental Acceleration of Foot in between Group 1 (mean=20.25, SD= 7.29) and Group 2 (mean= 20.40, SD=6.65) showed no significant difference (t= -0.04, p= 0.96) (Table 1.2).

The comparison of pre intervention scores of 10-meter walk test between Group 1 (mean=0.84, SD= 0.02) and Group 2 (mean= 0.85, SD=0.01) showed no significant difference (t= -1.48, p=0.15) (Table 1.2).

The comparison of pre intervention scores of Oswestry Disability Index between Group 1 (mean=48.80, SD= 5.67) and Group 2 (mean= 47.20, SD=4.63) showed no significant difference (t= 0.69, p= 0.49) (Table 1.2).

Comparison of Pre- intervention and Post intervention scores of Group 1

The comparison of pre intervention scores (mean=26.60, SD=4.48) and post intervention scores (mean=29.83, SD=4.55) of hip flexion /extension angle in

sagittal plane for Group 1 showed significant difference (t=-2.63, p=0.02) (Table 1.3, Figure 1.10)

The comparison of pre intervention scores (mean=51.28, SD=7.25) and post intervention scores (mean=57.37, SD=4.25) of knee flexion /extension angle in sagittal plane for Group 1 showed significant difference (t=-3.30, p=0.00) (Table 1.3, Figure 1.10)

The comparison of pre intervention scores (mean=16.64, SD=3.32) and post intervention scores (mean=18.56, SD=2.78) of ankle Plantar flexion/dorsiflexion angle in sagittal plane for Group 1 showed significant difference (t=-3.83, p=0.00) (Table 1.3, Figure 1.10)

The comparison of pre intervention scores (mean=9.85, SD=4.68) and post intervention scores (mean=14.41, SD=4.77) of segmental acceleration of upper leg for Group 1 showed significant difference (t=-3.78, p=0.00) (Table 1.3, Figure 1.10)

The comparison of pre intervention scores (mean=11.01, SD=3.94) and post intervention scores (mean=13.20, SD=3.71) of Segmental acceleration of Lower Leg for Group 1 Showed significant difference (t=-2.70, p=0.02) (Table 1.3, Figure1.11)

The comparison of pre intervention scores (mean=20.25, SD=7.29) and post intervention scores (mean=24.38, SD=6.67) of Segmental Acceleration of Foot for Group 1 Showed significant difference (t=-2.26, p=0.05) (Table 1.3, Figure 1.11)

The comparison of pre intervention scores (mean=0.84, SD=0.02) and post intervention scores (mean=0.94, SD=0.01) of 10-meter walk test for Group 1 Showed significant difference (t=-11.00, p=0.00) (Table 1.3, Figure 1.12)

The comparison of pre intervention scores (mean=48.80, SD=5.6) and post intervention scores (mean=38.80, SD=5.09) of Oswestry Disability Index for Group 1 Showed significant difference (t=15.00, p=0.00) (Table 1.3, Figure1.12)

Comparison of Pre- intervention and Post intervention scores of Group 2

The comparison of pre intervention scores (mean=29.82, SD=2.31) and post intervention scores (mean=30.82, SD=3.61) of hip flexion /extension angle in sagittal plane for Group 2 showed no significant difference (t=-1.81, p=0.10) (Table 1.4, Figure 1.13)

The comparison of pre intervention scores (mean=50.97, SD=3.35) and post intervention scores (mean=54.75, SD=2.84) of knee flexion /extension angle in sagittal plane for Group 2 showed significant difference (t=-3.31, p=0.00) (Table 1.4, Figure 1.13)

The comparison of pre intervention scores (mean=17.02, SD=2.06) and post intervention scores (mean=18.01, SD=1.42) of ankle Plantar flexion/dorsiflexion angle in sagittal plane for Group 2 showed no significant difference (t=-1.62 p=0.13) (Table 1.4, Figure 1.13)

The comparison of pre intervention scores (mean=9.79, SD=3.69) and post intervention scores (mean=9.33, SD=3.09) of segmental acceleration of upper

leg in the affected side for Group 2 showed no significant difference (t=0.46, p=0.65) (Table 1.4, Figure 1.14)

The comparison of pre intervention scores (mean=9.52, SD=3.34) and post intervention scores (mean=8.81, SD=1.37) of Segmental acceleration of Lower Leg for Group 2 showed no significant difference (t=0.81, p=0.43) (Table 1.4, Figure 1.14)

The comparison of pre intervention scores (mean=20.40, SD=6.65) and post intervention scores (mean=18.87, SD=4.46) of Segmental Acceleration of Foot for Group 2 showed no significant difference (t=1.40, p=0.19) (Table 1.4, Figure 1.14)

The comparison of pre intervention scores (mean=0.85, SD=0.01) and post intervention scores (mean=0.87, SD=0.02) of 10-meter walk test for Group 2 showed no significant difference (t=-1.72, p=0.11) (Table 1.4, Figure 1.15)

The comparison of pre intervention scores (mean=47.20, SD=4.63) and post intervention scores (mean=46.20, SD=4.66) of Oswestry Disability Index for Group 2 showed significant difference (t=3.87, p=0.00) (Table 1.4, Figure 1.15)

Comparison of mean change scores of Group 1 and Group 2

The comparison of mean change scores of hip flexion /extension angle in sagittal plane between Group 1 (mean=29.83, SD=4.55) and Group 2 (mean=30.82, SD=3.61) showed no significant difference (MD=2.23 t = 1.62, P=0.11) (Table 1.5, Figure 1.16).

The comparison of mean change scores of knee flexion /extension angle in sagittal plane between Group 1 (mean=57.37, SD=4.25) and Group 2 (mean=54.75. SD=2.84) showed no significant difference (MD=2.30 t=1.06, P=0.30) (Table 1.5, Figure 1.16).

The comparison of mean change scores of ankle Plantar flexion/dorsiflexion angle in sagittal plane between Group 1 (mean=18.56, SD=2.78) and Group 2 (mean=18.01 SD=1.42) showed no significant difference (MD=0.93, T= 1.18, P=0.25) (Table 1.5, Figure 1.16).

The comparison of post intervention scores of segmental acceleration of upper leg between Group 1 (mean=14.41, SD=4.77) and Group 2 (mean=9.33. SD=3.09) showed significant difference (MD=5.02, T=3.22, P=0.00) (Table 1.5, Figure 1.17).

The comparison of mean change scores of Segmental acceleration of Lower Leg between Group 1 (mean=13.20, SD=3.71) and Group 2 (mean=8.81 SD=1.37) showed significant difference (MD=2.89, T=2.44, P=0.02) (Table 1.5, Figure 1.17)

The comparison of mean change scores of Segmental Acceleration of Foot between Group 1 (mean=24.38, SD=6.67) and Group 2 (mean=18.87 SD=4.46) showed significant difference (MD=5.66, T=2.66, P=0.01) (Table 1.5, Figure= 1.17)

The comparison of mean change scores of 10-meter walk test between Group 1 (mean=0.94, SD=0.01) and Group 2 (mean=0.87 SD=0.02) showed significant difference (MD=0.08, T=5.88, P=0.00) (Table 1.5, Figure= 1.18)

The comparison of mean change scores of Oswestry Disability Index between Group 1 (mean=38.80, SD=5.09) and Group 2 (mean=46.20 SD=4.66) showed significant difference (MD=-9.00, T=-12.58, P=0.00) (Table 1.5, Figure= 1.19)

Table 1.1: Demographic details of Group 1 and Group 2

Variables	Group 1 (n=10)	Group 2(n=10)
	Mean ± SD	Mean ± SD
Age (in years)	54.4 ± 3.92	52.36 ± 5.58
Gender (male / female)	4:6	3:7

Group 1 = Experimental group

Group 2 = Sham group

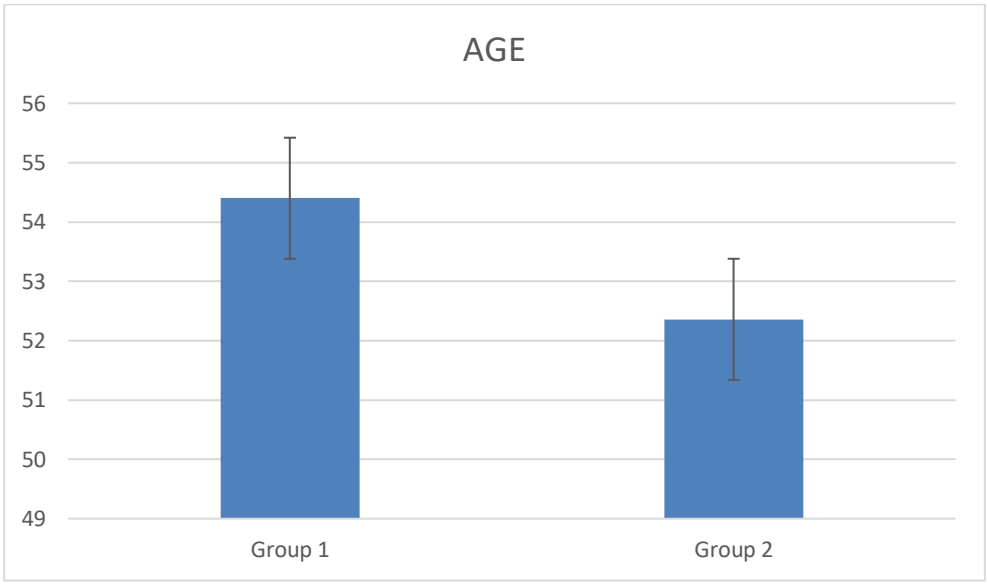


Figure:1.9: Graphical presentation of Demographic Details

Table 1.2: Comparison of pre intervention scores of Group1 and Group 2

Variables	Group 1 (n=15)	Group 2 (n=12)	t	P*
	Mean± SD	Mean ± SD		
Hip F/E Angle (in degrees)	26.60±4.48	29.82±2.31	-2.01	0.06
Knee F/E Angle (in degrees)	51.28±7.25	50.97±3.35	0.12	0.90
Ankle PF/DF Angle (in Degrees)	16.64±3.32	17.02±2.06	-0.30	0.76
SA UL	9.85±4.68	9.79±3.69	0.03	0.97
SA LL	11.01±3.94	9.52±3.34	0.91	0.37
SA F	20.25±7.29	20.40±6.65	-0.04	0.96
10MWT	0.84±0.02	0.85±0.01	-1.48	0.15
ODI	48.80±5.67	47.20±4.63	0.69	0.49

n = number of subjects

Group 1 = Experimental Group

Group 2 = Sham Group

SD= Standard Deviation

T = Value obtained after analysis with independent t-test

P*= not significant at ≤ 0.05

Hip F/E Angle (in degrees) = Hip Flexion/Extension angle in Sagittal plane

Knee F/E Angle (in degrees) = Knee Flexion/extension angle in Sagittalplane

Ankle PF/DF Angle (in degrees) = Ankle Flexion/extension angle in Sagittal plane

SA UL = Segmental Acceleration Upper Leg of affected side in Sagittal plane

SA LL = Segmental Acceleration Lower Leg of affected side in Sagittal plane

SA F = Segmental Acceleration Foot of affected side in Sagittal plane

10MWT = 10 Meter Walk Test

ODI= Oswestry Disability Index

Table 1.3: Comparison of pre and post intervention scores of Group 1

Variables	Scores		t	P*
	Pre Mean (SD)	Post Mean (SD)		
Hip F/E Angle (in degrees)	26.60±4.48	29.83±4.55	-2.630	0.02
Knee F/E Angle	51.28±7.25	57.37±4.25	-3.30	0.00
ANKLE PF/DF Angle	16.64±3.32	18.56±2.78	-3.83	0.00
SA UL	9.85±4.68	14.41±4.77	-3.78	0.00
SA LL	11.01±3.94	13.20±3.71	-2.70	0.02
SA F	20.25±7.29	24.38±6.67	-2.26	0.05
10MWT	0.84±0.02	0.94±0.01	-11.00	0.00
ODI	48.80±5.6	38.80±5.09	15.00	0.00

Group 1 = Experimental Group

SD = Standard Deviation

T = Value obtained after analysis with Paired t-test

P* = Significant at ≤ 0.05

Hip F/E Angle (in degrees) = Hip Flexion/Extension angle in Sagittal plane

Knee F/E Angle (in degrees) = Knee Flexion/extension angle in Sagittal plane

Ankle PF/DF Angle (in degrees) = Ankle Flexion/extension angle in Sagittal plane

SA UL = Segmental Acceleration Upper Leg of affected side in Sagittal plane

SA LL = Segmental Acceleration Lower Leg of affected side in Sagittal plane

SA F = Segmental Acceleration Foot of affected side in Sagittal plane

10MWT = 10 Meter Walk Test

ODI= Oswestry Disability Index

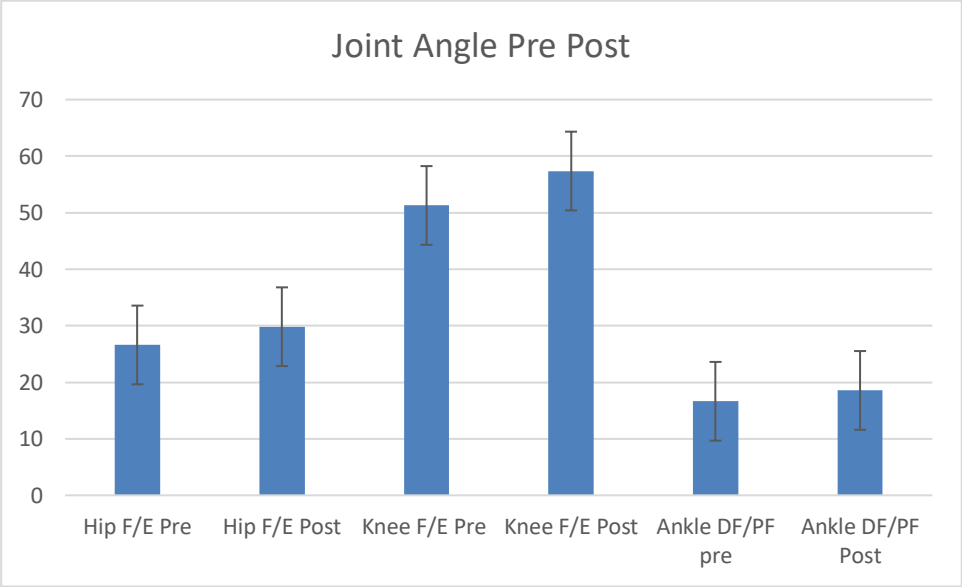


Figure:1.10: Graphical presentation of Joint angle: Pre and Post within Group 1

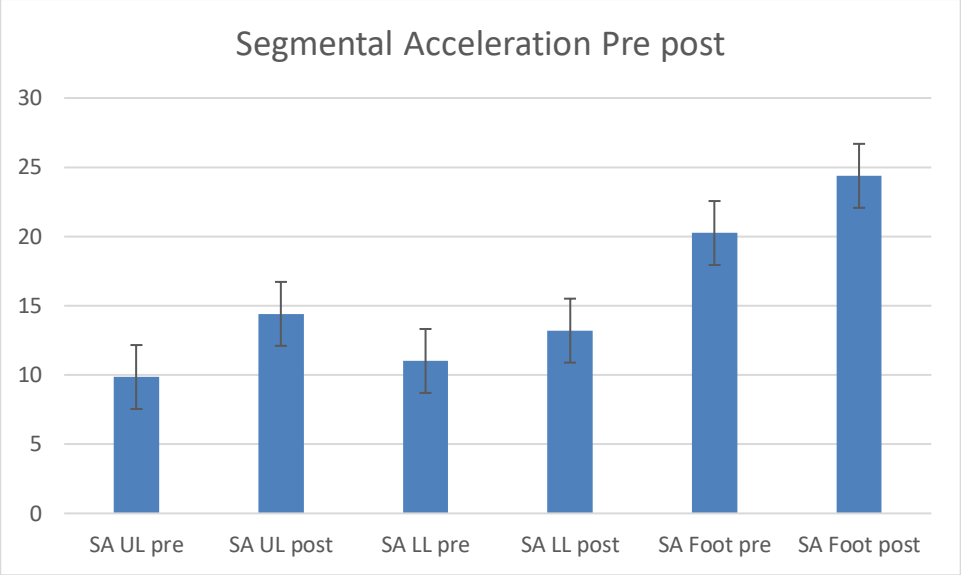


Figure 1.11: Graphical presentation of Segmental Acceleration: Pre and Post within Group 1

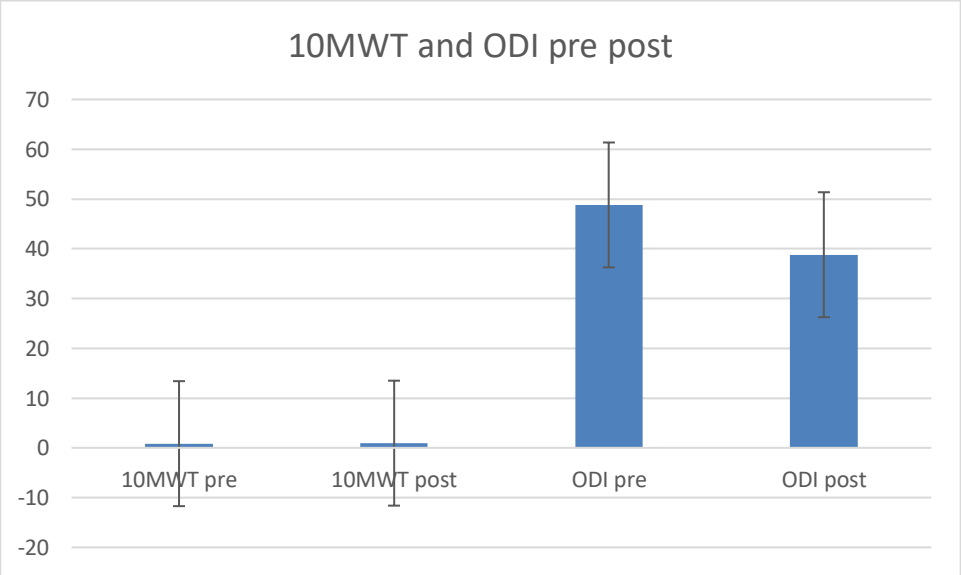


Figure:1.12: Graphical presentation of 10 MWT and ODI: Pre and Post within group 1

Table 1.4: Comparison of pre and post intervention scores of Group 2

Variables	Scores		t	P*
	Pre Mean (SD)	Post Mean (SD)		
Hip F/E Angle (in degrees)	29.82±2.31	30.82±3.61	-1.81	0.10
Knee F/E Angle	50.97±3.35	54.75±2.84	-3.31	0.00
ANKLE PF/DF Angle (in degrees)	17.02±2.06	18.01±1.42	-1.62	0.13
SA UL	9.79±3.69	9.33±3.09	0.46	0.65
SA LL	9.52±3.34	8.81±1.37	0.81	0.43
SA F	20.40±6.65	18.87±4.46	1.40	0.19
10MWT	0.85±0.01	0.87±0.02	-1.72	0.11
ODI	47.20±4.63	46.20±4.66	3.87	0.00

Group 2 = Sham Group

SD= Standard Deviation

T = Value obtained after analysis with Paired t-test

P*= Significant at ≤ 0.05

Hip F/E Angle (in degrees) = Hip Flexion/Extension angle in Sagittal plane

Knee F/E Angle (in degrees) = Knee Flexion/extension angle in Sagittal plane

Ankle PF/DF Angle (in degrees) = Ankle Flexion/extension angle in Sagittal plane

SA UL = Segmental Acceleration Upper Leg of affected side in Sagittal plane

SA LL = Segmental Acceleration Lower Leg of affected side in Sagittal plane

SA F = Segmental Acceleration Foot of affected side in Sagittal plane

10MWT = 10 Meter Walk Test

ODI= Oswestry Disability Index

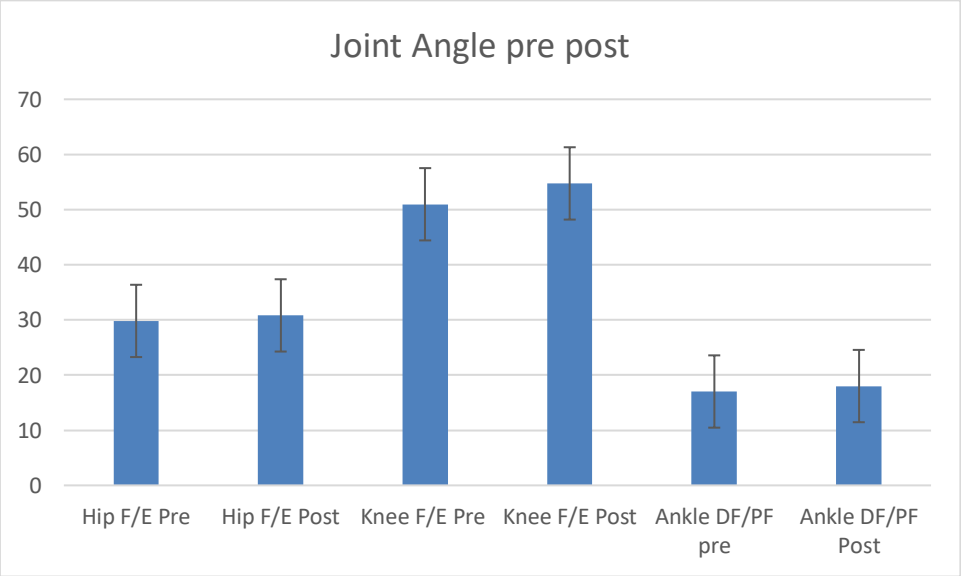


Figure:1.13: Graphical presentation of Joint angle: Pre and Post within Group 2

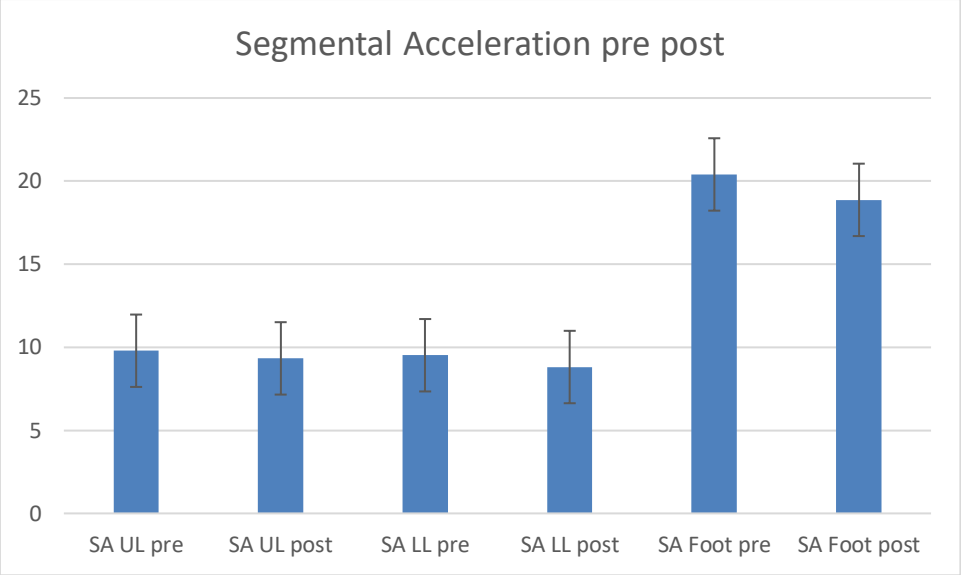


Figure:1.14: Graphical presentation of Segmental Acceleration: Pre and Post within Group 2

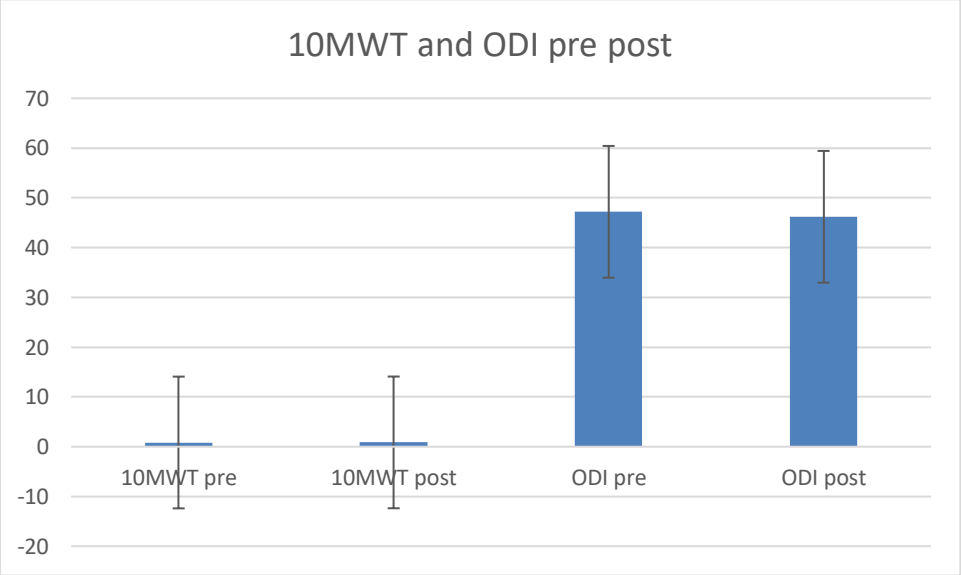


Figure:1.15: Graphical presentation of 10 MWT and ODI: Pre and Post within group 2

Table 1.5: Comparison of mean change of scores in group 1 and group 2

Variables	Group1 (n=10)		Group2(n=10)		Mean Difference	t	P*
	Pre Mean (SD)	Post Mean (SD)	Pre Mean (SD)	Post Mean (SD)			
Hip F/E Angle (in degrees)	26.60±4.48	29.83±4.55	29.82±2.31	30.82±3.61	2.23	1.65	0.11
Knee F/E Angle (in degrees)	51.28±7.25	57.37±4.25	50.97±3.35	54.75±2.84	2.30	1.06	0.30
ANKLE PF/DF Angle (in degrees)	16.64±3.32	18.56±2.78	17.02±2.06	18.01±1.42	0.93	1.18	0.25
SA UL	9.85±4.68	14.41±4.77	9.79±3.69	9.33±3.09	5.02	3.22	0.00
SSA LL	11.01±3.94	13.20±3.71	9.52±3.34	8.81±1.37	2.89	2.44	0.02
SSA F	20.25±7.29	24.38±6.67	20.40±6.65	18.87±4.46	5.66	2.66	0.01
10MWT	0.84±0.02	0.94±0.01	0.85±0.01	0.87±0.02	0.08	5.88	0.00
ODI	48.80±5.67	38.80±5.09	47.20±4.63	46.20±4.66	-9.00	-12.58	0.00

Group 1= Experimental group

Group 2 = Sham Group

SD = Standard Deviation

MD =Mean difference.

T = Value obtained after analysis with Paired t-test

P* = Significant at ≤ 0.05

Hip F/E Angle (in degrees) = Hip Flexion/Extension angle in Sagittal plane

Knee F/E Angle (in degrees) = Knee Flexion/extension angle in Sagittal plane

Ankle PF/DF Angle (in degrees) = Ankle Flexion/extension angle in Sagittal plane

SA UL = Segmental Acceleration Upper Leg of affected side in Sagittal plane

SA LL = Segmental Acceleration Lower Leg of affected side in Sagittal plane

SA F = Segmental Acceleration Foot of affected side in Sagittal plane

10MWT = 10 Meter Walk Test

ODI= Oswestry Disability Index

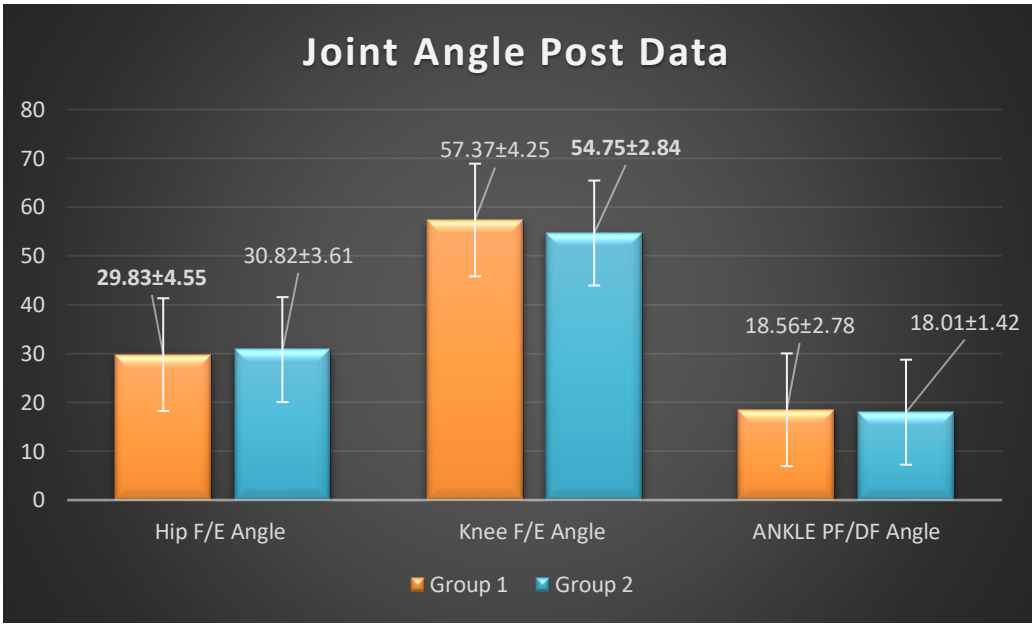


Figure:1.16: Graphical presentation of joint angle: Post data between groups

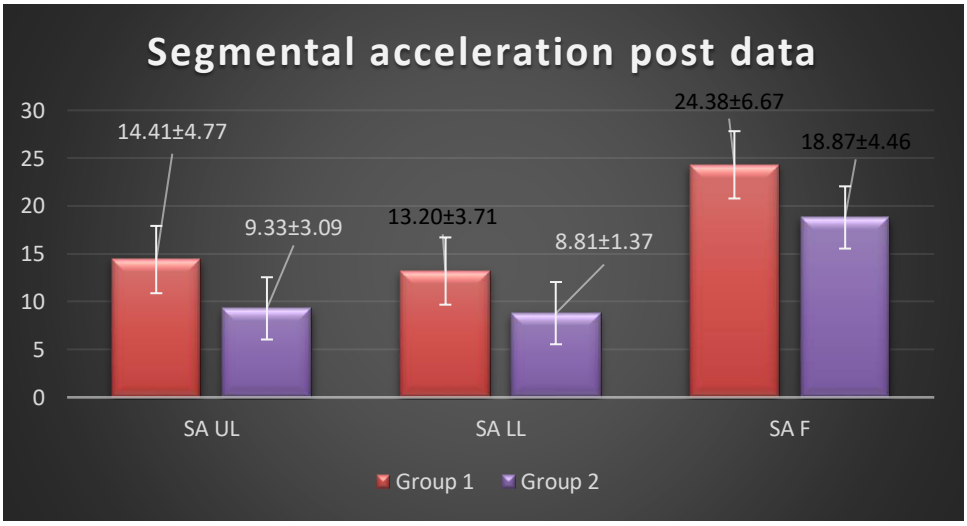


Figure:1.17: Graphical presentation of Segmental acceleration: Post data between groups

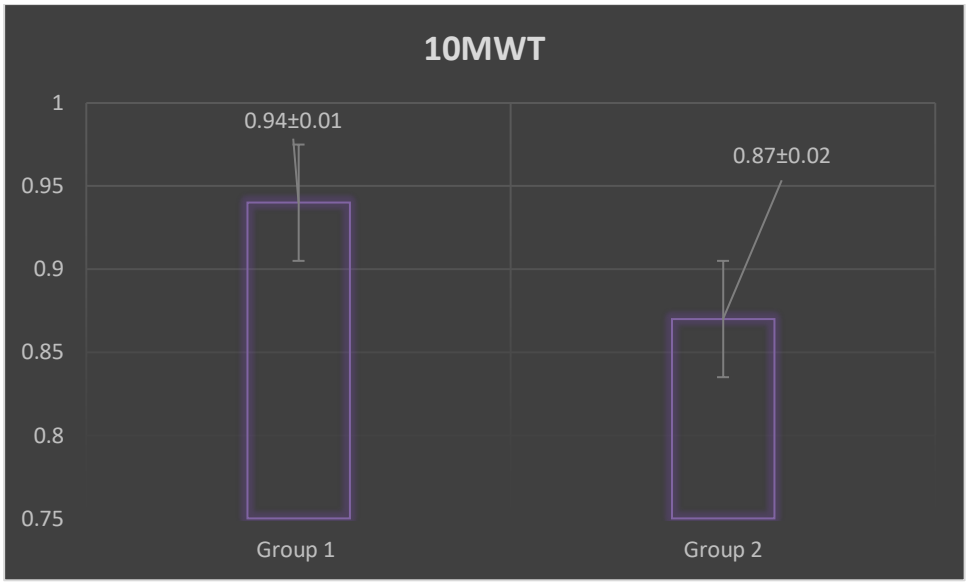


Figure: 1.18: Graphical presentation of 10 MWT: Post data between groups

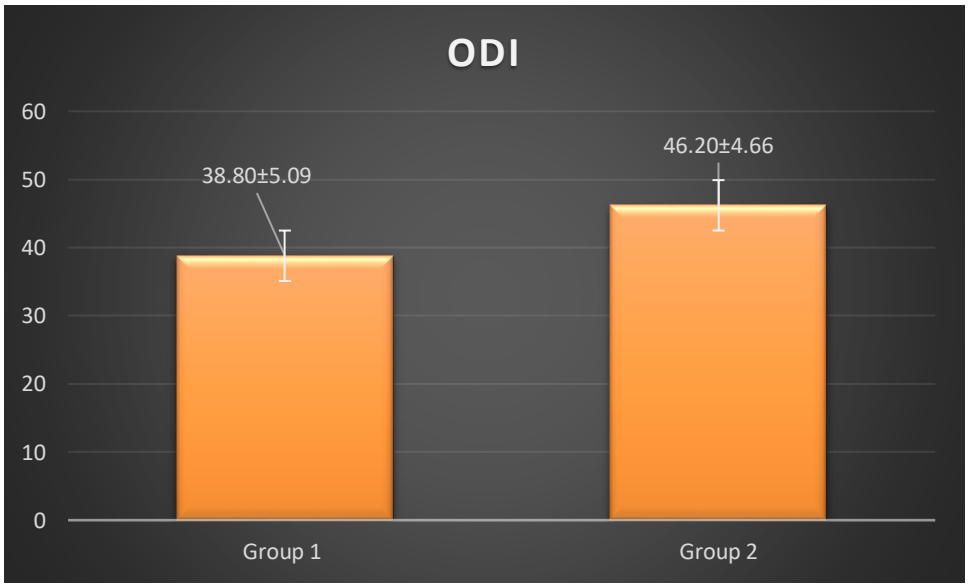


Figure: 1.19: Graphical presentation of ODI: Post data between groups

Discussion

Lumbar spinal canal stenosis individuals have neuropathic type of radiating pain to unilateral or bilateral lower extremities leading to gait abnormalities. (7) Nerve gliding releases compression on the nerve root relieving the neuropathic pain. In this study passive neural mobilization technique was used to glide the sciatic nerve.

Previous studies have shown that gait disturbances in lumbar canal stenosis condition occur due to nerve compression & neuropathic pain, hence Passive Neurodynamic slider technique was used to release compression on nerve root.

Due to increased pressure in the epidural and intraforaminal spaces and due to decreased of spinal canal makes the patients with lumbar canal stenosis facing difficulty in prolonged standing and walking. (14)

Individuals with lumbar canal stenosis have gait variability due to increased variation of neuropathic pain. Neurodynamic sliding technique has a beneficiary effect in reducing gait variability in subjects with lumbar canal stenosis. In our study we used Passive Neurodynamic slider technique to reduce gait variability by overcoming the Neuropathic pain in subject with lumbar canal stenosis.

Out of a total sample of 20 subjects,10 subjects were given Neurodynamic Slider technique for experimental group and 10 subjects were given sham neurodynamic Slider technique for sham group.

Within Group Comparisons

The results of within group comparison show significant improvement in range of motion of hip flexion/extension, knee flexion/extension, and ankle dorsiflexion/plantar flexion in the sagittal plane of experimental group. This could be due to the neurodynamic gliding of the affected extremity resulting in alteration of neural fluid dynamics thereby increasing the fluid dispersion in the nerve root thus increasing the proprioceptive impulse from joints. (14). Improvement in rom could have also been due to the improvement in neural mobility and reduction in internal and external stress of nervous tissues (28).

Gait variability measured by segmental acceleration in different segments of lower extremity showed significant improvements in the experimental group. Passive neurodynamic sliders technique is thought to have decreased the mechanosensitivity of nerve which must have resulted in enhancing the conduction velocity of nerve & thus reducing any restriction or compression that might have been affecting them (28).

The gait velocity measured by 10meter walk test showed significant improvement in pre post comparison of the experimental group. The results of this study are consistent with findings of Rosimers de Lima Souza et al. who also showed improvement in gait velocity following Neural mobilization. Passive neurodynamic slider facilitate the movement of axoplasmic flow, thus improving the health of muscular tissue innervated by the mobilized structure & finally potentiating the muscular activity.

The results of this study showed significant improvement in Oswestry Disability index in experimental group. The primary thought behind this could

be decrease in pain due to nerve gliding attributed by increased neural excursion between nerve and adjacent tissues, reducing pressure on nerve, increasing blood flow and controlled release of harmful substances. This reduction of pain results in reduction of disability thus improving the functional ability and quality of life (28).

The results of within group comparisons showed significant improvements in range of motion of Knee flexion/extension in the sham group. Posterior pelvic tilt coupled with Lumbar spine flexion increases the cross-sectional area of the spinal canal resulting in partial relief of symptoms. Gliding of the nerve in the lower extremity contralateral to the side of pain as is done in the sham group must have produced impact on the affected side compressed nerve root. Gliding technique applied to the sham group provided a mechanical stimulus inducing hypoalgesia thereby stimulating larger non-nociceptive afferent fibres and in turn increasing mechanical afferent stimulus from the muscles and joints to the dorsal horn of spinal cord. This might have led to improvement in knee joint range of motion probably due to activation of more knee joint receptors during gait. (27)

The results of within group comparison showed significant improvement of Oswestry Disability Index in sham group. Possible explanation for the improved quality of life & functional ability for participants in the sham group could be because of the viscoelastic nature of muscles due to some stretch effect that must have increased the pain threshold level (19). Another reason could be that it gives some amount of similar type of effect on neural canal as compared to affected side thus promoting opening of the neural canal (14) and Passive neurodynamic slider exhibited reduction in demyelination

resulting from nerve root pressure and microcirculatory dysfunction thus restoring homeostasis between the neural tissue and surrounding structures thereby leading to greater decrease in pain and disability and marked increase in function (30).

The results of within group comparisons did not showed any significant difference in Hip flexion/extension, ankle flexion/extension, Segmental acceleration of different segments in lower extremities and 10 meter walk test of Sham group, this might be because the passive neurodynamic slider when applied to non-affected side, it has some amount of release of compression of nerve and therefore reduction of neural stress on that side as well as have some effect on affected side also but the effect was very less on affected side which results in not giving that much relief of pain on affected side thus giving rise to no improvement in the above parameters (22).

Between group Comparison

The comparison between mean change scores of experimental group and sham group for Hip flexion/extension did not show any significant result. This might be because of the larger difference in baseline values. Though the experimental group showed the improvement in post test score, the sham group did not show any significant difference. Therefore, no significant changes could be established between both groups.

Both groups exhibited improvements in post-test scores for knee flexion/extension and ankle dorsiflexion/plantarflexion. Despite these gains, there was no significant difference between the groups. This outcome suggests that the act of passive neurodynamic slider, whether targeting the

affected or non-affected side, may have the effect on the Nervi nervorum. The impact likely contributes to a generalized enhancement in joint range of motion across both groups (28). The involvement of Nervi nervorum in this process might explain why both sides benefit from passive neurodynamic slider, leading to overall improvement in joint mobility of the initial condition.

Gait variability measured by segmental acceleration in different segments of lower extremities showed significant difference between both groups. Previous studies have demonstrated decrease in gait variability following decrease in radicular pain (29). Passive neurodynamic slider technique is thought to have increased the space within the spinal canal, thereby decreasing the claudication and reduction of pain. This in term must have led to reverse in the fear avoidance mechanism and reduction in gait instability measured by improvement by segmental acceleration (30). The fear avoidance behavior in patients with radicular pain leads to changes in the pelvic angle as the patient, in order to avoid the flexion of lumbar spine persistently keeps the spine in extension and hence increasing the lumbar lordosis and alteration of pelvic angle.

The gait velocity measured by 10-meter walk test showed significant difference between both the groups. The result of this study is consistent with findings of Vedat Kurt et al. who also showed improvement in gait velocity following neural mobilization (31). Lumbar canal stenosis cause gait disturbances like increased step length, decreased gait velocity due to defect in the neuromuscular system. These changes are mainly attributed to neuropathic pain and neurological claudication. Lumbar canal stenosis also alters the motor strategies disturbing the gait characteristics (Arif et al.2002)

(29). Passive Neurodynamic slider technique promotes movement between nerve and the surrounding structures and have been found to reduce the intra-neural pressure leading to increasing in the axonal transport, reduction in accumulation of mechanosensitivity factors (that often leads to pain and movement restriction) (22) and therefore the increase in gait velocity.

Conclusion

The study concluded that Passive neurodynamic slider is an effective therapeutic technique for reducing Gait variability and reducing disability of individuals hence improving the quality of life in lumbar spinal stenosis subjects related to neuropathic pain.

Clinical Relevance

The results of this study show a significant improvement in the gait parameters & quality of life in LSS patients. Based on the results of this study we believe that PNS can be used as a clinical tool to improve pain & gait variations in LSS condition.

Limitations of the Study

1. Sample size was limited.
2. Carry over effect of training was not assessed.
3. Spatiotemporal parameters were not assessed

Future Research

1. Future studies should be conducted using large samples
2. 3 D gait analysis with spatiotemporal parameters can be used to get accurate results.
3. 3 D gait analysis between frontal plane and sagittal plane analysis comparison to get more accurate results.

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ANNEXURES:1

CONSENT FORM

Title of the study-

"EFFECT OF PASSIVE NEURODYNAMIC SLIDER ON GAIT PARAMETERS IN SUBJECT WITH LUMBAR CANAL STENOSIS RELATED TO NEUROPATHIC PAIN": A SHAM RANDOMIZED TRIAL

I have been informed by Mr. Soumya Ranjan Lenka, pursing MPT (Neuro) conducting the above-study under the guidance of Dr. Deepak Kumar Pradhan, Assistant Professor, Department of Neurology, Physiotherapy, ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE (ABSMARI), BHUBANESWAR.

I have no objection and will be a part of that group. I also understand that the study does not have negative implication on my health. I understand that the information produced by the study will become a part of the institute's record and will be utilized, as per confidentiality regulations of the institute. I am also aware that the data might be used for medical literature and teaching purposes, but all my personal details will be kept confidential.

I am well informed to ask as many questions as I can to Mr. Soumya Ranjan Lenka either during the study or later.

I understand that my assent is voluntary and I reserve the right to withdraw or discontinue the participation from the study at any point of time during the study.

I have explained to MR/MISS/MRS the purpose of the research, the procedure required in the language he/she could understand to the best of my ability.

Signature:

Date:

ANNEXURES:2

DATA COLLECTION FORM

SUBJECT NUMBER - DATE- / /

AGE/GENDER-

HEIGHT

WEIGHT

ADDRESS-

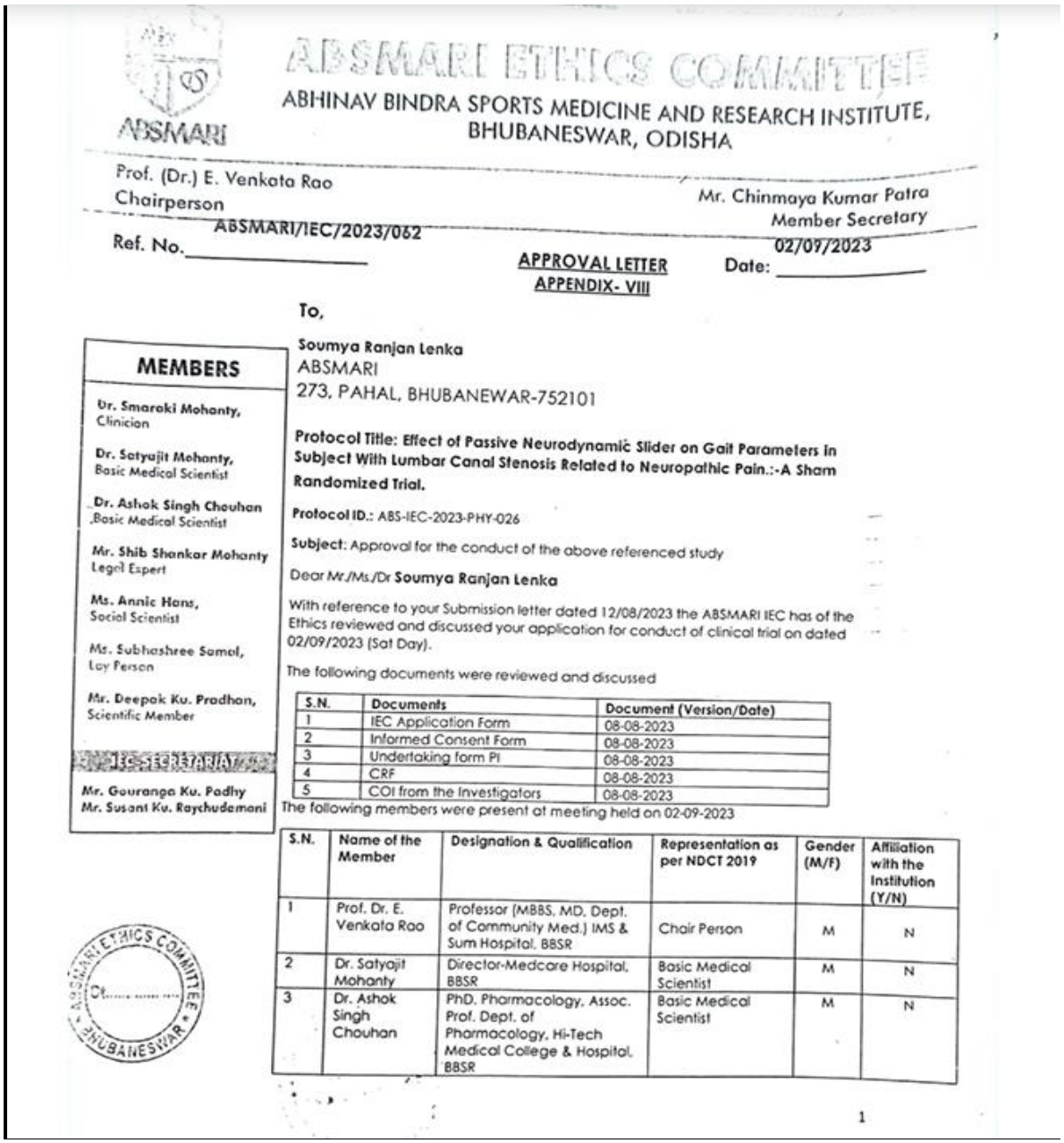
CONTACT NO.-

Name of the test	Pretest reading	Post test reading
ODI		
10 MWT		
Joint Angle	Hip- Knee- Ankle-	Hip- Knee- Ankle-
Segmental Acceleration	Upper Leg- Lower Leg- Foot-	Upper Leg- Lower Leg- Foot-

ANNEXURES:3

PT id	group	HIP pre	HIP POST	Hip Post minus pre	KNEE PRE	KNEE POST	KNEE POST MINUS PRE	ANKLE PRE	ANKLE POST	ANKLE POST MINUS PRE	SA UL PRE	SA UL POST	SA UL POST MINUS PRE	SA LL PRE	SA LL POST	SA LL POST MINUS PRE	SA F PRE	SA F POST	SA F POST MINUS PREE	10m PRE	10m Post	10m POST MINUS PRE	ODI PRE	ODI POST	ODI POST MINUS PRE
1	1	24.16	35.13	11	39.83	59.69	19.86	11.98	16.69	4.71	6.44	13.41	6.97	5.59	12.59	7	14.14	17.17	3.03	0.8	0.95	0.15	58	46	-12
2	1	27.98	32.61	4.63	53.7	60.62	6.92	14.9	17.47	2.57	6.98	17.92	10.94	9.5	13.36	3.86	19.54	31.97	12.43	0.89	0.94	0.05	46	36	-10
3	1	28.24	31.04	2.8	55.15	56.07	0.92	18.73	20.56	1.83	16.42	18.64	2.22	11.5	12.57	1.1	21.32	26.01	4.69	0.81	0.93	0.12	52	38	-14
4	1	28.21	31.88	3.67	59.21	58.51	-0.7	17.78	17.44	-0.34	11.65	14.29	2.64	13.4	11.42	-2.02	32.03	27.01	-5.02	0.82	0.94	0.12	40	32	-8
5	1	23.01	30.88	7.87	54.05	58.7	4.65	13.78	17.07	3.29	7.21	18.22	11.01	13.5	13.27	-0.27	23.63	28.36	4.73	0.85	0.94	0.09	56	46	-10
6	1	30.33	31.98	1.65	59.32	62.33	3.01	22.66	24.16	1.5	14.39	17.89	3.5	17.1	20.53	3.41	22.16	25.89	3.73	0.86	0.94	0.08	46	38	-8
7	1	22.25	23.92	1.67	44.07	53.09	9.02	18.55	18.17	-0.38	3.23	6.8	3.57	5.91	9.73	3.82	10.55	25.31	14.76	0.84	0.93	0.09	42	32	-10
8	1	35.6	32.95	-2.65	57.62	62.22	4.6	19.44	22.12	2.68	10.2	10.19	-0.01	8.47	9.53	1.06	11.02	11.4	0.38	0.85	0.94	0.09	50	42	-8
9	1	20.2	20.33	0.13	42.26	51.82	9.56	13.25	15.67	2.42	5.64	7.47	1.83	9.3	10.16	0.86	17.88	18.59	0.71	0.87	0.95	0.08	48	36	-12
10	1	26.07	27.62	1.55	47.6	50.69	3.09	15.41	16.31	0.9	16.35	19.28	2.93	15.8	18.86	3.06	30.31	32.15	1.84	0.85	0.97	0.12	50	42	-8
11	2	29.06	29.2	0.14	49.3	53.84	4.54	15.43	16.49	1.06	14.01	10.81	-3.2	13.4	11.46	-1.9	27.67	24.61	-3.06	0.85	0.86	0.01	52	51	-1
12	2	31.65	33.68	2.03	46.71	49.42	2.71	15.42	18.74	3.32	7.02	7.98	0.96	7.96	8.51	0.55	20.05	19.8	-0.25	0.85	0.86	0.01	44	43	-1
13	2	31.65	33.87	2.22	48.99	59.13	10.14	15.16	19.54	4.38	9.19	13.8	4.61	5.6	8.61	3.01	15.05	17.19	2.14	0.89	0.9	0.01	46	44	-2
14	2	29.23	28.67	-0.56	53.08	54.48	1.4	18.85	20.08	1.23	7.36	4.94	-2.42	8.08	6.34	-1.74	12.3	9.96	-2.34	0.84	0.95	0.11	42	42	0
15	2	31.5	32.92	1.42	57.58	55.7	-1.88	20.36	18.26	-2.1	13.32	11.48	-1.84	8.66	8.33	-0.33	23.76	22.19	-1.57	0.85	0.86	0.01	44	44	0
16	2	24.59	22.18	-2.41	46.88	53.09	6.21	14.3	16.4	2.1	8.75	7.14	-1.61	8.6	8.78	0.18	13.02	13.62	0.6	0.85	0.86	0.01	46	45	-1
17	2	32.26	32.74	0.48	51.65	54.32	2.67	16.04	16.8	0.76	9.3	12.64	3.34	7.94	8.72	0.78	22.95	20.77	-2.18	0.86	0.86	0	50	48	-2
18	2	28.31	29.4	1.09	54.1	53.99	-0.11	17.6	17.48	-0.12	8.04	9.02	0.98	8.23	7.71	-0.52	20.25	20.33	0.08	0.87	0.87	0	42	40	-2
19	2	31.06	32.62	1.56	51.55	59.18	7.63	19.55	19.64	0.09	4.41	4.81	0.4	9.53	9.86	0.33	15.99	17.31	1.32	0.85	0.87	0.02	50	50	0
20	2	28.96	32.96	4	49.91	54.44	4.53	17.53	16.67	-0.86	16.53	10.71	-5.82	17.3	9.87	-7.41	33.03	22.94	-10.09	0.88	0.88	0	56	55	-1

ANNEXURES:4



ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE, BHUBANESWAR, ODISHA

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2023/062

Date: 02/09/2023

APPROVAL LETTER
APPENDIX- VIII

To,

Soumya Ranjan Lenka
ABSMARI
273, PAHAL, BHUBANEWAR-752101

MEMBERS

Dr. Smaraki Mohanty, Clinician
Dr. Satyajit Mohanty, Basic Medical Scientist
Dr. Ashok Singh Chouhan, Basic Medical Scientist
Mr. Shib Shankar Mohanty, Legal Expert
Ms. Annie Hans, Social Scientist
Ms. Subhashree Samal, Lay Person
Mr. Deepak Ku. Pradhan, Scientific Member

IEC SECRETARIAT
Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

Protocol Title: Effect of Passive Neurodynamic Slider on Gait Parameters in Subject With Lumbar Canal Stenosis Related to Neuropathic Pain.:-A Sham Randomized Trial.

Protocol ID.: ABS-IEC-2023-PHY-026

Subject: Approval for the conduct of the above referenced study

Dear Mr./Ms./Dr **Soumya Ranjan Lenka**

With reference to your Submission letter dated 12/08/2023 the ABSMARI IEC has of the Ethics reviewed and discussed your application for conduct of clinical trial on dated 02/09/2023 (Sat Day).

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	08-08-2023
2	Informed Consent Form	08-08-2023
3	Undertaking form PI	08-08-2023
4	CRF	08-08-2023
5	COI from the Investigators	08-08-2023

The following members were present at meeting held on 02-09-2023

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
1	Prof. Dr. E. Venkata Rao	Professor (MBBS, MD, Dept. of Community Med.) IMS & Sum Hospital, BBSR	Chair Person	M	N
2	Dr. Satyajit Mohanty	Director-Medcare Hospital, BBSR	Basic Medical Scientist	M	N
3	Dr. Ashok Singh Chouhan	PhD. Pharmacology, Assoc. Prof. Dept. of Pharmacology, Hi-Tech Medical College & Hospital, BBSR	Basic Medical Scientist	M	N

ABSMARI ETHICS COMMITTEE BHUBANESWAR

1