Original Article

A Comparative Analysis of Neural Mobilization Techniques and Conventional Physical Therapy for Sciatica Pain Management in Lumbar Radiculopathy

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ABSTRACT

Background: Lumbar radiculopathy (LR), often manifesting as sciatica, is a prevalent and debilitating condition characterized by neuropathic pain radiating along the sciatic nerve. While conventional physical therapy (CPT) remains a cornerstone of conservative management, the efficacy of targeted neural mobilization techniques (NMT) is a growing area of investigation. This study aimed to compare the effectiveness of NMT versus CPT on pain, disability, and functional outcomes in patients with sciatica due to LR.

Methods: A randomized controlled trial was conducted with 60 participants diagnosed with LR. Participants were allocated to either an NMT group (n=30), receiving slider and tensioner techniques for the sciatic nerve, or a CPT group (n=30), receiving a standardized protocol of lumbar stabilization exercises, stretching, and electrotherapy. The primary outcome was pain intensity measured by the Visual Analogue Scale (VAS). Secondary outcomes included disability, measured by the Oswestry Disability Index (ODI), and lumbar range of motion (ROM). Assessments were performed at baseline, 4 weeks, and 8 weeks post-intervention.

Results: Both groups demonstrated significant improvements in all outcome measures over time ($p<0.05$). However, the NMT group exhibited significantly greater reductions in VAS scores (Mean Difference at 8 weeks: -2.4, 95% CI: -3.1 to -1.7, $p<0.001$) and ODI scores (Mean Difference at 8 weeks: -12.8%, 95% CI: -16.1 to -9.5, $p<0.001$) compared to the CPT group at the 4- and 8-week follow-ups. Improvements in straight leg raise (SLR) ROM were also significantly superior in the NMT group.

Conclusion: Neural mobilization techniques were more effective than conventional physical therapy alone in reducing pain and disability and improving functional outcomes in patients with sciatica from lumbar radiculopathy. Integrating NMT into standard rehabilitation protocols should be considered for optimal management.

Keywords: *Neural Conduction; Pain Management; Physical Therapy Modalities; Radiculopathy; Sciatica.*

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INTRODUCTION

Lumbar radiculopathy (LR) is a common neurological disorder arising from compression, irritation, or inflammation of one or more nerve roots in the lumbar spine, most frequently affecting the L5 and S1 levels.[1] Its most recognizable symptom is sciatica, characterized by sharp, shooting, or burning pain that radiates from the lower back through the buttock and down the posterior or lateral aspect of the leg, often extending below the knee.[2] This radicular pain may be accompanied by sensory disturbances (e.g., paresthesia, numbness) and motor weaknesses, significantly impairing an individual's functional capacity, quality of life, and ability to work.[3]

The global prevalence of sciatica is substantial, with lifetime incidence estimates ranging from 10% to 40%, making it a leading cause of disability and a significant socioeconomic burden.[4]

The pathophysiological mechanisms underlying sciatica are multifactorial. While a herniated intervertebral disc is the most common etiology, other causes include lumbar spinal stenosis, facet joint arthropathy, and spondylolisthesis.[5] The resultant nerve root compromise initiates a cascade of events, including mechanical deformation, impaired blood flow, and a robust inflammatory response involving cytokines like tumor necrosis factor-alpha (TNF-α) and interleukin-1 (IL-1).[6] This combination of mechanical and biochemical insults leads to altered neurodynamics, heightened neural tissue sensitivity, and subsequent neuropathic pain.[7]

Conservative management is the first-line treatment for the majority of patients with acute sciatica.[8] Conventional Physical Therapy (CPT) encompasses a range of modalities aimed at reducing pain, improving function, and preventing recurrence. Typical CPT protocols include patient education, core stabilization and strengthening exercises, flexibility training for the hamstrings and hip musculature, manual therapy (e.g., joint mobilizations), and passive modalities such as ultrasound or transcutaneous electrical nerve stimulation (TENS).[9] The goal of CPT is to address biomechanical deficits and promote a conducive environment for healing.

In recent years, there has been increased focus on the role of the nervous system itself as a source of pain and dysfunction. Neural Mobilization Techniques (NMT), also known as neurodynamic techniques, are specialized interventions designed to restore the normal neurophysiological and mechanical functions of the nervous system.[10] These techniques are based on the principle that the peripheral nerves must be able to glide and stretch freely relative to their surrounding interfaces. In LR, this normal movement is impaired. NMTs, such as "sliders" (which create a pressure differential to promote nerve gliding) and "tensioners" (which apply a gentle stretch to the nerve), aim to reduce neural adherence, improve intraneural blood flow, and desensitize the nervous system.[11]

Preliminary studies have suggested that NMT can be beneficial for pain and function in various neuropathic pain conditions.[12,13] However, the comparative effectiveness of a structured NMT protocol against a comprehensive CPT program specifically for sciatica in LR remains a subject of ongoing research. While some systematic reviews have shown positive trends, they often highlight the heterogeneity of interventions and the need for more robust, high-quality trials.[14,15] Therefore, the primary objective of this study was to conduct a randomized controlled trial to directly compare the efficacy of neural mobilization techniques with conventional physical therapy in managing pain, reducing disability, and improving functional outcomes in patients with sciatica due to lumbar radiculopathy.

METHODOLOGY

Study Design

A prospective, single-blind, randomized controlled trial with two parallel groups.

Participants

Sixty participants aged between 30 and 55 years were recruited from the outpatient orthopedic and physiotherapy departments from Butt Rehab and Medical Center and Mukkabbir University of Sciences & Technology, Gujrat, Pakistan from November 2024 to May 2025. The diagnosis of LR was confirmed by a physiatrist based on clinical presentation (unilateral leg pain radiating below the knee, positive neural tension signs like Slump Test or Straight Leg Raise test) and corroborated by magnetic resonance imaging (MRI) evidence of nerve root compression at L4-L5 or L5-S1 levels.

Inclusion Criteria

- Unilateral sciatica for a duration of 4 to 12 weeks.
- A Visual Analogue Scale (VAS) score for leg pain of at least 5/10.
- Positive neurodynamic test (Slump Test or SLR reproducing symptoms).

Exclusion Criteria

- Cauda equina syndrome, spinal fractures, or tumors.
- Severe motor deficits (manual muscle testing <3/5).
- Previous spinal surgery.
- Systemic neurological diseases, diabetes mellitus, or pregnancy.
- Receiving spinal injections or other concurrent physiotherapy.

Randomization and Blinding

Participants were randomly allocated to either the NMT group (n=30) or the CPT group (n=30) using computer-generated random numbers sealed in opaque envelopes. The outcome assessor was blinded to group allocation.

Interventions

Both groups received 12 treatment sessions over 4 weeks, three times per week.

Neural Mobilization Technique (NMT) Group

- **Sciatic Nerve Slider Technique**
  In supine lying with hip and knee flexed, the participant simultaneously extended the knee while flexing the neck (creating tension) and then flexed the knee while extending the neck (releasing tension), performing 3 sets of 10 repetitions.[16]
- **Sciatic Nerve Tensioner Technique**
  In slump sitting position, the participant actively performed knee extension to the point of symptom provocation and then returned, performing 3 sets of 10 repetitions.[17]

  No other exercises or electrotherapy were provided.

Conventional Physical Therapy (CPT) Group

- **Electrotherapy**
  Transcutaneous Electrical Nerve Stimulation (TENS) for 20 minutes over the painful lumbar region.
- **Stretching Exercises**
  Hamstring and piriformis muscle stretches, held for 30 seconds and repeated 3 times.
- **Strengthening Exercises**
  Williams's flexion exercises and core stabilization exercises (e.g., bridging, partial crunches), 3 sets of 10 repetitions.[18]
- **Lumbar Mobilization**
  Grade III or IV posterior-anterior mobilizations to the affected lumbar segment for 2 minutes.[19]

Outcome Measures

Assessed at baseline, 4 weeks (post-intervention), and 8 weeks (follow-up).

- **Primary Outcome**
  Pain Intensity using the 100-mm Visual Analogue Scale (VAS) for leg pain.

- **Secondary Outcomes**
  Functional Disability using the Oswestry Disability Index (ODI), scored as a percentage (0-100%).

Neurodynamic Mobility using the Active Knee Extension (AKE) test, measured in degrees of knee extension with the hip flexed at 90° in the supine position.[20]

Statistical Analysis

Data were analyzed using SPSS version 26.0. Normality was confirmed with the Shapiro-Wilk test. An independent t-test and Chi-square test were used for baseline comparisons. A two-way repeated-measures ANOVA was used to analyze the effects of time, group, and time-group interaction on VAS, ODI, and AKE. The significance level was set at $p < 0.05$.

RESULTS

Participant Demographics and Baseline Characteristics

A total of 60 participants were enrolled and randomly assigned to either the Neural Mobilization Therapy (NMT) group (n=30) or the Conventional Physiotherapy (CPT) group (n=30). The demographic characteristics of participants were comparable across both groups. The mean age in the NMT group was 45.2 ± 6.8 years, while in the CPT group it was 43.9 ± 7.1 years. Both groups had a similar gender distribution (NMT: 16 males, 14 females; CPT: 17 males, 13 females). The mean duration of symptoms was 7.5 ± 2.3 weeks in the NMT group and 7.8 ± 2.1 weeks in the CPT group. The groups were also comparable in body mass index, side of involvement, and occupational activity levels. At baseline, no significant

between-group differences were observed in pain intensity (VAS), functional disability (ODI), or neurodynamic mobility (AKE), confirming successful randomization (Table 1).

Table 1: Baseline Characteristics of Participants

Characteristic	NMT Group (n=30)	CPT Group (n=30)	p-value
Age (years), Mean ± SD	45.2 ± 6.8	43.9 ± 7.1	0.47
Gender (Male/Female)	16/14	17/13	0.80
Body Mass Index (kg/m²), Mean ± SD	25.6 ± 3.2	26.1 ± 3.5	0.58
Duration of Symptoms (weeks), Mean ± SD	7.5 ± 2.3	7.8 ± 2.1	0.59
Affected Side (Right/Left)	18/12	19/11	0.79
Occupation (Sedentary/Active)	14/16	13/17	0.82
Baseline VAS (mm), Mean ± SD	78.4 ± 9.1	76.9 ± 10.3	0.54
Baseline ODI (%), Mean ± SD	58.6 ± 7.2	57.1 ± 8.0	0.43
Baseline AKE (degrees), Mean ± SD	45.3 ± 8.5	46.8 ± 9.2	0.51

Intergroup and Intragroup Comparisons

A two-way repeated-measures ANOVA showed significant main effects for time ($p<0.001$) and group ($p<0.001$), as well as a significant time × group interaction for all outcome measures ($p<0.001$). These results indicate that both interventions led to improvements over time, but the magnitude of improvement was significantly greater in the NMT group.

Pain (VAS)

VAS scores decreased significantly in both groups across all time points ($F(2,116)=142.5$, $p<0.001$, $\eta^2=0.71$). However, the NMT group showed a greater reduction in pain intensity at both 4 and 8 weeks compared to the CPT group ($p<0.001$).

Table-2 Within-Group and Between-Group Comparisons of Outcome Measures (Mean ± SD)

Outcome Measure	Group	Baseline	4 Weeks	8 Weeks	Within-Group *p*-value (Time Effect)	Between-Group *p*-value (Group Effect)
VAS (mm)	NMT	78.4 ± 9.1	32.1 ± 8.4*	18.5 ± 6.2*†	<0.001	<0.001
	CPT	76.9 ± 10.3	48.7 ± 9.8*	35.3 ± 8.1*†	<0.001	
ODI (%)	NMT	58.6 ± 7.2	28.4 ± 6.5*	16.2 ± 5.1*†	<0.001	<0.001
	CPT	57.1 ± 8.0	39.8 ± 7.1*	29.0 ± 6.3*†	<0.001	
AKE (degrees)	NMT	45.3 ± 8.5	62.1 ± 7.2*	72.8 ± 6.0*†	<0.001	<0.001
	CPT	46.8 ± 9.2	55.4 ± 8.1*	63.5 ± 7.4*†	<0.001	

*Significant difference from baseline ($p<0.05$).
†Significant difference from 4-week assessment ($p<0.05$).

Disability (ODI)

A significant main effect of time ($F(2,116)=158.2$, $p<0.001$, $\eta^2=0.73$) and group ($F(1,58)=19.4$, $p<0.001$) was observed for ODI scores, with a significant interaction ($F(2,116)=15.6$, $p<0.001$).

The NMT group demonstrated a greater reduction in disability scores than the CPT group at both post-intervention and follow-up.

Neurodynamics (AKE)
AKE angle improved significantly in both groups over time ($F(2,116)=120.9$, $p<0.001$, $\eta^2=0.68$), with a significant group effect ($F(1,58)=17.8$, $p<0.001$) and time × group interaction ($F(2,116)=14.3$, $p<0.001$). The NMT group showed superior gains in nerve mobility at both assessment points.

Both interventions resulted in significant improvements in pain, disability, and neurodynamic mobility over time. However, participants receiving Neural Mobilization Therapy experienced faster and greater recovery across all outcome measures, suggesting that NMT provides enhanced clinical benefits compared to conventional physiotherapy in patients with lumbar radiculopathy.

DISCUSSION

The principal finding of this randomized controlled trial is that a targeted intervention program consisting of neural mobilization techniques was superior to a conventional physical therapy program in reducing pain and disability and improving neurodynamics in patients with subacute sciatica due to lumbar radiculopathy. While both groups exhibited statistically and clinically significant improvements over the 8-week period, the magnitude of change was consistently and significantly greater in the NMT group.

The pronounced reduction in VAS scores for leg pain in the NMT group aligns with the proposed physiological mechanisms of neural mobilization. Sciatica in LR is not solely a product of mechanical compression but is heavily mediated by inflammatory processes and altered neuroimmune function.[6] NMTs, particularly slider techniques, are theorized to facilitate the dispersion of inflammatory mediators and edema from the site of nerve root injury by promoting a "pumping" action through longitudinal movement of the nerve.[21] This can directly alleviate chemical irritation, thereby reducing pain. Furthermore, by gently stressing the neural tissue in a controlled manner, NMTs may stimulate mechanosensitive neurons to adapt, leading to a gradual desensitization of the nervous system and a raised threshold for pain perception.[22] In contrast, while CPT modalities like TENS and stretching provide symptomatic relief, they may not directly address this pathophysiological component of neural sensitization.

The superior outcomes in functional disability, as measured by the ODI, in the NMT group can be interpreted as a direct consequence of improved pain control and enhanced neural mobility. Patients with sciatica often develop fear-avoidance behaviors, limiting movements that provoke their radicular symptoms.[23] The significant improvement in the Active Knee Extension test, a direct measure of sciatic nerve mobility, in the NMT group indicates that these techniques effectively restored the normal gliding capacity of the neural tissue. This restored mobility likely empowered participants to engage more confidently in daily activities such as bending, sitting, and walking, which are core components of the ODI questionnaire. The CPT program, though including stretching and strengthening, did not specifically target the neurodynamic component of the disorder, which may explain its relatively lesser impact on self-reported disability.

Our results are consistent with a growing body of contemporary research. A recent randomized trial by Ahmed et al.[24] found that adding neural mobilization to core stability exercises led to significantly better outcomes in pain and function than exercises alone in patients with lumbar radiculopathy. Similarly, a systematic review and meta-analysis by Basson et al.[25] concluded that neurodynamic techniques are effective for pain and disability in various peripheral neuropathies, with a moderate level of evidence.[25] Our study strengthens this evidence by demonstrating the superiority of a pure NMT protocol over a comprehensive, multi-modal CPT approach, suggesting that the specific effects of neural mobilization are potent and perhaps central to recovery in this patient population.

The concept of central sensitization is increasingly recognized in persistent radicular pain.[26] The repetitive, graded exposure of the sensitive nervous system to movement through NMTs may have a neuromodulatory effect,

helping to normalize aberrant central nervous system processing. This is a potential mechanism that CPT, with its focus on peripheral musculoskeletal structures, does not directly engage. The continued improvement observed at the 8-week follow-up in the NMT group suggests that these techniques may induce longer-lasting neurophysiological adaptations, promoting sustained recovery and potentially reducing the risk of chronicity.

From a clinical perspective, these findings advocate for a paradigm shift in the conservative management of sciatica. Rather than viewing it purely as a musculoskeletal issue, clinicians should assess and treat the neurodynamic component explicitly. The Slump Test and Straight Leg Raise test should not only be used for diagnosis but also to guide and progress mobilization techniques. Integrating slider and tensioner techniques early in the rehabilitation process could lead to faster pain relief and functional recovery, potentially reducing the need for analgesic medications or invasive procedures.

However, it is crucial to emphasize that NMTs are not a standalone solution. The principles of a biopsychosocial approach remain paramount. Patient education regarding the nature of their neuropathic pain is essential to reduce fear and enhance adherence to the mobilization program, which can initially provoke familiar symptoms. Furthermore, once acute pain and neural sensitivity are controlled, the integration of CPT elements like core stabilization becomes critical to address the underlying musculoskeletal predispositions to LR and prevent recurrence.[27] Therefore, an optimal model of care may be a sequential or integrated approach, starting with NMT to manage acute neuropathic pain and neural sensitivity, followed by or combined with CPT to build lasting musculoskeletal resilience.

Strengths and Limitations

The study design was robust, featuring randomization, assessor blinding, and a follow-up period. The interventions were clearly defined and reproducible, and the use of validated outcome measures enhances the reliability of the findings. The comparison against a comprehensive CPT protocol, rather than a placebo or no-treatment control, provides a strong and clinically relevant contrast.

The study was not double-blinded, as the treating therapists could not be blinded to the intervention. The sample size, though adequate, was relatively small and recruited from a single center, which may limit generalizability. The mid-term (8-week) follow-up does not provide information on the long-term durability of the observed benefits. Furthermore, we did not include quantitative sensory testing to objectively measure changes in neural sensitization, which would have provided deeper mechanistic insights.

Recommendations for Future Research

Future studies should include larger, multi-center trials with longer follow-up periods (e.g., 6 months, 1 year) to assess long-term efficacy. Research comparing a combined NMT+CPT approach against each intervention alone would help clarify the most efficient treatment model. Investigations incorporating biomarkers of inflammation and advanced neuroimaging could further elucidate the specific mechanisms through which NMT exerts its effects. Finally, research is needed to identify patient-specific predictors of response to NMT to facilitate personalized treatment planning.

CONCLUSION

This study provides compelling evidence that neural mobilization techniques are a highly effective intervention for the management of sciatica pain and disability in patients with lumbar radiculopathy. The findings demonstrate that NMT leads to significantly greater improvements in pain intensity, functional disability, and neurodynamic mobility compared to a conventional physical therapy program comprising electrotherapy, stretching, and strengthening exercises.

The results underscore the importance of directly addressing the pathological state of the nervous system in the rehabilitation of radiculopathy. Clinicians are encouraged to incorporate targeted neural mobilization strategies into their practice to optimize outcomes for individuals suffering from sciatica.

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None.

Author Contributions
Snodia Arshad conceived and designed the study, collected data, and drafted the manuscript. **Maryam Raza** analyzed data and assisted in interpretation. **Nusrat Naseem** supervised the project and approved the final version. **Abdul Waheed performed statistical analysis. Jeetandar** contributed to the literature review and methodology. **Abdul Rasheed** handled proofreading and reference formatting.

Ethical Approval
The study was approved by the Institutional Review Board of Butt Rehab and Medical Center (IRB No. BRMC/IRB/2024/112) and the Institutional Review Board of Mukkabbir University of Sciences & Technology, Gujrat, Pakistan (IRB No. MUST/IRB/2024/045).

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None.

Conflict of Interests
None.

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