

EFFECTIVENESS OF NEURAL MOBILIZATION VERSUS STRENGTHENING EXERCISES IN REDUCING PAIN AND DISABILITY IN PATIENTS WITH LUMBAR RADICULOPATHY

Original Research (ID: 1675)

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ABSTRACT

Background: Lumbar radiculopathy is a disabling condition commonly associated with radiating leg pain, sensory symptoms, and functional restriction. Conservative physiotherapy remains a preferred first-line approach, yet the comparative benefit of neural mobilization and strengthening exercises is still debated. Neural mobilization targets neural mobility and mechanosensitivity, whereas strengthening exercises improve lumbopelvic control and muscular support. Clear comparative evidence is needed to guide practical, patient-centered rehabilitation planning for individuals with lumbar radiculopathy in routine clinical settings more effectively.

Objective: To compare the effectiveness of neural mobilization and strengthening exercises in reducing pain and disability among patients with lumbar radiculopathy.

Methods: This single-center, parallel-group randomized controlled trial enrolled 44 adults with clinically and radiologically diagnosed lumbar radiculopathy. Participants were randomly allocated into Group A and Group B, with 22 participants in each group. Group A received neural mobilization using nerve sliding and tensioning techniques, while Group B received lumbar stabilization and strengthening exercises. Both groups completed 8 supervised sessions over 4 weeks. Pain was assessed by the Numeric Pain Rating Scale and disability by the Oswestry Disability Index. Wilcoxon signed-rank and Mann-Whitney U tests were applied using SPSS version 27.

Results: Pain intensity improved significantly within both groups after intervention, including Group A receiving neural mobilization ($Z = -4.165$, $p < 0.001$) and Group B receiving strengthening exercises ($Z = -3.810$, $p < 0.001$). Group A showed significant improvement across all ODI domains ($p < 0.05$), while Group B showed significant improvement in most ODI domains ($p < 0.05$), except walking ($p = 0.171$) and standing ($p = 0.172$). Between-group analysis showed a significant post-intervention difference in NPRS, with Group A having a lower mean rank than Group B, indicating lower post-treatment pain in the neural mobilization group (mean rank: 16.86 vs. 28.14; $Z = -3.104$, $p = 0.002$). However, total post-intervention ODI scores did not differ significantly between groups (mean rank: 23.27 vs. 21.73; $Z = -0.465$, $p = 0.642$).

Conclusion: Both interventions reduced pain and disability in lumbar radiculopathy. Strengthening exercises showed greater short-term pain relief, while disability outcomes remained comparable, supporting individualized physiotherapy planning.

Keywords: Exercise Therapy; Low Back Pain; Neuralgia; Pain Measurement; Physical Therapy Modalities; Radiculopathy; Rehabilitation.

INTRODUCTION

Low back pain is one of the most common and disabling musculoskeletal conditions worldwide, affecting people across different age groups and occupational backgrounds. Its lifetime prevalence has been reported to approach 80%, and it remains a major contributor to years lived with disability, loss of productivity, healthcare utilization, and economic burden, with annual costs exceeding 100 billion dollars in the United States alone (1, 2). Among the different clinical presentations of low back pain, lumbar radiculopathy is particularly important because it is not limited to local spinal discomfort; it commonly produces radiating leg pain, sensory disturbance, paresthesia, weakness, altered reflexes, and meaningful restriction in daily activities. These symptoms can interfere with walking, standing, sitting tolerance, sleep, work performance, and overall quality of life, making lumbar radiculopathy a condition of considerable clinical and rehabilitative concern (3, 4). Lumbar radiculopathy usually occurs when one or more lumbar or sacral nerve roots, most commonly L4, L5, or S1, become irritated or compressed due to intervertebral disc herniation, foraminal stenosis, degenerative changes, or segmental instability (3, 4). Although mechanical compression is an important component, current understanding suggests that the condition is not purely structural. Nerve root irritation is also influenced by inflammatory and biochemical mechanisms, including the release of pro-inflammatory cytokines such as TNF-alpha, IL-1, IL-6, IL-8, and IL-17, along with enzymes and mediators including phospholipase A2, COX-2, matrix metalloproteinases, nitric oxide, and prostaglandin E2 (5-7). These substances may activate intracellular pathways such as MAPK, NF-kB, and TLR4, contributing to nociceptor sensitization, impaired axonal transport, endoneurial edema, and increased neural mechanosensitivity (5-7). As a result, patients may experience pain and disability that are disproportionate to imaging findings alone, highlighting the need for rehabilitation approaches that address both mechanical and neurophysiological contributors to symptoms.

The burden of lumbar radiculopathy is commonly observed among middle-aged adults, particularly those between 30 and 65 years of age, and may be influenced by modifiable and occupational risk factors such as smoking, increased body mass index, cardiovascular risk factors, prolonged sitting, repetitive bending, lifting, vibration exposure, and lumbar loading at work (8, 9). Accurate clinical identification is essential because the presentation may overlap with other causes of low back and lower limb pain. Diagnosis is usually guided by history and physical examination, including dermatomal pain distribution, neurological deficits, reflex changes, myotomal weakness, sensory alteration, and provocative tests such as the straight leg raise. Imaging, particularly magnetic resonance imaging, may help identify structural nerve root compression, while electrodiagnostic studies such as electromyography and nerve conduction studies may assist in confirming functional nerve involvement where clinical findings are unclear (10-12). However, because radiological findings do not always correspond directly with symptom severity, treatment decisions should be based on a combination of clinical examination, functional limitation, pain behavior, and patient-specific rehabilitation needs. Conservative management remains the first-line approach for most patients with lumbar radiculopathy, especially in the absence of serious neurological compromise. Pharmacological management, patient education, activity modification, exercise therapy, and physiotherapy-based interventions are commonly used to reduce symptoms and restore function (10-12). During the acute stage, pain control and symptom centralization strategies are often emphasized, whereas the subacute and recovery stages usually focus on restoring mobility, improving neuromuscular control, reducing neural sensitivity, and enhancing functional capacity (10-12). Among physiotherapy interventions, neural mobilization and strengthening exercises are frequently used because both aim to reduce pain and disability, although they are based on different therapeutic mechanisms.

Neural mobilization is a manual or exercise-based technique designed to improve the mobility of peripheral nerves and surrounding tissues through controlled movements such as sliders and tensioners. In lumbar radiculopathy, neural mobilization may help reduce nerve root mechanosensitivity, improve intraneural circulation, enhance axoplasmic flow, decrease adhesions around neural structures, and improve tolerance to movement (13-15). It may also influence pain through modulation of peripheral and central pain mechanisms, thereby reducing protective muscle guarding and improving functional movement patterns (13-15). Because lumbar radiculopathy often includes neural irritation and altered nerve mobility, neural mobilization offers a mechanism-specific approach that directly targets the neural component of the condition. Strengthening exercises, on the other hand, are commonly prescribed to improve spinal stability, lumbopelvic control, posture, and load distribution across the lumbar spine and pelvis. These exercises often target the transversus abdominis, multifidus, gluteal muscles, abdominal wall, and hip stabilizers, which play an important role in controlling lumbar movement and reducing excessive mechanical stress on spinal structures (16-18). Improved muscular support may help reduce recurrent irritation, enhance functional performance, and promote confidence in daily movement. Strengthening exercises may therefore be particularly useful for patients whose symptoms are influenced by poor trunk control, muscle weakness, deconditioning, or impaired movement patterns (16-18).

Although both neural mobilization and strengthening exercises are widely used in clinical practice, their comparative effectiveness in patients with lumbar radiculopathy remains uncertain. Existing literature supports the potential benefits of both interventions, yet direct comparisons are limited, and available findings are not always consistent (13-18). This lack of clarity may lead clinicians to select

treatment approaches based on personal preference, training background, or local practice patterns rather than strong comparative evidence. As lumbar radiculopathy is a condition with both neural and mechanical components, determining whether neural mobilization or strengthening exercises provide greater improvement in pain and disability has practical importance for designing more targeted, efficient, and patient-centered rehabilitation programs. Therefore, the research question guiding the present study is whether neural mobilization is more effective than strengthening exercises in reducing pain and disability among patients with lumbar radiculopathy. It is hypothesized that neural mobilization may produce greater improvement in pain and disability by directly addressing neural mechanosensitivity, although strengthening exercises may also provide meaningful functional benefits through improved lumbopelvic stability. The objective of the present study is to compare the effectiveness of neural mobilization and strengthening exercises in reducing pain and disability among patients with lumbar radiculopathy, with the intention of supporting evidence-based, mechanism-oriented rehabilitation and reducing unnecessary variation in clinical practice.

METHODS

The present study was conducted as a single-center, parallel-group, randomized controlled trial to compare the effects of neurodynamic mobilization and strengthening exercises on pain and disability among patients with lumbar radiculopathy. The study was carried out after approval from the Institutional Ethics Committee of the TIMES Institute, Multan. Data were collected over a period of four months. All participants were informed about the purpose, procedure, potential benefits, and possible risks of the study, and written informed consent was obtained before enrollment. Participant confidentiality was maintained by anonymizing the collected data, and any adverse events during the intervention period were recorded. The study population included adults aged 30 to 50 years with clinically and radiologically diagnosed lumbar radiculopathy. Eligible participants had symptoms lasting from 4 weeks to 6 months and demonstrated a positive straight leg raise test, indicating neural involvement. Participants were excluded if they had serious spinal pathology, previous lumbar spine surgery, cauda equina syndrome, progressive neurological deficit, spinal fracture, tumor, infection, inflammatory spinal disease, severe osteoporosis, pregnancy, uncontrolled systemic illness, or any condition that could limit safe participation in exercise therapy. Patients who had recently received spinal injections or were undergoing any other structured physiotherapy program for the same condition were also considered unsuitable for inclusion.

An a priori sample size calculation was performed using G*Power version 3.1.9.4 for comparison between two independent groups. The required sample size was calculated as 44 participants. After screening, three individuals were excluded because they did not meet the eligibility criteria, and one individual refused to participate. Therefore, a total of 44 participants were finally enrolled and randomly allocated into two equal groups, with 22 participants in each group. The experimental group received neurodynamic mobilization, while the control group received lumbar stabilization and strengthening exercises. No participant dropped out during the treatment or follow-up period, and all enrolled participants completed the four-week intervention. Participants in the experimental group received neurodynamic mobilization based on the principles described by Butler and Shacklock. The intervention included nerve sliding and nerve tensioning techniques designed to improve neural mobility, reduce mechanosensitivity, and restore functional movement tolerance. Each session included a brief warm-up, neurodynamic mobilization exercises, lumbar range of motion exercises, and a cool-down period. The control group received a structured lumbar stabilization and strengthening exercise program. This included abdominal draw-in maneuvers, bridging exercises, bird-dog exercises, pelvic tilts on a Swiss ball, and modified side planks, along with warm-up and cool-down activities. Both groups received standard baseline physiotherapy, including patient education, postural advice, hot pack application, and general mobility exercises. Treatment sessions were provided twice weekly for four weeks, and each session lasted approximately 30 minutes.

Outcome measures were recorded at baseline and after four weeks of intervention. Pain intensity was assessed using the Numeric Pain Rating Scale, an 11-point scale ranging from 0 to 10, where 0 indicated no pain and 10 indicated the worst imaginable pain. A reduction of more than 2 points was considered clinically meaningful. Functional disability was assessed using the Oswestry Disability Index, which measured the degree of disability related to low back pain and was expressed as a percentage score ranging from 0% to 100%, with higher scores indicating greater disability. Data collection was performed using standardized assessment procedures to ensure consistency between baseline and post-intervention measurements. Data were analyzed using SPSS version 27. Descriptive statistics were calculated for demographic and clinical variables. The Shapiro-Wilk test was applied to assess the normality of the data distribution. Within-group changes from baseline to four weeks were analyzed using the Wilcoxon signed-rank test, while between-group differences were assessed using the Mann-Whitney U test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 44 participants completed the study and were included in the final analysis, with 22 participants allocated to Group A and 22 participants allocated to Group B. The overall median age of the participants was 48.0 years with an interquartile range of 10 years, while the mean age was 47.95 ± 8.19 years. The minimum and maximum ages were 34 and 65 years, respectively. The median body weight was 75.50 kg with an interquartile range of 12 kg, and the mean body weight was 77.93 ± 8.30 kg, ranging from 55 to 95 kg.

The median height was 5.30 feet with an interquartile range of 0.20 feet, while the mean height was 5.386 ± 0.211 feet, with values ranging from 4.9 to 6.1 feet. Both treatment groups had an equal number of participants. Group A included 22 participants who received neural mobilization, while Group B included 22 participants who received strengthening exercises. In Group A, 10 participants were male and 12 were female, whereas Group B included 13 male and 9 female participants. Regarding socioeconomic status, Group A included 8 participants from the lower class, 7 from the middle class, and 7 from the elite class. In Group B, 5 participants belonged to the lower class, 9 to the middle class, and 8 to the elite class.

The Shapiro-Wilk test was applied to assess the distribution of baseline data. The normality results showed statistically significant values for NPRS and ODI-related variables, with p-values below 0.05. NPRS baseline scores were non-normally distributed in both groups, with a Shapiro-Wilk statistic of 0.613 and $p < 0.001$ in each group. ODI-related baseline domains also showed non-normal distribution, including pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex life, and social life, with p-values ranging from <0.001 to 0.025. Therefore, non-parametric statistical tests were applied for within-group and between-group comparisons. Within-group analysis showed that both interventions produced statistically significant reductions in pain after four weeks. In Group A, NPRS scores improved significantly from baseline to post-intervention, with a Wilcoxon Z-value of -4.165 and $p < 0.001$. Group B also showed a statistically significant improvement in NPRS, with a Wilcoxon Z-value of -3.810 and $p < 0.001$.

ODI domain-wise analysis also showed improvement in both groups, although the pattern of change differed slightly between interventions. In Group A, statistically significant improvements were observed in all measured ODI domains, including pain intensity ($Z = -3.428$, $p < 0.001$), personal care ($Z = -3.380$, $p < 0.001$), lifting ($Z = -3.845$, $p < 0.001$), walking ($Z = -2.862$, $p = 0.004$), sitting ($Z = -2.584$, $p = 0.010$), standing ($Z = -2.112$, $p = 0.035$), sleeping ($Z = -2.711$, $p = 0.007$), sex life ($Z = -3.028$, $p = 0.002$), social life ($Z = -2.999$, $p = 0.003$), and travelling ($Z = -3.145$, $p = 0.002$). In Group B, statistically significant improvements were observed in most ODI domains. Significant changes were found in pain intensity ($Z = -2.841$, $p = 0.004$), personal care ($Z = -3.450$, $p < 0.001$), lifting ($Z = -4.050$, $p < 0.001$), sitting ($Z = -2.593$, $p = 0.010$), sleeping ($Z = -3.099$, $p = 0.002$), sex life ($Z = -2.593$, $p = 0.010$), social life ($Z = -3.030$, $p = 0.002$), and travelling ($Z = -2.400$, $p = 0.016$). However, walking and standing did not show statistically significant within-group changes in Group B, with walking showing $Z = -1.368$ and $p = 0.171$, and standing showing $Z = -1.365$ and $p = 0.172$.

Between-group comparison at baseline showed no statistically significant difference between Group A and Group B for NPRS and ODI-related outcomes. The mean rank for baseline NPRS was 22.50 in both groups, with $Z = 0.000$ and $p = 1.000$. Similarly, the pre-intervention total ODI mean rank was 22.50 in both groups, with $Z = 0.000$ and $p = 1.000$. Baseline ODI domains, including pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life, and travelling, also showed equal or comparable mean ranks between groups, indicating baseline comparability before intervention. Post-intervention between-group analysis showed a statistically significant difference in NPRS scores between the two groups. Group A had a lower post-intervention mean rank for NPRS than Group B, with mean ranks of 16.86 and 28.14, respectively. The Mann-Whitney U test showed $Z = -3.104$ with a reported p-value of 0.020. For functional disability, no statistically significant difference was found between the two groups in total post-intervention ODI score, where Group A had a mean rank of 23.27 and Group B had a mean rank of 21.73, with $Z = -0.465$ and $p = 0.642$.

Post-intervention comparison of individual ODI domains also showed no statistically significant difference between Group A and Group B. Pain intensity had mean ranks of 20.84 and 24.16 in Group A and Group B, respectively, with $p = 0.398$. Personal care showed mean ranks of 22.20 and 22.80, with $p = 0.876$. Lifting showed mean ranks of 24.91 and 20.09, with $p = 0.195$. Walking showed mean ranks of 20.07 and 24.93, with $p = 0.195$. Sitting showed mean ranks of 22.45 and 22.55, with $p = 0.981$. Standing showed mean ranks of 21.52 and 23.48, with $p = 0.607$. Sleeping showed mean ranks of 22.75 and 22.25, with $p = 0.892$. Sex life showed mean ranks of 21.70 and 23.30, with $p = 0.673$. Social life showed mean ranks of 22.45 and 22.55, with $p = 0.981$. Travelling showed mean ranks of 21.70 and 23.30, with $p = 0.675$. Overall, both groups improved after treatment, while between-group differences were statistically significant only for post-intervention NPRS and not for total ODI or individual ODI domains.

Table 1 Descriptive statistics of quantitative demographic variables

Variables	N	Minimum	Maximum	Mean \pm SD	Median (IQR)
Age	44	34	65	47.95 ± 8.189	48.0 (10)
Weight	44	55	95	77.93 ± 8.295	75.50 (12)
Height	44	4.9	6.1	5.386 ± 0.2109	5.30 (0.2)

Table 2 Frequency/percentage of qualitative demographic variables

Variable	Construct	Group A		Group B	
		Frequency	%	Frequency	%
Gender	Male	10	45.5	13	59.1
	Female	12	54.5	9	40.9
Group	Experimental (A)	22	50	22	50
	Lower class	8	36.4	5	22.7

Social Status	Middle class	7	31.8	9	40.9
	Elite class	7	31.8	8	36.4

Table 3 Wilcoxon signed-rank test results showing changes in NPRS and ODI domains from baseline to post-intervention in both groups.

Variables	Total	Group	Negative Ranks (Mean/Sum)	Positive Ranks (Mean/Sum)	Z	Asymp. Sig. (2-tailed)
NPRS (Post/Pre)	44	A	11.50 / 253.00	0.00 / 0.00	-4.165	<.001
		B	9.50 / 171.00	0.00 / 0.00	-3.810	<.001
Pain Intensity (Post/Pre)	44	A	10.56 / 179.50	5.25 / 10.50	-3.428	<.001
		B	12.03 / 180.50	5.90 / 29.50	-2.841	0.004
Personal Care (Post/Pre)	44	A	8.87 / 133.00	3.00 / 3.00	-3.380	<.001
		B	10.25 / 164.00	3.50 / 7.00	-3.450	<.001
Lifting (Post/Pre)	44	A	10.87 / 206.50	3.50 / 3.50	-3.845	<.001
		B	11.00 / 231.00	0.00 / 0.00	-4.050	<.001
Walking (Post/Pre)	44	A	8.75 / 122.50	6.75 / 13.50	-2.862	0.004
		B	10.71 / 128.50	8.79 / 61.50	-1.368	0.171
Sitting (Post/Pre)	44	A	11.04 / 143.50	5.50 / 27.50	-2.584	0.010
		B	11.32 / 158.50	6.30 / 31.50	-2.593	0.010
Standing (Post/Pre)	44	A	10.91 / 120.00	5.50 / 33.00	-2.112	0.035
		B	10.59 / 116.50	7.79 / 54.50	-1.365	0.172
Sleeping (Post/Pre)	44	A	11.08 / 133.00	4.00 / 20.00	-2.711	0.007
		B	9.07 / 127.00	4.50 / 9.00	-3.099	0.002
Sex Life (Post/Pre)	44	A	11.30 / 169.50	5.13 / 20.50	-3.028	0.002
		B	12.19 / 158.50	5.25 / 31.50	-2.593	0.010
Social Life (Post/Pre)	44	A	10.82 / 184.00	8.67 / 26.00	-2.999	0.003
		B	12.33 / 185.00	5.00 / 25.00	-3.030	0.002
Traveling (Post/Pre)	44	A	9.14 / 128.00	4.00 / 8.00	-3.145	0.002
		B	10.54 / 126.50	5.30 / 26.50	-2.400	0.016

Table 4 Between-Group Differences in Pain and Disability Measured by Mann-Whitney U Test.

Variables	Group A		Group B		Z (cont. corr.)	Asymp. Sig. (2-tailed) (approx.)
	Mean Rank	Sum of Ranks	Mean Ranks	Sum of Ranks		
NPRS Baseline	22.50	495.00	22.50	495.00	0.000	1.0000
NPRS Post Intervention	16.86	371.00	28.14	619.00	-3.104	0.02
Pre ODI Total	22.50	495.00	22.50	495.00	0.000	1.0000
TotalPost ODI	23.27	512.00	21.73	478.00	-.465	0.642
Pain Intensity Pre	22.50	495.00	22.50	495.00	0.000	1.0000
Pain Intensity Post	20.84	458.50	24.16	531.50	-0.845	-0.3981
Personal Care Pre	22.50	495.00	22.50	495.00	0.000	1.0000
Personal Care Post	22.20	488.50	22.80	501.50	-0.157	876
Lifting Pre	22.50	495.00	22.50	495.00	0.000	1.0000
Lifting Post	24.91	548.00	20.09	442.00	-1.297	.195
Walking Pre	22.50	495.00	22.50	495.00	0.000	1.0000
Walking Post	20.07	441.50	24.93	548.50	-1.297	.195
Sitting Pre	22.50	495.00	22.50	495.00	0.000	1.0000

Sitting Post	22.45	494.00	22.55	496.00	0.024	0.981
Standing Pre	22.50	495.00	22.50	495.00	0.000	1.0000
Standing Post	21.52	473.50	23.48	516.50	-.515	607
Sleeping Pre	22.50	495.00	22.50	495.00	0.000	1.0000
Sleeping Post	22.75	500.50	22.25	489.50	-.135	892
Sex Life Pre	22.50	495.00	22.50	495.00	0.000	1.0000
Sex Life Post	21.70	477.50	23.30	512.50	-.421	0.673
Social Life Pre	22.50	495.00	22.50	495.00	0.000	1.0000
Social Life Post	22.45	494.00	22.55	496.00	-0.024	0.981
Travelling Pre	22.50	495.00	22.50	495.00	0.000	1.0000
Travelling Post	21.70	477.50	23.30	512.50	0.419	0.675

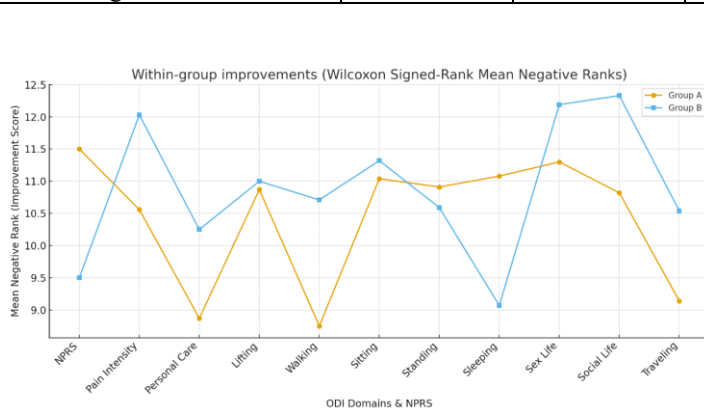


Figure Line graph showing within-group improvements (mean negative ranks from Wilcoxon signed-rank test) across NPRS and ODI domains in Group A and Group B. Higher negative rank mean indicates greater improvement from baseline to post-intervention.

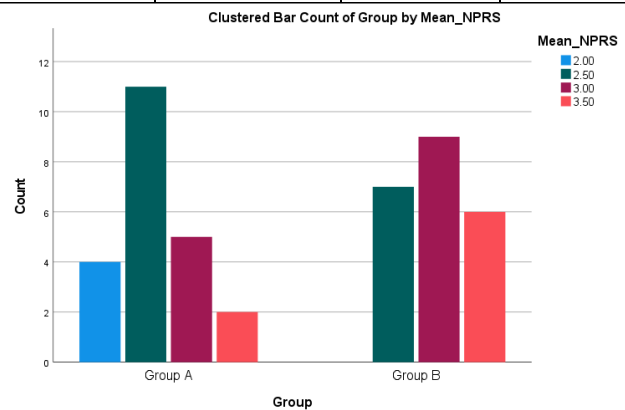


Figure Comparison of post-intervention NPRS scores between the intervention and control groups using the Mann-Whitney U test.

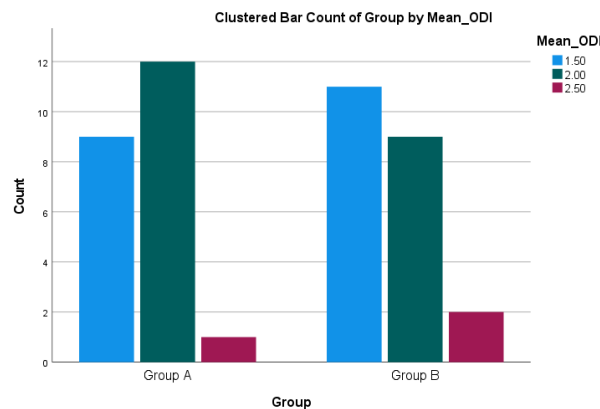


Figure Between-group comparison of post-intervention ODI scores using the Mann-Whitney U test

DISCUSSION

The present study compared the effects of neural mobilization and strengthening exercises on pain and disability among patients with lumbar radiculopathy. The findings showed that both interventions produced significant within-group improvement in pain intensity and functional disability after the treatment period. Neural mobilization demonstrated significant improvement across all measured ODI domains, whereas strengthening exercises produced significant improvement in most domains but did not show statistically significant change in walking and standing. Between-group analysis showed a statistically significant difference in post-intervention NPRS scores,

while total ODI and individual ODI domains did not differ significantly between the two groups. These findings suggested that both approaches were clinically useful in the short-term management of lumbar radiculopathy, although neural mobilization appeared to produce broader improvement across functional domains, while overall disability improvement remained comparable between groups. The reduction in pain observed in both groups reflected the value of conservative physiotherapy management in lumbar radiculopathy. Neural mobilization may have contributed to symptom improvement by improving neural excursion, reducing neural mechanosensitivity, enhancing intraneural circulation, and decreasing sensitivity of the irritated nerve root. These mechanisms were particularly relevant in lumbar radiculopathy, where symptoms were not only related to mechanical compression but also to inflammatory irritation and altered neural mobility. Strengthening exercises, on the other hand, may have reduced symptoms by improving lumbopelvic control, enhancing trunk muscle activation, supporting spinal stability, and reducing excessive mechanical loading on lumbar structures. Therefore, the improvement observed in both groups was biologically plausible, as each intervention addressed a different but clinically relevant component of lumbar radiculopathy.

The findings were broadly consistent with previous evidence showing that neural mobilization was effective in improving pain and disability among patients with lumbar radiculopathy. A recent meta-analysis of 20 randomized controlled trials involving 877 participants reported that neural mobilization produced significant improvement in pain, with a substantial effect size, and also improved disability outcomes. The reported pooled effects supported neural mobilization as a useful stand-alone or adjunctive intervention, particularly in patients with persistent or chronic radicular symptoms (19). The present study supported this evidence by showing significant within-group improvement in NPRS and ODI domains following neural mobilization. However, the shorter intervention duration and smaller sample size in the present trial may have limited the ability to demonstrate stronger between-group superiority for disability outcomes. The comparison with previous trials using neurodynamic techniques also strengthened the clinical relevance of the present findings. Earlier randomized work comparing manual therapy combined with neurodynamic mobilization against other manual therapy approaches reported meaningful improvements in back pain, leg pain, activity limitation, functional mobility, and quality of life at multiple follow-up points (20). The current study showed a similar direction of improvement, particularly in pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life, and travelling in the neural mobilization group. Although the present study measured short-term outcomes only, the pattern of improvement supported the role of neurodynamic treatment in reducing radicular symptoms and improving functional tolerance.

The results also aligned with evidence from studies in which sustained mobilization techniques combined with neural mobilization were used for patients with lumbar radicular symptoms. In those studies, clinically meaningful changes were reported in pain, disability, straight leg raise range, lumbar mobility, and global perceived recovery (21). The present study differed because it directly compared neural mobilization with strengthening exercises rather than adding neural mobilization to another manual therapy technique. Despite this difference, both lines of evidence suggested that interventions targeting neural mobility could contribute meaningfully to symptom reduction in radicular pain conditions. The broader improvement across ODI domains in the neural mobilization group further supported the view that reducing neural sensitivity may allow patients to perform daily activities with less fear, pain, and movement restriction. Strengthening exercises also showed important clinical value in the present study. Significant improvements were observed in NPRS and most ODI domains, including pain intensity, personal care, lifting, sitting, sleeping, sex life, social life, and travelling. These findings were consistent with reviews of non-surgical management of lumbar disc herniation with radiculopathy, where exercise therapy, mobilization, manipulation, and neural mobilization were reported to have beneficial effects on pain and function in the absence of red flags (22). Strengthening exercises may have been particularly helpful by improving core stability, correcting impaired movement patterns, and enhancing confidence in functional activities. However, the lack of statistically significant improvement in walking and standing within the strengthening group indicated that muscle strengthening alone may not fully address neural mechanosensitivity or leg-dominant symptoms over a short treatment period.

The absence of a significant between-group difference in total ODI suggested that both interventions improved disability to a comparable extent over four weeks. This finding was clinically important because lumbar radiculopathy usually involves both neural and mechanical contributors. Neural mobilization may have addressed neural mobility and radicular sensitivity, while strengthening exercises may have improved spinal support and functional control. Comparable disability outcomes therefore suggested that both approaches could be useful depending on the patient's dominant clinical presentation. Patients with marked neural tension, positive straight leg raise, radiating pain, or movement-related neural sensitivity may benefit more from neural mobilization, whereas patients with poor trunk control, weakness, deconditioning, or mechanical instability may respond well to strengthening exercises. The findings also had practical implications for rehabilitation planning. Instead of viewing neural mobilization and strengthening exercises as competing interventions, the results supported a mechanism-based approach in which both methods could be integrated according to patient need. Neural mobilization may be prioritized during the early phase when radicular pain and neural mechanosensitivity are prominent, while strengthening exercises may be gradually progressed to improve lumbopelvic stability, muscular endurance, and long-term functional resilience. Such an integrated approach may provide a more complete rehabilitation strategy by addressing both neuropathic and musculoskeletal contributors to lumbar radiculopathy. Previous evidence from postoperative lumbar spine rehabilitation also suggested that combining neural mobilization or soft-tissue techniques with strengthening exercises produced clinically meaningful improvement in pain and disability compared with strengthening alone (23).

A key strength of the present study was its randomized controlled design, which allowed a direct comparison between two commonly used physiotherapy interventions. The use of standardized outcome measures, including NPRS and ODI, improved the clinical relevance of the findings because these tools were directly related to pain intensity and functional disability. Equal group allocation and complete follow-up further strengthened the internal consistency of the study. The study also had practical value because both interventions were low-cost, non-invasive, feasible in routine physiotherapy practice, and applicable in outpatient rehabilitation settings. Several limitations needed to be considered while interpreting the findings. The sample size was relatively small, which may have limited statistical power and reduced the generalizability of the results. The study was conducted at a single center, so the findings may not fully represent patients from different clinical settings, geographic areas, or healthcare systems. The treatment duration was short, and the absence of medium- or long-term follow-up limited the ability to determine whether the observed improvements were sustained over time. Complete participant blinding was not feasible because of the nature of physiotherapy interventions, which may have introduced performance or expectation bias. The outcomes were also based mainly on self-reported pain and disability measures, while objective measures such as straight leg raise range, lumbar range of motion, muscle strength, quality of life, analgesic use, work status, or electrodiagnostic parameters were not included.

Another important methodological consideration was the need for clearer reporting of change scores. Although post-intervention comparisons were useful, the objective of the study was to compare reduction in pain and disability; therefore, analysis of baseline-to-post-treatment change scores for NPRS and total ODI would have provided a more direct estimate of treatment effect. Reporting effect sizes, confidence intervals, and clinically meaningful improvement rates would also have strengthened interpretation beyond p-values. Future studies should include larger multicenter samples, concealed allocation, assessor blinding, longer follow-up periods, and objective functional or neurophysiological outcomes. Additional research should also explore whether combining neural mobilization with strengthening exercises produces superior outcomes compared with either intervention alone. Overall, the present study showed that both neural mobilization and strengthening exercises were effective conservative interventions for reducing pain and disability in patients with lumbar radiculopathy. Neural mobilization produced significant improvement across all functional domains and appeared particularly relevant for radicular pain and neural mechanosensitivity, while strengthening exercises showed meaningful benefits in pain reduction and functional restoration through improved lumbopelvic stability. The findings supported the use of individualized, mechanism-based rehabilitation, with consideration of an integrated protocol that combines neural mobilization and strengthening exercises to address the multidimensional nature of lumbar radiculopathy.

CONCLUSION

The study concluded that both neural mobilization and strengthening exercises were beneficial in reducing pain and disability among patients with lumbar radiculopathy. However, neural mobilization showed broader improvement in functional limitations and appeared to be particularly useful for patients with radiating pain and neural mechanosensitivity. These findings support the clinical value of neural mobilization as an effective physiotherapy intervention, while also highlighting the importance of strengthening exercises in restoring spinal stability and functional capacity. Overall, the study emphasized that rehabilitation for lumbar radiculopathy should be patient-centered and mechanism-based, with neural mobilization considered as an important treatment option to improve recovery and daily functional performance.

AUTHOR CONTRIBUTION

Author	Contribution
Aleezay Fatima	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Hafiz Muhammad Abu Bakar Rashid	Methodology, Investigation, Data Curation, Writing - Review & Editing
Dr sidra Iqbal	Investigation, Data Curation, Formal Analysis, Software
Dr Syeda Fareesa Hassan Zaidi	Software, Validation, Writing - Original Draft
Ammara Manzoor Malik	Formal Analysis, Writing - Review & Editing
Muhammad Abdullah Hamza Masood	Writing - Review & Editing, Assistance with Data Curation

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