Research Article

Dose response of neural mobilization on hamstring flexibility in patients with non-specific low back pain: a randomized control trial

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ABSTRACT

Background: Non-specific low back pain (NSLBP) often correlates with reduced hamstring flexibility, contributing to altered biomechanics and recurrent symptoms. Neural mobilization (NM) techniques are increasingly integrated into management strategies to address neurogenic inflammation and neural tissue mobility. However, the dose-response relationship of NM for hamstring flexibility remains unclear, with limited studies isolating dosage effects amid multimodal interventions.

Objectives: to determine the dose-response effect of NM on hamstring flexibility, pain, and disability in NSLBP patients, comparing high-dose versus low-dose protocols over a 4-week intervention. Methodology: A single-blinded randomized controlled trial allocated 34 NSLBP patients (aged 18–40) to Group A (High-dose NM) and Group B (Low-dose NM. The outcomes (NPRS for pain, ODI for disability, AKE test for flexibility) were assessed at baseline, 2 weeks, and 4 weeks.

Results: Group A showed a significantly greater reduction at 2 weeks ($p=0.007$, $d=0.58$), though differences became non-significant by week 4. At the same time, Group A demonstrated superior reductions at both 2 weeks ($p=0.0316$, $d=1.06$) and 4 weeks ($p<0.001$, $d=2.01$). Finally, both groups improved equally in AKE ($p\geq0.05$ between groups).

Conclusion: High-dose NM provides acute advantages for pain and disability reduction, However, equivalent hamstring flexibility gains across doses suggest that concurrent stretching dominates flexibility outcomes, overshadowing NM's dose-dependent effects.

Keywords: disability; hamstring; knee extension; low back pain; lumbar flexion; neural mobilization

Clinical trial #: NCT05101200

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INTRODUCTION

Low back pain (LBP) is a complex clinical condition that is common in over 80% of adults, and it is experienced at some point in their lives[1]. Among these cases, non-specific LBP covers a substantial proportion without any definitive underlying pathology[2]. In NSLBP, reduced hamstring flexibility has been frequently observed, which may contribute to altered lumbar pelvic mechanics, compensatory movements, and recurrent pain episodes[3, 4]. Conventional management strategies include thermal therapy[5], stretching[6, 7], and strengthening exercises[8]. Recent advances have emphasized the inclusion of neural mobilization techniques, especially for restoring neural tissue mobility and reducing neurogenic inflammation[9, 10].

Neural mobilization (NM), including techniques such as slump stretching and sciatic nerve gliding, has shown promise in enhancing flexibility, reducing pain, and improving functional outcomes[11, 12]. However, the therapeutic efficacy of NM may vary depending on the dosage, intensity, and frequency of application. Despite growing clinical usage, there is limited clarity regarding the optimal dose-response relationship of neural mobilization for improving hamstring flexibility in NSLBP populations.

Several studies have explored the impact of neural mobilization in individuals with LBP. For instance, Lin et al. have demonstrated the effectiveness of NM in improving nerve mobility and reducing pain sensitivity[12]. Similarly, clinical trials have reported improvements in hamstring flexibility following sciatic and slump nerve glides[11, 13]. Moreover, integrating NM with therapeutic exercises and heat therapy has yielded promising outcomes for symptom reduction and flexibility enhancement[14]. A recent study tested dosage response through neural mobilization on acute athletic performance. It was inferred that the five-minute neural gliding protocol is a more effective post-test than dynamic stretching [15].

However, lack of well-controlled, randomized trials that explicitly compare the dose-response effect of neural mobilization on hamstring flexibility in patients with NSLBP. Most available research examines NM as a singular intervention or in conjunction with exercises but does not systematically investigate how differing intensities influence outcomes. Furthermore, limited studies explored how neural mobilization dosage affects the interplay between flexibility improvement and pain reduction over time. So the purpose of the study was to determine the dose-response of neural mobilization on hamstring flexibility in patients with non-specific low back pain.

METHODOLOGY

Study Design and setting: A single-blinded Randomized control trial was conducted at Darul Sehat Hospital; Karachi completed prior official conduct of the study ethical approval was obtained from the Riphah Ethical Committee for the duration of one year (2021 to 2022). The individuals were told of the study's objectives, and they provided their written informed permission in line with the Declaration of Helsinki [16].

Selection Criteria: In the study, both males and females of age between 18 to 40 years were recruited with nonspecific low back pain in sub-acute and chronic phases. Individuals with specific low back pain cause, central or peripheral neurologic signs, systemic illness, psychiatric deficits, any surgical procedure was done 6 months past, and mental deficits were excluded from the study.

Intervention: Group A received high-dose neural mobilization consisting of; a neural mobilization technique (slump, sciatic), hot pack for 15 minutes, and strengthening exercises for quadriceps, hamstring, and erector spinae with 10-12 rep/2 sets [17]. Group B received low-dose neural mobilization with minimal intensity which consisted of; a hot pack: 15 minutes, strengthening exercises with 5-7 rep/1 set, strengthening exercises for quadriceps and erector spinae 5-7 rep/1 set, and static stretching exercises for hamstring 5-7 rep/1 set of AKE. Both groups were given sessions of 30 min/day, 2 days/week for 4 weeks, assessment was done at baseline, 2nd week & the end of 4th week [18] (Table 1)

Table 1: Intervention protocol.

Description	Group A (n=17) High Dose of NM	Group B (n=17) Low Dose of NM
Neural mobilization (slump, sciatic)	Knee extension, ankle dorsiflexion, and head extension in a slumped posture followed by ankle plantar flexion together with knee and head flexion	
Dosage	10-12 reps / 2 sets	5-7 reps / 1 set
Hot pack	15 minutes	15 minutes
Strengthening exercises (Erector spinae, quadriceps)	10-12 reps / 2 sets	10-12 reps / 2 sets
Hamstring stretching	10-12 reps / 2 sets	10-12 reps / 2 sets
Frequency and Duration	40 min/session, 2 days/week for 4 weeks; assessments at baseline, 2nd, and 4th week	

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Back pain intensity was measured via the 11-point Numeric Pain Rating Scale (NPRS) which is a known valid and reliable tool in the back pain population [19]. The disability associated with low back pain was assessed by the validated Oswestry Disability Index (ODI) the final score/index ranges from 0-100 [20]. Hamstring flexibility was measured via the active knee extension test AKE and is a valid and reliable tool [21]. The lumbar flexion range was assessed via the Schober test; a distance of less than 4 cm is indicated for compromised lumbar flexibility [22].

Sample Size: The required sample size was estimated a priori using G*Power 3.1.9.7 with medium effect size f=0.24, alpha error probability α=0.05, and desired statistical power (1-β)=0.85. So, the total required sample size was calculated as n=34 participants. A total of n=50 potential individuals were approached among which n=10 didn't meet the eligibility criteria and n=6 declined to participate. There was no loss of follow-up, and all participants completed the intervention completely. The final analysis was done on n=34 participants who were then randomly divided into Group A (n=17) and Group B (n=17). (Figure 1).

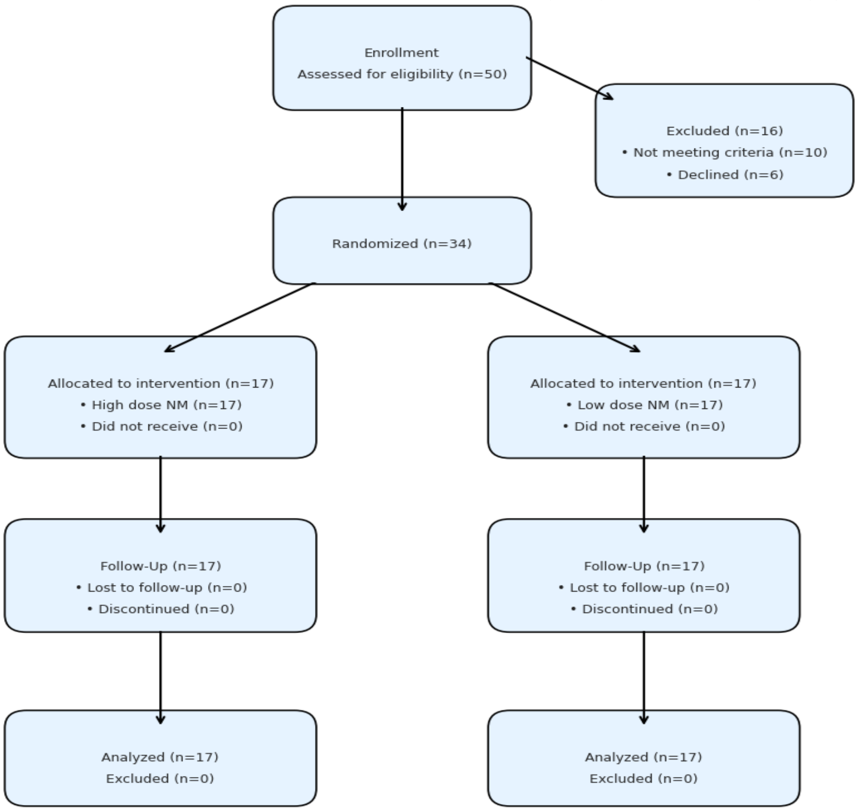

Figure 1: Consort Diagram

Individuals were equally allocated into two treatment groups based on randomization via the sealed envelope method. Group A (high-dose neural mobilization) and Group B (low-dose neural mobilization) were the titles of the two sealed envelopes that were blinded to the patients. When a participant agreed to participate in the study and was ready for allocation, they were asked to blindly draw one of the sealed envelopes, without knowing its contents. This process ensured that participants had an equal and unpredictable chance of being assigned to either intervention group. Once one group was selected, the next participant was automatically allocated to the remaining group to maintain balanced group sizes. This procedure prevented selection bias and maintained allocation concealment until the intervention assignment was revealed.

The statistical values were analyzed using SPSS version 23. Based on the normality testing between groups, analysis was performed via Independent sample t-test. While within-group analysis was performed via RMANOVA with pairwise comparison. The significance value was determined as $p<0.05$.

RESULTS

Total 34 individuals participated in the study including 4 (23.5 %) males and 13 (76.5 %) females in Group A and 6 (35.5 %) males and 11 (64.7 %) females were in Group B. Among the participants the mean age in group A was 33.69 ± 6.06 and in group B mean was 33.12 ± 6.70 years.

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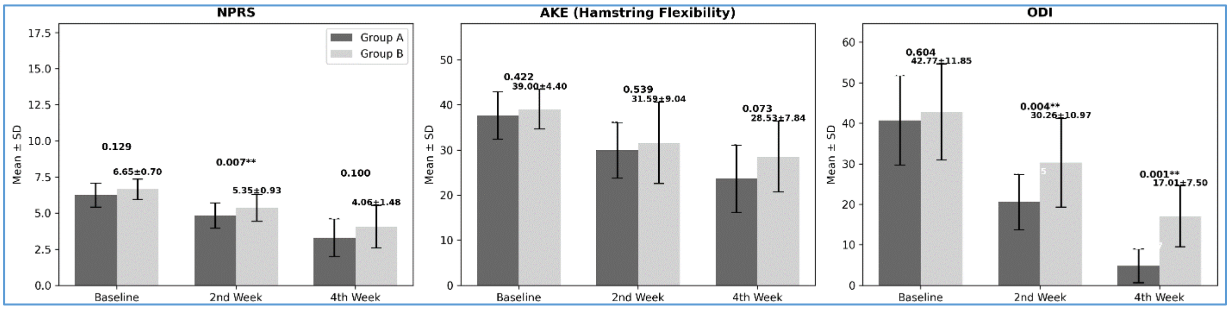

Figure 2: Between group comparison of outcomes

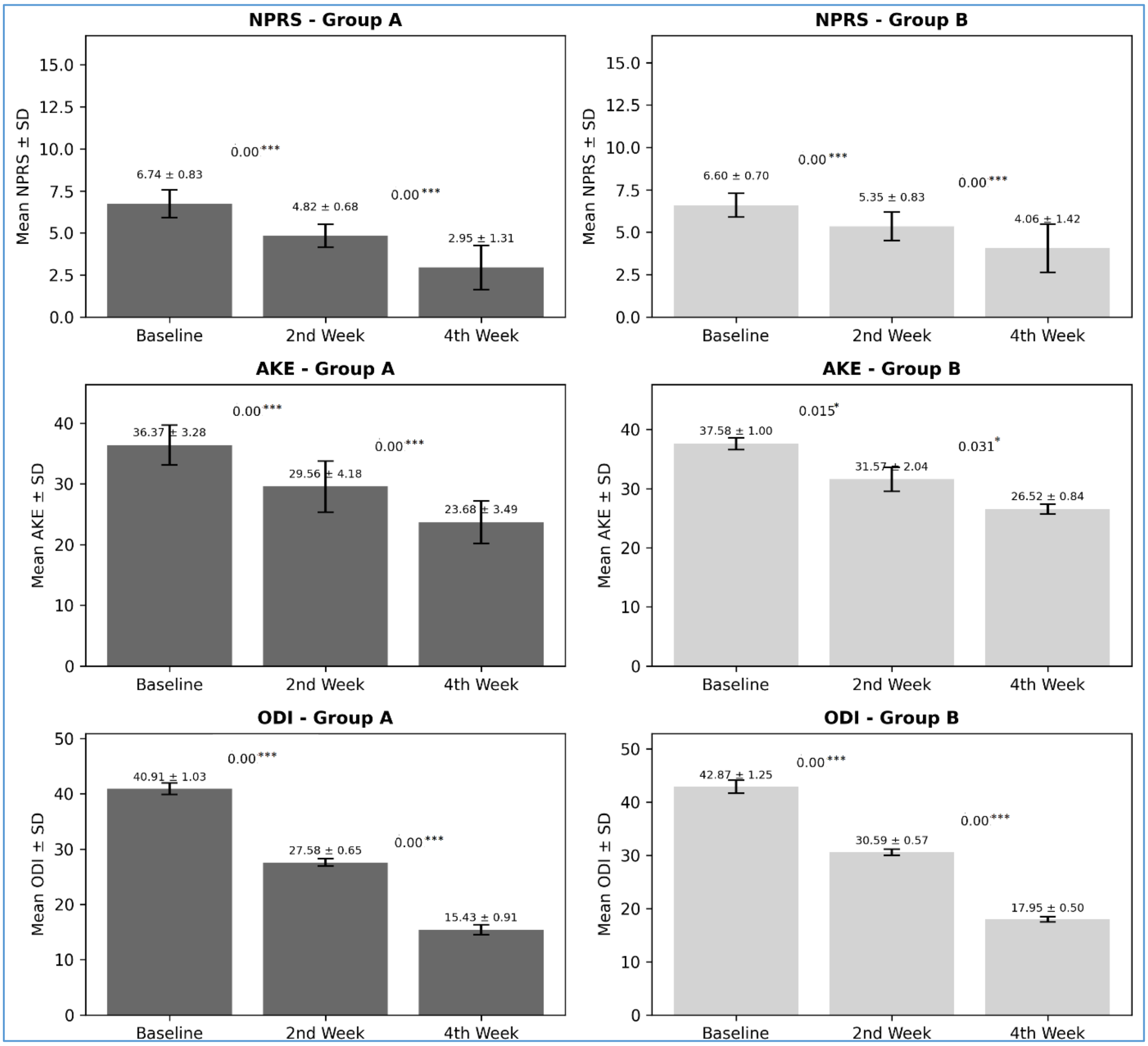

Figure 3: Within Group Analysis (Repeated Measure ANOVA-Pairwise Comparison)

At baseline, the two groups showed comparable scores across all outcome measures. The pain intensity, measured by the 2nd week Group A reported significantly (p=0.007, Cohen's d-0.58) lower pain scores than Group B). This trend continued but the difference was not statistically (p0.100) significant at the 4th week. For hamstring flexibility on active knee extension (AKE), both groups demonstrated similar improvements over time; however, differences between groups at all time points were small and not statistically (p≥0.05) significant. Finally, disability scores assessed with the Oswestry Disability Index (ODI) by the 2nd and 4th weeks Group A showed significantly greater reductions in disability than Group B 2nd week (p=0.004) and 4th week (p=0.001). These findings indicate that the intervention was effective in reducing pain and disability, with large effect sizes favoring Group A, while improvements in hamstring

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flexibility were modest and not significantly different between groups. (Figure 2)

The pain intensity was significantly (p<0.001) improved in both group at each assessment till 4th week with large effect size. It was observed that, in Group A (High Dose), there was a significant improvement in Active Knee Extension (AKE) over time {F=53.59 (1.29, 20.68), p=0.003, ηp^2=0.77} with a large effect. The mean AKE scores improved significantly (p<0.001) from 37.65±5.25 degrees at baseline to 29.94±6.17 degrees at the 2nd week and further to 23.65±7.49 degrees at the 4th week. Similarly, Group B (Low Dose) also showed a significant improvement in AKE {F=13.165(1.54, 24.69), p=0.015, ηp^2=0.45}, with a moderately large effect size. The Mean AKE decreased significantly (p<0.001) from 39.00±4.40 degrees at baseline to 31.59±9.03 degrees at the 2nd week and 28.53±7.83 degrees at the 4th week. For ODI Total Scores, Group A demonstrated a highly significant improvement across time points {F=13.165 (1.54, 24.69), p=0.001, ηp^2=0.92}, with a very large effect size. The mean ODI score reduced significantly from 40.70±11.03 at baseline to 20.53±6.85 in the 2nd week and 4.78±4.16 in the 4th week. While in Group B, there was also a significant decrease {F=194.86 (1.71, 27.43), p=0.005, ηp^2=0.92} in ODI scores across the time points (p=0.005), with a similarly large effect size (ηp^2=0.92). The ODI scores decreased from 42.76±11.85 at baseline to 30.26±10.97 at the 2nd week and17.00±7.50 at the 4th week. (Figure 3)

DISCUSSION

The current study aimed to compare the dose-response of neural mobilization on hamstring flexibility in nonspecific LBP on outcomes including pain, active knee extension, lumbar flexion, and disability.

Regarding the pain intensity within-group analysis showed that high and low-dose neural mobilization both significantly reduced the low back pain. while the group difference was observed between groups at the end of the intervention. However, Group A's significant pain reduction after 2nd week reflects NM's dose-dependent neurophysiological impact. Higher repetitions (10–12 reps/set) may enhance mechano-transduction in neural tissues, optimizing ion channel function and reducing ectopic firing[23]. Earlier research lends evidence to the present study's claim by Balcı A et al. (2020) stated that the neural mobilization with 3 sets was found significantly effective in lowering the pain intensity in the wrestlers' population (P<0.05) [18]. Similarly, a study by Krishna H et al. (2019) conducted to examine the efficacy of neural mobilization on pain found similar findings as; a significant immediate reduction of pain (P<0.05) on the visual analogue scale in young adult athletes after the application of hamstring neural mobilization [24].

However, these findings contradict the finding of a study conducted by Jin-yong et al. (2021) to determine the immediate effectiveness of the neural slider technique with hamstring tightness; where no significant improvement was observed in lumbar flexion at within-group analysis (p=0.27) as well as between group analysis (p=0.33) [25]. The difference might be due to the concern that Jin-yong et al. (2021) studied only immediate effects, while in our study comparison was done till 4th week. This extended duration allowed for the cumulative effects of the interventions, leading to significant improvements in the lumbar flexion range. While Jin-yong et al. only focused on the immediate effects of the neural slider technique on hamstring tightness and lumbar flexion, immediate assessments might not capture the full therapeutic benefits of neural mobilization, which can accrue over time with repeated sessions.

The results of this study in the AKE Test within-group analysis showed that the groups with high and low dose neural mobilization were significantly effective with a large effect size. However, no significant group difference was found between group analyses showing that both doses are equally effective. Previous studies have also declared similar findings such as a study conducted by Balcı A et al. (2020) reported significant improvement (P<0.05) in the AKE test after the application of low-dose neural mobilization in wrestlers with back pain. [18]. Furthermore, Jin-yong Limet al. (2021) also found a significant increase in hamstring flexibility with low-dose mobilization of the nerve [26]. The observed findings in knee extension match the physiological goal of neural sliding which can improve nervous system function and facilitate better flexibility irrespective of the dosage [27]. Moreover, previous literature is consistent with current findings thus further aiding the physiological reasoning of the current study. The similar results observed with high-dose interventions might be explained by a ceiling effect, where a certain threshold of neural mobilization achieves the maximum possible benefit, beyond which additional improvements are minimal. Both low and high doses might have exceeded this threshold, leading to similar findings.

Oswestry Disability Index (ODI) analysis shows both groups were found significantly effective in reducing the disability level with moderate to large effect size when compared in pairwise comparison analysis. While significant group difference was observed with more disability reduction in Group A than in Group B explaining the fact that high-dose

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neural mobilization is more effective in reducing the disability in variables related to physical functioning. The result of this study is in coherence with a meta-analysis showing larger effect sizes were discovered for NM's impact on pain relief and disability improvement [28]. This could be justified by the physiological response of high-dose neural mobilization explained by Romero-Morales et al. (2022) that the intensity of the nerve gliding and sliding during stretching is correlated to improved functional status of muscle locally and overall limb functional status [29].

The use of co-interventions (hot packs and strengthening exercises) in both groups confounds the isolated effects of neural mobilization (NM), making it difficult to establish a clear dose-response relationship. Furthermore, the lack of a true control group receiving no NM prevents meaningful comparisons to standard care or placebo effects.

CONCLUSION

High-dose neural mobilization (NM) demonstrates acute neurophysiological benefits for pain and disability in NSLBP, mediated through anti-inflammatory and descending modulatory pathways. However, its limited dose-response effect on flexibility highlights the dominance of concurrent stretching. Future studies should integrate biomarker assays, isolate NM dosage, and extend follow-up to elucidate long-term neuroadaptation.

DECLARATIONS & STATEMENTS

Author's Contribution

RL: substantial contributions to the conception and design of the study.
AZ: acquisition of data for the study.
AZ: interpretation of data for the study.
RL: analysis of the data for the study.
RL and AZ: drafted the work.
RL and AZ: revised it critically for important intellectual content.
RL and AZ: final approval of the version to be published and agreement to be accountable for all aspects.
of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed to the article and approved the submitted version.

Ethical Statement

The study was conducted in accordance with the Declaration of Helsinki. Prior to conduction of study the approval was obtained from ethical committee of Riphah International University (RIPHAH/RCRS/REC/Letter-01058).

AI Use Statement

No AI was used for content generation, data analysis, or interpretation.

Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

This study does not involve the creation or analysis of new data, and therefore, data sharing is not applicable to this article

Conflicts of Interest

The authors declare no conflict of interest.

Funding

The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

REFERENCES

1. Taylor JL, Regier NG, Li Q, Liu M, Szanton SL, Skolasky RL. The impact of low back pain and vigorous activity on mental and physical health outcomes in older adults with arthritis. Front Pain Res (Lausanne) .2022;3:886985. [CrossRef] [PubMed]
2. Orrillo E, Vidal Neira L, Piedimonte F, Plancarte Sanchez R, Astudillllo Mihovilovic S, Narvaez Tamayo MA, et al. What is new in the clinical management of low back pain: a narrative review. Cureus. 2022;14(3):e22992. [CrossRef] [PubMed]
3. Jandre Reis FJ, Macedo AR. Influence of hamstring tightness in pelvic, lumbar and trunk range of motion in low back pain and asymptomatic volunteers during forward bending. Asian Spine J. 2015;9(4):535-40. [CrossRef] [PubMed]
4. Rahim M, Khalid S, Saad Z, Khattak K. Effects of hamstring stretching using pressure bio feedback unit in patients with low back pain. T. Rehabili. J.2024;8(01):26-32. [CrossRef]
5. Freiwald J, Magni A, Fanlo-Mazas P, Paulino E, Sequeira de Medeiros L, Moretti B, et al. A role for superficial heat therapy in the management of non-specific, mild-to-moderate low back pain in current clinical practice: a narrative review. Life (Basel).2021;11(8). [CrossRef] [PubMed]
6. Afonso J, Ramirez-Campillo R, Moscão J, Rocha T, Zacca R, Martins A, et al. Strength training versus stretching for improving range of motion: a systematic review and meta-analysis. Healthcare (Basel).2021;9(4). [CrossRef] [PubMed]
7. Hayden JA, van Tulder MW, Malmivaara A, Koes BW. Exercise therapy for treatment of non-specific low back pain. Cochrane Database Syst Rev. 2005;2005(3):Cd000335. [CrossRef] [PubMed]
8. Shipton EA. Physical therapy approaches in the treatment of low back pain. Pain Ther. 2018;7(2):127-37. [CrossRef] [PubMed]
9. Chen Q, Wang Z, Zhang S. Mechanism, application and effect evaluation of nerve mobilization in the treatment of low back pain: A narrative review. Medicine (Baltimore). 2023;102(34):e34961. [CrossRef] [PubMed]
10. Alshami AM, Alghamdi MA, Abdelsalam MS. Effect of neural mobilization exercises in patients with low back-related leg pain with peripheral nerve sensitization: a prospective, controlled trial. J Chiropr Med. 2021;20(2):59-69. [CrossRef] [PubMed]
11. Zahid S, Nizami GN. Effectiveness of neural mobilization and stretching exercise for the management of sciatica. Pak. j. rehabil. 2014;3(2):11-5. [CrossRef]

12. Lin LH, Lin TY, Chang KV, Wu WT, Özçakar L. Neural mobilization for reducing pain and disability in patients with lumbar radiculopathy: a systematic review and meta-analysis. Life (Basel) .2023;13(12). [CrossRef] [PubMed]
13. Eladl HM, Ali OI, Abdelraouf OR, Ibrahim ZM, Bin Sheeha B, Alabas AM, et al. The additional effect of neurodynamic slump and suboccipital muscle inhibition to passive stretching of the short hamstring: a single-blind, randomized controlled trial. Healthcare (Basel). 2024;12(21). [CrossRef] [PubMed]
14. Kurt V, Aras O, Buker N. Comparison of conservative treatment with and without neural mobilization for patients with low back pain: A prospective, randomized clinical trial. J Back Musculoskelet Rehabil. 2020;33(6):969-75. [CrossRef] [PubMed]
15. Waldhelm A, Gacek M, Davis H, Saia C, Kirby B. Acute effects of neural gliding on athletic performance. Int J Sports Phys Ther .2019;14(4):603-12. [PubMed]
16. Goodyear MD, Krleza-Jeric K, Lemmens T. The declaration of Helsinki. BMJ. 29;335(7621):; 2007. p. 624-5. [CrossRef] [PubMed]
17. Sharma S, Balthillaya G, Rao R, Mani R. Short term effectiveness of neural sliders and neural tensioners as an adjunct to static stretching of hamstrings on knee extension angle in healthy individuals: A randomized controlled trial. Phys Ther Sport.2016;17:30-7. [CrossRef] [PubMed]
18. Balcı A, Ünüvar E, Akınoğlu B, Kocahan T. The effect of different neural mobilization exercises on hamstring flexibility and functional flexibility in wrestlers. J Exerc Rehabil.2020;16(6):503. [CrossRef] [PubMed]
19. Firdous S, Mehta Z, Fernandez C, Behm B, Davis M. A comparison of numeric pain rating scale (nprs) and the visual analog scale (vas) in patients with chronic cancer-associated pain. J Clin Oncol; 2017. [CrossRef]
20. Irmak R. Relatively short term test re-test reliability of neck disability index by long term test re-retest reliability method of oswestry disability index in healthy office workers. Work. 2019;64(3):635-40. [CrossRef] [PubMed]
21. Olivencia O, Godinez GM, Dages J, Duda C, Kaplan K, Kolber MJ. The reliability and minimal detectable change of the Ely and active knee extension tests Int J Sports Phys Ther.2020;15(5):776. [CrossRef] [PubMed]
22. Gültekin H, Bayram D, Yüksel GA, Bayram T, Tireli H. Assessment of modified-modified schober test and lomber range of motion in patients with parkinson's disease with and without low back pain. Turk nörol. derg. 2022;28(1). [CrossRef]
23. Baptista FM, Cruz EB, Afreixo V, Silva AG. Effectiveness of neural mobilization on pain intensity, disability, and physical performance in adults with musculoskeletal pain-A protocol for a systematic review of randomized and quasi-randomized controlled trials and planned meta-analysis. PloS one. 2022;17(3):e0264230. [CrossRef] [PubMed]
24. Krishna H, Sreejisha P, Dhote C. Comparison between immediate effect of neural mobilization and myofascial release of suboccipital muscle on hamstring length in younger adults-an interventional study. injury. 6:10. [CrossRef]
25. Lim J-y, Lee I-w, Kim K-d. Immediate Effects of Neural Slider and Neural Tensioner on Forward Bending in Subjects with Hamstring Tightness. J. musculoskelet. sci. technol. 2021;5(1):6-13. [CrossRef]
26. Castellote-Caballero Y, Valenza MC, Puentedura EJ, Fernández-de-Las-Peñas C, Alburquerque-Sendín F. Immediate effects of neurodynamic sliding versus muscle stretching on hamstring flexibility in subjects with short hamstring syndrome. J Sports Med (Hindawi Publ Corp) .2014;2014. [CrossRef] [PubMed]
27. Bunales I, Geraldizo J, Zabielski C, Enriquez C. Determining the relationship between hamstring flexibility and low back pain a correlational study. [CrossRef]
28. Neto T, Freitas SR, Marques M, Gomes L, Andrade R, Oliveira R. Effects of lower body quadrant neural mobilization in healthy and low back pain populations: a systematic review and meta-analysis. Musculoskelet Sci Pract. 2017;27:14-22. [CrossRef] [PubMed]
29. Romero-Morales C, Calvo-Lobo C, Rodríguez-Sanz D, López-López D, Antolín MS, Mazoteras-Pardo V, et al. Chapter 46 - Effectiveness of neural mobilization on pain and disability in individuals with musculoskeletal disorders. In: Rajendram R, Patel VB, Preedy VR, Martin CR, editors. Treatments, Mechanisms, and Adverse Reactions of Anesthetics and Analgesics: Academic Press; 2022. p. 555-64. [CrossRef]

https://doi.org/10.52567/trehabj.v9i02.107