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Effects of Core Stability Exercise and Lumbar Rotation Manipulation: A Quasi-Experimental Study

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Abstract
Background: Myogenic low back pain is a common occupational musculoskeletal condition associated with reduced lumbar flexibility and functional mobility. Exercise-based and manual therapy interventions are widely applied; however, comparative evidence in physically demanding work settings remains limited.
Objective: To compare the effects of Core Stability Exercise (CSE) and Lumbar Rotation Manipulation (LRM) on lumbar flexibility and pain intensity in workers with myogenic low back pain.
Methods: A quasi-experimental pre–post two-group study was conducted among 30 workers at the Fish Smoking Center in Bandarharjo, Semarang. Participants were allocated to either the CSE group (n = 15) or the LRM group (n = 15). Pain intensity was measured using the Visual Analogue Scale (VAS), and lumbar flexibility was assessed using the Schober Test. Paired t-tests were used for within-group analyses, and independent t-tests compared change scores (Δ = post–pre) between groups.
Results: Both groups demonstrated significant improvements in lumbar flexibility ($p < 0.001$). The CSE group showed an increase in Schober scores from 3.45 ± 0.32 to 4.89 ± 0.45, while the LRM group improved from 3.42 ± 0.32 to 5.43 ± 0.42. No significant within-group reductions in pain intensity were observed in either group. Between-group comparisons revealed significant differences in change scores for lumbar flexibility and pain intensity ($p < 0.001$).
Conclusion: CSE and LRM effectively improved lumbar flexibility but did not produce meaningful short-term pain reduction. Longer intervention durations or multimodal physiotherapy approaches may be required to achieve clinically relevant analgesic outcomes.

Keywords
core stability exercise; lumbar rotation manipulation; myogenic low back pain; lumbar flexibility; Schober Test; Visual Analogue Scale.

Introduction

Myogenic low back pain is a prevalent musculoskeletal disorder characterized by nociceptive pain originating from excessive mechanical loading of the paraspinal muscles and surrounding soft tissues.[1] It commonly arises in individuals exposed to non-ergonomic postures, repetitive trunk movements, or prolonged static positions, leading to muscle fatigue, ischemia, and protective spasms that restrict lumbar mobility.[2,3] This condition is frequently observed among workers engaged in physically demanding or repetitive manual tasks, where biomechanical stress accumulates throughout daily activities and contributes to persistent functional limitations.[3] Recent studies have emphasized that muscle imbalance, reduced activation of deep stabilizers, and inadequate neuromuscular control play important roles in the development and perpetuation of myogenic low back pain, further compromising lumbar flexibility and functional efficiency.[4–6]

Clinically, myogenic low back pain is distinguished from discogenic or neuropathic sources by its localized, movement-related discomfort and muscle tenderness.[7,8] Altered recruitment patterns in core musculature, particularly the transversus abdominis and multifidus, may diminish spinal stability and increase the likelihood of recurrent symptoms.[9] In addition, workplace-related factors—including posture, repetitive lifting, load handling, age, and body mass index—have been consistently identified as contributors to lumbar musculoskeletal strain.[3] In occupational groups with high physical demands, such as traditional laborers, ergonomic risks are frequently unaddressed, resulting in elevated rates of musculoskeletal complaints.[3]

Physiotherapy interventions for myogenic low back pain commonly incorporate therapeutic exercise and manual therapy to restore spinal mobility, improve neuromuscular control, and reduce pain. Core Stability Exercise (CSE) aims to enhance activation and coordination of deep trunk musculature, supporting spinal alignment and movement efficiency.[9,10] Conversely, Lumbar Rotation Manipulation (LRM) applies high-velocity, low-amplitude thrusts to improve segmental mobility, reduce joint restrictions, and decrease muscle guarding through mechanical and neurophysiological mechanisms.[11,12] Both interventions are widely used in clinical practice, and empirical evidence suggests that they may enhance lumbar range of motion. However, the magnitude and duration of their effects may differ across patient populations and clinical contexts.[13]

Although previous research has demonstrated the benefits of stabilization exercises and spinal manipulation, comparative evidence for their effectiveness in occupational populations remains limited. Most existing studies have focused on clinical or recreational cohorts, with few addressing workers who experience repetitive mechanical stress as part of their daily job demands. Occupational groups may respond differently to physiotherapy interventions due to persistent exposure to physical workloads, which could attenuate pain relief or limit functional recovery. Moreover, the majority of available studies have not directly compared exercise-based and manipulation-based approaches within the same population using reproducible intervention protocols.

In Indonesia, research examining physiotherapy interventions for myogenic low back pain in traditional labor settings remains scarce. Workers in industries such as fish processing, agriculture, and small manufacturing often perform tasks involving forward bending, lifting, and sustained trunk flexion, placing them at elevated risk for developing recurrent musculoskeletal disorders.[3] Despite this high-risk profile, there is a notable absence of studies evaluating whether exercise-based interventions like CSE or manual therapy approaches such as LRM provide meaningful improvements in pain or mobility in this specific population.[14,15] The lack of locally contextualized evidence limits clinicians' ability to select the most appropriate and effective intervention strategies for workers experiencing myogenic low back pain.

This gap highlights the need for research comparing the effects of CSE and LRM on clinically relevant outcomes—specifically lumbar flexibility and pain intensity—within occupational settings. Understanding how these two interventions differ in their short-term effects may inform physiotherapy management strategies that better address the functional demands and ergonomic risks faced by workers.

Therefore, the present study aims to compare the effects of Core Stability Exercise and Lumbar Rotation Manipulation on lumbar flexibility and pain intensity among workers with myogenic low back pain at a traditional fish-smoking center in Indonesia. The primary outcome is lumbar flexibility, measured using the Schober Test, and the secondary outcome is pain intensity, assessed using the Visual Analogue Scale.

We hypothesized that both interventions would lead to significant improvements in lumbar flexibility, while reductions in pain intensity would be less pronounced over the short two-week intervention period. Additionally, we hypothesized that the magnitude of improvement might differ between groups due to the distinct biomechanical and neuromuscular mechanisms associated with each intervention.

Methods

This study employed a quasi-experimental pre–post two-group design to compare the effects of Core Stability Exercise (CSE) and Lumbar Rotation Manipulation (LRM) on lumbar flexibility and pain intensity among workers with myogenic low back pain. A quasi-experimental design was selected because random allocation was not feasible within the operational constraints of the workplace. The study enabled evaluation of within-group changes over time as well as between-group differences in the magnitude of improvement.

The study was conducted at the Fish Smoking Center in Bandarharjo, Semarang, involving a population of 133 workers. Recruitment occurred through workplace announcements and physiotherapy screening sessions. Eligible workers were assessed through structured interviews, musculoskeletal screening, and administration of the Nordic Body Map questionnaire to identify musculoskeletal complaints consistent with myogenic low back pain.

Participants were included if they were between 40 and 60 years of age, had worked at the Fish Smoking Center for at least one year, and presented with clinical features of myogenic low back pain. The clinical presentation was defined as a localized dull ache without radicular symptoms, tenderness on palpation of the lumbar paraspinal muscles, and a symptom duration of at least one week. Individuals were also required to be able to follow exercise or manual therapy instructions. Participants were excluded if they exhibited signs of discogenic or neuropathic pain, such as radiating symptoms or a positive Straight Leg Raise test, or if they had a history of lumbar fracture, spinal surgery, or suspected spinal instability. Additional exclusion criteria included severe cardiopulmonary disease that contraindicated participation in exercise or manipulation, current physiotherapy or analgesic treatment, and pregnancy.

Of the 133 workers screened, 30 met the inclusion criteria and consented to participate. No participants withdrew or were lost to follow-up. Allocation to the CSE or LRM group (n = 15 each) was based on work schedule compatibility and participant availability, a common procedure in field-based quasi-experimental designs. Although practical, this non-random allocation introduced potential selection bias, acknowledged as a study limitation.

The interventions consisted of two distinct physiotherapy protocols delivered over a two-week period. The Core Stability Exercise (CSE) program was designed to activate deep trunk stabilizers and enhance neuromuscular control. Sessions were administered individually by a licensed physiotherapist three times per week, with each session lasting approximately 20–25 minutes. The exercise sequence included abdominal bracing, pelvic tilting, bridge exercises, bird–dog exercises, and a modified side plank. For most exercises, participants performed three sets of ten repetitions, while the modified side plank was held for three sets of twenty seconds per side. Progression was implemented by increasing hold duration or the number of repetitions based on individual tolerance. These exercises specifically targeted the transversus abdominis, multifidus, obliques, and global stabilizers to improve spinal control and lumbar flexibility.

The Lumbar Rotation Manipulation (LRM) protocol employed a standardized high-velocity low-amplitude thrust technique delivered by a trained manual therapist. Sessions occurred three times per week for approximately 10–15 minutes. During manipulation, participants were positioned in a side-lying posture with the upper body counter-rotated relative to the pelvis, followed by segmental locking at lumbar levels L3–L5 and the application of an HVLA rotational thrust to the restricted segment. Two to three thrusts were administered per session depending on participant comfort. This intervention aimed to restore segmental mobility, decrease muscle guarding, and enhance overall lumbar motion.

Outcome measures included pain intensity and lumbar flexibility. Pain intensity was assessed using the Visual Analogue Scale (VAS), a 10 cm line anchored with "no pain" and "worst pain imaginable," which is widely validated for musculoskeletal conditions and demonstrates strong test–retest reliability. Lumbar flexibility was evaluated using the Schober Test, a clinical measure that quantifies lumbar flexion by recording the change in distance between two marked anatomical points during forward bending. The Schober Test exhibits high reliability, with intraclass correlation coefficients exceeding 0.85. All measurements were conducted at baseline (pre-test) and after the two-week intervention (post-test), and a single trained examiner performed all assessments to minimize variability.

Participants who met the eligibility criteria completed baseline assessments before being assigned to either the CSE or LRM group. Interventions were delivered according to standardized protocols under physiotherapist supervision in a designated area at the workplace. Participants were advised to maintain their usual work routines but not to initiate new exercise or treatment programs during the study period. Upon completion of six intervention sessions across two weeks, all participants underwent post-test evaluations using identical procedures to those administered at baseline.

The sample size was determined by the number of eligible and available workers during the recruitment period. Because formal sample size estimation or power analysis was not performed, the relatively small sample represents a methodological limitation that may reduce sensitivity for detecting smaller changes, particularly in pain outcomes.

Statistical analyses were performed using SPSS version 27. The Shapiro–Wilk test was used to assess data normality, and continuous variables were summarized as mean ± standard deviation. Within-group changes from pre-test to post-test were evaluated using paired t-tests, while between-group differences were examined using independent t-tests applied to change scores (Δ = post–

pre) to account for baseline variability, following best practices for quasi-experimental research. The significance threshold was set at α = 0.05. Effect sizes and confidence intervals were not computed due to the limitations of the original dataset, although future studies are encouraged to include these metrics.

This study involved non-invasive procedures and posed minimal risk to participants. In accordance with institutional guidelines, this type of exercise-based quasi-experimental research did not require formal ethical approval. All procedures were conducted in compliance with ethical principles for human subjects research, and all participants provided written informed consent prior to participation.

Results

A total of 30 participants met the eligibility criteria and completed all procedures in the study. No missing data, protocol deviations, or dropouts occurred during the two-week intervention period. All outcome measures were successfully obtained at baseline and post-intervention. The flow of participants through screening, eligibility assessment, and group allocation ensured complete data for analysis.

Table 1 presents the demographic and anthropometric characteristics of the participants. Both groups exhibited comparable distributions in age, sex, years of work experience, and body mass index categories. Although no statistical tests for baseline comparability were performed due to the relatively small sample size, descriptive values indicated no substantial imbalances between the groups.

Table 1. Participant Characteristics (n = 30)

Variable	Category	CSE n (%)	LRM n (%)
Age (years)	40–45	7 (46.7%)	7 (46.7%)
	46–50	3 (20.0%)	3 (20.0%)
	51–55	1 (6.7%)	3 (20.0%)
	56–60	4 (26.7%)	2 (13.3%)
Sex	Male	9 (60.0%)	5 (33.3%)
	Female	6 (40.0%)	10 (66.7%)
Work Experience (years)	1–5	7 (46.7%)	9 (60.0%)
	6–10	8 (53.3%)	6 (40.0%)
BMI Category	Underweight (<18.5 kg/m²)	2 (13.3%)	1 (6.6%)
	Normal (18.5–22.9 kg/m²)	6 (40.0%)	10 (66.8%)
	Overweight (23–24.9 kg/m²)	4 (26.7%)	1 (6.6%)
	Obesity I (25–29.9 kg/m²)	3 (20.0%)	3 (20.0%)
	Obesity II (≥30 kg/m²)	0 (0%)	0 (0%)

Normality testing using the Shapiro–Wilk test indicated that all variables were normally distributed (p > 0.05), allowing the use of parametric analysis. Table 2 presents the pre-test and post-test mean values for pain intensity (VAS) and lumbar flexibility (Schober Test), along with the change scores (Δ = post–pre) and corresponding paired t-test results for each group. The CSE group demonstrated an increase in VAS scores and a substantial improvement in Schober Test values. Similarly, the LRM group showed increased VAS scores and improved lumbar flexibility. Paired t-tests showed that both groups exhibited statistically significant improvements in lumbar flexibility, while changes in pain intensity were not statistically significant.

Table 2. Within-Group Comparison (Paired t-test)

Outcome	Group	Pre-test Mean ± SD	Post-test Mean ± SD	Δ (Post–Pre) Mean ± SD	p-value
VAS	CSE	3.13 ± 1.32	4.13 ± 2.29	+1.00 ± 1.77	0.499
VAS	LRM	3.13 ± 1.93	3.80 ± 2.47	+0.67 ± 1.79	0.876
Schober	CSE	3.45 ± 0.32	4.89 ± 0.45	+1.44 ± 0.32	<0.001
Schober	LRM	3.42 ± 0.32	5.43 ± 0.42	+2.01 ± 0.33	<0.001

To minimize the effect of baseline differences, between-group comparisons were conducted using independent t-tests applied to change scores (Δ). Table 3 summarizes the results. Between-group differences were statistically significant for both outcomes (p < 0.001). The LRM group demonstrated a larger mean improvement in Schober scores, whereas mean differences in VAS scores were small but statistically significant. These statistical differences are numerical findings only; interpretation is presented in the Discussion section.

Table 3. Between-Group Comparison of Δ Scores (Independent t-test)

Outcome	Δ CSE (Mean ± SD)	Δ LRM (Mean ± SD)	Mean Difference	p-value
VAS	+1.00 ± 1.77	+0.67 ± 1.79	−0.33	<0.001
Schober	+1.44 ± 0.32	+2.01 ± 0.33	−0.57	<0.001

The main numerical findings of the study indicated that both the CSE and LRM groups demonstrated statistically significant improvements in lumbar flexibility, with p-values less than 0.001 for each intervention. In contrast, neither group showed statistically significant reductions in pain intensity as measured by VAS scores. Between-group comparisons of change scores revealed significant numerical differences for both outcomes, also with p-values below 0.001. All participants completed the full intervention protocol and both assessment sessions without deviation, and no adverse events were reported throughout the study period.

Discussion

The present study aimed to compare the effects of Core Stability Exercise (CSE) and Lumbar Rotation Manipulation (LRM) on lumbar flexibility and pain intensity in workers with myogenic low back pain. The findings indicated that both interventions produced significant improvements in lumbar flexibility, whereas neither resulted in statistically significant reductions in pain within their respective groups. Between-group comparisons of change scores (Δ) demonstrated statistically significant numerical differences for both outcomes; however, these findings require careful interpretation given the study design and the absence of significant within-group analgesic effects.

Neither CSE nor LRM resulted in significant reductions in pain intensity, despite both groups showing slight increases in mean VAS scores at post-test. These findings are consistent with research indicating that short-term physiotherapy interventions may be insufficient to produce measurable analgesic effects in populations experiencing persistent mechanical loading. Myogenic pain often arises from sustained muscular tension, ischemia, and local sensitization, which typically respond to extended treatment durations or multimodal interventions rather than isolated modalities administered over short periods.[16,17] Previous studies have shown mixed results, with some reporting meaningful pain reductions after several weeks of structured exercise or manual therapy, while others—particularly those involving occupational groups exposed to ongoing physical strain—demonstrated limited short-term improvements.[18,19]

The lack of significant pain reduction observed in the present study may also be attributed to continuous exposure to workplace demands. Workers at a traditional fish-smoking center routinely perform repetitive trunk flexion, forward bending, and load handling activities, all of which impose ongoing biomechanical stress on the lumbar musculature. Persistent exposure may hinder physiological recovery and limit the effectiveness of short-duration interventions. Additionally, neither intervention addressed ergonomic factors, which are known to influence both the onset and persistence of low back pain symptoms. Without modification of workplace postures or mechanical loads, therapeutic gains—particularly in relation to pain—may remain modest.

Moreover, the small sample size may have reduced the statistical power to detect clinically meaningful changes in pain. Pain is a multidimensional experience influenced not only by biomechanics but also by psychosocial and environmental factors. Variability in pain perception among participants could have contributed to wide standard deviations, reducing the likelihood of detecting significant changes over time.

Both groups demonstrated statistically significant improvements in lumbar flexibility, with the LRM group exhibiting a larger mean increase in Schober scores. This finding aligns with mechanistic theories underlying both interventions. CSE enhances neuromuscular control and activation of deep stabilizing muscles, facilitating improved spinal alignment and movement efficiency. Greater activation of the transversus abdominis, multifidus, and synergistic trunk muscles reduces compensatory guarding and allows increased lumbar excursion during flexion.[20,21]

LRM, in contrast, typically produces immediate mechanical effects by reducing joint restrictions, mobilizing hypomobile segments, and decreasing reflexive muscle guarding. High-velocity low-amplitude thrusts can induce cavitation and rapid changes in joint stiffness, resulting in instantaneous increases in segmental mobility.[22,23] These mechanisms explain the larger Δ flexibility values observed in the LRM group. While statistical comparisons indicated significant between-group differences, the clinical implications must be interpreted cautiously, as the present study did not include long-term follow-up to determine whether mobility gains persisted beyond the immediate post-intervention period.

The findings of this study are partially consistent with prior research. Previous investigations have demonstrated that stabilization exercises can improve lumbar flexibility and trunk control, particularly when administered over several weeks.[24] However, studies involving manual therapy have often reported quicker gains in mobility due to the immediate mechanical effects of manipulation.[25] In the context of pain outcomes, some studies have reported reductions following CSE or LRM, but these typically involve longer intervention durations or multimodal physiotherapy programs. The present results align with studies showing minimal short-term analgesic effects in occupational populations exposed to repetitive mechanical stress.

Additionally, research comparing exercise-based and manipulation-based interventions has yielded mixed findings, with some studies favoring stabilization exercises for long-term outcomes and others highlighting the immediate but transient benefits of spinal manipulation.[26] The variability in findings across studies underscores the complexity of musculoskeletal pain and the influence of population-specific characteristics.

The results of this study suggest that both CSE and LRM may be considered effective modalities for improving lumbar flexibility in individuals with myogenic low back pain. Improvements in flexibility may support increased movement tolerance and functional efficiency during daily activities. However, clinicians should not expect significant short-term reductions in pain when these interventions are delivered in isolation over brief durations.

Given the absence of notable pain improvements, practitioners may consider incorporating longer treatment periods, greater frequency of sessions, or multimodal approaches that combine exercise, manual therapy, postural retraining, and ergonomic modification. In occupational populations such as the workers in this study, addressing workplace demands is essential for translating improvements in mobility into meaningful reductions in pain and functional limitations.

This study offers several strengths. First, it was conducted in a real-world occupational environment, enhancing ecological validity and supporting the applicability of findings to similar settings. Second, the study achieved complete participant retention with no missing data, strengthening the reliability of the results. Third, the use of validated outcome measures—with high reliability for musculoskeletal assessment—supports the credibility of the observed changes. Finally, the direct comparison of two commonly used physiotherapy interventions provides useful insights for clinical decision-making.

Despite its strengths, the study has notable limitations. The quasi-experimental design and non-random allocation introduce potential selection bias, limiting causal inference. The relatively small sample size (n = 15 per group) reduces statistical power, particularly for detecting subtle changes in pain. The short two-week intervention period may have been insufficient to elicit meaningful analgesic effects, given the chronicity and mechanical nature of myogenic low back pain. Additionally, the study did not control for confounding variables such as daily workload, ergonomic exposure, sleep quality, psychosocial factors, or comorbidities. The absence of follow-up assessments prevents evaluation of long-term outcomes or sustainability of therapeutic effects. Finally, outcome assessors were not blinded, potentially introducing measurement bias.

Future investigations should incorporate randomized controlled designs with larger sample sizes to increase methodological rigor and improve generalizability. Longer intervention durations and structured ergonomic programs are recommended to more fully evaluate pain outcomes. The inclusion of additional outcome measures, such as functional disability indices, patient-reported outcomes, and biomechanical assessments, may provide a more comprehensive understanding of intervention effects. Longitudinal follow-up is essential to determine whether improvements in flexibility persist and whether they translate into sustained reductions in pain and functional limitations.

Conclusion

This study compared the effects of Core Stability Exercise (CSE) and Lumbar Rotation Manipulation (LRM) on lumbar flexibility and pain intensity in workers with myogenic low back pain. Both interventions resulted in significant improvements in lumbar flexibility over the two-week period, indicating that each modality can effectively enhance spinal mobility in occupational populations exposed to repetitive mechanical demands. The LRM group demonstrated a larger mean improvement in flexibility, which aligns with the expected immediate mechanical effects of spinal manipulation; however, both interventions produced clinically relevant gains.

In contrast, neither intervention led to significant reductions in pain intensity within their respective groups. The absence of notable analgesic effects suggests that short-term application of CSE or LRM alone may be insufficient to address pain arising from persistent muscular tension and ongoing biomechanical loading in the workplace. These findings highlight the need for longer treatment durations, ergonomic adjustments, or multimodal physiotherapy approaches when targeting pain outcomes in individuals with myogenic low back pain.

Between-group comparisons of change scores showed statistically significant numerical differences for both outcomes, yet these results should be interpreted with caution due to the non-randomized design, small sample size, and potential baseline variability. Accordingly, the present study does not provide definitive evidence of superiority for either intervention with respect to pain reduction.

Overall, both CSE and LRM may serve as valuable components of physiotherapy programs aimed at improving lumbar flexibility. Future research employing randomized designs, larger samples, extended intervention periods, and long-term follow-up is recommended to better determine comparative effectiveness and to inform clinical decision-making in occupational settings.

Author Contribution

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Conflict of Interest Statement

The authors declare no conflict of interest.

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Ethics Statement

This study involved minimal-risk procedures and, in accordance with institutional policies, did not require formal ethical approval for non-invasive, exercise-based quasi-experimental research. All participants provided written informed consent prior to data collection.

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