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Efficacy of Dynamic Neuromuscular Stabilization with Hip Strengthening Exercises on Pain, Range of Motion, and Kinesiophobia in Older Women with Chronic Low Back Pain

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ABSTRACT

Aims: This study aimed to evaluate the efficacy of Dynamic Neuromuscular Stabilization (DNS) combined with hip strengthening exercises on pain, Range of Motion (ROM), and kinesiophobia in older women with chronic low back pain.

Method and Materials: Thirty-two older women with Chronic Low Back Pain (CLBP) participated and were randomly assigned to either the DNS or DNS with hip strengthening (DNSH) exercise groups. Both groups received training over eight weeks. Lumbar ROM was assessed using a tape measure, pain was measured using the Visual Analog Scale (VAS), and kinesiophobia was evaluated using the Tampa Scale for Kinesiophobia.

Findings: Significant intergroup differences were found in lumbar flexion and extension ROM, with greater improvements in the combined group ($p < 0.05$). No significant differences occurred in pain or kinesiophobia ($p > 0.05$). Both groups demonstrated significant improvements from pre- to post-measures in all aspects ($p < 0.01$).

Conclusion: Combining DNS with hip strengthening exercises effectively enhances lumbar ROM in older women with CLBP, offering a practical approach for improving mobility. While pain and kinesiophobia improvements were comparable across groups, this combined intervention can be prioritized for mobility-focused rehabilitation programs.

Keywords: Chronic Low Back Pain, Elderly Women, Hip Strengthening, Range of Motion

Introduction

Chronic Low Back Pain (CLBP) is a prevalent condition among older women, with its incidence increasing with age, particularly in those with sedentary lifestyles [(1)]. This condition imposes significant economic and social burdens, including reduced functional capacity, increased healthcare costs, and diminished Quality of Life (QoL), necessitating targeted rehabilitation strategies [(2)].

Biomechanical impairments, including restricted lumbar Range Of Motion (ROM), pain, and kinesiophobia, significantly influence CLBP in older women [(3)]. Research indicates that kinesiophobia, or the fear of movement, correlates strongly with impaired lumbar joint position sense and increased disability in this demographic. The interplay between these factors exacerbates the pain experience and limits functional mobility [(4)]. Pain often reduces physical activity, leading to muscular imbalances characterized by over activation of superficial muscles and weakening of core stabilizers [(5)]. These imbalances impair core muscle strength, limit lumbar ROM, and reduce proprioception, exacerbating disability [(6)]. Restricted lumbar ROM can also induce compensatory movements in adjacent structures, increasing mechanical stress and perpetuating lumbar dysfunction. The lumbo-pelvic-hip complex plays a critical role in chronic low back pain management for older women. Limited hip joint mobility, particularly in extension and abduction, is common and often results in excessive lumbar spine movement as a compensatory mechanism [(7)]. Reduced hip ROM, coupled with hamstring tightness, hip joint pain, morning stiffness, and weakness in surrounding muscles, contributes to lumbo-pelvic dysfunction [8, 9]. The gluteal muscles, including the gluteus maximus and medius, are crucial for maintaining pelvic stability and transferring force during dynamic tasks. Impaired gluteal function can lead to compensatory anterior pelvic tilt, altering lumbar spine activation patterns and increasing mechanical stress, particularly in older women due to age-related muscle decline [10, 11]. Reduced hip extension, often caused by shortened hip flexors, increases lumbar extensor activity, resulting in early muscle fatigue, reduced protection against shear forces, and impaired postural control [12, 13].

Kinesiophobia, a psychosocial factor, significantly influences chronic low back pain in older women [14]. Negative pain beliefs reinforce movement avoidance, fostering pessimistic expectations and contributing to disability [15]. Effective rehabilitation must address both biomechanical impairments and kinesiophobia to optimize functional outcomes.

Exercise-based interventions are a cornerstone of chronic low back pain management in sports rehabilitation [16]. Dynamic Neuromuscular Stabilization (DNS), grounded in developmental kinesiology, restores natural movement patterns by replicating early developmental postures and optimizing core and diaphragmatic function [17]. Inefficient core and diaphragmatic function can increase spinal compressive forces due to compensatory activation of superficial spinal extensors, a common issue in older women with chronic low back pain [18]. While core stability training strengthens the lumbar region, it may not fully address lumbopelvic hip dysfunctions, given their interconnected biomechanics. Integrating hip-strengthening exercises with DNS may enhance outcomes by targeting gluteal and hip muscle deficits, improving pelvic stability, and reducing compensatory lumbar stress.

Limited research has evaluated the combined efficacy of DNS and hip strengthening exercises compared to DNS alone for chronic low back pain in older women. This study addresses this gap by investigating the effects of adding hip-strengthening exercises to DNS on pain, lumbar ROM, and kinesiophobia. We hypothesize that DNS combined with hip strengthening exercises will significantly reduce pain, improve lumbar ROM, and decrease kinesiophobia compared to DNS alone in older women with chronic low back pain.

Method and Materials

This 8-week, double-blind, randomized controlled trial (RCT) was conducted at the Sports Science Laboratory of Bu-Ali Sina University, Hamedan, Iran, from October 1 to November 26, 2024. The study adhered to the CONSORT guidelines for transparent reporting of trial design, randomization, blinding, and participant flow (Figure 1).

Thirty-two older women with CLBP were recruited in Hamedan province, Iran, using convenience sampling through referrals to treatment clinics and physician confirmation. Participants underwent a medical screening by a physician to confirm eligibility based on the inclusion and exclusion criteria, and provided written informed consent before enrollment. The inclusion criteria were age 60–80 years, chronic low back pain for at least 3 months (as indicated by a VAS score >3), and the ability to perform activities of daily living independently, as evaluated using the Barthel Index. Exclusion criteria included non-completion of the corrective exercise program, voluntary withdrawal, severe pain conditions limiting exercise capacity, or a body mass index (BMI) greater than 35, selected to minimize exercise-related complications.

The sample size was calculated using G*Power 3.1, based on pain scores from previous study with an effect size of 1.25 for the pain variable [19], α = 0.05, and power = 0.95, requiring a minimum of 24 participants (12 per group). To account for potential dropouts, 16 participants were allocated to each group. Participants were randomly assigned to either the DNS group (n = 16) or the DNS with Hip Strengthening (DNSHS) group (n = 16) in a 1:1 ratio using a computer-generated random sequence via a Random Number Generator. Allocation concealment was achieved through the use of sequentially numbered, sealed, and opaque envelopes prepared by an independent researcher not involved in the study's execution or data collection. Participants and outcome assessors remained blinded to group assignments during baseline and post-intervention assessments. An independent evaluator, distinct from the intervention trainers, performed all measurements to uphold blinding integrity.

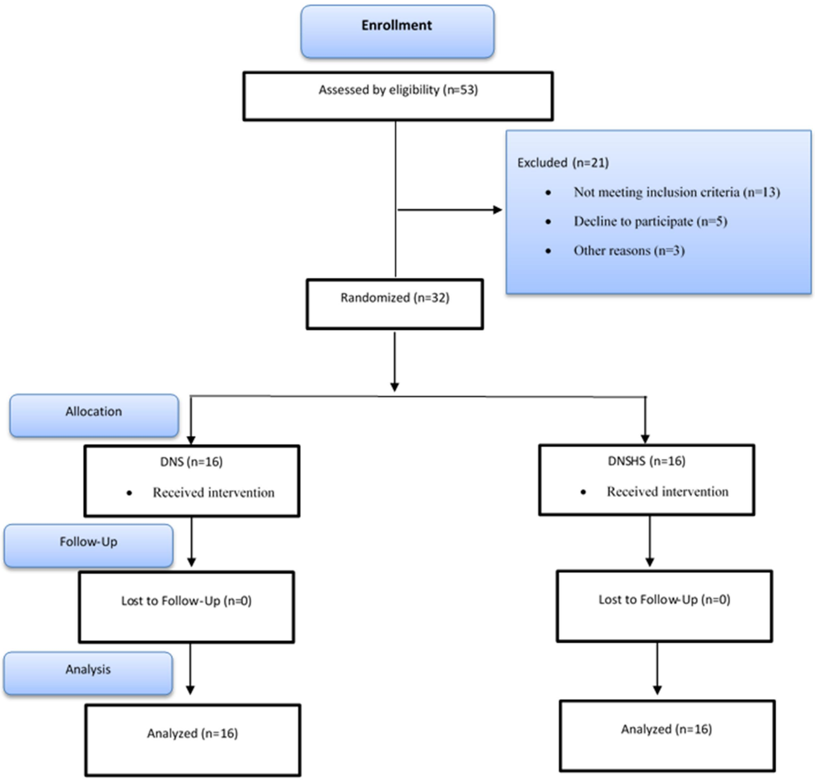
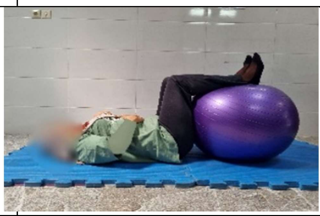


Figure 1) CONSORT flowchart diagram of the study

The 8-week intervention consisted of three 60-minute sessions per week for the DNS group and five 60-minute sessions per week for the DNSHS group (comprising three DNS sessions and two hip strengthening sessions on separate days), supervised by certified rehabilitation specialists. Each session included a 5-minute warm-up (gentle stretches and mobility exercises tailored for geriatric populations), a main exercise phase (50 minutes for DNS sessions, 30 minutes for hip strengthening sessions), and a ۵-minute cool-down (relaxation techniques and gentle stretches to reduce muscle tension). Exercises were designed to be simple, safe, and tailored to participants' physical capacities, with modifications applied based on individual limitations and verbal feedback to prevent fatigue and ensure safety. No assistive devices were used. No adverse events were reported during the intervention, and participant feedback was monitored to ensure the program's tolerability and safety.

Both groups performed the DNS protocol to enhance core stability and motor control through diaphragmatic breathing and progressive positional exercises (Figure 2). Initial sessions used verbal instructions and anatomical visuals to teach proper diaphragmatic breathing techniques. Exercises progressed from basic positions to more complex postures over the 8 weeks, with intensity adjusted based on verbal feedback and specialist supervision. The protocol consisted of three sets: Set 1 (10 repetitions, 1-second inhalation, 2-second exhalation, 60–90 seconds rest), Set 2 (15 repetitions, 2-second inhalation, 4-second exhalation, 60–90 seconds rest), and Set 3 (20 repetitions, 3-second inhalation, 6-second exhalation, 120–150 seconds rest). Modifications, such as reducing repetitions or simplifying positions, ensured accessibility for all participants [20, 21].

The DNSHS group performed additional gluteal and hip strengthening exercises in two separate 40-minute sessions per week, on days distinct from DNS sessions, to enhance pelvic stability and support spinal alignment. The main exercise phase (30 minutes) consisted of exercises such as clamshell, donkey kick, single-leg bridge, hip abduction, and double-leg bridge with a ball, performed in three sets of 10–15 repetitions with 30–40 seconds of rest between sets (Figure 3). Resistance was progressively increased using body weight or light resistance bands, adjusted based on verbal feedback and specialist supervision. Modifications, such as reducing the ROM, decreasing repetitions, or providing support, were applied for participants with limited mobility or strength [22].

Exercise	Level 1	Level 2	Level 3
Lying on Back 90-90			
Prone Lying			
Rolling			
Kneeling			
Sit Incline			
Tripod			
Squats			

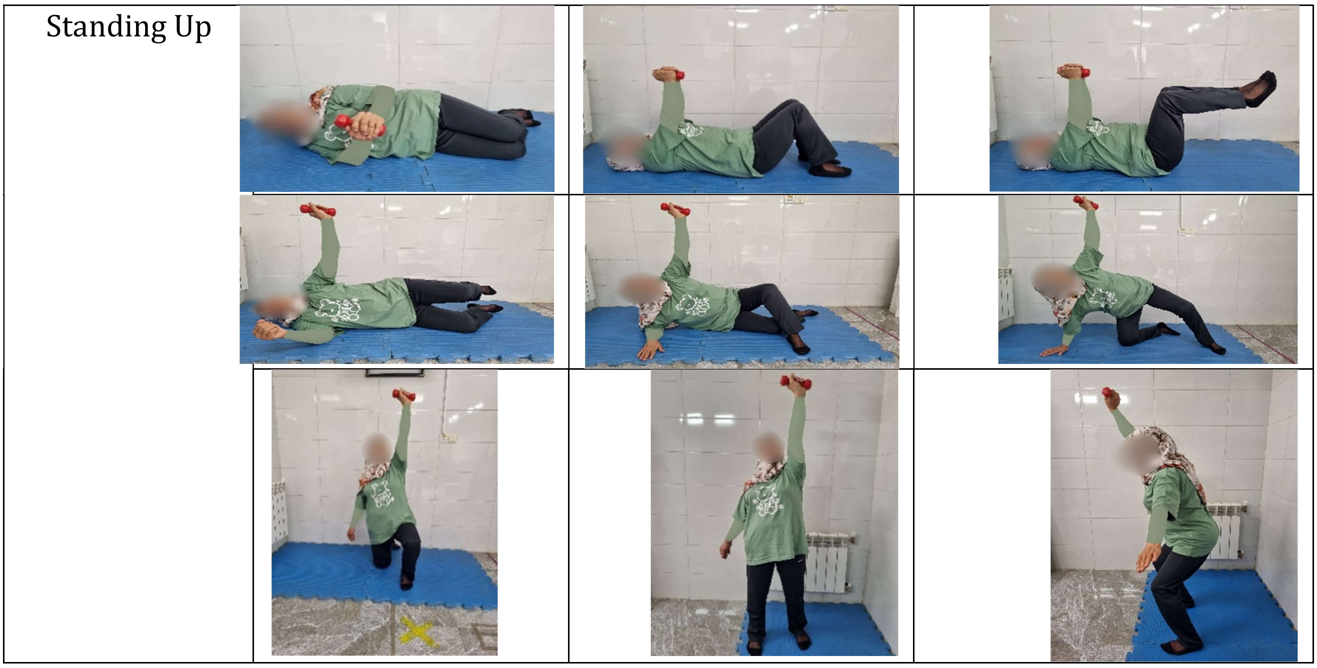


Fig 2) DNS exercises

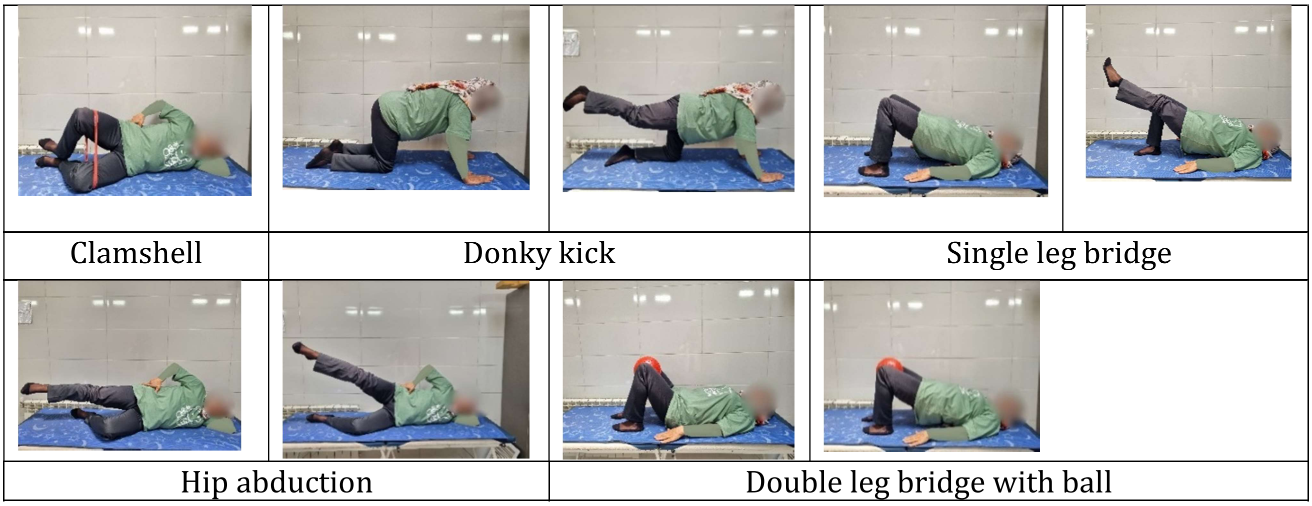


Fig 3) Hip Strengthening Exercises

Pain intensity and fear of movement were assessed as primary outcomes, while lumbar flexion and extension ROM were secondary outcomes. Measurements were conducted 48 hours before the first session and 48 hours after the 24th session by a trained assessor between 9:00 and 12:00 AM in a sports science laboratory of Bu-Ali Sina University.

The intensity of low back pain was assessed using a self-reported Visual Analog Scale (VAS). Participants marked a point on a 10-cm linear scale to indicate their pain level, with scores ranging from 0 (no pain) to 10 (worst possible pain). Higher scores indicated greater pain intensity [23].

The fear of pain during movement was evaluated using the Tampa Scale for Kinesiophobia (TSK-17). This 17-item psychological questionnaire assesses variables related to fear, movement, and re-injury in relation to an individual's pain. Scores range from 17 to 68, with higher scores indicating greater fear of movement and lower scores reflecting less fear [24]. The scale has demonstrated significant validity and reliability in individuals with chronic low back pain [25].

Lumbar flexion and extension ROM were assessed using a standardized method. The examiner placed their thumb on the participant's posterior superior iliac spine (PSIS) and marked a horizontal line along the midline of the lumbar spine at the PSIS level as the lower marker, with a second marker placed 15 cm above. For flexion, participants actively flexed their trunk without increasing pain, and the distance between markers was measured [26, 27]. For extension, participants placed their hands on their hips and actively extended their trunk, with the distance between markers re -measured [27]. The extent of lumbar flexion and extension was calculated as the difference between the initial distance and the distance in the flexed or extended position, measured using a ruler. Three measurements were taken for each movement, and the mean value was calculated to ensure reliability [28].Descriptive and inferential statistical methods were used to analyze the data. The normality of data distribution was assessed using the Shapiro-Wilk test. To compare outcomes between groups while controlling for baseline covariates, a one-way analysis of covariance (ANCOVA) was employed, with the assumption of homogeneity of variances and regression slopes confirmed. Within-group changes were analyzed using paired t-tests. All statistical analyses were conducted using SPSS software (version 26) at a significance level of $\alpha \leq 0.05$.

Findings

Demographic characteristics for each group, along with the results of the independent t-test, are presented in Table 1. The findings indicate that the demographic characteristics were homogeneous across the groups, with no significant differences observed in the mean age, weight, height, and BMI between the groups ($P > 0.05$).

Between-group comparisons revealed no

Table 1) Demographic Characteristics of Participants

Characteristics	DNS Group (n=16)	DNSHS Group (n=16)	P-value
Age (years)	64.56 ± 4.11	66.00 ± 3.91	0.319
Height (m)	1.60 ± 0.09	1.64 ± 0.08	0.307
Weight (kg)	74.82 ± 13.22	72.29 ± 10.77	0.594
BMI (kg/m2)	28.65 ± 4.10	26.65 ± 1.98	0.067

Table 2) between and within group changes in pain, kinesiophobia and lumbar ROM

outcomes	Group	Pre-test	Post-test	Mean Difference (95% CI)	P-value Within group	Cohen's d	P-value Between group	η_p^2
Pain (VAS)	DNS	8.37 ± 1.25	4.68 ± 1.44	3.26 - 4.11	< 0.001[a]	0.79	0.106	0.088
	DNSHS	8.12 ± 1.20	3.93 ± 1.43	3.70 - 4.67	< 0.001[a]	0.91		
Kinesiophobia (TSK)	DNS	52.25 ± 6.20	37.62 ± 3.93	11.56 - 17.68	< 0.001[a]	5.73	0.350	0.030
	DNSHS	51.31 ± 4.81	36.00 ± 4.77	11.71 - 18.91	< 0.001[a]	6.75		
Lumbar flexion ROM (cm)	DNS	5.29 ± 0.95	6.63 ± 0.87	-1.66 to -1.10	< 0.001[a]	0.52	<0.001 [b]	0.327
	DNSHS	4.80 ± 0.89	7.30 ± 0.99	-2.99 to -2.00	< 0.001[a]	0.93		
Lumbar extension ROM(cm)	DNS	0.95 ± 0.39	1.61 ± 0.51	-0.89 to -0.54	< 0.001[a]	0.32	<0.001 [b]	0.363
	DNSHS	0.74 ± 0.19	1.89 ± 0.36	-1.28 to -1.01	< 0.001[a]	0.25		

DNS: Dynamic Neuromuscular Stabilization; DNSHS; DNS with hip strengthening exercises; VAS: Visual Analog Scale; ROM: Range Of Motion

[a] Denotes significant within group improvement between the baseline and 8-weeks exercises period. [b] Significant between DNSHS and DNS groups.

significant differences in pain intensity (VAS; $p = 0.106$, $\eta p^2 = 0.088$) or kinesiophobia (Tampa Scale of Kinesiophobia (TSK); $p = 0.350$, $\eta p^2 = 0.030$) between the DNS and DNSHS groups. However, significant differences were observed for lumbar flexion ROM (ROM; $p < 0.001$, $\eta p^2 = 0.327$) and lumbar extension ROM ($p < 0.001$, $\eta p^2 = 0.363$), with the DNSHS group showing greater improvements in both measures (Table 2).

The DNS group exhibited significant within-group improvements across all outcomes. Pain intensity decreased from 8.37 ± 1.25 to

4.68 ± 1.44 (95% CI: 3.26 to 4.11, $p < 0.001$, Cohen's d = 0.79). Kinesiophobia scores reduced from 52.25 ± 6.20 to 37.62 ± 3.93 (95% CI: 11.56 to 17.68, $p < 0.001$, Cohen's d = 5.73). Lumbar flexion ROM increased from 5.29 ± 0.95 cm to 6.63 ± 0.87 cm (95% CI: -1.66 to -1.10, $p < 0.001$, Cohen's d = 0.52), and lumbar extension ROM improved from 0.95 ± 0.39 cm to 1.61 ± 0.51 cm (95% CI: -0.89 to -0.54, $p < 0.001$, Cohen's d = 0.32).

The DNSHS group also showed significant within-group improvements across all outcomes. Pain intensity decreased from 8.12 ± 1.20 to 3.93 ± 1.43 (95% CI: 3.70 to 4.67, $p < 0.001$, Cohen's d = 0.91). Kinesiophobia scores reduced from 51.31 ± 4.81 to 36.00 ± 4.77 (95% CI: 11.71 to 18.91, $p < 0.001$, Cohen's d = 6.75). Lumbar flexion ROM increased from 4.80 ± 0.89 cm to 7.30 ± 0.99 cm (95% CI: -2.99 to -2.00, $p < 0.001$, Cohen's d = 0.93), and lumbar extension ROM improved from 0.74 ± 0.19 cm to 1.89 ± 0.36 cm (95% CI: -1.28 to -1.01, $p < 0.001$, Cohen's d = 0.25).

Discussion

This study compared the effectiveness of DNS exercises and a combined DNS-hip strengthening (DNSHS) exercise protocol in elderly women with chronic low back pain. Within-group comparisons showed significant improvements in lumbar flexion and extension ROM, pain, and fear of movement from pre-test to post-test in both groups. Inter-group comparisons revealed that, after eight weeks, the DNSHS group exhibited significantly greater improvements in lumbar ROM; however, no significant differences were observed for pain or fear of movement.

Both groups demonstrated improved pain levels from pre-test to post-test; however, no significant inter-group differences were observed. DNS and hip-strengthening exercises reduce tension and alleviate pressure on lumbar spine nerves by enhancing muscle activity and restoring joint function. Pain, defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage [29], is influenced by physical, psychological, and social factors. This study addressed biological and physical factors but not psychological factors, such as depression or pain catastrophizing, which may have limited pain reduction. Social isolation and stress can exacerbate chronic low back pain by activating the hypothalamic-pituitary-adrenal axis, increasing cortisol levels [29, 30]. The lack of intergroup differences may be attributed to the short duration of the intervention or the absence of psychological interventions. Studies have shown that adding hip strengthening exercises to conventional rehabilitation or motor control programs can reduce pain and disability in individuals with low back pain [31, 32]. Similarly, a core exercise program has been shown to reduce pain significantly [33]. Integrating psychological interventions, such as cognitive-behavioral therapy, with DNS and hip strengthening exercises could enhance pain reduction outcomes in individuals with chronic low back pain.

Both groups exhibited reduced fear of movement from the pre-test to the post-test, with no significant intergroup differences. The eight-week DNS and combined DNS and hip strengthening exercise protocols likely contributed to this improvement by enhancing motor function and reducing pain perception, enabling patients to perceive movements as safer [34]. DNS enhances spinal stability by activating core muscles. At the same time, combined DNS and hip strengthening further enhances lumbo-pelvic coordination via hip strengthening, both of which may reduce kinesiophobia by increasing movement confidence [35]. Regular participation in structured exercise programs may also improve self-efficacy, indirectly mitigating fear of movement [36]. Previous research suggests that exercise-induced improvements in physical function and pain reduction are correlated with a decrease in fear-avoidant beliefs in patients with chronic low back pain [34, 37]. However, the lack of intergroup differences may be attributed to the short intervention duration, the similarity in core focused approaches between DNS and DNSHS, or the absence of psychological interventions, as longer programs or those incorporating Cognitive Behavioral Therapy (CBT) have shown greater reductions in kinesiophobia [36]. Future studies should combine DNS and hip exercises with CBT, extend the intervention duration, and utilize validated tools, such as the Tampa Scale for Kinesiophobia, to assess fear of movement more precisely.

Both groups demonstrated significant improvements in lumbar flexion and extension ROM, with the DNSHS group showing greater progress, and the intergroup difference was statistically significant. Dysfunction and weakness in deep and superficial muscle systems, often due to habitual incorrect postures, contribute to low back pain [28, 38]. Weakness in deep muscles, such as the multifidus, is common, necessitating targeted interventions [38]. The DNS approach enhances central control, muscle coordination, and joint stability by activating core muscles, including the diaphragm, pelvic floor, and transverse abdominis, which regulate intra-abdominal pressure to stabilize the lumbo-pelvic region [17]. Core muscle activation, through exercises like core stabilization, improves low back pain and functional disability [39, 40]. Preliminary evidence suggests that DNS exercises may enhance lumbar ROM by improving spinal stability and muscle coordination [41]. The greater improvement in the DNSHS group may result from the synergistic effect of hip strengthening exercises, which enhance force transfer through the global muscle system, improving lumbo-pelvic mobility [28, 42]. Patients with low back pain often exhibit reduced hip abductor and extensor strength, contributing to dysfunctional force transfer during standing activities [42]. DNS and hip strengthening exercises, which target both local and global muscles, increase muscle activity and joint mobility, thereby reducing tension in the lumbar and pelvic areas. Supporting this, core stabilization programs have been shown to significantly improve active ROM in the lumbar spine by focusing on lumbo-pelvic-hip control, with notable benefits in pain reduction and functional gains [33]. Combined core and hip exercises further amplify these effects, leading to better physical function, activity levels, and lumbar mobility in low back pain patients, including those with instability, as they address compensatory patterns and enhance overall kinetic chain efficiency [43, 44].

This study had several limitations. First, the long-term effects of the intervention were not assessed, limiting insights into sustained outcomes. Second, psychological factors, such as stress and anxiety, were not evaluated, which may have potentially influenced the results. Third, the small sample size may reduce generalizability. Finally, the lack of control over participants' medication use could have confounded findings.

Conclusion

The combined DNS and hip strengthening exercises significantly improved lumbar ROM compared to DNS alone, while both groups showed improvements in pain and fear of movement. The lack of intergroup differences in pain and fear of movement likely reflects the short intervention duration and the absence of psychological interventions. Future research should integrate cognitive behavioral therapy with DNS and hip strengthening exercises, extend the intervention duration, and utilize validated tools, such as the pain catastrophizing scale and the fear avoidance beliefs questionnaire, to address psychological factors and enhance outcomes for elderly women with chronic low back pain. A comprehensive approach targeting physical, psychological, and social aspects can promote coordination among the muscles involved in low back pain, thereby optimizing rehabilitation outcomes.

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Authors' Contributions

FS and ZM conceptualized and designed the study, with FS and MN handling data collection and statistical analysis. FS and MN drafted the manuscript, while all authors contributed to data interpretation and critical revisions. All authors approved the final manuscript.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Ethics Permission

This article is derived from a master's thesis in Corrective Exercises and Sports Injuries at the Faculty of Sports Sciences, Bu-Ali Sina University, approved under the ethics code IR.BASU.REC.1403.012. The study was registered with the Iranian Registry of Clinical Trials under the identifier IRCT20240916063063N1. Written informed consent to participate was obtained from all participants before their involvement in the study.

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