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Randomized Clinical Trial

The Impact of Stabilization Exercises on Pain, Quality of Life, and Lower Extremity Strength in Older Women with Low Back Pain: A Randomized Clinical Trial

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Abstract

Background: Low back pain is a significant musculoskeletal condition which leads to limitations in physical function and a poor quality of life in older adults. This study aimed to investigate the impact of dynamic neuromuscular stabilization (DNS) exercises on the quality of life, lower extremity strength, and pain levels in elderly women.
Method: This clinical trial was designed as a single-blind randomized controlled study. A total number of 30 female participants, aged between 60 and 80, who had experienced persistent lower back pain and voluntarily participated in this study. The allocation method using Random Number Generator software with block randomization involves dividing participants into smaller blocks and randomly assigning them to study groups (control, n=15 and dynamic neuromuscular stabilization, n=15). The group performing DNS exercises engaged in sessions three times weekly over an eight-week period, whereas the control group did not participate in any physical activity. This study was registered with the code of IRCT20180626040244N2 in the Iranian Registry of Clinical Trials. The study took place in Hamedan, Iran during September -December 2024. All participants received assessments, including the 30-second sit-to-stand (STS) test for measuring lower limb strength, SF-36 questionnaire for measuring quality of life (QOL), and visual analog scale (VAS) for measuring pain, three days prior to the first intervention session and one to three days following the last intervention session after eight weeks. The data were analyzed using a paired-sample t-test and covariance analysis (ANCOVA), with statistical significance established at $P<0.05$.
Results: The results of ANCOVA indicated that an 8-week DNS exercise program significantly decreased pain (DNSE: baseline=8.64±1.22, week eight=4.79±1.58; Control: baseline=8.07±1.16, week eight=7.33±1.05) (P=0.009), and significantly increased QOL (DNSE: baseline=32.38±4.86, week eight=68.74±6.45; Control: baseline=32.90±8.39, week eight=30.66±6.92) (P=0.004), as well as 30-Sec STS (DNSE: baseline=6.57±1.09, week eight=9.10±1.04; Control: baseline=6.67±1.01, week eight=6.33±0.62) (P=0.004).
Conclusions: These findings implied that DNS exercises may elevate the overall well-being in older women with chronic low back pain by reducing pain and enhancing lower limb strength.

Keywords: Back pain, Exercise therapy, Elderly, Quality of life, Strength

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1. Introduction

Pain in the lower back is the major musculoskeletal problem that causes physical limitations and reduces the well-being of older adults (1). Low back pain (LBP) is a leading contributor to disability in people over the age of 60. Besides intense physical distress, LBP involves high economic and social costs (2). A systematic review of twenty-eight studies indicated that the prevalence of chronic low back pain (CLBP) progressively increases from the third decade of life until the age of 60 (3). Furthermore, results from another review indicated that 21% to 68% of participants aged over 60 reported CLBP during the preceding year, indicating a significant prevalence of this condition in this age category (4). Aging is rapidly accelerating worldwide, and by 2050, the number of people aged 65 and older will have more than doubled to reach 1.5 billion and represent 16% of the global population (5). Thus, developing an effective, comprehensive strategy for back pain management and improvement in functional capacity gains importance. On the other hand, evidence regarding the effectiveness of conventional treatments in the elderly with CLBP remains of low certainty

DNS exercises, which stand for Dynamic Neuromuscular Stabilization, represent a motor system therapeutic approach aimed at developing motor function and body stabilization through reconstructive infant movement patterns. The DNS concept is also based on the premise that, from birth and throughout life, the body progresses through well-defined developmental movement stages that have an intrinsic relationship with the maturation of the neuromuscular system. In DNS, these developmental stages are replicated through exercises to enhance motor performance and spinal stability (6, 7). The DNS method primarily focuses on regulating intra-abdominal pressure, which enhances core and spinal stability. This intra-abdominal pressure provides an internal stabilization system for the body during complex and dynamic movements. Various DNS exercises address different movement positions that infants use while developing in the supine, quadruped, and sitting positions. Correspondingly, each of these positions serves as a starting point for more general and advanced exercises aimed at improving core muscle endurance, motor control, and coordination (8, 9).

Various studies have been conducted on different pathologies concerning the effects of DNS (6, 9). More recently, it has been considered a treatment option for women and elderly patients who present with chronic nonspecific low back pain (CNSLBP) (10, 11). Recently, Kang and colleagues reported that DNS exercises with added inertial loading through water facilitated improvements in functional movements, balance, and dynamic stability in middle-aged women (11). Additionally, Karartı and co-workers noted that the DNS approach was more effective in enhancing functional movement patterns and balance compared to routine physiotherapy among chronically symptomatic elderly men with CLBP (10).

The high prevalence of CLBP among the elderly, along with its impact on both physical and mental well-being, makes effective treatment options highly necessary. While the incidence of CLBP is rising in this age group, treatments to date have primarily focused on pain management, with little attention to the underlying motor deficits. This makes the introduction of DNS exercises significant, as they may introduce novelty in improving core stability and functional capacity that conventional therapies could not address. Consequently, this study aimed to address this gap by investigating the impact of DNS exercises on well-being, extremity strength, and pain reduction in older women experiencing CLBP. Indeed, this stabilization technique has made the investigation of this topic particularly relevant to the specific needs of older adults with CLBP and has contributed to a better understanding of more effective therapeutic strategies in this population.

2. Methods

2.1. Study Design

This study was a single-blind randomized controlled clinical trial in which the assessor remained unaware of the participants' group assignments during both baseline and follow-up assessments. The prospective investigation was approved by the Ethics Committee of Bu-Ali Sina University, Hamedan, Iran, with the registration code IR.BASU.REC.1403.011, and was registered in the Iranian Registry of Clinical Trials with the code IRCT20211018052801N2 on September 17, 2024. The trial adhered to the CONSORT guidelines in its design, and all experimental activities complied with the standards set forth in the Declaration of Helsinki. The study was conducted in Hamedan, Iran, from September 2024 to December 2024.

2.2. Participants

The study participants were elderly women suffering from CLBP. A clinician conducted clinical evaluations to assess their eligibility. Those diagnosed with CLBP were subsequently referred for exercise interventions. The inclusion criteria were: women aged between 60 and 80 years with CLBP, pain intensity greater than 5 on the visual analog scale (VAS), and at least three months of symptoms. Participants were required to perform daily activities independently and have no history of cardiovascular or respiratory diseases, fractures, or severe injuries to the lower extremities or spine. The exclusion criteria were: pain or disability preventing exercise performance, non-compliance, or withdrawal from the study; absence from two consecutive sessions or three non-consecutive sessions; and a BMI above 35.

Using G*Power software, version 3.1.9.4, the required sample size was calculated based on pain Mean±SD values (DNS group=1.95±0.88, control group=4.75±1.06) from the study by Ghavipanje and colleagues (12), with an alpha of 0.05 and a target power of 0.95. To account for potential dropouts, 15 participants were allocated to each group: the Dynamic Neuromuscular Stabilization Exercise group (DNSE) or the control group (CON). The allocation method, using Random Number Generator software with block randomization, involved dividing participants into smaller blocks and randomly assigning them to the study groups (CON (n=15) and DNSE (n=15)) (Figure 1).

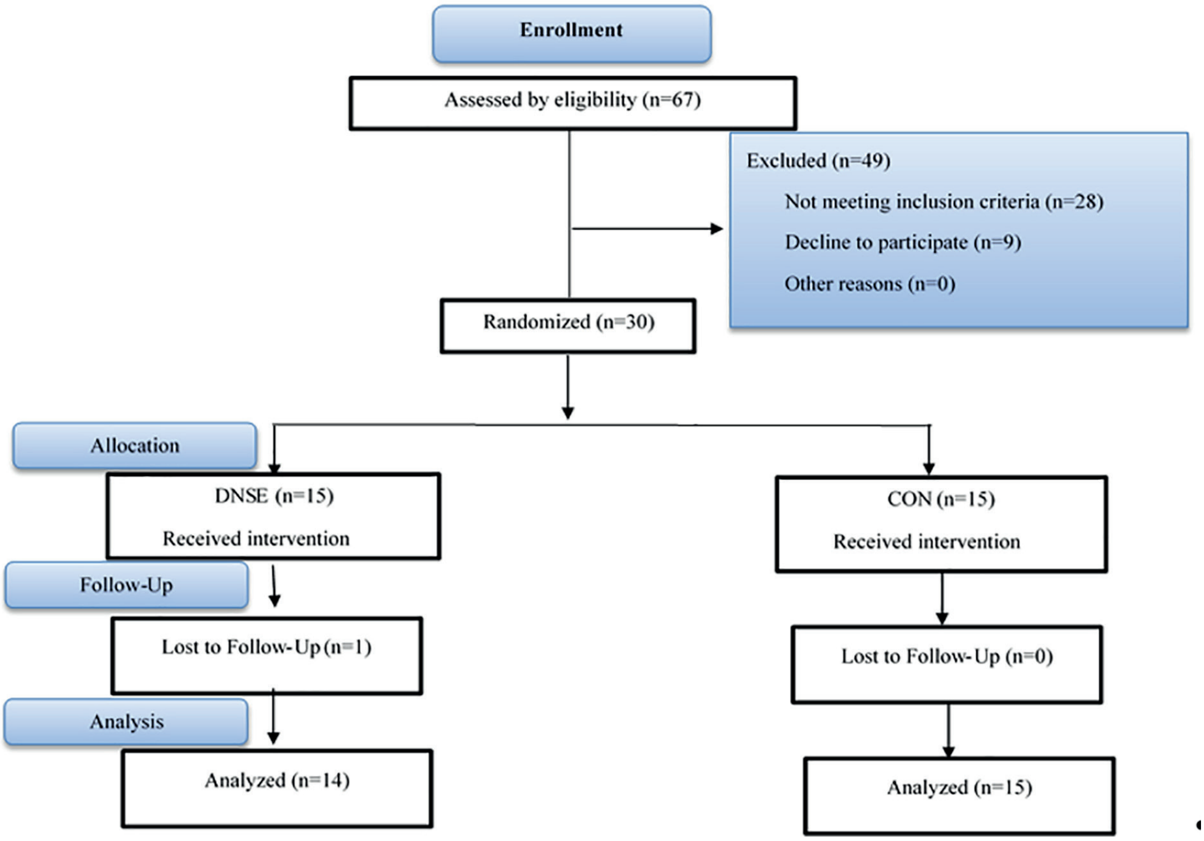

Figure 1: The figure shows the CONSORT Flowchart of study.

2.3. Exercise Intervention

The DNS training consisted of activities such as diaphragmatic breathing, baby rock (performed in the supine 90-90 posture), prone positioning, rolling movements, side-lying, oblique sitting, tripod posture, kneeling, squatting, and standing (10, 12). It lasted for eight weeks, with three sessions per week, each session lasting 50 minutes. Every session began with a warm-up and ended with a cool-down. Exercise intensity was personalized based on each participant's ability. Study participants could only advance to the next level after mastering the current one. In the first week, the primary goal was to introduce the main principles of DNS to the experimental group through practical activities. The treatment method was explained using verbal instructions and visual aids, such as images. Participants also received verbal and hands-on guidance to achieve correct alignment of the pelvis, spine, ribcage, and scapulae. Sessions were supervised to ensure accurate execution of each exercise, with the researcher carefully monitoring every step, as progress depended on proper completion of prior exercises. Throughout the training, emphasis was placed on correct movement patterns and the coordinated function of muscles in each position, focusing on the spine and pelvis. This approach enhanced body awareness and core control, helping participants gradually improve their motor control, reduce pain, and achieve better physical performance overall (10, 12). The exercises became increasingly difficult each week by incorporating an additional task into previously learned movements. This progression enabled participants to automate their performance. To assess whether the work was automated and ensure that adding new tasks did not interfere with diaphragmatic breathing, we used the dual-task paradigm (Appendix A and B).

2.4. Measurements

In this study, pain was the primary outcome, and QOL and lower limb strength (measured by the 30-second STS test) were secondary outcomes.

2.4.1. Pain: The intensity of pain was evaluated using the Numerical Pain Rating Scale (NPRS), where values range from 0, representing no discomfort, to 10, indicating extreme pain. The study participants were instructed to select and indicate a number that reflected their pain level on that particular day (13).

2.5. Quality of Life

Assessment of Quality of Life (QOL) was conducted using SF-36 questionnaire, a self-administered questionnaire comprising 36 questions with measures across eight dimensions including physical functioning, role limitations due to physical health, bodily pain, overall health, energy levels, social engagement, emotional well-being, and mental wellness. The questions in this questionnaire capture both positive and negative aspects of health. Each scale contains between two to ten items. Each of the 36 questions has five response options, with scoring instructions assigning a value between 0 and 100 to each option (0, 25, 50, 75, and 100). Ultimately, a higher score indicates a better QOL (14).

2.6. Lower Limb Strength

In this study, the strength of the lower limbs in older adults was evaluated using the 30-second sit-to-stand test, a method recognized in prior studies as valid, reliable, and consistent for assessing lower limb strength in elderly populations (15). During the assessment, participants were instructed to sit upright on a chair with their feet placed shoulder-width apart and their hands joined in front of their chest. At the "start" command, they were tasked with fully standing up from the chair and then sitting back down. The goal was for each participant to complete as many correct sit-to-stand cycles as possible within 30 seconds, with the final score based on the total number of accurate repetitions achieved during that time frame (15).

2.7. Statistical Analysis

To outline the variables, descriptive statistics were applied, with findings expressed as means accompanied by standard deviations (SD). The normality of the data was evaluated using the Shapiro-Wilk test. For within-group comparisons, paired t-tests were applied, whereas between-group differences were assessed using analysis of covariance (ANCOVA). Results are presented as means with standard deviations and 95% confidence intervals (CIs). A significance level of $P<0.05$ was adopted for all statistical tests. All analyses were performed using SPSS version 26.0 (SPSS Inc., Chicago, IL, USA).

3. Results

At baseline, the DNS group was similar to the control group in terms of age, height, weight, and BMI ($P>0.05$) (Table 1).

The results of paired-sample t-tests revealed significant changes in pain (P=0.001), QOL (P=0.001), and the 30-second sit-to-stand (STS) test (P=0.001) within the intervention group (Table 2).

Table 1: Demographic characteristics of the participants

Variables	DNSE (Mean±SD)	CON (Mean±SD)	P value
Age (Years)	65.14±4.07	65.33±3.31	0.453
Height (m)	1.62±0.10	1.64±0.09	0.471
Weight (kg)	77.48±13.11	73.31±10.83	0.925
BMI (kg/m^2)	29.71±4.48	27.05±2.85	0.135

m: Meter, kg: Kilograms; BMI: Body Mass Index; SD: Standard Deviation; DNSE: Dynamic Neuromuscular Stabilization Exercise, CON: Control

Table 2: The results of within and between group differences in postural angles

Variable	Mean±SD		Time effect			Between-group P
	Baseline	Week eight	95% CI	t	P	
Pain (VAS)						
DNSE	8.64±1.22	4.79±1.58	3.147 _ 4.586	11.720	0.001 [a]	0.009 [b]
CON	8.07±1.16	7.33±1.05	-0.006 _ 1.472	2.128	0.052	
QOL						
DNSE	32.38±4.86	68.74±6.45	-40.185 _ -32.532	-20.525	0.001 [a]	0.004 [b]
CON	32.90±8.39	30.66±6.92	-1.439 _ 5.903	1.304	0.231	
30-Sec STS						
DNSE	6.57±1.09	9.10±1.04	-3.005 _ -2.042	-11.319	0.001 [a]	0.004 [b]
CON	6.67±1.01	6.33±0.62	-0.239 _ 0.909	1.252	0.213	

SD: Standard Deviation; CI: Confidence Interval; VAS: Visual Analog Scale; DNSE: Dynamic Neuromuscular Stabilization Exercise; CON: Control; QOL: Quality of Life

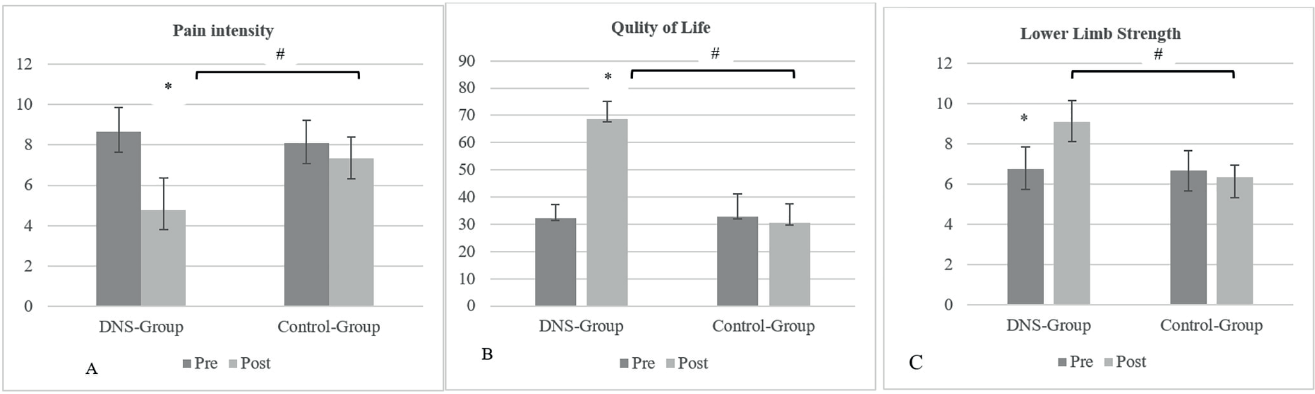

Figure 2: The figure show the mean difference of pre and post-test for pain (A), Quality of life (B) and Lower Limb strength (C) in both groups. *Indicates significant differences within group. #Indicates significant differences between groups. DNS: Dynamic Neuromuscular Stabilization

To compare groups, ANCOVA was performed using the pre-test scores as a covariate. The ANCOVA results indicated that the 8-week DNS exercise program significantly reduced pain (DNSE: baseline=8.64±1.22, week 8=4.79±1.58; CON: baseline=8.07±1.16, week 8=7.33±1.05), $F(1, 28)=7.905$, $P=0.009$; increased QOL (DNSE: baseline=32.38±4.86, week 8=68.74±6.45; CON: baseline=32.90±8.39, week 8=30.66±6.92), $F(1, 28)=9.971$, $P=0.004$; and improved performance on the 30-second STS test (DNSE: baseline=6.57±1.09, week 8=9.10±1.04; CON: baseline=6.67±1.01, week 8=6.33±0.62), $F(1, 28)=9.750$, $P=0.004$ in the intervention group (Table 2, Figure 2).

4. Discussion

The results of this study revealed that DNS exercises are effective in alleviating pain and enhancing the quality of life in older women experiencing CLBP. DNS exercises not only impact physical structures but also aid in pain reduction by enhancing neuromuscular function. By strengthening the deep stabilizing muscles of the spine, DNS exercises improve spinal stability.

CLBP is a multifaceted condition that can impair the function of key spinal stabilizer muscles, including the multifidus, transversus abdominis, and gluteus maximus, potentially leading to reduced spinal flexibility and altered motor control (16). The transversus abdominis muscle is directly connected to the thoracolumbar fascia and plays a crucial role in lumbar spine stability by increasing intra-abdominal pressure. Weakness in the transversus abdominis leads to reduced tension in the thoracolumbar fascia, impairing its ability to effectively contribute to the elevation of intra-abdominal pressure (17). This impairment may reduce spinal stability and increased loading on the lumbar spine, exacerbating the condition.

DNS also improves coordination and motor control. A major factor contributing to CLBP is disruption in movement patterns, which leads to compensatory and abnormal movements. These faulty movements place continuous stress on the spine, resulting in chronic tissue irritation and pain. By focusing on the reeducation of natural movement patterns and the principles of motor development, DNS helps correct dysfunctional movement patterns and prevent compensatory strategies. This correction not only alleviates pain but also optimizes motor function and enhances patients' quality of life. Another key aspect of DNS is the regulation of intra-abdominal pressure. The exercises aim to improve abdominal muscle tone and enhance diaphragm function, thereby facilitating effective control of intra-abdominal pressure. This pressure acts as an internal stabilizing mechanism that supports the spine by reducing stress on the lower back. (17).

This approach is effective not only for decreasing acute pain but also for managing and preventing chronic pain (6). The QOL of the elderly benefits from various factors like independence, performing activities of daily living, and enhancement of mental status. DNS, by stabilizing the trunk and improving motor functions, advances an individual's capability to carry out routine tasks such as standing, sitting, and walking, thereby enhancing self-sufficiency and reducing dependence on others (17). This can also be successfully incorporated into rehabilitation program in managing CLBP among older population.

This study showed that lower limb strength in the intervention group increased significantly compared with the control group following the implementation of DNS exercises. Weakness of the trunk muscles is closely associated with low back pain (LBP). Many individuals with CLBP exhibit delayed or impaired activation of trunk muscles. This muscle atrophy or insufficient activation results in spinal instability, which subsequently increases pressure on the intervertebral discs and contributes to heightened pain levels (18). More specifically, impairment of deep muscles, especially the transversus abdominis, leads to impaired postural control and spinal stability. The lower limb muscles, particularly the quadriceps, hamstrings, and gluteal muscles, play a crucial role in load supply and distribution, as well as stabilization during movements such as walking and standing up from a chair. In elderly patients with low back pain, muscle weakness in the lower limbs can result in imbalance and increase the risk of falls (19). Weakness of the gluteal muscles—especially the gluteus maximus and medius—which are involved in controlling pelvic alignment and lower limb posture, may contribute to the development of abnormal movement patterns that increase stress on the spine (20, 21). Rahimi and colleagues reported that the DNS group exhibited substantial progress in static balance, dynamic balance, and lower limb strength, along with a considerable decline in the risk of falling (22). In a different study by Kang and colleagues, DNS training programs using water's inertial resistance were shown to enhance motion fluidity and posture maintenance. These advantages promote functional mobility, balance strategies, and dynamic stability among middle-aged women (11). In this context, the potential mechanism behind the effects of DNS exercises on lower limb strength in elderly women with CLBP is through strengthening certain weakened abdominal and gluteal muscles. DNS workouts have been conceptually developed to improve neuromuscular coordination and core stability, especially among elderly individuals experiencing CLBP. Thus, they may have substantial effects on lower limb strength. By focusing on natural movement pattern retraining and enhancement of deep muscle function, DNS can increase lower limb strength.

4.1. Limitations

There were several limitations in this study. The sample consisted of elderly women with CLBP; thus, generalization to other groups, such as men or different age ranges, should be made cautiously. Moreover, the present study did not analyze the long-term effects of DNS exercises on the studied variables. Therefore, it is difficult to conclude from these results that pain, quality of life, and lower limb strength are fully improved and maintained over time. An additional limitation was the lack of a direct comparison between DNS and other treatment methods or exercise programs. Such a comparison could provide a more precise evaluation of DNS's effectiveness relative to other therapeutic approaches. Furthermore, the measurement of lower limb strength could have been enhanced by using more advanced methods. Tools such as isometric or isokinetic dynamometers could offer more comprehensive information on changes in muscle strength.

5. Conclusions

The results of this study indicated that an eight-week DNS exercise program can alleviate pain, enhance quality of life, and improve performance in the 30-second sit-to-stand test among older women experiencing chronic low back pain. These exercises could be valuable for exercise specialists and healthcare professionals to incorporate into prevention and rehabilitation strategies.

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Authors' Contribution

Marziyeh Ziya: Contributed to study design, data analysis; drafting the work. Farzaneh Saki: Contributed to study design, data analysis and interpretation; critically reviewed the manuscript for important intellectual content. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work, such as the questions related to the accuracy or integrity of any part of the work.

Conflict of interest: None declared.

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Ethical Approval

This study was approved by the Ethics Committee of Bu-Ali Sina University with the code of IR.BASU.REC.1403.011 and was registered in the Iranian Registry of Clinical Trials with the code of IRCTID IRCT20211018052801N2 on September 17, 2024. The study was designed based on CONSORT guideline 10, and all experimental conditions adhered to the principles of the Declaration of Helsinki. The objectives were thoroughly explained to all participants before their involvement, and written informed consent was obtained from each individual prior to enrollment.

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