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Simultaneous Effect of Dynamic Neuromuscular Stabilization Exercise and Low-Level Laser Therapy on Depression and Quality of Life in Women with Chronic Low Back Pain

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Abstract

Background: Chronic low back pain is a health concern. Evidence indicates that both dynamic neuromuscular stabilization (DNS) exercise and low-level laser therapy (LLLT) can reduce the psychological consequences of this condition and improve quality of life. However, the simultaneous effect of these two interventions on depression and quality of life in women with chronic low back pain was not previously investigated. Therefore, the present study determined the simultaneous effect of DNS exercise combined with LLLT on depression and quality of life in women with non-specific chronic low back pain.
Methods: In a clinical trial, forty women with non-specific chronic low back pain were selected from among patients referred to the Sarzamin-e Salamat Rehabilitation Center in Isfahan. They were randomly assigned to four groups: DNS exercise combined with LLLT, DNS exercise alone, LLLT alone, and a control group. DNS exercise and LLLT were performed three times per week for eight weeks. Depression, quality of life, and endurance of the lumbar flexor and extensor muscles were measured before and after the intervention.

Results: DNS exercise, LLLT, and the combination of both interventions resulted in significant reductions in depression (P=0.001), improvements in quality of life (P=0.001), and increased endurance of the lumbar flexor and extensor muscles (P=0.001). The greatest changes were observed in the group that received combined DNS and LLLT interventions.

Conclusion: Based on these findings, it is concluded that the use of both interventions can be considered an effective, non-invasive strategy for reducing the psychological consequences of chronic low back pain and improving quality of life in women with non-specific chronic low back pain.

Keywords: DNS exercise, LLLT, depression, quality of life

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Introduction

Low-back pain is a public health issue worldwide (1). Among them, chronic low back pain (CLBP) has drawn considerable attention as a chronic health problem due to its persistent suffering, high disability rates, and substantial medical burden (2). CLBP not only causes long-term suffering, impairs patients' physical functions, and can lead to disability, but also increases personal and societal healthcare costs (3). Furthermore, as the pain persists and the condition progresses, the risk of psychological problems in CLBP patients increases significantly (4,5). Depression and reduced quality of life are highly prevalent among CLBP patients and significantly impact their quality of life and treatment outcomes (6,7,8). Studies indicate that over 40% of individuals with CLBP experience symptoms of depression and anxiety, with the prevalence often higher among women and younger patients (9). Large-scale epidemiological data also confirm that patients with CLBP have an increased risk of depression and anxiety compared to those without pain. This is due to an adjusted hazard ratio of approximately 1.8 for depression and 3.5 for anxiety (10). Indeed, recent research confirmed the bidirectional relationship between CLBP and mental health. This shows how each intensifies the other in a vicious cycle. Individuals with chronic low back pain often display high levels of depression and anxiety, which compound their difficulties and disrupt their overall well-being (11). Results from numerous studies show that individuals with chronic low back pain experience poorer physical function, increased limitations in daily activities, and increased difficulties fulfilling social and occupational responsibilities. This is compared with those without CLBP. These individuals also reported higher levels of depressive symptoms, anxiety, and psychological distress, all of which contribute to lower health-related quality of life (12). Evidence suggests that DNS (Dynamic Neuromuscular Stabilization) exercise can reduce depression and anxiety in individuals with LBP by addressing pain-related disability and improving functional outcomes. A randomized controlled trial on patients with non-specific neck pain demonstrated that DNS exercise significantly reduced depression and anxiety scores compared to dynamic exercise, highlighting the broader mental health benefits of stability-based interventions (13). Similarly, an 8-week DNS exercise program significantly improved pain intensity, functional disability, and quality of life in patients with non-specific chronic LBP, indicating indirect benefits for mental health through the reduction of physical symptoms that often exacerbate depression and anxiety (14). Additionally, DNS exercise has been shown to improve sleep quality and reduce pain-related disability, further contributing to the alleviation of anxiety and depression in CLBP patients (15). On the other hand, evidence also indicates that low-level laser therapy (LLLT) can alleviate depression and anxiety in CLBP patients (16). LLLT has demonstrated beneficial effects on reducing depressive symptoms in people with chronic low back pain, mainly through its analgesic and neuromodulatory effects. In this regard, LLLT reduces depression and anxiety in CLBP patients (17).Although the separate effects of DNS and LLLT on quality of life and depression in patients with chronic low back pain have been studied, a review of the literature reveals that the simultaneous impact of these two interventions on depression and anxiety has not been investigated. Therefore, the present study determined the simultaneous effect of DNS exercise combined with LLLT on quality of life and depression in women with chronic low back pain.

Material and method

Participants

In a clinical trial, forty women aged 40–50 years with CLBP were selected from patients referred to the Sarzamin-e Salamat Rehabilitation Center in Isfahan via convenience sampling based on inclusion criteria. Inclusion criteria included: age (40–50 years), CLBP without disco-pathy persisting for over six months, absence of low back pain due to specific pathological conditions (e.g., infection, metastatic disease, neoplasms, osteoporosis, rheumatoid arthritis, vertebral fractures), no medical contraindications for physical activity, no use of anti-inflammatory or analgesic medications, no regular weekly exercise, and pain intensity between 3 and 6 on the Visual Analog Scale (VAS). After selection, participants were informed of all study procedures in a briefing session and signed informed consent forms. Participants were randomly assigned via a lottery method supervised by the principal investigator to one of four groups: DNS-LLLT, DNS exercise , LLLT and a control group. The study received ethical approval from Islamic Azad University, Marvdasht Branch (Code: IR.IAU.M.REC.1403.560). All data collection procedures adhered to the Helsinki Declaration guidelines. The general characteristics of Participants divided by groups are presented in Table 1.

Table1. The general characteristics of Participants. Data are reported based on the mean and standard deviation.

	DNS-LLLT	DNS exercise	LLLT	control
Age (years)	44.70 ±2.62	45.70±2.40	46.20±1.61	44.70±2.35
Height (Cm)	163.00±2.00	163±4.00	164.00±2.00	163.00±3.00
Weight (Kg)	70.20±4.23	67.60±4.97	71.10±3.92	69.30±4.98
Body mass index (KG/m2)	26.27±1.56	25.28± 0.75	26.44±1.56	26.05±1.08

Body Composition Assessment

Body weight was measured using a Seca 813 digital scale (Germany; ±100 g accuracy), and height was assessed with a Seca 206 stadiometer (precision: 0.1 cm). Body fat percentage was calculated using the Cordoba equation (18).

DNS Exercise Protocol

The DNS exercise protocol was conducted over eight weeks, with three 50-minute sessions per week (40 minutes of DNS exercises, 10 minutes of cooldown) (19). The protocol, based on reflex muscle chain activation, was divided into simple, intermediate, and advanced levels, and the intensity was adjusted according to individual ability. Initial sessions focused on a lower intensity, progressing to a moderate intensity later. Exercises were divided into four 10-minute blocks, including: Diaphragmatic breathing in the 90-90 supine position, Prone lying, rolling maneuvers, Side-lying sitting, oblique sitting, Tripod position, kneeling, squatting, and standing. Participants performed 10–15 breaths per set in three sets for each position. Exercises were performed with 10 repetitions per set, with 30-60 seconds of rest between sets. Complexity increased weekly, with resistance tools (e.g., dumbbells, resistance bands) introduced once participants mastered movement patterns and proper breathing. Progression was individualized: upcoming tasks were added only after the correct execution of prior exercises with appropriate intra-abdominal pressure regulation.

LLLT Protocol

LLLT was administered three times weekly for 8 consecutive weeks using a GaAIAs semiconductor laser device (810 nm wavelength), delivering 5.4 J per point at a power density of 20 mW/cm², each treatment session lasted 180 seconds based on Ip and Fu's methodology (20).

Quality of Life Assessment

Quality of life was evaluated using the SF-36 questionnaire (21), which assesses eight domains: physical functioning, role limitations due to physical health, bodily pain, general health perceptions, vitality, social functioning, role limitations due to emotional health, and mental health. Scores range from 0 (at worst) to 100 (optimal). The SF-36 demonstrates high reliability, with Cronbach's alpha coefficients ranging from 77% to 90% for all domains except vitality (65%) (22).

Depression assessment.

The modified Beck Depression Inventory (BDI) was used. Pain and depression share biological pathways and neurotransmitters, as well as common therapeutic outcomes. According to research, depression strongly influences the pain intensity and the degree of disability in individuals with CLBP, making prevention and treatment of depression essential. Moreover, the pain in patients with severe depression is significantly greater than in those with mild or no depression. This questionnaire is a self-report survey which evaluates depressive symptoms (23). In this questionnaire, depression severity is divided into four categories: minimal depression (total score 0–13), mild depression (14–19), moderate depression (20–28), and severe depression (≥29). The BDI demonstrate high validity and reliability (24, 25).

Endurance measurement

To assess the endurance of the lumbar extensor muscles, the trunk extension hold test (extensor endurance test) was used. In this test, participants were asked to lie prone on a table with their upper limbs alongside their bodies and the palms of their hands resting on the lateral aspect of their thighs. They were then instructed to keep their heads and necks in a neutral position and to lift their sternum off the table. The duration for which this position could be maintained was measured with a stopwatch and recorded as Lumbar extensor muscle endurance. The test was stopped when participants could no longer maintain the position or when muscle contractions ceased. The internal reliability of this test is 97% for healthy individuals and 93% for patients with low back pain (26). For the dynamic endurance assessment of the trunk flexors, a modified sit-up test was used. Participants were instructed to lie on their backs with their knees bent and their feet flat on the floor. They were instructed to lift their heads and upper backs to a 45-degree angle from the floor without lifting their lower backs. The number of repetitions performed in 30 seconds was recorded as a participant's score. In the traditional sit-up test, participants must move from lying to sitting and repeat the movement. This can excessively strengthen the rectus abdominis, shorten this muscle, and exacerbate hyperlodosis in individuals predisposed to this condition. Therefore, to prevent the development or worsening of this condition, the modified sit-up test was used. This test has high validity, and studies report its reliability at 98% (27).

Statistical model

All data are presented as mean and standard deviations in figures and tables. The assumptions for repeated measures analysis of variance (ANOVA), including the normality of the data distribution and homogeneity of variance, were tested by the Shapiro-Wilk and Levene tests, respectively. Repeated measures ANOVA with a between-group factor was then used to analyze the effects of DNS exercises and LLLT on study outcomes. This model tests the effect of time, groups, and the time × group interaction on study outcomes. If significant differences were observed, post-hoc Bonferroni tests were performed. To better understand the impact of the interventions, within-group changes were also compared using paired T-tests. The correlation between depression, quality of life, and endurance of the flexor and extensor muscles was determined by Pearson's correlation coefficient. The significance level was set at $p < 0.05$ for all calculations. All analyses were performed using SPSS version 22.

Results

The results of the Shapiro-Wilk and Levene tests indicated that the distribution of the study outcomes was normal and that the assumption of homogeneity of variance was met. On the other hand, the Sphericity assumptions were met for all calculations. The main effect of time (F = 57.73, P = 0.001, η = 0.616), the main effect of group (F = 16.61, P = 0.001, η = 0.581), and the time × group interaction (F = 43.71, P = 0.001, η = 0.785) had significant effects on the quality of life of individuals with CLBP. Within-group analysis showed that quality of life increased significantly after the intervention in the DNS–LLLT group (P = 0.001), the DNS group (P = 0.001), and the LLLT group (P = 0.001), while it decreased significantly in the control group (P = 0.002). The mean differences indicated that the greatest increase in quality of life occurred in the DNS–LLLT group (15.50), followed by the DNS group (10.60) and the LLLT group (6.20). Given the significance of the time × group interaction on quality of life, it can be concluded that the intervention groups exhibited different patterns of change in quality of life, with the greatest effect observed in the combined DNS–LLLT group. (Figure 1).

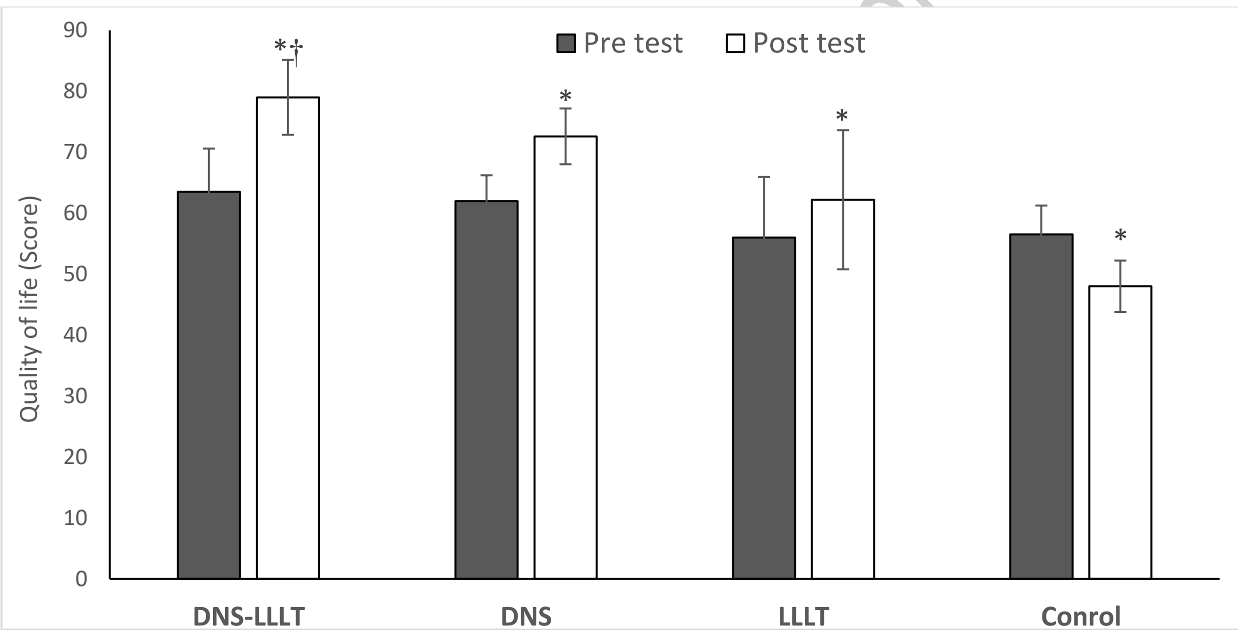

Figure 1. Changes in quality of life in the study groups pre-test and post-test. * Indicate a significant difference from the pre-test. † Indicate a significant difference from the DNS and LLLT groups. Data represent Mean ± SD (n = 10). Repeated measures ANOVA with a between-group factor, followed by the post hoc test of Bonferroni.

Regarding depression, the results showed that the main effect of time (F = 201.97, P = 0.001, η = 0.849), the main effect of group (F = 18.85, P = 0.001, η = 0.611), and the time × group interaction (F = 62.67, P = 0.001, η = 0.839) had a significant effect on depression in individuals with CLBP. Depression scores significantly decreased after intervention in the DNS–LLLT group (P = 0.001), the DNS group (P = 0.001), and the LLLT group (P = 0.001), while they significantly increased in the control group (P = 0.011). Based on the mean differences, the greatest reduction in depression occurred in the DNS–LLLT group (24.00), followed by the DNS group (13.20), and then the LLLT group (5.90). Given the significance of the time × group interaction on depression, it was determined that the intervention groups exhibited different patterns of change in depression. The greatest effect was observed in the combined DNS–LLLT group. DNS exercise was also more effective than LLLT. (Figure 2).

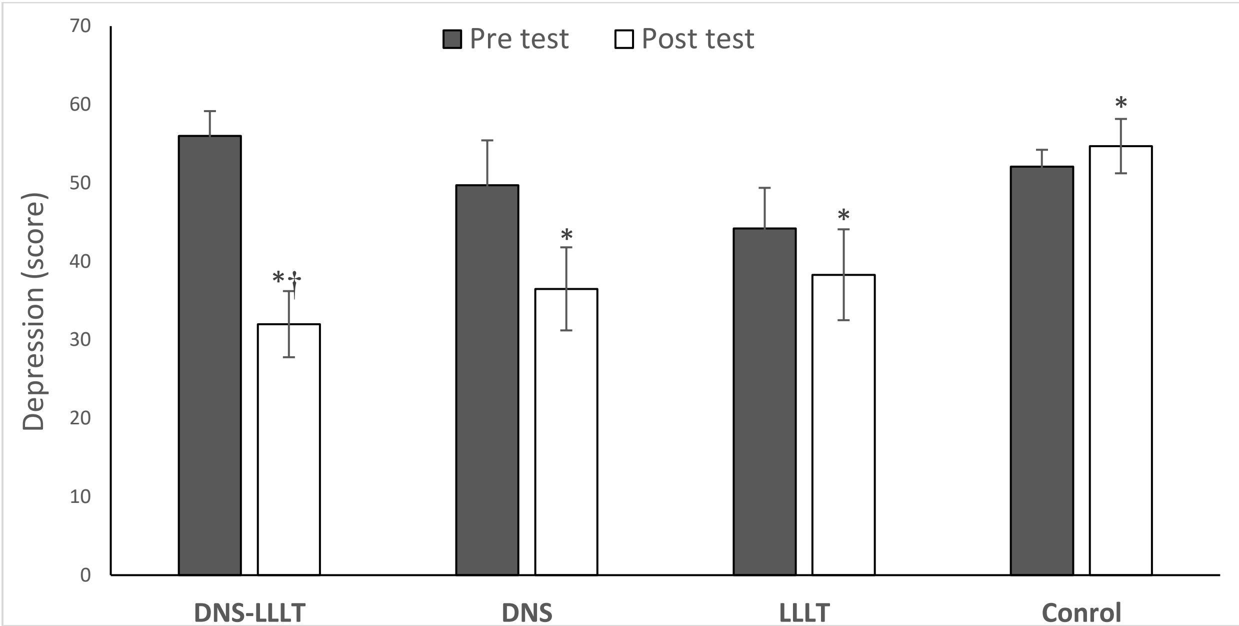

Figure 2. Changes in depression in the study groups pre-test and post-test. * Indicate a significant difference from the pre-test. † Indicate a significant difference from the DNS and LLLT groups. Data represent Mean ± SD (n = 10). Repeated measures ANOVA with a between-group factor, followed by the post hoc test of Bonferroni.

The main effect of time (F = 132.39, P = 0.001, η = 0.786), the main effect of group (F = 17.59, P = 0.001, η = 0.549), and the time × group interaction (F = 45.73, P = 0.001, η = 0.792) had a significant effect on the endurance of the flexor muscles in individuals with CLBP. The flexor muscles endurance significantly increased after the intervention in the DNS–LLLT group (P = 0.001), the DNS group (P = 0.001), and the LLLT group (P = 0.001), while it significantly decreased in the control group (P = 0.041). Based on the mean differences, the greatest increase in flexor muscle endurance occurred in the DNS–LLLT group (9.40), followed by the DNS group (4.00), and then in the LLLT group (2.20). Given the significance of the time × group interaction on muscle endurance, it can be concluded that the intervention groups exhibited different patterns of change in flexor muscle endurance. The greatest effect was observed in the combined DNS–LLLT group. (Figure 3).

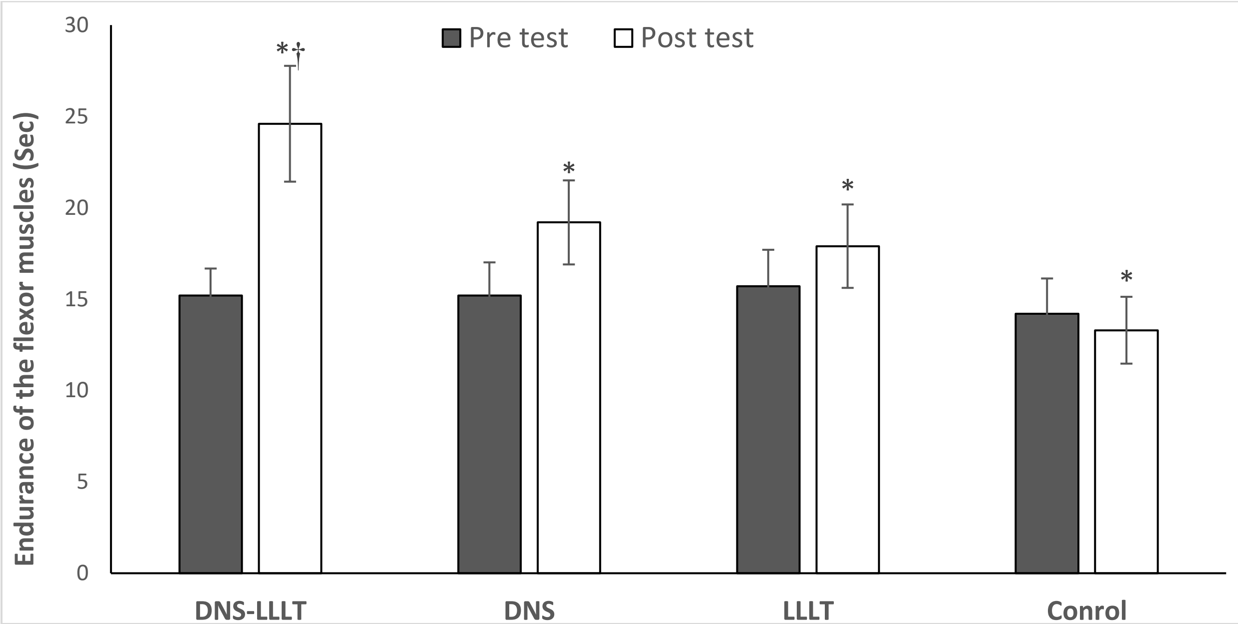

Figure 3. Changes in endurance of the flexor muscles in the study groups pre-test and post-test. * Indicate a significant difference from the pre-test. † Indicate a significant difference from the DNS and LLLT groups. Data represent Mean ± SD (n = 10). Repeated measures ANOVA with a between-group factor, followed by the post hoc test of Bonferroni.

Regarding the endurance of the extensor muscles, the results showed that time ($F = 293.47$, $P = 0.001$, $\eta = 0.891$), group ($F = 31.65$, $P = 0.001$, $\eta = 0.725$), and the time × group interaction ($F = 71.11$, $P = 0.001$, $\eta = 0.851$) had a significant effect on the endurance of the extensor muscles in individuals with low back pain caused by muscle weakness. The endurance of the extensor muscles significantly increased after the intervention in the DNS–LLLT group ($P = 0.001$), the DNS group ($P = 0.001$), and the LLLT group ($P = 0.001$), while it significantly decreased in the control group ($P = 0.001$). Based on the mean differences, the greatest increase in extensor muscle endurance occurred in the DNS–LLLT group (6.40), followed by the DNS group (4.00), and then the LLLT group (2.40). Given the significance of the time × group interactions on muscle endurance, it can be concluded that the intervention groups exhibited different patterns of change in extensor muscle endurance. The greatest effect was observed in the combined DNS–LLLT group. The effectiveness of DNS exercises was greater than that of LLLT. (Figure 4).

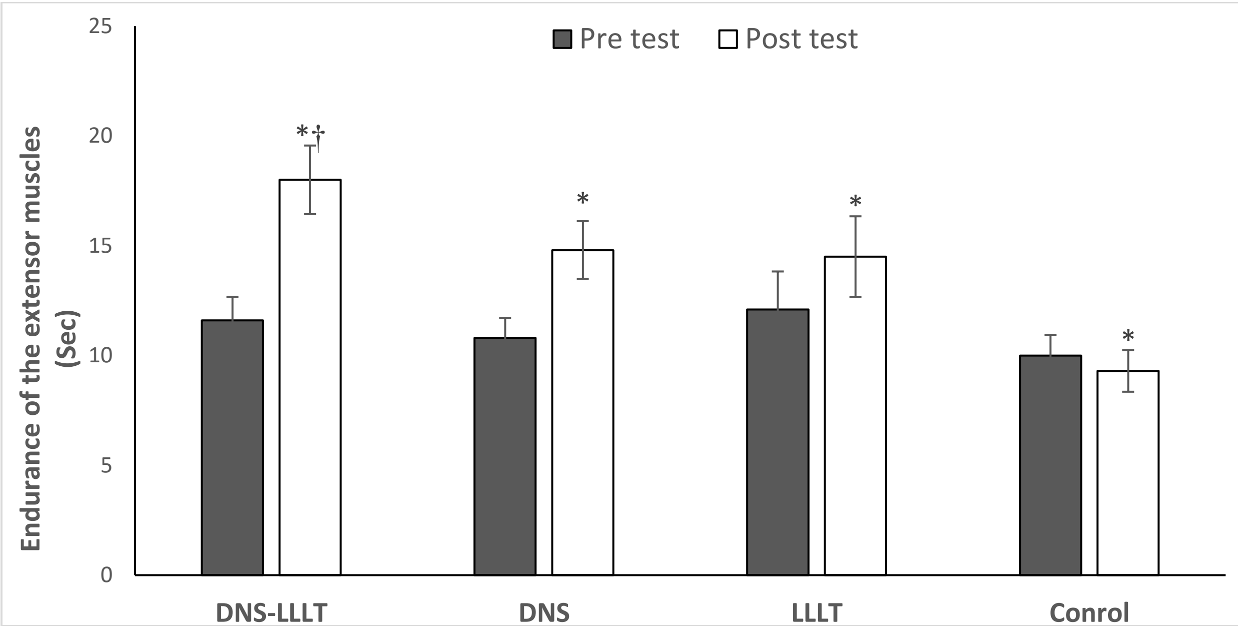

Figure 4. Changes in endurance of the extensor muscles in the study groups pre-test and post-test. * Indicate a significant difference from the pre-test. † Indicate a significant difference from the DNS and LLLT groups. Data represent Mean ± SD (n = 10). Repeated measures ANOVA with a between-group factor, followed by the post hoc test of Bonferroni.

Pearson correlation coefficient test results showed a significant negative relationship between depression and quality of life (r = -0.688, P = 0.001), flexor muscle endurance (r = -0.786, P = 0.001), and extensor muscle endurance (r = -0.826, P = 0.001). A significant positive relationship was observed between quality of life and flexor muscle endurance (r = 0.821, P = 0.001) and extensor muscle endurance (r = 0.729, P = 0.001).

Discussion

The first finding of the present study showed that DNS exercise, LLLT, and their combination decreased depression in women with CLBP. It is well established that DNS exercise reduces depression in individuals with chronic low back pain through biomechanical, functional, and psychological mechanisms. DNS targets inefficient movement patterns by activating deep core muscles (such as the diaphragm and transversus abdominis) and restoring optimal spinal stability. This reduces mechanical stress on the lumbar spine and pain intensity, improving functional capacity (28, 29). For example, an 8-week DNS program in patients with chronic low back pain significantly decreased pain and enhanced functional movement scores such as deep squats and rotary trunk stability. This led to increased participation in daily activities and reduced pain-related disability. By improving posture, balance, and movement efficiency, DNS fosters independence in daily tasks and social interactions. Studies have reported sustained improvements in health-related quality of life (SF-36 scores) after DNS intervention, which are associated with reduced psychological distress, feelings of helplessness, and social isolation—key contributors to depression in CLBP patients (29). In the present study, quality of life improved following DNS, LLLT, and their combination, which may explain the observed reduction in depression scores. Furthermore, DNS stimulates proprioceptors and exteroceptors through specific tactile cues, enhancing the cortical integration of sensory-motor signals. This reconfigures maladaptive movement strategies and reduces fear-avoidance behaviors, which are common in chronic pain and closely linked to anxiety and depression. Improved neuromuscular control also increases self-efficacy and fosters positive psychological states (30). DNS exercise has been reported to reduce depression and anxiety in patients with musculoskeletal pain (such as neck pain). While direct studies on DNS and depression in CLBP are limited, improvements in pain and function likely disrupt the pain-depression cycle, leading to better mental health outcomes (29).Regarding the reduction in depression following LLLT in the present study, it appears that this intervention reduces depression in chronic low back pain sufferers mainly through its analgesic and anti-inflammatory effects, which lower perceived pain and improve physical function, thereby indirectly enhancing mood and psychological well-being. LLLT promotes tissue repair and regeneration by stimulating mitochondrial activity and increasing cellular energy production. This decreases inflammation and oxidative stress in affected tissues (31). Pain relief resulting from LLLT is a key factor in reducing depression in chronic pain patients. Additionally, LLLT may directly influence brain function by modulating neural activity and promoting the release of endorphins, which can reduce anxiety and depression Clinical studies have shown significant reductions in depression and anxiety scores following near-infrared laser treatment targeting brain regions associated with mood regulation. Thus, by combining peripheral pain reduction with central neuromodulatory effects, LLLT improves depressive symptoms in people suffering from chronic low back pain (32). Another finding from this study shows that women with CLBP's quality of life improved significantly following DNS exercise, LLLT, and their combination. The greatest effect was observed when the two interventions were combined. Evidence shows that DNS improves quality of life for chronic low back pain sufferers by reducing pain, improving core muscle function, and enhancing functional ability. An 8-week DNS exercise program has been reported to significantly decrease pain intensity and functional disability while increasing quality of life scores in individuals with non-specific chronic low back pain (14). DNS achieves these effects by activating core muscles such as the multifidus and transversus abdominis, which stabilize the lumbar spine and optimize intra-abdominal pressure, thereby enhancing spinal control and reducing mechanical stress (33,34). Improved neuromuscular control leads to better posture, movement patterns, and balance, translating into enhanced physical function and reduced limitations in daily activities (28, 35). These physical improvements alleviate the psychological burden of chronic pain, contributing to better mental well-being and overall quality of life. However, studies also suggest that continued practice is necessary to maintain these benefits over time (14).On the other hand, LLLT improves the quality of life for people with chronic low back pain by reducing pain, inflammation, and tissue damage. This leads to enhanced mobility and functional ability. LLLT delivers specific wavelengths of light that stimulate cellular processes such as increased ATP production, collagen synthesis, and improved microcirculation, promoting tissue repair and reducing inflammatory mediators in the affected area. This photobiomodulation effect alleviates pain and edema, enabling patients to move more freely and engage in daily activities with less discomfort. Clinical studies have demonstrated significant and sustained reductions in pain intensity and disability scores after LLLT, along with improvements in patient-reported quality of life measures. Furthermore, LLLT is a non-invasive treatment with minimal side effects, offering a safe alternative to long-term medication use or surgery.In the present study, the endurance of the lumbar extensor and flexor muscles improved significantly following DNS exercise and LLLT, indicating a greater functional capacity. Enhanced physical capacity increases ability to perform daily activities and improves independence. This, in turn, leads to increased patient satisfaction and can contribute to an improved quality of life.As noted, the endurance of the lumbar extensor and flexor muscles increased significantly following DNS exercise and LLLT. DNS improves the endurance of the back extensor and flexor muscles in CLBP sufferers through neuromuscular re-education, enhanced core stability, and optimized intra-abdominal pressure regulation. DNS exercises emphasize the coordinated activation of deep stabilizers (e.g., transversus abdominis, multifidus) and superficial muscles (e.g., external obliques, erector spinae). By restoring synergistic muscle recruitment, DNS reduces compensatory overuse of the back extensors and flexors. This allows these muscles to build endurance without premature fatigue. For example, a 6-week DNS program significantly enhanced endurance in the flexor, extensor, and lateral core muscles in nonspecific CLBP patients. Improved intra-abdominal pressure through diaphragmatic breathing and pelvic floor engagement stabilizes the lumbar spine, reduces mechanical stress on the extensor and flexor muscles during sustained postures or movements, and enables them to maintain activity longer. Advanced intra-abdominal pressure regulation also improves load distribution across the trunk, mitigating localized muscle fatigue (36).DNS retrains movement patterns by replicating developmental positions, optimizing alignment and muscle firing sequences, ensuring balanced force production between antagonistic muscle groups (extensors vs. flexors), and delaying fatigue. An 8-week DNS intervention increased EMG activity in the external oblique muscle, reflecting broader gains in trunk muscle endurance (33,34). Chronic pain often leads to muscle atrophy and weakened endurance. By alleviating pain through better biomechanics, DNS encourages sustained physical activity, which enhances muscle stamina. Reduced fear of movement further promotes adherence to functional tasks that build endurance (37).In this study, LLLT also improved the endurance of the lumbar flexor and extensor muscles. LLLT enhances the endurance of these muscles in chronic low back pain sufferers mainly by reducing pain and inflammation. This allows better muscle function and increased physical activity. By stimulating cellular processes such as mitochondrial activity and ATP production, LLLT promotes tissue repair and reduces oxidative stress and inflammatory mediators in the lumbar region. This leads to decreased muscle fatigue and improved muscle metabolism, enabling the back extensor and flexor muscles to sustain activity for longer periods (38). Studies have reported that patients receiving simultaneously LLLT and exercise (including strengthening, stretching, mobilizing, coordination, and stabilizing the abdominal, back, pelvic, and lower limb muscles) experienced significantly greater improvements in pain relief, lumbar range of motion, and functional ability compared to exercise alone, indicating increased muscle endurance as part of overall functional gains (40). Another study combining high-intensity laser therapy with physical activity showed significant pain reduction, improved lumbar flexibility, and reduced disability, all supporting increased muscle endurance in treated patients. Additionally, LLLT's effects on microcirculation and nerve conduction may further facilitate muscle performance and endurance by improving oxygen and nutrient delivery. In addition, it may modulate pain signals that limit muscle use (41).

Conclusion

The results of the present study indicated that dynamic neuromuscular stabilization exercises, low-level laser therapy, and the combination of these two interventions led to a reduction in depression, improvement in quality of life, and increased endurance of the lumbar flexor and extensor muscles in women with non-specific chronic low back pain. The most significant changes were observed when dynamic neuromuscular stabilization exercises were combined with low-level laser therapy, suggesting that these two interventions mutually reinforce their effects on the studied outcomes and have a synergistic impact. It appears that these interventions improve functional capacity by increasing the endurance of the lumbar muscles, thereby reducing the depression associated with chronic low back pain Furthermore, the increase in functional capacity was also accompanied by improved quality of life. This reflected an enhanced daily activities ability. Based on these findings, it is concluded that both interventions can be considered an effective and non-invasive strategy for women with non-specific chronic low back pain.

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Conflicts of interest

The authors declare no conflicts of interest in this work.

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