Journal of Sports Physiology and Athletic Conditioning (J.S.P.A.C) 2026;1 (19): 57-64

Research Article

Effect of Dynamic Neuromuscular Stability Training on Lumbar Flexor and Extensor Muscle Strength in Women with Chronic Low-Back Pain

Atefeh Rafeieamjad[1], Heshmatollah Parsian[2*], Mohammad Ali Azarbayjani[3], Shahram Soheili[2], Rouhallah Ershadi[4]

1- Department of Physical Education and Sport Sciences, Ki.C., Islamic Azad University, Kish, Iran.
2- Department of Physical Education and Sport Sciences, ShQ.C., Islamic Azad University, Shahr-e Qods, Iran.
3- Department of Physical Education and Sport Sciences, CT.C., Islamic Azad University, Tehran, Iran.
4- Department of Physical Education and sport sciences, Bu.C., Islamic Azad University, Bushehr, Iran

Received: 7 January 2026
Accepted: 9 March 2026

Abstract

Weakness of the lumbar flexor and extensor muscles is among the most important contributors to low-back pain. Considering the role of dynamic neuromuscular stability (DNS) training on muscular strength, the present study was conducted to determine the effect of DNS training on lumbar flexor and extensor strength in women with chronic low-back pain. Twenty middle-aged women with at least six months of chronic low-back pain were recruited as participants and randomly assigned to a DNS-training group or a control group. DNS training was performed three times per week for eight weeks. Lumbar flexor and extensor strength was measured with a digital dynamometer before and after the intervention. Results indicated that DNS training produced a significant increase in flexor strength (P = 0.001) and extensor strength (P = 0.001), whereas the control group showed no significant changes for flexors (P = 0.141) or extensors (P = 0.104). The findings suggest that DNS training can enhance lumbar flexor and extensor strength in women with chronic low-back pain. Because weakness of these muscles is a major factor in the development of chronic low-back pain, the program can be considered a suitable strategy for reducing related impairments. Nevertheless, further studies are needed to confirm these results.

Keywords:
Dynamic neuromuscular stability training; lumbar flexor strength; lumbar extensor strength; chronic low-back pain.

***Corresponding author:** Heshmatollah Parsian
Address: Department of Physical Education and Sport Sciences, ShQ.C., Islamic Azad University, Shahr-e Qods, Iran.
Email: h.parsian@qodsiau.ac.ir **Tell:** 09124332370

1. Introduction

Low-back pain (LBP) is one of the most common spinal disorders among young and middle-aged populations and a prevalent musculoskeletal problem in developed countries. Approximately 80 % of people experience LBP at least once during their lifetime (1). Symptoms include pain, limited range of motion, or inability to stand upright, which adversely affect daily activities. LBP is recognized as a major public-health issue (2) and imposes substantial direct medical costs on individuals and societies (3).

LBP may arise from acute strains due to lifting heavy objects, rotating the trunk, sports activities, postural imbalance, or obesity, as well as from traumatic events (e.g., automobile accidents, falls) or degenerative conditions such as arthritis, disc disease, osteoporosis, viral infections, osteoarthritis, rheumatoid arthritis, disc herniation, vertebral fractures, and prior joint or disc injuries that have not received adequate treatment. Congenital spinal anomalies, obesity, smoking, weight gain during pregnancy, psychological stress, physical weakness, poor posture, and sleep disturbances can also contribute. Chronic pain is often accompanied by anxiety, depression, reduced quality of life, and functional limitations (4).

Patients with chronic nonspecific LBP represent 73–77 % of all LBP patients; in 85 % of these cases no specific pathology is identified, and factors such as individual, psychological, anatomical–biomechanical, and trunk muscle weakness play significant roles (5,6). Chronic specific LBP persists for more than three months without a known pathophysiology (7) and negatively impacts functional, socioeconomic, occupational, and psychological status (8,9). The majority of societal and economic costs linked to LBP are incurred by individuals who have long-term or recurrent disability (10).

Primary goals of chronic LBP treatment are pain reduction, improvement of soft-tissue flexibility, enhancement of strength and endurance of trunk stabilizers, and restoration of mobility and posture, leading to better functional capacity and prevention of work loss (11,12). Numerous studies have demonstrated a strong association between LBP and reduced endurance of core muscles; significant differences in core muscle performance have been reported between healthy individuals and LBP patients (13,١٤). Therefore, increasing lumbar muscle strength is a key objective of regular physical activity.

Dynamic neuromuscular stability (DNS) training, a program designed to improve chronic pain, has attracted considerable attention. DNS is based on a precise assessment of stability and movement quality, aiming to restore an integrated spinal system through functional, evolutionarily-derived movement patterns. The main focus is on central (core) stability, primarily provided by the lumbar flexors and extensors, diaphragm, transverse abdominis, and multifidus. Emphasis is placed on correct diaphragm activation, breathing patterns, and core stabilization before any purposeful movement (15). DNS seeks to re-establish physiologic movement patterns defined by developmental kinesiology, requiring optimal central stability for maximal force production during functional tasks. This coordination influences local and global anatomical-biomechanical parameters within the kinematic chain (16).

DNS also targets intra-abdominal pressure (IAP) regulation and the spinal stabilizing system (ISS) to optimise movement efficiency and avoid excessive joint loading. By balancing deep flexor and extensor activity, as well as diaphragm-pelvic floor coordination, DNS enhances lumbar segmental stiffness and reduces compressive forces on the vertebrae (17). Chronic LBP reduces quality of life, functional performance, and may increase anxiety and depression (18). Exercise programmes that focus on deep trunk stabilisers, stretching, and relaxation are recommended to alleviate LBP (19).

Given the documented influence of DNS on skeletal muscles, the present study aimed to determine the effect of DNS training on lumbar flexor and extensor strength in women with chronic low-back pain.

2. Materials and Methods

Participants

In this semi-experimental study, 20 middle-aged women with chronic low-back pain were recruited from a rehabilitation centre in Isfahan. Inclusion criteria were: age 40–50 years, low-back pain lasting > 6 months, no medical contraindications to exercise, no use of anti-inflammatory or analgesic medication, and no regular weekly physical activity. After informed consent, participants were randomly allocated (draw) to either the DNS-training group or a control group. All procedures complied with the Helsinki Declaration.

DNS Training Program

The DNS protocol consisted of 8 weeks, three sessions per week. Each session lasted 50 minutes (40 minutes of DNS exercises plus 10 minutes of cool-down) (reference 11). The session was divided into four 10-minute blocks covering diaphragmatic breathing, supine, prone, rolling, side-lying, inclined sitting, quadruped, knee-to-chest, squat, and standing. Throughout, diaphragmatic breathing and maintenance of IAP were emphasized.

Strength Measurement

Isometric lumbar flexor and extensor strength (abdominal lateral wall and back muscles) were measured with a digital dynamometer (Commander™ Muscle Tester, JTECH Medical, USA). The device reports an intraclass correlation of 0.94 and has validated reliability (20).

Flexor test: participants lay supine, the dynamometer was placed on the sternum, and resistance was applied while the subject lifted the head and shoulders to 45°; the peak flexion force was recorded.

Extensor test: participants lay prone, the dynamometer was positioned between the scapulae, and resistance was applied while the trunk extended to ~15°. Three trials were performed for each test, and the average value was recorded.

Statistical Analysis

Outcome data are presented as mean ± standard deviation. Repeated-measures ANOVA with a between-subjects factor (group) was used to assess the effect of DNS training on lumbar flexor and extensor strength. The model examined main effects of time, group, and the time × group interaction. When a significant interaction was found, post-hoc Bonferroni pairwise comparisons were applied. Within-group changes were also examined using paired-sample t-tests. Significance was set at $p < 0.05$. All analyses were performed with SPSS 22.

3. Results

The Shapiro-Wilk and Levene tests confirmed normal distribution and homogeneity of variance for flexor and extensor strength data in both groups (pre- and post-intervention).

Flexor Strength

Two-way ANOVA revealed significant main effects of time ($F = 21.48, p = 0.001, \eta^2 = 0.544$) and a significant time × group interaction ($F = 51.51, p = 0.001, \eta^2 = 0.741$). The group main effect was non-significant ($F = 1.32, p = 0.256, \eta^2 = 0.069$). Post-hoc Bonferroni tests showed that the DNS group increased significantly from pre- to post-training ($p = 0.001$), whereas the control group showed no significant change ($p = 0.141$).

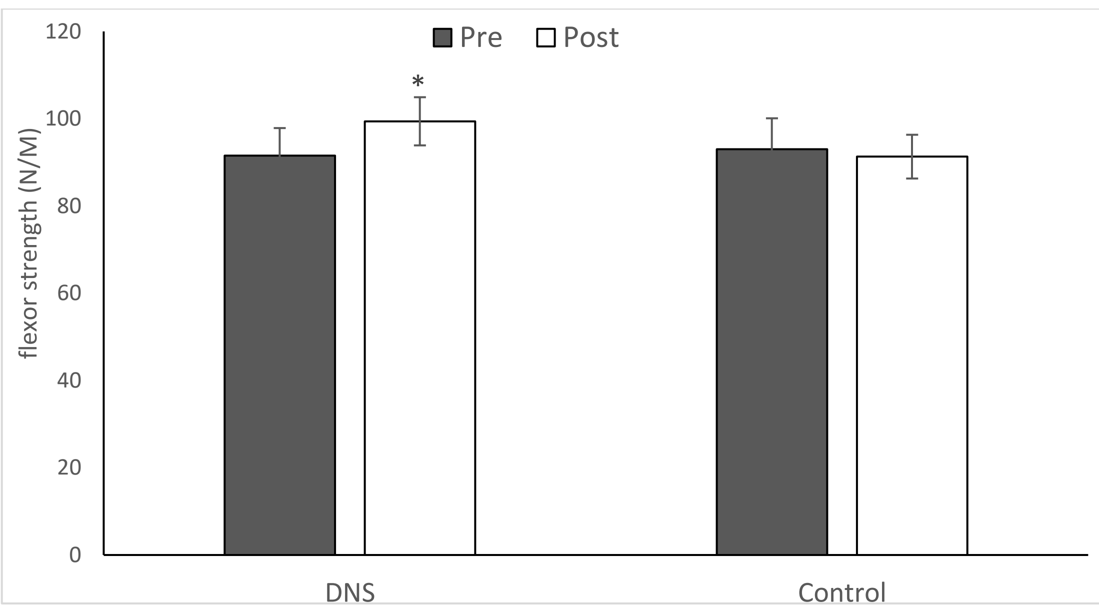

Figure 1 illustrates the mean ± SD flexor strength before and after the intervention for both groups. *Denote significant differences to pre-test.

Extensor Strength

Similarly, ANOVA demonstrated significant main effects of time ($F = 18.96, p = 0.001, \eta^2 = 0.513$) and a significant time × group interaction ($F = 49.48, p = 0.001, \eta^2 = 0.733$). The group effect alone was non-significant ($F = 1.15, p = 0.297, \eta^2 = 0.060$). Bonferroni comparisons indicated a significant increase in extensor strength in the DNS group ($p = 0.001$) but not in the control group ($p = 0.104$).

4. Discussion

In the present study, lumbar flexor and extensor strength increased significantly after the dynamic neuromuscular stability (DNS) program. Evidence indicates that DNS enhances flexor-and-extensor strength primarily by improving joint stability, feed-forward motor control (a predictive, pre-emptive process that uses a pre-planned movement model to generate commands and, by anticipating and correcting errors before they occur, provides greater speed and accuracy), and coordinated activation of agonist–antagonist muscle pairs rather than by simple muscle hypertrophy. These neuromuscular adaptations allow the flexors and extensors to generate higher torques on a more stable base with more efficient force transmission along the kinetic chain, resulting in greater muscular output—that is, an increase in strength of these muscles (21,22).

Furthermore, DNS, which is grounded in developmental kinesiology, exerts its effect on muscular strength by re-training movement patterns during early neuro-developmental stages and linking cortical and sub-cortical centers to automatic stabilization. Repetition of DNS postures together with diaphragmatic breathing shifts control from conscious correction to automatic sub-cortical patterns, so that stabilizers become feed-forward-active before the prime mover (flexor-extensor) contracts (21). This anticipatory activation reduces latency of deep trunk muscles such as the diaphragm, transverse abdominis, and pelvic floor—muscles that are often delayed in individuals with poor motor control or central pain. When these core muscles fire a few milliseconds before limb movement, the flexors and extensors can contract against a pre-tensed trunk, increasing effective torque and decreasing muscular energy waste (23).

A key mechanism of DNS is the coordinated recruitment of the diaphragm, pelvic floor, and abdominal wall to raise intra-abdominal pressure (IAP), thereby stiffening the lumbar segment. A higher, well-regulated IAP creates a more rigid lumbar-pelvic segment, allowing flexion and extension forces to be transmitted more efficiently without excessive shear on the vertebral joints (22). DNS deliberately couples diaphragmatic breathing with postural tasks, training the diaphragm both as a respiratory muscle and as a stabilizer. This dual role means that every flexion or extension effort, which is reflexively better stabilized, is supported, consequently increasing the net torque that the muscles can produce during functional tasks (21).

One of the most important effects of DNS may be joint-centred co-activation, whereby agonists (e.g., flexors) and antagonists (e.g., extensors) fire together to keep the joint in a neutral, highly coordinated position under load. In this state, muscle force vectors are optimised, passive structures are protected, and both flexors and extensors can generate force through a more favourable length-tension relationship, thereby increasing overall muscular strength (24). Because DNS patterns require simultaneous, precisely timed contraction of deep and superficial muscles, they promote balanced co-contraction of flexor–extensor groups across the spine, pelvis and shoulders. Over time, this improves neuromuscular coordination and endurance of both muscle groups, manifesting as greater strength, stability and movement quality (24,25).

The DNS positions (e.g., arch-back, prone, quadruped, kneeling, standing) are organized to progressively challenge the integrated stabilizing system during both closed- and open-chain limb movements. As stability improves, load, lever arm length and task complexity increase, allowing the principle of progressive overload to be applied to the flexors and extensors in functional patterns (26). Intervention studies have shown that DNS programmes produce greater gains in core strength, lower-extremity endurance and functional-movement scores than traditional exercise programmes, indicating that the neuromuscular adaptations translate into measurable improvements in muscular power and performance. Consequently, DNS, by integrating motor-control re-training, core-mediated stiffening, and simultaneous joint activation in realistic movement patterns, strengthens the spinal flexors and extensors (22, 27).

۵. Conclusion

Eight weeks of dynamic neuromuscular stability training increased lumbar flexor and extensor strength in women with chronic low-back pain. Because weakness of these muscles is a primary factor in the development of chronic low-back pain, the DNS programmed can be considered an effective strategy for reducing the adverse effects of chronic low-back pain. Nevertheless, further research with larger samples and longer follow-up periods is required.

Acknowledgements

This work is derived from a doctoral dissertation in Exercise Physiology, Department of Physical Education and Sports Sciences, Islamic Azad University, International Campus, Kish. The authors thank all participants for their cooperation and the staff of the rehabilitation center for their assistance.

Funding

This study did not have any funds.

Compliance with ethical standards

Conflict of interest None declared.

Ethical approval the research was conducted with regard to the ethical principles.

Informed consent Informed consent was obtained from all participants.

Author contributions

Conceptualization: A.R, H.P, M.A.A, SH.S, R.E ; Methodology: A.R, H.P, M.A.A, SH.S, R.E ; Software: A.R, H.P, M.A.A, SH.S, R.E ; Validation: A.R, H.P, M.A.A, SH.S, R.E ; Formal analysis: A.R, H.P, M.A.A, SH.S, R.E ; Investigation: A.R, H.P, M.A.A, SH.S, R.E ; Resources: A.R, H.P, M.A.A, SH.S, R.E ; Data curation: A.R, H.P, M.A.A, SH.S, R.E ; Writing - original draft: A.R, H.P, M.A.A, SH.S, R.E ; Writing - review & editing: A.R, H.P, M.A.A, SH.S, R.E ; Visualization: A.R, H.P, M.A.A, SH.S, R.E ; Supervision: A.R, H.P, M.A.A, SH.S, R.E ; Project administration: A.R, H.P, M.A.A, SH.S, R.E ; Funding acquisition: : A.R, H.P, M.A.A, SH.S, R.E .

References

1. Hoy D, March L, Brooks P, Brooks P, Blyth F, Woolf A, et al. The global burden of low back pain: estimates from the Global Burden of Disease 2010 study. Ann Rheum Dis. 2014;73:968–74.

2. Strine TW, Hootman JM. US national prevalence and correlates of low back and neck pain among adults. Arthritis Rheum. 2007;57:656–65

3. Maniadakis, N., & Gray, A. (2000). The economic burden of back pain in the UK. Pain, 84(1), 95-103.

4.Kaushik M, Ahmad I. Bridging Dynamic Neuromuscular Stabilization Synergism with Movement Control Impairment Related Non-Specific Low Back Pain: Scoping Review. J Musculoskelet Neuronal Interact. 2024 Dec 1;24(4):420-432.

5. Zadro, J. R., Shirley, D., Sánchez-Romera, J. F., Ordoñana, J. R., & Ferreira, P. H. (2017). Does familial aggregation of chronic low back pain affect recovery?: A population-based twin study. Spine, 42(17), 1295-1301.

6. Collaborators, G. B. D. (2018). Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017

7. Chou, R., Deyo, R., Friedly, J., Skelly, A., Hashimoto, R., Weimer, M., ... & Brodt, E. D. (2017). Nonpharmacologic therapies for low back pain: a systematic review for an American College of Physicians clinical practice guideline. Annals of internal medicine, 166(7), 493-505.

8. Abdelraouf, O. R., & Abdel-Aziem, A. A. (2016). The relationship between core endurance and back dysfunction in collegiate male athletes with and without nonspecific low back pain. International journal of sports physical therapy, 11(3), 337.

9. Babatunde OO, Jordan JL, Van der Windt DA, Hill JC, Foster NE, Protheroe J (2017) Effective treatment options for musculoskeletal pain in primary care: a systematic overview of current evidence. PLoS ONE 12(6):e0178621

10. Hartvigsen, J., Hancock, M. J., Kongsted, A., Louw, Q., Ferreira, M. L., Genevay, S.,& Woolf, A. (2018). What low back pain is and why we need to pay attention. The Lancet, 391(10137), 2356-2367.

11. Alvani E, Golpayegani M, Bokaie M, Soleymani haji kandi S. [Investigating the effect of dynamic neuromuscular stability (DNS) exercises on chronic non-specific low back pain: a narrative review article (Persian)]. J Anesth Pain 2023;14(2):98- 106.

12. Simmonds, M. J., Olson, S. L., Jones, S., Hussein, T., Lee, C. E., Novy, D., & Radwan, H. (1998). Psychometric characteristics and clinical usefulness of physical performance tests in patients with low back pain. Spine, 23(22), 2412-2421.

13. Abdelraouf, O. R., & Abdel-Aziem, A. A. (2016). The relationship between core endurance and back dysfunction in collegiate male athletes with and without nonspecific low back pain. International journal of sports physical therapy, 11(3), 337.

14. Mannion, A. F., & Dolan, P. (1994). Electromyographic median frequency changes during isometric contraction of the back extensors to fatigue. Spine, 19(11), 1223-1229.

1156. Sharma K, Yadav A. Dynamic neuromuscular stabilization-a narrative. International Journal of HealthSciences and Research. 2020;10(9):221-31.

16. Davidek, P., Andel, R., & Kobesova, A. (2018). Influence of dynamic neuromuscular stabilization approach on maximum kayak paddling force. Journal of human kinetics, 61(1), 15-27.

17. Ghavipanje, V. , Mohammad Rahimi, N. and Akhlaghi, F. (2022). The effect of 6 weeks dynamic neuromuscular stabilization (DNS) breathing exercises on postpartum balance and quality of life in primiparous women with low back pain. *The Iranian Journal of Obstetrics, Gynecology and Infertility*, *25*(5), 78-86.

18. Schäfer, R., Niederer, D., Levenig, C., Hasenbring, M., Tas, T., Fett, D., ... & Platen, P. (2022). Effectiveness and mechanisms of a multimodal treatment for low back pain: a pragmatic matched cohort study. medRxiv, 2022-09.

19. Tomanova, M., Lippert-Grüner, M., & Lhotska, L. (2015). Specific rehabilitation exercise for the treatment of patients with chronic low back pain. Journal of physical therapy science, 27(8), 2413-2417.

20. Bohannon, R. W. (1990). Hand-held compared with isokinetic dynamometry for measurement of static knee extension torque (parallel reliability of dynamometers). Clinical Physics and Physiological Measurement, 11(3), 217.

21. Frank C, Kobesova A, Kolar P. Dynamic neuromuscular stabilization & sports rehabilitation. Int J Sports Phys Ther. 2013 Feb;8(1):62-73.

22. Babagoltabar-Samakoush, H., Aminikhah, B. & Bahiraei, S. Effectiveness of dynamic neuromuscular stabilization training on strength, endurance, and flexibility in adults with intellectual disabilities, a randomized controlled trial. *Sci Rep* **15**, 768 (2025).

23. Desai R, Rathi M, Agrawal P, Palekar TJ. Core stabilization exercises versus yoga on feedforward activation of core muscles in chronic mechanical low back pain: An experimental study. J Bodyw Mov Ther. 2024 Oct;40:203-210.

24. Hosseini H, Rahimi A, Javanshir K, Taghipour M, Daryabor A, Naimi SS. Effect of Dynamic Neuromuscular Stabilization Exercises on Activity of External Oblique Muscle in Low Back Pain. jmr. 2024;19(1):90-97.

25. Mahdieh L, Zolaktaf V, Karimi MT. Effects of dynamic neuromuscular stabilization (DNS) training on functional movements. Hum Mov Sci. 2020 Apr;70:102568.

26. Türkmen G, Kurbetli N. (2025). The Role of Dynamic Neuromuscular Stabilization Exercises in Pelvic Floor Rehabilitation: A Literature Review. Van Sağlık Bilimleri Dergisi, 18(2), 147-155.

27. Naghizadeh, N., Riyahi Malayeri, S., Roozbahani, M., Khademi, A., Shirvani, H. The Effectiveness of Endurance Training and Nano Curcumin Supplementation on the Expression of Mir-21and P53 Genes in Brain Tumor Tissue in an Animal Model of Glioblastoma Multiform. Journal of Nutrition,Fasting and Health, 2024; 12(1): 26-35. doi: 10.22038/jnfh.2023.73964.1455.