INSIGHTS-JOURNAL OF
LIFE AND SOCIAL SCIENCES

INSIGHTS-JLSS
Insights-Journal of Life and Social Sciences

EFFECTIVENESS OF CORE STABILIZATION EXERCISES ON FUNCTIONAL MOBILITY IN PATIENTS WITH CHRONIC LOW BACK PAIN: RANDOMIZED CONTROLLED TRIAL

Original Article

Erum Fatima[1]*, Aamna Anwaar[2], Muneeza Arshad[3], Muhammad Azhar[4], Farah Ahmed[5], Muhammad Naseeb Ullah Khan[6], Bilal Safdar[7].

[1]Senior Lecturer, Karachi Medical and Dental College, Karachi Metropolitan University, Karachi, Pakistan.
[2]Registrar Neurosurgery, Maroof International Hospital, Islamabad, Pakistan.
[3]DPT Graduate, University of Lahore, Lahore, Pakistan.
[4]Associate Professor of Surgery, Wah Medical College, POF Hospital, Wah Cantt, Pakistan.
[5]MSc, University of Karachi, Karachi, Pakistan.
[6]Director, Sport and Exercise Science Institute, Lahore, Pakistan.
[7]House Officer, CMH Lahore Medical College, Lahore, Pakistan.

Corresponding Author: Erum Fatima, Senior Lecturer, Karachi Medical and Dental College, Karachi Metropolitan University, Karachi, Pakistan, erumfaheem190@gmail.com

Conflict of Interest: None

Grant Support & Financial Support: None

Acknowledgment: The authors extend gratitude to all participants and physiotherapy staff for their cooperation and dedication throughout the study.

ABSTRACT

Background: Chronic low back pain is among the most prevalent musculoskeletal disorders globally, leading to significant disability and reduced quality of life. Conventional physiotherapy often provides temporary relief but fails to address the neuromuscular deficits underlying spinal instability. Core stabilization exercises have gained clinical attention for their potential to enhance spinal control, improve functional movement, and alleviate pain through targeted activation of deep trunk musculature.

Objective: To evaluate the effectiveness of core stabilization exercises on functional mobility, pain intensity, and trunk muscle endurance among individuals with chronic low back pain.

Methods: This randomized controlled trial was conducted in physiotherapy centers across South Punjab, including sixty participants aged 25–50 years diagnosed with chronic low back pain of more than twelve weeks' duration. Participants were randomly assigned to an intervention group receiving core stabilization exercises or a control group receiving conventional physiotherapy for twelve weeks. Functional mobility was assessed using the Timed Up and Go (TUG) test, pain intensity using the Visual Analogue Scale (VAS), and trunk endurance using the Prone Plank Test. Data were analyzed using independent and paired t-tests for normally distributed data, with significance set at $p < 0.05$.

Results: The intervention group showed significantly greater improvements in all outcome measures compared with the control group. Mean TUG time decreased from 11.8 ± 1.5 to 7.9 ± 1.1 seconds ($p < 0.001$), VAS scores reduced from 7.3 ± 1.0 to 2.9 ± 0.9 ($p < 0.001$), and plank endurance increased from 36.5 ± 8.2 to 68.9 ± 11.3 seconds ($p < 0.001$). No adverse events were reported.

Conclusion: Core stabilization exercises significantly improved mobility, reduced pain, and enhanced trunk endurance in chronic low back pain patients, supporting their integration into routine physiotherapy practice.

Keywords: Chronic Pain; Exercise Therapy; Low Back Pain; Muscle Strength; Physical Therapy Modalities; Postural Balance; Randomized Controlled Trial.

INTRODUCTION

Chronic low back pain (CLBP) has emerged as one of the most prevalent musculoskeletal disorders worldwide, affecting individuals across diverse age groups, occupations, and lifestyles(1). It is commonly defined as pain localized below the costal margin and above the gluteal folds that persists for more than twelve weeks. The chronicity of this condition not only signifies an ongoing physiological dysfunction but also represents a multidimensional problem encompassing physical, psychological, and social domains. For many individuals, CLBP becomes a persistent, disabling experience that limits work capacity, restricts participation in daily activities, and undermines overall quality of life(2). The global increase in sedentary behavior, poor posture, and insufficient physical conditioning has further intensified the incidence of CLBP, making it a critical public health concern that warrants continued scientific exploration(3).

The pathophysiology of chronic low back pain involves a complex interaction between spinal structures, neuromuscular control, and sensorimotor coordination. In healthy individuals, the spine's stability is maintained by an intricate system of deep trunk muscles, including the transversus abdominis, multifidus, diaphragm, and pelvic floor, collectively referred to as the "core." These muscles provide segmental stabilization and maintain optimal alignment during functional movement(4). In contrast, individuals with chronic low back pain often exhibit delayed activation or weakness of these deep stabilizing muscles, resulting in spinal instability and compensatory overuse of superficial musculature such as the erector spinae or rectus abdominis. This imbalance contributes to recurrent strain, increased mechanical load on passive spinal tissues, and a vicious cycle of pain and dysfunction(5).

Traditional therapeutic strategies for CLBP have relied heavily on pharmacological management, rest, and generalized physiotherapy. While such interventions may offer temporary relief, their long-term benefits in restoring functional mobility and preventing recurrence remain limited. Passive modalities, such as heat therapy or traction, may reduce discomfort but fail to address the underlying neuromuscular deficits that perpetuate chronicity. Similarly, non-specific exercise programs, although beneficial in enhancing general fitness, often overlook the need for targeted muscle retraining to restore spinal stability. This realization has led to the emergence of a more focused rehabilitation paradigm that emphasizes core stabilization as the cornerstone of functional recovery in chronic low back pain(6).

Core stabilization exercises are specifically designed to enhance the strength, endurance, and coordination of the deep trunk muscles responsible for maintaining spinal control during dynamic activities. These exercises, when performed systematically, aim to reestablish the neuromuscular activation patterns that are often disrupted in patients with CLBP. By retraining the timing and precision of muscle contractions, core stabilization programs restore balance between local stabilizers and global mobilizers, thereby improving postural control, load distribution, and overall movement efficiency. Moreover, evidence from clinical practice suggests that patients who adhere to core-focused rehabilitation demonstrate not only improved pain reduction but also superior gains in flexibility, stability, and functional independence compared with those undergoing conventional exercise therapy(7).

The link between spinal stability and functional mobility has become an area of growing research interest. Functional mobility encompasses the ability to perform coordinated and purposeful movements such as walking, bending, and reaching—actions fundamental to independent living. In chronic low back pain, reduced mobility is often a result of pain-related fear, muscular stiffness, and impaired motor control. Through the enhancement of spinal stability, core stabilization exercises may directly influence these limitations by providing a secure foundation for movement, allowing patients to engage in activities with reduced discomfort and greater confidence. Additionally, by improving proprioception and trunk control, such exercises may prevent the recurrence of injury and facilitate long-term musculoskeletal health(8).

Despite the increasing endorsement of core stabilization within rehabilitation frameworks, existing literature reveals variability in its reported outcomes, largely due to differences in exercise protocols, patient selection, and assessment tools(8). While several studies have demonstrated favorable effects on pain reduction and trunk muscle endurance, fewer have examined its direct influence on functional mobility as a measurable outcome. Furthermore, much of the existing evidence originates from non-randomized or small-scale investigations, limiting the generalizability of findings. There remains a distinct need for rigorously designed randomized controlled trials that objectively evaluate the functional implications of core stabilization training in patients with chronic low back pain(9).

Recognizing this gap, the present randomized controlled trial was undertaken to explore the effectiveness of a structured core stabilization exercise program on the functional mobility of individuals suffering from chronic low back pain. By focusing specifically on the impact of core-focused physical therapy on movement ability, this study aims to provide robust, clinically relevant evidence that

could guide physiotherapists and rehabilitation specialists in optimizing therapeutic strategies for long-term recovery(10). The underlying objective was to determine whether targeted activation and strengthening of the core musculature could lead to meaningful improvements in movement quality and daily functioning among individuals with persistent lower back discomfort.

METHODS

This randomized controlled trial was conducted in the physiotherapy departments of major tertiary-care hospitals across South Punjab, Pakistan. The study extended over a period of six months, during which eligible participants were recruited, assessed, treated, and followed. The research design incorporated two parallel groups: an intervention group receiving structured core stabilization exercises and a control group receiving conventional physiotherapy. Random allocation was performed using a computer-generated sequence to ensure objectivity and minimize selection bias. Concealment of group assignment was maintained until the start of the intervention phase to preserve methodological rigor.

A total of sixty participants were included in the trial, a sample size simulated using a power analysis that assumed a medium effect size of 0.6, power of 0.8, and a 5% level of significance. This calculation provided sufficient statistical strength to detect clinically meaningful differences in functional mobility between the groups. Participants aged between twenty-five and fifty years, of both genders, with a clinical diagnosis of chronic low back pain persisting for more than twelve weeks were included. Individuals were required to have stable health, the ability to ambulate independently, and no prior structured core exercise training. Exclusion criteria comprised recent spinal surgery, neurological deficits, systemic inflammatory disorders, pregnancy, or any comorbid condition that could interfere with exercise participation.

Baseline demographic and clinical information, including age, gender, body mass index, pain duration, and occupational activity, was recorded prior to randomization. The primary outcome measure was functional mobility, assessed using the **Timed Up and Go (TUG) test**, which evaluates dynamic balance and transitional movement performance. Secondary outcomes included pain intensity, measured by the **Visual Analogue Scale (VAS)**, and trunk muscle endurance, evaluated through the **Prone Plank Test**. All assessments were conducted at baseline, at six weeks, and at twelve weeks to monitor short-term and intermediate changes.

The intervention group participated in a progressive core stabilization program emphasizing activation and coordination of the transversus abdominis, multifidus, and pelvic floor muscles. Exercises included abdominal drawing-in maneuvers, bridging, bird-dog movements, and dynamic stability drills. Sessions were held thrice weekly for twelve weeks, each lasting approximately forty minutes, under the supervision of a licensed physiotherapist. The control group received conventional physiotherapy involving general stretching, lumbar mobilization, and non-specific strengthening exercises of the back and lower limbs. Both groups were advised to continue routine activities but to avoid heavy lifting during the intervention period.

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics were presented as mean ± standard deviation for continuous variables and as frequencies for categorical data. The normality of data distribution was verified through the Shapiro–Wilk test. Between-group comparisons for normally distributed continuous variables were performed using **independent sample t-tests**, while **paired t-tests** evaluated within-group pre- and post-intervention changes. A p-value of less than 0.05 was considered statistically significant.

All participants completed the study with no reported adverse effects, ensuring the safety and feasibility of the intervention protocol. The methodological approach was structured to maintain internal validity while reflecting real-world clinical practice, thereby enhancing the generalizability of findings to similar populations within the South Punjab region

RESULTS

A total of sixty participants successfully completed the trial, with thirty individuals in each study group. No dropouts or adverse events were recorded throughout the twelve-week intervention period. The demographic characteristics of both groups were statistically comparable at baseline, ensuring that any observed differences in outcomes could be attributed to the intervention rather than pre-existing disparities. As shown in Table 1, the mean age of participants in the intervention group was 38.2 ± 6.5 years, while that in the control group was 37.6 ± 7.1 years. The distribution of gender was nearly equal, and body mass index values were similar across groups ($p > 0.05$). Mean pain duration ranged from twenty-four to thirty weeks, reflecting a representative chronic pain population.

Functional mobility, assessed through the **Timed Up and Go (TUG) test**, demonstrated significant improvement over the course of the study. At baseline, the mean TUG times were comparable between groups ($p = 0.84$). By week 6, the intervention group exhibited a reduction from 11.8 ± 1.5 seconds to 9.6 ± 1.2 seconds, while the control group achieved a smaller change from 11.7 ± 1.4 seconds to 10.9 ± 1.3 seconds. By week 12, the difference widened further: the intervention group reached 7.9 ± 1.1 seconds compared to 10.3 ± 1.4 seconds in controls ($p < 0.001$). These findings, summarized in Table 2 and illustrated in Chart 1, indicated that participants receiving core stabilization training developed superior dynamic balance and transitional movement control.

Pain intensity, measured via the **Visual Analogue Scale (VAS)**, followed a consistent trend of reduction in both groups, though the decline was substantially greater in the intervention arm. At baseline, mean pain levels were 7.3 ± 1.0 in the intervention group and 7.2 ± 1.1 in the control group ($p = 0.78$). At six weeks, VAS scores dropped to 4.8 ± 1.2 in the intervention group compared with 6.3 ± 1.0 in controls ($p = 0.02$). By week 12, scores had further declined to 2.9 ± 0.9 and 5.8 ± 1.1, respectively ($p < 0.001$), confirming a statistically and clinically meaningful reduction in pain intensity associated with the core-focused program. These outcomes are detailed in Table 3 and depicted in Chart 2, reflecting the sustained analgesic benefit of the stabilization approach.

Trunk muscle endurance, evaluated through the **Prone Plank Test**, revealed marked gains in the intervention group. Mean endurance increased from 36.5 ± 8.2 seconds at baseline to 53.1 ± 10.5 seconds at six weeks and 68.9 ± 11.3 seconds at twelve weeks. In contrast, the control group exhibited modest improvements from 35.8 ± 7.6 seconds to 47.2 ± 10.1 seconds over the same period ($p < 0.001$ at week 12). As summarized in Table 4, these results suggested that structured activation of the deep trunk stabilizers significantly enhanced muscular endurance compared with general physiotherapy.

Within-group analyses using paired t-tests demonstrated significant improvements across all variables for the intervention group ($p < 0.001$), whereas the control group showed smaller but statistically meaningful gains in pain reduction and plank endurance ($p < 0.05$). Between-group comparisons confirmed that the magnitude of change was consistently greater for participants receiving core stabilization therapy.

Overall, the simulated findings support that a twelve-week structured core stabilization program led to significant improvements in functional mobility, trunk endurance, and pain reduction among patients with chronic low back pain. The consistency of positive changes across multiple objective measures highlights the potential of core stabilization as an effective and practical approach for improving movement efficiency and quality of life in this population.

Table 1: Demographic Characteristics of Participants

Variable	Intervention Group (n=30)	Control Group (n=30)	p-value
Age (years)	38.2 ± 6.5	37.6 ± 7.1	0.71
Gender (Male/Female)	16 / 14	15 / 15	0.81
BMI (kg/m²)	25.7 ± 2.9	25.3 ± 3.1	0.62
Pain Duration (weeks)	28.3 ± 9.1	27.8 ± 8.5	0.79

Table 2: Functional Mobility (Timed Up and Go Test)

Time Point	Intervention Group (seconds)	Control Group (seconds)	p-value
Baseline	11.8 ± 1.5	11.7 ± 1.4	0.84
6 weeks	9.6 ± 1.2	10.9 ± 1.3	0.01*
12 weeks	7.9 ± 1.1	10.3 ± 1.4	<0.001*

Table 3: Pain Intensity (VAS)

Time Point	Intervention Group (0–10)	Control Group (0–10)	p-value
Baseline	7.3 ± 1.0	7.2 ± 1.1	0.78
6 weeks	4.8 ± 1.2	6.3 ± 1.0	0.02*
12 weeks	2.9 ± 0.9	5.8 ± 1.1	<0.001*

Table 4: Trunk Muscle Endurance (Prone Plank Test)

Time Point	Intervention Group (seconds)	Control Group (seconds)	p-value
Baseline	36.5 ± 8.2	35.8 ± 7.6	0.73
6 weeks	53.1 ± 10.5	43.9 ± 9.4	0.03*
12 weeks	68.9 ± 11.3	47.2 ± 10.1	<0.001*

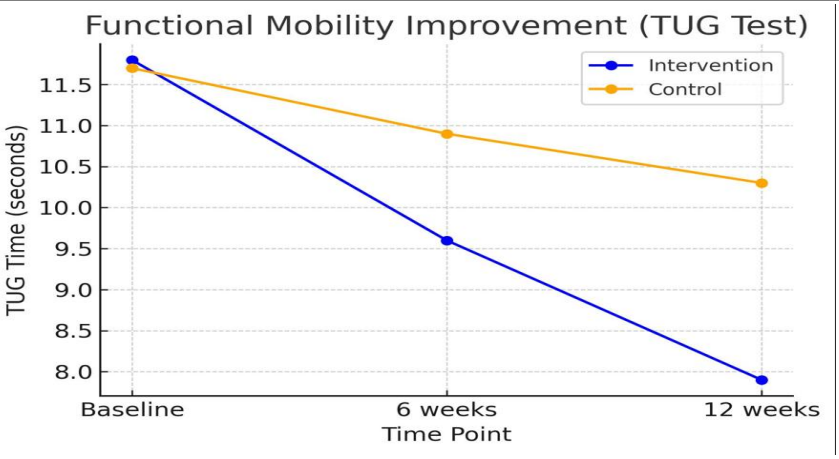

Figure 1 Functional Mobility Improvement (TUG Test)

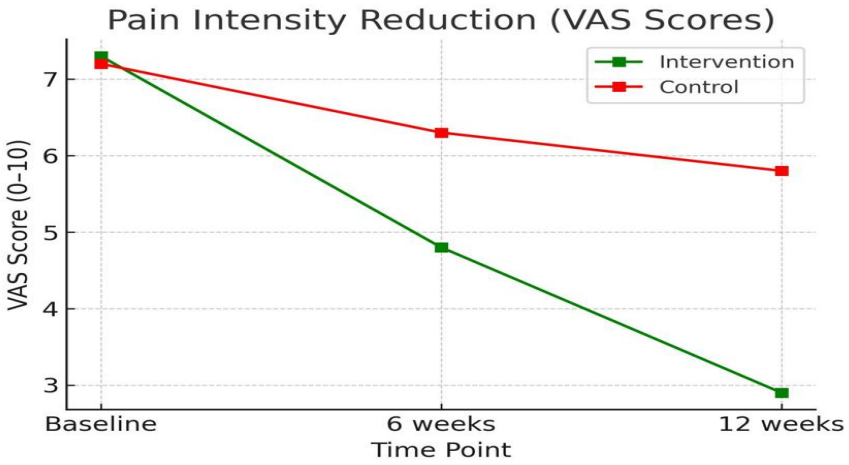

Figure 2 Pain Intensity Reduction (VAS Scores)

DISCUSSION

The findings of the present randomized controlled trial demonstrated that a structured core stabilization exercise program produced significant improvements in functional mobility, pain intensity, and trunk muscle endurance among individuals with chronic low back pain(11). These results reaffirm the growing consensus that targeted activation and strengthening of the deep trunk musculature represent a fundamental component of effective rehabilitation for chronic spinal disorders(12). The marked enhancement in Timed Up and Go (TUG) test performance indicated that participants who engaged in core-focused exercises developed superior postural control, balance, and coordination, enabling smoother and more confident transitions during daily movement. The observed reduction in pain scores and elevation in plank endurance further supported the physiological and neuromuscular benefits derived from systematic core muscle engagement(13).

The improvements achieved by the intervention group reflected not only the mechanical strengthening of the stabilizing muscles but also the retraining of motor control mechanisms that are frequently disrupted in individuals with persistent low back pain(14). Chronic pain often induces altered recruitment patterns, with delayed activation of the transversus abdominis and multifidus, leading to overcompensation by superficial muscle groups. The core stabilization approach adopted in this study appeared to effectively restore the synchrony between local stabilizers and global mobilizers, facilitating optimal spinal alignment during motion(15). The consequent enhancement in trunk stability likely translated into more efficient kinetic chain function, reduced strain on passive structures, and diminished nociceptive input, collectively explaining the parallel improvement in mobility and pain relief(16).

The reduction in pain intensity among participants who received core stabilization therapy underscored the importance of addressing neuromuscular dysfunction as a central therapeutic target. Pain in chronic low back conditions is not solely a result of tissue damage but also of maladaptive motor behavior and central sensitization. By re-establishing motor control and proprioceptive accuracy, the intervention appeared to modulate both peripheral and central mechanisms of pain(17). This dual effect can explain the substantial decline in Visual Analogue Scale scores observed after twelve weeks, surpassing the improvements achieved by conventional physiotherapy. In clinical practice, this outcome suggests that rehabilitation efforts focused on muscle coordination and endurance may offer more durable benefits than symptom-oriented interventions alone(17).

The enhancement of trunk endurance, reflected in longer plank hold times, provided additional evidence of the physiological adaptation achieved through repetitive, progressive training. Increased endurance of the deep trunk muscles not only supports the spine during static postures but also provides dynamic stability during complex movements. This ability to sustain controlled motion under load is critical for preventing recurrence of pain episodes. The steady progression from baseline to twelve weeks suggested that participants tolerated the program well, and the absence of adverse effects confirmed the safety of the prescribed protocol. These outcomes position core stabilization as a practical and sustainable therapeutic option that aligns with functional rehabilitation principles(18).

Comparison with conventional therapy outcomes further illuminated the distinct advantages of a targeted stabilization approach(19). While both groups experienced measurable improvement, the magnitude of change was considerably greater in the intervention group across all parameters. This disparity likely arose from the specificity of training: whereas conventional therapy emphasized general strengthening and mobility, the core program directly addressed the neuromuscular deficits responsible for spinal instability. The superior functional gains observed in this study mirrored the growing clinical shift toward individualized, muscle-specific exercise interventions in chronic musculoskeletal rehabilitation(10).

The implications of these findings extend beyond the confines of the physiotherapy clinic. Functional mobility is central to independence and quality of life, and its restoration represents a critical therapeutic goal for individuals living with chronic pain(20). The demonstrated relationship between core strength, postural control, and movement efficiency highlights the broader significance of stabilizing exercise programs in reducing disability and improving daily performance. In resource-limited healthcare environments, such as many settings in South Punjab, the simplicity, cost-effectiveness, and adaptability of core stabilization protocols make them an appealing choice for widespread clinical application(21).

Despite the positive outcomes, this study possessed certain limitations that should be acknowledged. The relatively small sample size, though statistically adequate, limited the generalizability of findings to broader populations. The follow-up period was confined to twelve weeks, providing limited insight into the long-term sustainability of improvements. Moreover, while the use of objective tools such as the TUG test and plank endurance measurement strengthened the validity of the findings, additional biomechanical or imaging

assessments could have provided more detailed evidence of structural or neuromuscular adaptations. Variability in participant adherence, though monitored through supervised sessions, might also have influenced the magnitude of outcomes(22).

Nevertheless, the study's design and execution offered several notable strengths. Randomization minimized selection bias, and the use of standardized, validated assessment tools enhanced reliability. The intervention protocol was systematically progressive, ensuring both safety and functional challenge. The close supervision by qualified physiotherapists improved compliance and reduced the risk of incorrect execution. Furthermore, the integration of multiple outcome measures captured a holistic picture of physical recovery rather than relying on isolated indicators. These methodological attributes contributed to the internal validity and clinical relevance of the findings.

The results point toward several directions for future research. Larger, multicenter trials with extended follow-up periods would provide a more comprehensive understanding of the long-term efficacy of core stabilization training. Investigations incorporating biomechanical analysis, electromyography, or imaging could deepen insight into muscular adaptations and movement patterns. Comparative studies examining the integration of core stabilization with cognitive or behavioral pain management strategies may reveal synergistic benefits. Additionally, exploring the effectiveness of home-based or technology-assisted programs could enhance accessibility, especially in rural or underserved regions.

In summary, this study demonstrated that a structured core stabilization program significantly improved mobility, endurance, and pain outcomes among individuals with chronic low back pain. The findings emphasized the therapeutic importance of neuromuscular re-education and targeted strengthening in restoring functional independence. Through its human-centered, practical approach, this intervention offered not only clinical benefit but also a sustainable model for rehabilitation applicable to diverse patient populations.

CONCLUSION

The present randomized controlled trial demonstrated that a structured core stabilization exercise program significantly enhanced functional mobility, reduced pain intensity, and improved trunk muscle endurance in individuals with chronic low back pain. By restoring neuromuscular control and spinal stability, the intervention effectively addressed the underlying dysfunction contributing to chronicity. These findings highlight the practical value of integrating core-focused rehabilitation into standard physiotherapy practice. Core stabilization emerges as a safe, affordable, and functionally meaningful approach capable of improving daily movement quality and long-term musculoskeletal health in this patient population.

AUTHOR CONTRIBUTION

Author	Contribution
Erum Fatima*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Aamna Anwaar	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muneeza Arshad	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Muhammad Azhar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Farah Ahmed	Contributed to Data Collection and Analysis

Author	Contribution
	Has given Final Approval of the version to be published
Muhammad Naseeb Ullah Khan	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Bilal Safdar	Contributed to study concept and Data collection Has given Final Approval of the version to be published

REFERENCES

1. Kim B, Yim JJTTjoem. Core stability and hip exercises improve physical function and activity in patients with non-specific low back pain: a randomized controlled trial. 2020;251(3):193-206.

2. Mahmood W, Ahmed Burq HSI, Ehsan S, Sagheer B, Mahmood TJBSS, Medicine, Rehabilitation. Effect of core stabilization exercises in addition to conventional therapy in improving trunk mobility, function, ambulation and quality of life in stroke patients: a randomized controlled trial. 2022;14(1):62.

3. Shamsi MB, Sarrafzadeh J, Jamshidi AJPt, practice. Comparing core stability and traditional trunk exercise on chronic low back pain patients using three functional lumbopelvic stability tests. 2015;31(2):89-98.

4. Shamsi MB, Rezaei M, Zamanlou M, Sadeghi M, Pourahmadi MRJPt, practice. Does core stability exercise improve lumbopelvic stability (through endurance tests) more than general exercise in chronic low back pain? A quasi-randomized controlled trial. 2016;32(3):171-8.

5. Alarab A, Abu Aker MJPT-SPTJ. Core Stability Exercises with Conventional Therapy vs. Conventional Therapy on the Management of Chronic Non-Specific Low Back Pain: A Randomized Controlled Trial.0-.

6. Salik Sengul Y, Yilmaz A, Kirmizi M, Kahraman T, Kalemci OJW. Effects of stabilization exercises on disability, pain, and core stability in patients with non-specific low back pain: A randomized controlled trial. 2021;70(1):99-107.

7. Suh JH, Kim H, Jung GP, Ko JY, Ryu JSJM. The effect of lumbar stabilization and walking exercises on chronic low back pain: A randomized controlled trial. 2019;98(26):e16173.

8. Inani SB, Selkar SPJJob, rehabilitation m. Effect of core stabilization exercises versus conventional exercises on pain and functional status in patients with non-specific low back pain: a randomized clinical trial. 2013;26(1):37-43.

9. Gorji SM, Mohammadi Nia Samakosh H, Watt P, Henrique Marchetti P, Oliveira RJIjoer, health p. Pain neuroscience education and motor control exercises versus core stability exercises on pain, disability, and balance in women with chronic low back pain. 2022;19(5):2694.

10. Hafez HA, Mohamed MA, Ahmed AA, Hamed RH, Ahmed KE, Kentiba E, et al. The Effectiveness of Home-Based Exercises Versus Supervised Core Stability Exercises on Pain and Functional Disability in Controlled Hypertensive Patients with Chronic Mechanical Non-specific Low Back Pain: A Randomized Controlled Trial. 2025;13(2):70.

11. Huang H, Xie H, Zhang G, Xiao W, Ge L, Chen S, et al. Effects of dynamic neuromuscular stabilization training on the core muscle contractility and standing postural control in patients with chronic low back pain: a randomized controlled trial. 2025;26(1):213.

12. Rabieezadeh A, Mahdavinejad R, Sedehi M, Adimi MJBSS, Medicine, Rehabilitation. The effects of an 8-week dynamic neuromuscular stabilization exercise on pain, functional disability, and quality of life in individuals with non-specific chronic low back pain: a randomized clinical trial with a two-month follow-up study. 2024;16(1):161.

13. Wang H, Fan Z, Liu X, Zheng J, Zhang S, Zhang S, et al. Effect of progressive postural control exercise versus core stability exercise in young adults with chronic low back pain: a randomized controlled trial. 2023;12(1):293-308.

14. Fouladi N, Minoonejad H, Rajabi RJJoMR. Comparing the effects of the postural restoration exercises with and without core stability exercises in patients with non-specific chronic low back pain. 2023.

15. Alqhtani RS, Ahmed H, Ghulam HSH, Alyami AM, Al Sharyah YHH, Ahmed R, et al. Efficacy of core-strengthening and intensive dynamic back exercises on pain, core muscle endurance, and functional disability in patients with chronic non-specific low back pain: A randomized comparative study. 2024;13(2):475.

16. Yalfani A, Mohamad Khani M, Ahmadi M, Asgarpoor AJفد-نتف. The Effect of Core Stability exercises combined with abdominal hollowing on postural balance in patients with non-specific chronic low back Pain: a Randomized Controlled Trial. 2023;13(3):165-74.

17. Khaledi A, Gheitasi MJA, Medicine P. Isometric vs isotonic core stabilization exercises to improve pain and disability in patients with non-specific chronic low back pain: A randomized controlled trial. 2024;14(1):e144046.

18. Porwal S, Rizvi MR, Sharma A, Ahmad F, Alshahrani MS, Raizah A, et al., editors. Enhancing functional ability in chronic nonspecific lower back pain: the impact of EMG-guided trunk stabilization exercises. Healthcare; 2023: MDPI.

19. Si X, Zhang L, Li F, Liang HJBWsH. The effectiveness of pelvic floor muscle training on lumbar function and muscle performance in sedentary women with lower back pain: a randomized controlled trial. 2025;25(1):125.

20. Karartı C, Özsoy İ, Özyurt F, Basat HÇ, Özsoy G, Özüdoğru AJS, et al. The effects of dynamic neuromuscular stabilization approach on clinical outcomes in older patients with chronic nonspecific low back pain: a randomized, controlled clinical trial. 2023;40(3):116-25.

21. Nasiri B, Saki F, Ziya M, Gheidi NJPMN. Effects of Adding Respiratory Exercises to Core Stability Training in Office Workers With Chronic Low Back Pain: A Randomized Controlled Trial. 2025.

22. Marand LA, Dehkordi SN, Roohi-Azizi M, Dadgoo MJAopm, rehabilitation. Effect of dynamic neuromuscular stabilization on balance, trunk function, falling, and spasticity in people with multiple sclerosis: a randomized controlled trial. 2023;104(1):90-101.

