RESEARCH PAPER

"Influence Of Sling-Based Neuromuscular Training On Core Muscle Endurance In Patients With Chronic Low Back Pain"

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ABSTRACT

Background: Chronic low back pain (CLBP) is a prevalent musculoskeletal condition associated with reduced core muscle endurance, impaired neuromuscular control, pain, and functional disability. Improving trunk muscle endurance is essential for restoring spinal stability and reducing recurrence. Sling-based neuromuscular training (SBNT) has emerged as an instability-based rehabilitation approach designed to enhance deep stabilizer activation and motor control.

Objective: To evaluate the effectiveness of sling-based neuromuscular training on core muscle endurance, pain intensity, and functional disability in patients with chronic low back pain.

Methods: Thirty participants with chronic low back pain (duration >3 months) were randomly allocated into two groups: Experimental group (n = 15) received sling-based neuromuscular training along with conventional therapy, while Control group (n = 15) received conventional therapy alone. The intervention was conducted for 4 weeks (3 sessions per week). Outcome measures included McGill's Torso Muscular Endurance Test Battery (trunk flexor, lateral, and extensor endurance tests), Numeric Pain Rating Scale (NPRS), and Oswestry Disability Index (ODI). Assessments were performed pre and post-intervention. Data were analyzed using paired and independent t-tests with significance set at $p < 0.05$.

Results: Both groups showed statistically significant improvements ($p < 0.001$). However, the experimental group demonstrated significantly greater gains in trunk flexor, lateral, and extensor endurance compared to the control group ($p < 0.001$). NPRS scores decreased from 6.7 ± 1.0 to 2.4 ± 0.9 in the experimental group, while the control group improved from 6.9 ± 1.2 to 4.8 ± 1.1. ODI scores improved by 20.9% in the experimental group compared to 8.2% in the control group. Between-group comparisons at 4 weeks favored the experimental group across all outcome measures.

Conclusion: Sling-based neuromuscular training is more effective than conventional therapy in improving core muscle endurance and reducing pain and disability in patients with chronic low back pain. It can be recommended as an effective adjunct in rehabilitation programs targeting spinal stability..

Keywords: Chronic low back pain, Sling exercise therapy, Core muscle endurance, Neuromuscular training, Spinal stability, Rehabilitation..

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INTRODUCTION

Chronic low back pain (CLBP) is one of the most prevalent musculoskeletal disorders worldwide and represents a major cause of disability and socioeconomic burden. Low back pain has been identified as the leading cause of years lived with disability globally by the World Health Organization[1]. The lifetime prevalence of low back pain ranges between 60–80%, and nearly 20% of affected individuals develop chronic symptoms lasting more than three months[2]. In India, the prevalence of chronic low back pain has been reported to range between 6% and 23%, significantly impacting working-age populations[3].

Chronic low back pain is multifactorial in nature and involves complex interactions between biomechanical, neuromuscular, psychological, and social factors[4]. Among these, deficits in core muscle endurance and impaired neuromuscular control play a critical role in the persistence and recurrence of symptoms[5]. According to Panjabi's spinal

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stability model, spinal stability depends on the coordinated function of three subsystems: the passive (ligaments and vertebrae), active (muscles), and neural control systems[6]. Dysfunction in any of these subsystems, particularly delayed activation of deep trunk muscles such as the transversus abdominis and lumbar multifidus, can compromise spinal stability and contribute to chronic pain[7]. Research has demonstrated that individuals with CLBP exhibit reduced endurance of trunk flexor and extensor muscles compared to asymptomatic individuals[8]. Poor endurance of the core musculature leads to early fatigue, altered movement patterns, and increased mechanical stress on spinal structures[9]. McGill emphasized the importance of endurance rather than maximal strength in maintaining spinal stability and preventing recurrent low back pain[10].

Conventional rehabilitation programs for CLBP commonly include strengthening exercises, stretching, and motor control training. While these approaches have shown moderate effectiveness, there is growing interest in instability-based and neuromuscular training methods that challenge proprioception and enhance coordinated muscle activation[11]. Sling Exercise Therapy (SET), also referred to as sling-based neuromuscular training, utilizes suspension systems to create an unstable support surface, thereby stimulating sensorimotor control and selective activation of deep stabilizing muscles[12].

Sling-based training has been shown to improve trunk muscle activation, enhance proprioceptive feedback, and restore neuromuscular coordination in patients with low back pain[13]. The unstable environment demands continuous postural adjustments, promoting co-contraction of local and global stabilizers and improving endurance capacity[14]. Several clinical trials have reported reductions in pain and disability following sling exercise interventions in patients with chronic low back pain[15].

However, despite increasing clinical application, limited evidence specifically examines the effect of sling-based neuromuscular training on objective measures of core muscle endurance using standardized endurance testing protocols. Therefore, the present study aims to investigate the influence of sling-based neuromuscular training on core muscle endurance in patients with chronic low back pain.

METHODOLOGY:

Study Design:
Randomized controlled trial (RCT)

Participants:
Participants diagnosed with chronic low back pain (>3 months) were recruited from the outpatient physiotherapy department.

Sample Size: Calculated using power analysis:
Power = 80%, Alpha = 0.05, Effect size = 0.8
Total sample = 30 (15 per group)

Sampling Method
Participants were selected using purposive sampling and randomly allocated into 2 groups using a computer-generated randomization sequence:

Group A (Experimental): Sling-Based Neuromuscular Training + Conventional Therapy

Group B (Control): Conventional Therapy only

INTERVENTION PROTOCOL

GROUP A – SLING-BASED NEUROMUSCULAR TRAINING

Warm-up (10 minutes): Gentle stretching, active exercise

Training program: Participants had to hold the end position for 8–10 seconds in 10 repetitions of each exercise. Therapist instructed participants to perform a pelvic backward tilt and keep their back straight during exercise to prevent injury through excessive loading of the lumbar spine during exercise.

Exercise 1: participants were instructed to flex the elbow to 90 degrees and kneel on the bed under the sling point. The forearms were put in straps and the body was extended.

Exercise 2: participants stood on the floor and under the sling point. The hands were put in the straps and the body was extended. Participants lay supine on the bed with their ankles under the sling point.

Exercise 3: the straps were 30 centimeters apart from the bed. Participants were instructed to carry out the bridge exercise.

Exercise 4: participants lay supine on the bed with the ankles under the sling point. The straps were 30 centimeters apart from the bed. Participants were instructed to carry out the bridge exercise combined with knee flexion.

Exercise 5: participants lay prone on the bed and the ankles were under the sling point. Straps were set at the height of the participants’ upper arm to make the body parallel to the bed during exercise. The participants supported their body with their forearms and ankles.

Exercise 6: participants lay prone on the bed and the ankles were under the sling point. Straps were set as high as the participants’ upper arm to make the body parallel to the bed during the exercise, and the participants supported their body with their forearms and ankles combined with knee flexion.

Total Session Duration: 40-45 minutes; 3 session/weekly, 4 weeks

GROUP B – CONVENTIONAL THERAPY

Participants in the control group received conventional physiotherapy consisting of:

McKenzie Extension Exercises: 10 repetitions × 3 sets

Mat-Based Core Strengthening: Static abdominal contractions, Bridging exercises and Bird-dog exercises

Hamstring and Hip Flexor Stretching: 20-second hold × 3 repetitions

Superficial Heat Therapy: Hot pack application for 15 minutes

Total Session Duration: 40-45 minutes; 3session/weekly, 4 weeks

OUTCOME MEASURES

Mcgill’s torso muscular endurance test battery
Trunk Flexor **ENDURANCE** Test
Trunk Lateral Endurance Test
Trunk Extensor Endurance Test
NPRS
Oswestry Disability Index (ODI).

STATISTICAL ANALYSIS

Data were analysed using SPSS version 26.0. Normality of distribution was assessed using the Shapiro-Wilk test, which demonstrated normal distribution of all outcome variables ($p > 0.05$). For within-group comparisons, a paired t-test was used and for between-group comparisons, Independent t-test was applied. The level of statistical significance was set at $p < 0.05$.

Table 1: Descriptive Statistics (Mean ± SD) of Group A

Outcome Measure	Pre-Treatment	Post-Treatment	Mean Difference	t-value	p-value
Trunk Flexor Endurance (sec)	39.1 ± 8.7	68.4 ± 9.6	29.3	11.82	<0.001
Trunk Lateral Endurance-Right (sec)	30.4 ± 7.3	55.6 ± 8.1	25.2	10.95	<0.001
Trunk Lateral Endurance-Left (sec)	29.8 ± 7.5	54.3 ± 8.4	24.5	10.71	<0.001
Trunk Extensor Endurance (sec)	53.7 ± 10.8	90.2 ± 11.3	36.5	12.46	<0.001
NPRS	6.7 ± 1.0	2.4 ± 0.9	4.3	13.28	<0.001
ODI (%)	39.2 ± 6.1	18.3 ± 5.2	20.9	12.04	<0.001

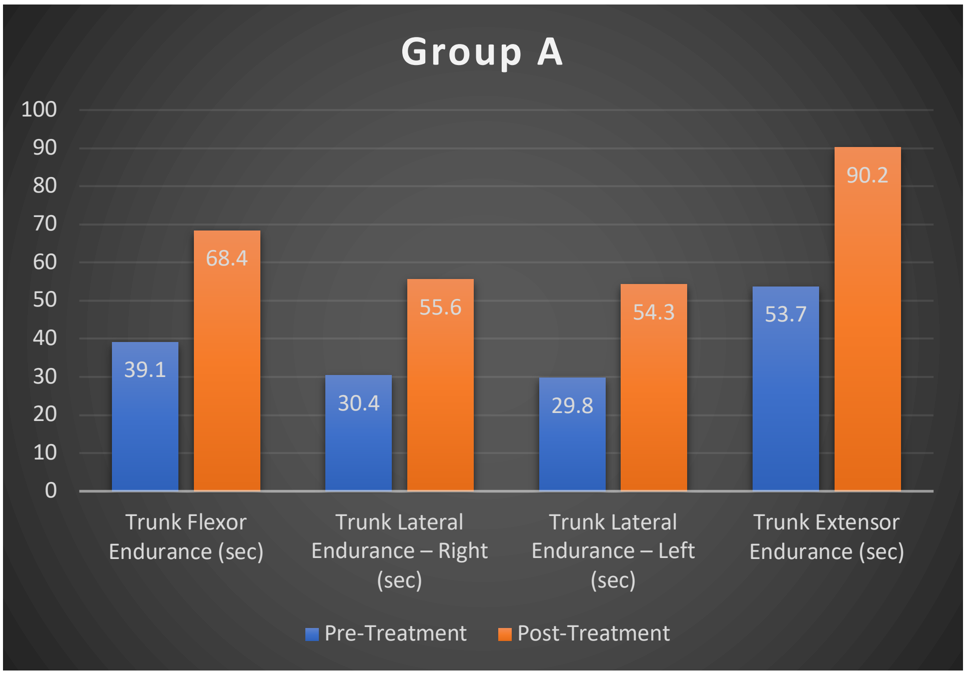


Table 2: Descriptive Statistics (Mean ± SD) of Group B

Outcome Measure	Pre-Treatment	Post-Treatment	Mean Difference	t-value	p-value
Trunk Flexor Endurance (sec)	37.8 ± 9.4	49.6 ± 8.8	11.8	5.14	<0.001
Trunk Lateral Endurance-Right (sec)	28.9 ± 8.2	38.4 ± 7.9	9.5	4.87	<0.001
Trunk Lateral Endurance-Left (sec)	28.1 ± 8.5	37.6 ± 8.2	9.5	4.73	<0.001
Trunk Extensor Endurance (sec)	51.2 ± 11.9	63.8 ± 10.7	12.6	5.26	<0.001

NPRS	6.9 ± 1.2	4.8 ± 1.1	2.1	6.02	<0.001
ODI (%)	37.8 ± 6.8	29.6 ± 6.0	8.2	5.68	<0.001

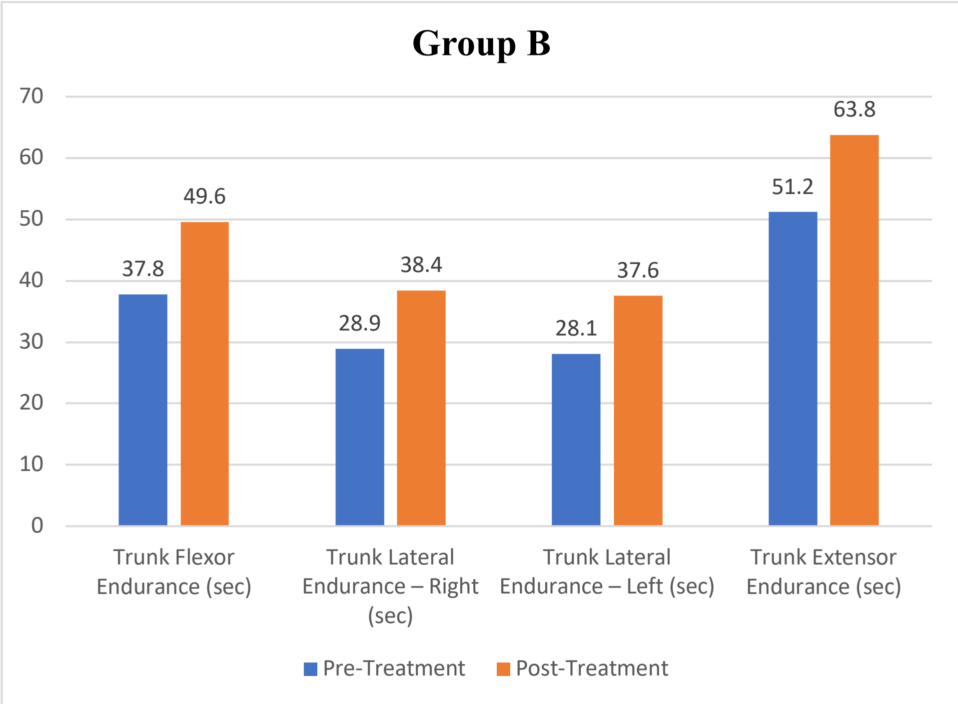
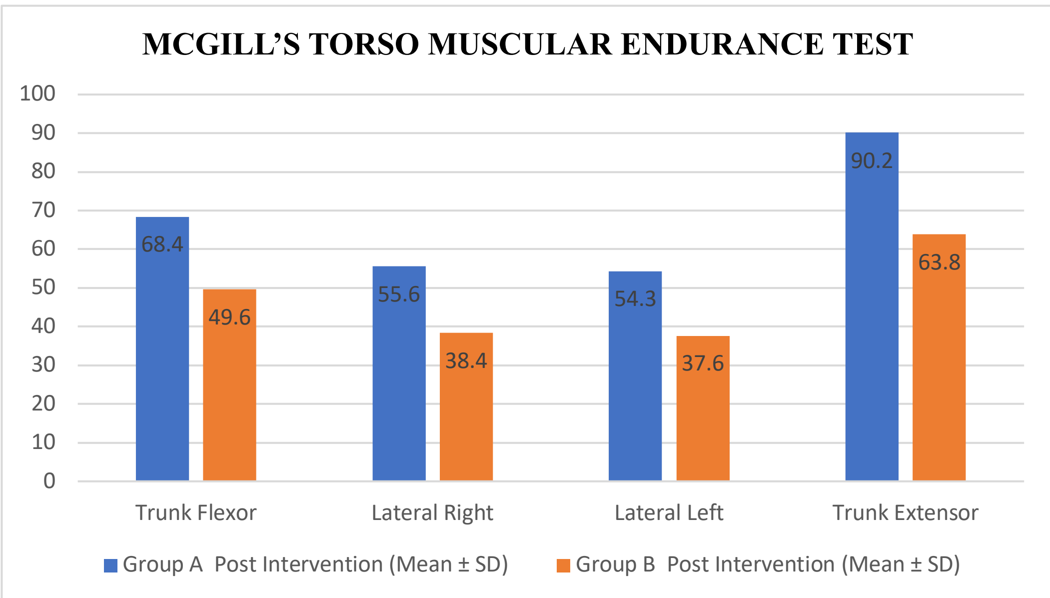
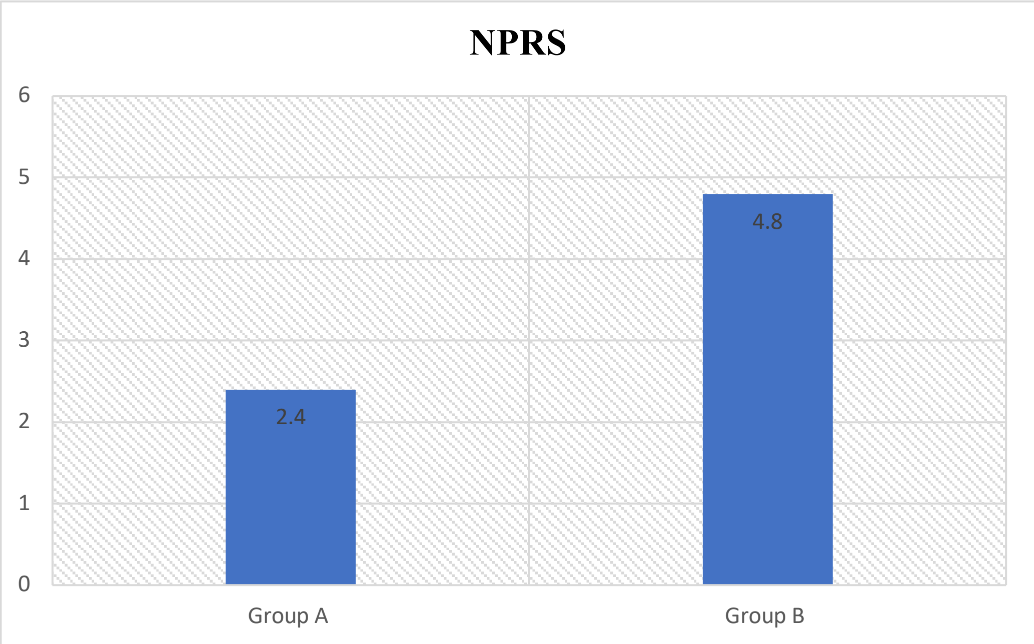
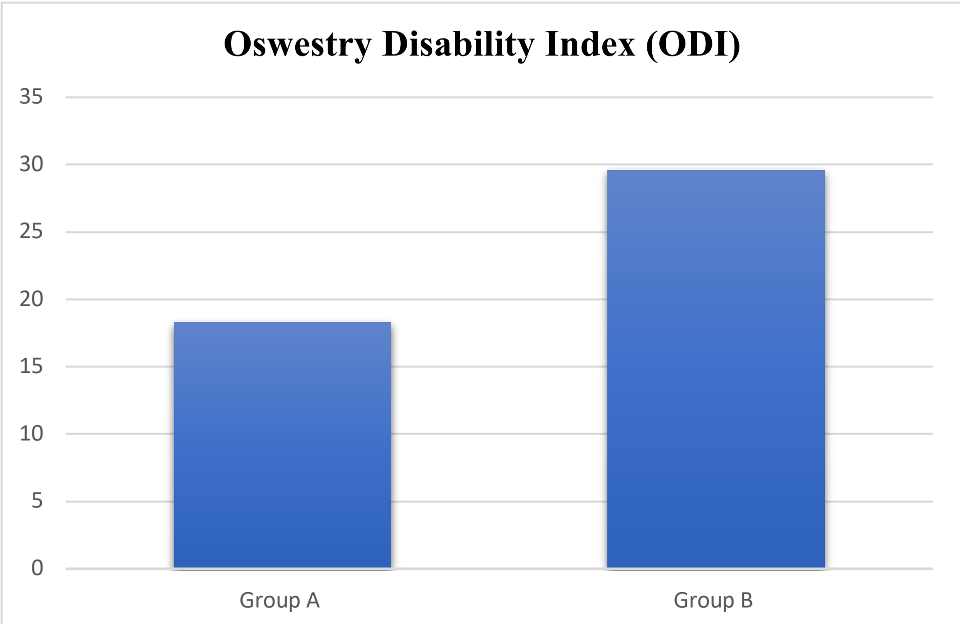


Table 3: Between-Group Comparison of Post-Intervention Scores Using Independent t-Test at 4 Weeks

Outcome Measure	**Group A Post Intervention (Mean ± SD)**	**Group B Post Intervention (Mean ± SD)**	**t-value**	**p-value**
Trunk Flexor	68.4 ± 9.6	49.6 ± 8.8	5.73	<0.001
Lateral Right	55.6 ± 8.1	38.4 ± 7.9	5.89	<0.001
Lateral Left	54.3 ± 8.4	37.6 ± 8.2	5.52	<0.001
Trunk Extensor	90.2 ± 11.3	63.8 ± 10.7	6.32	<0.001
NPRS	2.4 ± 0.9	4.8 ± 1.1	6.47	<0.001
ODI	18.3 ± 5.2	29.6 ± 6.0	5.54	<0.001







RESULTS

After 4 weeks of intervention, both the experimental (n = 15) and control (n = 15) groups demonstrated statistically significant improvements in core muscle endurance, pain, and disability ($p < 0.001$). However, the experimental group showed markedly greater improvements compared to the control group. Trunk flexor endurance increased from 39.1 ± 8.7 seconds to 68.4 ± 9.6 seconds in the experimental group, whereas the control group improved from 37.8 ± 9.4 seconds to 49.6 ± 8.8 seconds. Similarly, trunk extensor endurance improved by 36.5 seconds in the experimental group compared to 12.6 seconds in controls. Lateral endurance (right and left) also showed substantially higher gains in the experimental group. Pain intensity (NPRS) decreased from 6.7 ± 1.0 to 2.4 ± 0.9 in the experimental group, while the control group showed a reduction from 6.9 ± 1.2 to 4.8 ± 1.1. Functional disability (ODI) improved by 20.9% in the experimental group compared to 8.2% in the control group. Between-group analysis at 4 weeks revealed statistically significant differences favoring the experimental group across all outcome measures ($p < 0.001$), indicating that sling-based neuromuscular training was more effective than conventional therapy in improving core muscle endurance and reducing pain and disability in patients with chronic low back pain.

DISCUSSION:

The present study demonstrated that sling-based neuromuscular training produced significantly greater improvements in trunk flexor, lateral, and extensor endurance compared to conventional therapy after 4 weeks of intervention ($p < 0.001$). Additionally, participants in the experimental group showed clinically meaningful reductions in pain (NPRS) and disability (ODI). These findings suggest that instability-based training using sling systems enhances core muscle endurance and functional recovery in individuals with chronic low back pain (CLBP).

Improvement in trunk endurance observed in the experimental group may be explained by enhanced neuromuscular activation of deep stabilizing muscles. According to Panjabi’s spinal stability model, spinal stability depends on the coordinated function of the active muscular subsystem and neural control mechanisms[1]. Sling exercises create an unstable environment that challenges proprioceptive feedback and promotes co-contraction of local stabilizers such as transversus abdominis and multifidus[2]. Previous electromyographic studies have demonstrated increased trunk muscle activation during suspension exercises compared to stable surface training[3].

The significant increase in trunk extensor and flexor endurance in the experimental group aligns with findings from McGill, who emphasized that endurance capacity is more critical than maximal strength in preventing spinal instability and recurrent low back pain[4]. Individuals with CLBP commonly exhibit reduced endurance of trunk musculature compared to asymptomatic individuals[5]. Therefore, targeted endurance-based rehabilitation may restore muscular balance and improve spinal load tolerance.

Pain reduction observed in the experimental group may be attributed to improved motor control and decreased mechanical stress on passive spinal structures. A randomized controlled trial by Unsgaard-Tøndel et al. reported that sling exercises significantly reduced pain and improved function in patients with CLBP[6]. Similarly, Yoo and Lee demonstrated that sling exercise therapy enhanced trunk muscle activation and reduced pain intensity in chronic low back pain patients[7]. Enhanced neuromuscular coordination may reduce aberrant movement patterns and nociceptive input from overloaded spinal tissues.

The greater reduction in ODI scores in the experimental group indicates improved functional capacity. Core stabilization programs have been shown to reduce disability and recurrence rates in chronic low back pain populations[8]. Instability-based exercises may further enhance sensorimotor control, thereby improving postural stability and daily functional performance[9].

Although both groups showed significant within-group improvements, the magnitude of change was substantially greater in the sling-based training group, suggesting superior effectiveness over conventional therapy alone. These results support previous systematic reviews indicating that active, neuromuscular-based rehabilitation approaches provide better long-term outcomes than passive or general exercise programs[10].

Sling-based neuromuscular training can be considered an effective adjunct to conventional physiotherapy in CLBP rehabilitation. It appears particularly beneficial for improving trunk endurance, restoring muscular balance, and reducing pain-related disability.

CONCLUSION

The findings of the present study demonstrate that sling-based neuromuscular training is significantly more effective than conventional therapy alone in improving core muscle endurance, reducing pain intensity, and decreasing functional disability in patients with chronic low back pain. After 4 weeks of intervention, the experimental group showed greater improvements in trunk flexor, lateral, and extensor endurance, along with clinically meaningful reductions in NPRS and Oswestry Disability Index scores. The unstable training environment provided by sling exercises likely enhanced neuromuscular control, promoted co-contraction of deep stabilizing muscles, and improved spinal stability. Therefore, sling-based neuromuscular training can be recommended as an effective and clinically valuable adjunct to conventional physiotherapy in the management of chronic low back pain.

CONFLICT OF INTEREST:
None
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