RESEARCH PAPER

"Effect Of Biomechanics-Based Motion Control Training On Pain, Disability And Functional Mobility In Patients With Lumbar Disc Herniation"

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ABSTRACT
Background: Lumbar disc herniation is a common cause of low back pain leading to significant disability and impaired functional mobility. Conventional physiotherapy primarily focuses on pain relief and general strengthening. However, biomechanical dysfunction and impaired motor control may persist, contributing to symptom recurrence.
Objective: To evaluate the effect of biomechanics-based motion control training on pain, disability, and functional mobility in patients with lumbar disc herniation.
Methods: A randomized controlled trial was conducted among 30 participants diagnosed with lumbar disc herniation. Participants were randomly allocated into two groups: Group A (n = 15) received biomechanics-based motion control training along with conventional therapy, and Group B (n = 15) received conventional physiotherapy alone. The intervention was administered for 6 weeks (5 sessions/week). Outcome measures included Visual Analog Scale (VAS) for pain, Oswestry Disability Index (ODI) for disability, and 10-Meter Walk Test (10MWT) for functional mobility. Pre and post-intervention assessments were performed. Paired and independent t-tests were used for statistical analysis with significance set at $p < 0.05$.
Results: Both groups showed significant improvement in VAS, ODI and 10MWT scores after intervention ($p<0.001$). However, the experimental group demonstrated significantly greater reduction in pain and disability and superior improvement in gait speed compared to the control group ($p < 0.01$).
Conclusion: Biomechanics-based motion control training is more effective than conventional physiotherapy in reducing pain, improving disability, and enhancing functional mobility in patients with lumbar disc herniation. Incorporating biomechanical retraining into rehabilitation programs may optimize clinical outcomes.
Keywords: Lumbar disc herniation, Motion control training, Low back pain, Gait speed, Rehabilitation
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INTRODUCTION
Low back pain (LBP) is one of the most prevalent musculoskeletal disorders worldwide and a leading cause of disability across all age groups. The World Health Organization reports that low back pain affects hundreds of millions of people globally and is the primary contributor to years lived with disability[1]. Among the structural causes of LBP, lumbar disc herniation (LDH) is particularly significant due to its association with radicular pain, neurological symptoms, and functional limitation[2].
Lumbar disc herniation occurs when the nucleus pulposus protrudes or extrudes through the annulus fibrosus, often leading to compression or irritation of adjacent nerve roots[3]. The most commonly affected levels are L4–L5 and L5–S1 due to increased mechanical loading and mobility at these segments[4]. The pathophysiology of LDH involves both

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mechanical compression and inflammatory mediators released from disc material, contributing to nociceptive and neuropathic pain mechanisms[5].

Biomechanically, the lumbar spine is designed to balance mobility and stability. However, repetitive flexion, rotational stress, prolonged sitting, improper lifting techniques, and sedentary lifestyles increase intradiscal pressure and accelerate degenerative changes[6]. Studies have demonstrated that forward flexion combined with axial rotation significantly increases annular stress, predisposing individuals to disc herniation[7]. Additionally, impaired activation of deep stabilizing muscles such as the transversus abdominis and multifidus has been observed in individuals with chronic LBP, contributing to segmental instability[8].

Conventional physiotherapy management for LDH typically includes electrotherapy modalities, stretching, general strengthening, and directional preference exercises such as the McKenzie approach[9]. While these interventions are effective for short-term pain reduction, recurrence rates remain substantial, suggesting that symptom-focused treatment alone may not address underlying biomechanical dysfunction[10].

Emerging evidence highlights the importance of motor control and movement quality in spinal rehabilitation. Motion control training emphasizes retraining of faulty movement patterns, restoration of neutral spine alignment, and coordinated activation of local stabilizing muscles before global muscle strengthening[11]. This approach is grounded in the concept that poor movement strategies increase cumulative spinal loading, thereby perpetuating disc stress and pain[12].

Biomechanics-based motion control training (BMCT) integrates principles of spinal stabilization, segmental control, proprioceptive retraining, and functional movement correction. By improving neuromuscular coordination and load distribution across spinal segments, BMCT may reduce mechanical strain on the affected disc and improve overall functional mobility[13]. Furthermore, studies have demonstrated that motor control exercises are superior to minimal intervention in reducing pain and disability in chronic low back pain populations[14].

Despite growing interest in movement-based rehabilitation strategies, limited studies have specifically investigated biomechanics-oriented motion control training in patients with confirmed lumbar disc herniation. Most existing literature focuses broadly on nonspecific LBP, leaving a gap in condition-specific evidence[15]. Therefore, there is a need to evaluate whether a targeted biomechanical approach can produce superior outcomes in pain reduction, disability improvement, and functional mobility enhancement among individuals with LDH.

The present study aims to determine the effect of biomechanics-based motion control training on pain, disability, and functional mobility in patients with lumbar disc herniation.

METHODOLOGY:

Study Design:
Randomized Controlled Trial

Participants:
Patients with lumbar disc herniation.

Sample Size:
30 participants

Study Setting: Outpatient Physiotherapy Department

Sampling Method
Simple random sampling

Inclusion criteria:
Age 25–55 years
MRI-confirmed lumbar disc herniation
Chronic LBP > 6 weeks
ODI score between 20–60%

Exclusion criteria:
Previous lumbar surgery
Spinal fractures or malignancy
Severe neurological deficits
Systemic inflammatory disorders

INTERVENTION PROTOCOL

Experimental Group (Biomechanics-Based Motion Control Training and Conventional Therapy) and Control Group (Conventional Physiotherapy Alone). The intervention duration was 6 weeks, 5 sessions per week, each session lasting approximately 45–60 minutes.

GROUP A: BIOMECHANICS-BASED MOTION CONTROL TRAINING (BMCT)

The biomechanics-based motion control training program was structured into progressive phases focusing on activation of deep stabilizers, correction of faulty movement patterns and functional retraining. The program was designed based on principles of motor control theory and spinal stabilization research[13]

Phase I (Weeks 1–2): Activation and Awareness Phase

This phase emphasized pain education, postural correction, and activation of deep segmental stabilizing muscles.

1. Pain Neuroscience Education[19]

Participants were educated regarding spinal biomechanics, neutral spine posture, and avoidance of excessive flexion and rotation stresses.

2. Abdominal Drawing-In Maneuver (ADIM)

Selective activation of transversus abdominis was trained in crook-lying and quadruped positions. Contraction was held for 10 seconds, 10 repetitions per session.

3. Multifidus Activation

Low-load isometric contractions were performed in prone and quadruped positions to enhance lumbar segmental stability.

4. Pelvic Neutral Training

Patients were trained to maintain lumbar neutral position during static sitting and standing to reduce intradiscal pressure.

Phase II (Weeks 3–4): Controlled Movement and Segmental Stabilization

This phase focused on integrating deep stabilizer activation into controlled spinal movements.

1. Bridging with Segmental Control
Patients performed bridging while maintaining abdominal activation.
2. Quadruped Alternate Arm/Leg Raises (Bird Dog)
Performed while maintaining spinal neutrality to improve dynamic stability and proprioceptive control.
3. Controlled Lumbar Flexion-Extension Training
Slow controlled spinal movements
4. Sit-to-Stand Biomechanical Retraining

Phase III (Weeks 5–6): Functional and Dynamic Stability Training
This phase incorporated task-oriented movement retraining.
1. Squat and Lifting Retraining
Emphasis on hip-dominant strategy, neutral spine, and load distribution through lower extremities.
2. Perturbation Training
External manual perturbations were introduced to improve reflexive trunk muscle activation and neuromuscular control[13].
3. Gait Re-education
Correction of excessive lumbar rotation and anterior pelvic tilt during walking.
4. Functional Task Simulation
Repetitive practice of bending, reaching and transitional movements with optimal biomechanics.

Group B: Conventional Physiotherapy
Participants received standard conservative management commonly prescribed for lumbar disc herniation.
1. Interferential Therapy (IFT)
Applied for 15 minutes for pain relief[14].
2. Moist Heat Therapy
Applied for 10–15 minutes to reduce muscle spasm.
4. General Core Strengthening
5. McKenzie Extension Exercises
Repeated lumbar extension movements based on directional preference principles[15].

OUTCOME MEASURES

Pain: Visual Analog Scale (VAS)
Disability: Oswestry Disability Index (ODI)
10-Meter Walk Test (10MWT)

STATISTICAL ANALYSIS
The collected data were coded and entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 25.0. Both descriptive and inferential statistics were used to analyse the data.

Descriptive Statistics

Descriptive statistics were used to summarize demographic characteristics and baseline outcome measures of participants in both groups.

Mean and standard deviation (Mean ± SD) were calculated for Age
Frequency and percentage were calculated for categorical variables such as gender.

Table 1: AGE DISTRIBUTION

Variable	Group A (n=15)	Group B (n=15)
Age (years)	39.4 ± 7.2	38.8 ± 6.9

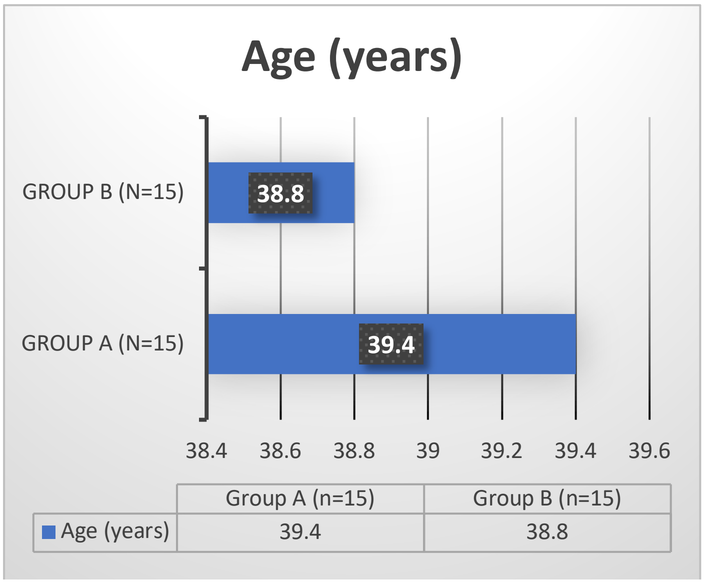
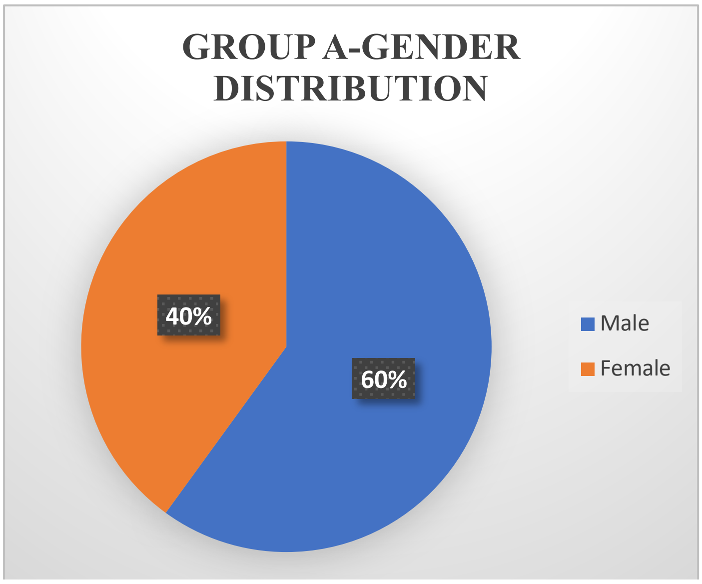
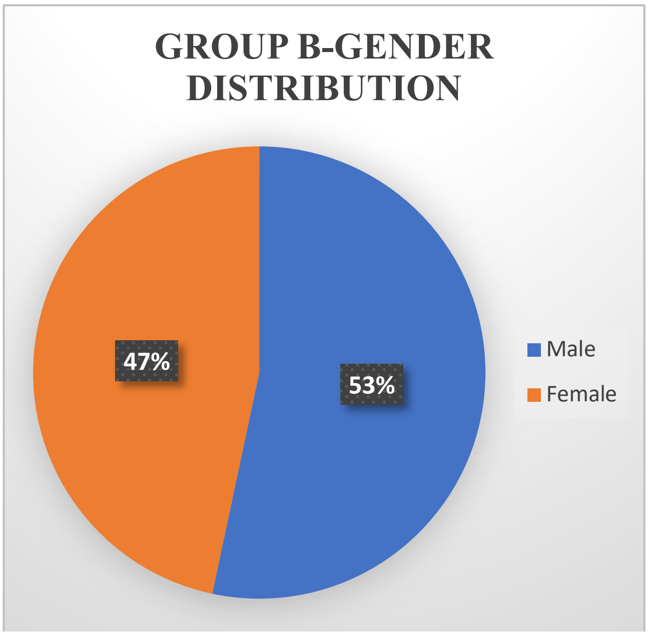


Table 2: GENDER DISTRIBUTION

Gender	Male	Female
Group A	9	6
Group B	8	7





Test for Normality
The Shapiro–Wilk test was used to assess the normality of data distribution. Since the data followed normal distribution ($p > 0.05$), parametric tests were applied.
Inferential Statistics
Within-Group Comparison
To determine the effectiveness of intervention within each group:
Paired t-test was used to compare pre and post-intervention scores of:
VAS, ODI, 10MWT gait speed

Table 3: Comparison of Pre and Post-Intervention Outcome measures Scores Using Paired t-Test in Group A

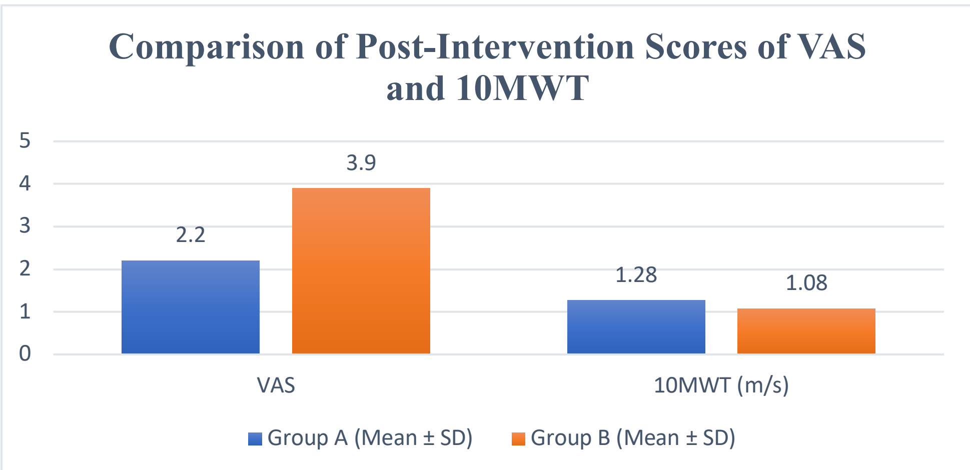
Outcome Measure	Pre (Mean ± SD)	Post (Mean ± SD)	t-value	p-value
VAS	7.3 ± 1.1	2.2 ± 0.9	14.82	<0.001
ODI (%)	48.6 ± 6.4	18.9 ± 4.1	16.27	<0.001
10MWT (m/s)	0.89 ± 0.12	1.28 ± 0.15	11.94	<0.001

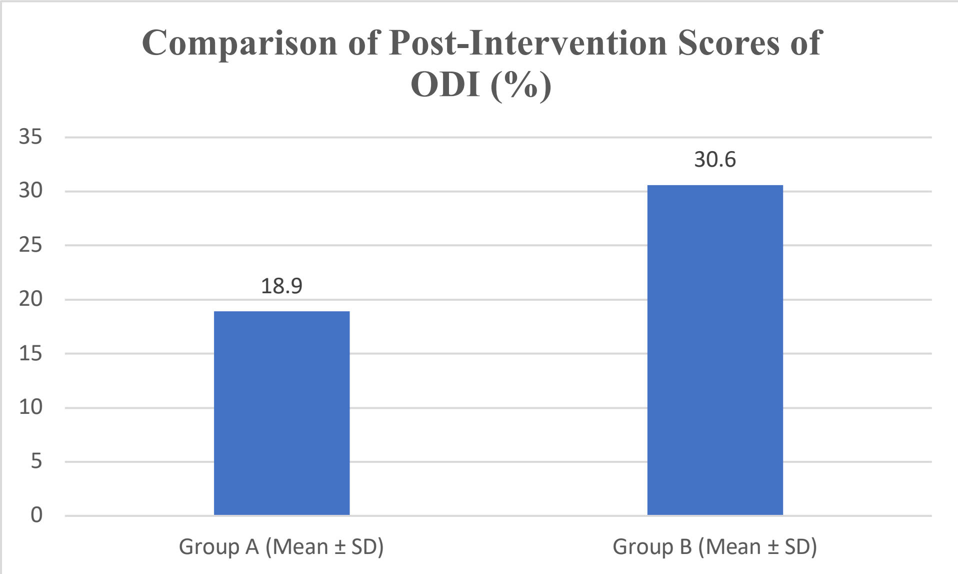
Table 4: Comparison of Pre and Post-Intervention Outcome measures Scores Using Paired t-Test in Group B

Outcome Measure	Pre (Mean ± SD)	Post (Mean ± SD)	t-value	p-value
VAS	7.1 ± 1.0	3.9 ± 1.2	8.63	<0.001
ODI (%)	47.9 ± 5.8	30.6 ± 5.2	9.74	<0.001
10MWT (m/s)	0.91 ± 0.10	1.08 ± 0.14	5.87	<0.001

Between-Group Comparison
To compare the effectiveness of biomechanics-based motion control training and conventional therapy:
Independent t-test was used to compare post-intervention mean values between Group A and Group B.
Table 5: Between-Group Comparison of Post-Intervention Scores Using Independent t-test

Outcome Measure	Group A (Mean ± SD)	Group B (Mean ± SD)	t-value	p-value
VAS	2.2 ± 0.9	3.9 ± 1.2	4.37	<0.001
ODI (%)	18.9 ± 4.1	30.6 ± 5.2	6.21	<0.001
10MWT (m/s)	1.28 ± 0.15	1.08 ± 0.14	3.87	<0.01





RESULTS

Both groups demonstrated statistically significant improvements in pain, disability, and functional mobility following the 6-week intervention ($p < 0.001$). However, the experimental group that received biomechanics-based motion control training showed significantly greater reductions in VAS and Oswestry Disability Index scores, along with superior improvement in gait speed measured by the 10-Meter Walk Test, compared to the control group ($p < 0.01$). These findings indicate that biomechanics-focused motion control training produced more pronounced clinical and functional benefits than conventional physiotherapy alone.

DISCUSSION:

The present study investigated the effect of biomechanics-based motion control training (BMCT) on pain, disability, and functional mobility in patients with lumbar disc herniation. The findings demonstrated statistically significant improvement in Visual Analog Scale (VAS), Oswestry Disability Index (ODI), and 10-Meter Walk Test (10MWT) scores in both groups; however, the experimental group showed significantly greater improvements compared to the control group.
Lumbar disc herniation is commonly associated with mechanical stress, altered spinal kinematics, and neuromuscular control deficits[1]. Traditional rehabilitation approaches primarily focus on pain reduction and general strengthening, but they may not sufficiently address underlying motor control impairments that contribute to recurrent symptoms[2]. The superior outcomes observed in the experimental group may be attributed to restoration of deep stabilizing muscle activation and correction of faulty movement patterns.
Motor control dysfunction, particularly delayed activation of the transversus abdominis and multifidus muscles, has been well documented in individuals with low back pain[3]. Hodges and Richardson reported altered trunk muscle recruitment patterns in patients with lumbar pathology, suggesting compromised segmental stability[4]. The BMCT program in the present study emphasized abdominal drawing-in maneuver and multifidus activation, which likely improved spinal segmental control and reduced mechanical stress on the affected disc.
The significant reduction in pain observed in the experimental group may be explained by improved load distribution and reduced nociceptive input resulting from enhanced spinal alignment and neuromuscular coordination[5]. According to McGill, abnormal movement patterns and repetitive spinal flexion increase intradiscal pressure and contribute to symptom persistence[6]. By retraining proper hip hinge mechanics and neutral spine control, BMCT may have minimized pathological disc loading.
In terms of disability, the marked improvement in ODI scores suggests that biomechanics-oriented retraining has a meaningful impact on daily functional activities. O'Sullivan emphasized that classification-based movement rehabilitation targeting specific dysfunction patterns produces better functional outcomes than generalized exercise programs[7]. The present findings support this concept, as patients who received structured movement retraining demonstrated superior disability reduction.
Functional mobility, measured using the 10-Meter Walk Test (10MWT), also improved significantly in the experimental group. Gait speed is considered a reliable indicator of overall functional capacity and quality of movement[8]. Individuals with lumbar pain often demonstrate reduced walking speed due to fear avoidance behavior, altered trunk rotation, and reduced stride length[9]. By enhancing trunk stability and proprioceptive control, BMCT may have facilitated improved gait efficiency and confidence during ambulation.
The results of this study are consistent with findings from motor control exercise research. A systematic review by

Saragiotto et al. reported that motor control exercises are effective in reducing pain and disability in chronic low back pain populations[10]. Although most studies focus on non-specific low back pain, the present study extends these findings to patients with confirmed lumbar disc herniation. Furthermore, stabilization-based interventions have been shown to reduce recurrence rates compared to conventional strengthening alone[11]. This suggests that incorporating biomechanics-focused retraining may not only improve short-term outcomes but also potentially reduce long-term symptom recurrence.

Despite the positive findings, some limitations must be considered. The sample size was relatively small, and long-term follow-up was not performed. Additionally, electromyographic analysis of deep stabilizing muscles was not included to objectively confirm neuromuscular activation changes.

Overall, the findings of this study suggest that biomechanics-based motion control training is more effective than conventional physiotherapy in reducing pain, improving disability, and enhancing functional mobility in patients with lumbar disc herniation.

CONCLUSION

Biomechanics-based motion control training was more effective than conventional physiotherapy in reducing pain, decreasing disability, and improving functional mobility in patients with lumbar disc herniation. Addressing underlying biomechanical dysfunction and enhancing segmental stability contributed to superior clinical outcomes. Incorporating motion control strategies into rehabilitation programs may optimize recovery and functional performance in this population.

CONFLICT OF INTEREST:

None

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None.

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