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Pelvic Inclination, Core Stability and Their Impact on Low Back Pain

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ABSTRACT

Pelvic inclination and core stability play a crucial role in maintaining spinal alignment and mechanical load distribution. Altered pelvic inclination, particularly increased anterior pelvic tilt, has been implicated in the development and persistence of chronic low back pain (LBP). This study aimed to investigate the relationship between pelvic inclination, core stability, and LBP and to evaluate the effects of a core stability training program on pain, disability, and pelvic alignment. A total of 60 patients with chronic LBP (aged 21–60 years) were recruited and assigned to an intervention group (n = 30) or control group (n = 30). Baseline assessments included anterior pelvic tilt, sacral slope, plank endurance time, pain intensity (Numeric Pain Rating Scale, NPRS), and disability (Oswestry Disability Index, ODI). The intervention group underwent a 6-week core stability training program, while the control group continued routine care. Post-intervention changes were analyzed using paired and independent t-tests. Baseline analysis showed significantly greater anterior pelvic tilt (16.4° ± 3.2° vs. 12.1° ± 2.8°, $p < 0.001$) and reduced core endurance (38.5 ± 8.2 sec vs. 62.1 ± 9.3 sec, $p < 0.001$) in LBP patients compared to controls. Following the intervention, the intervention group showed significant improvements in pain (6.3 ± 1.2 to 3.1 ± 1.0, $p < 0.001$), ODI scores (42.7 ± 7.5% to 25.3 ± 6.8%, $p < 0.001$), and anterior pelvic tilt (16.4° ± 3.2° to 13.7° ± 2.9°, $p = 0.002$). This study highlights the impact of pelvic inclination and core stability on LBP. A 6-week core stability intervention significantly improved pain, disability, and pelvic alignment, emphasizing the importance of core training in LBP rehabilitation.

Keywords: Pelvic inclination, Core stability, Low back pain, Core endurance

INTRODUCTION

Low back pain (LBP) is a prevalent musculoskeletal disorder affecting a significant portion of the global population, often leading to disability, reduced quality of life, and economic burden. Among the various biomechanical and physiological factors contributing to LBP, pelvic inclination and core stability play crucial roles in spinal alignment, load distribution, and functional movement. Abnormal pelvic inclination—either excessive anterior or posterior tilt—can alter lumbar lordosis, increasing stress on the intervertebral discs, facet joints, and paraspinal musculature, potentially exacerbating pain and dysfunction (Youdas JW et. al. 2000).

Core stability, which refers to the strength, endurance, and coordinated function of the deep trunk muscles, is essential for maintaining proper lumbopelvic alignment and spinal stability. Weak or imbalanced

core muscles can contribute to postural deviations, excessive pelvic tilt, and inefficient movement patterns, all of which may predispose individuals to LBP or prolong recovery (Skundric G et. al. 2021). Given the interplay between pelvic inclination and core stability, rehabilitation strategies that address both factors are essential for optimizing pain relief, restoring function, and preventing recurrence.

MATERIALS & METHODS

This cross-sectional observational study aimed to investigate the relationship between pelvic inclination, core stability, and their impact on low back pain. A total of 60 participants were recruited and divided into two groups: 30 individuals with chronic LBP (Group 1) and 30 healthy controls without this condition (Group 2).

Participants

Inclusion and Exclusion Criteria

A total of 60 participants were recruited from physiotherapy clinics and orthopedic outpatient departments. Participants were included if they were 21–60 years of age, had a diagnosis of non-specific chronic low back pain (≥3 months), and exhibited pelvic tilt abnormalities (anterior or posterior) confirmed through clinical and radiographic assessments.

Exclusion criteria included:

- Acute LBP (<6 weeks)
- Specific spinal pathologies (e.g., disc herniation, fractures, ankylosing spondylitis)
- Neurological disorders
- Pregnancy or postpartum status (<6 months)
- Severe musculoskeletal deformities (scoliosis >20° Cobb angle)
- Prior lumbar or pelvic surgeries
- Use of opioid analgesics

A power analysis conducted using G*Power software determined that a minimum of 60 participants was required to detect significant differences in pelvic inclination, core stability, and pain severity with a power of 0.80 and an alpha level of 0.05. The study included 30 individuals with chronic LBP and 30 healthy controls, ensuring adequate statistical power.

Data Collection and Assessment Procedures

1. Pelvic Inclination Measurement

- **Radiographic assessment**: Lateral radiographs were used to measure sagittal pelvic tilt, sacral slope, and lumbar lordosis.

2. Core Stability Assessment

- **Plank endurance test**: Maximum hold time (in seconds) was recorded.
- **Pressure biofeedback unit test**: Core muscle activation was assessed by monitoring lumbar stabilization during controlled movements.

3. Low Back Pain and Functional Disability Assessment

- **Numeric Pain Rating Scale (NPRS)**: Self-reported pain intensity was recorded on a **0–10 scale**.
- **Oswestry Disability Index (ODI)**: Functional disability due to LBP was assessed.
- **Modified Star Excursion Balance Test (SEBT)**: Dynamic postural stability and neuromuscular control were evaluated.

Intervention Protocol

For the interventional component, the 30 participants with LBP underwent a 6-week core stabilization program, which included:

1. **Pelvic tilt correction exercises** to normalize lumbopelvic posture.
2. **Core strengthening exercises**, including plank variations, dead bug exercises, and bird-dog exercises.
3. **Neuromuscular training** to improve proprioception and postural control.
4. **Postural correction strategies** to optimize functional movement and reduce pain.

Participants attended three supervised sessions per week, with progressive intensity adjustments based on individual performance.

STATISTICAL ANALYSIS

Data analysis was performed using SPSS version 28.0. The normality of the data was assessed using the Shapiro-Wilk test. Descriptive statistics were reported as mean ± standard deviation (SD) for continuous variables and as percentages for categorical variables. To compare pelvic inclination and core stability parameters between the low back pain and control groups, independent t-tests or Mann-Whitney U tests were conducted based on data distribution. Pearson or Spearman correlation analysis was used to examine the relationships between pelvic inclination, core stability, and pain severity. A significance level of $p < 0.05$ was considered statistically significant.

RESULT

Demographic and Baseline Characteristics

A total of 60 participants were included in the study, with 30 individuals diagnosed with chronic low back pain (LBP group) and 30 healthy controls (control group). The mean age of participants was 41.2 ± 10.5 years in the LBP group and 39.8 ± 9.7 years in the control group ($p = 0.62$, NS). No significant differences were found in baseline demographic variables such as gender distribution and BMI between the groups.

Comparison of Pelvic Inclination and Core Stability

The LBP group exhibited significantly increased anterior pelvic tilt compared to the control group (16.4° ± 3.2° vs. 12.1° ± 2.8°; $p < 0.001$). Similarly, sacral slope was significantly greater in the LBP group (42.3° ± 4.7° vs. 37.9° ± 3.9°; $p = 0.003$). Core stability measures showed that the plank endurance time was significantly lower in the LBP group (38.5 ± 8.2 sec vs. 62.1 ± 9.3 sec; $p < 0.001$), indicating poor core endurance.

Effect of Core Stability Training on LBP Group

After the 6-week intervention, the LBP group demonstrated significant improvements in core stability and pain levels. The NPRS score reduced from 6.3 ± 1.2 to 3.1 ± 1.0 ($p < 0.001$, paired t-test), and ODI scores improved from 42.7 ± 7.5% to 25.3 ± 6.8% ($p < 0.001$). Additionally, the pelvic inclination angle decreased significantly (16.4° ± 3.2° to 13.7° ± 2.9°, $p = 0.002$), and plank endurance time improved (38.5 ± 8.2 sec to 55.6 ± 7.5 sec, $p < 0.001$).

Correlation Analysis

Pearson correlation analysis revealed a strong negative correlation between core stability (plank endurance time) and NPRS scores ($r = -0.72$, $p < 0.001$), indicating that better core stability was associated with lower pain levels. Similarly, a positive correlation was observed between anterior pelvic tilt and ODI scores ($r = 0.65$, $p < 0.001$), suggesting that greater pelvic inclination was linked to higher disability.

Table 1. Baseline Characteristics of Participants

Variable	LBP Group (n = 30)	Control Group (n = 30)	p-value
Age (years)	41.2 ± 10.5	39.8 ± 9.7	0.62
BMI (kg/m²)	26.4 ± 3.2	25.8 ± 3.1	0.47
Male/Female (n)	16/14	17/13	0.78

Table 2. Comparison of Pelvic Inclination and Core Stability between **Groups**

Variable	LBP Group (n = 30)	Control Group (n = 30)	p-value
Anterior Pelvic Tilt (°)	16.4 ± 3.2	12.1 ± 2.8	<0.001**
Sacral Slope (°)	42.3 ± 4.7	37.9 ± 3.9	0.003**
Plank Endurance (sec)	38.5 ± 8.2	62.1 ± 9.3	<0.001**

Table 3. Pre- and Post-Intervention Changes in LBP Group

Variable	Pre-Intervention	Post-Intervention	p-value
NPRS (Pain Score)	6.3 ± 1.2	3.1 ± 1.0	<0.001**
ODI (%)	42.7 ± 7.5	25.3 ± 6.8	<0.001**
Anterior Pelvic Tilt (°)	16.4 ± 3.2	13.7 ± 2.9	0.002**
Plank Endurance (sec)	38.5 ± 8.2	55.6 ± 7.5	<0.001**

Table 4. Correlation Analysis

Variable 1	Variable 2	r-value	p-value
Plank Endurance (sec)	NPRS (Pain Score)	-0.72**	<0.001**
Anterior Pelvic Tilt (°)	ODI (%)	0.65**	<0.001**

DISCUSSION

The present study examined the relationship between pelvic inclination, core stability, and their impact on chronic low back pain (LBP) rehabilitation. Our findings indicate that individuals with LBP exhibited greater anterior pelvic tilt, increased sacral slope, and reduced core endurance compared to healthy controls. Furthermore, a structured 6-week core stability training program resulted in significant improvements in pain, disability, pelvic alignment, and core endurance, supporting the biomechanical role of lumbopelvic stability in LBP management.

Pelvic Inclination and Its Role in Low Back Pain

Pelvic inclination, particularly increased anterior pelvic tilt, has been identified as a contributing factor to lumbar hyperlordosis and increased spinal loading, potentially exacerbating pain and dysfunction in individuals with LBP. In our study, the LBP group demonstrated a significantly higher anterior pelvic tilt angle (16.4° ± 3.2° vs. 12.1° ± 2.8°, $p < 0.001$) and greater sacral slope (42.3° ± 4.7° vs. 37.9° ± 3.9°, $p = 0.003$) compared to controls. These findings align with previous studies that have reported pelvic malalignment as a biomechanical risk factor for spinal dysfunction and pain development.

A key observation in our study was the positive correlation between anterior pelvic tilt and disability ($r = 0.65$, $p < 0.001$), suggesting that greater pelvic inclination was associated with higher Oswestry Disability Index (ODI) scores. This supports the hypothesis that excessive pelvic tilt may contribute to abnormal load distribution, altered lumbar mechanics, and impaired movement patterns, leading to functional limitations in individuals with LBP (Lim HS et. al. 2013).

Core Stability and Its Impact on Pain and Function

Core stability plays a fundamental role in maintaining lumbopelvic alignment, distributing mechanical loads, and reducing stress on the lumbar spine. Our results demonstrate that the LBP group had significantly lower core endurance, as indicated by reduced plank hold time (38.5 ± 8.2 sec vs. 62.1 ± 9.3 sec, $p < 0.001$). The negative correlation between plank endurance and pain levels ($r = -0.72$, $p < 0.001$) further suggests that poor core stability is associated with higher pain intensity, emphasizing the importance of core muscle function in LBP rehabilitation (Hodges PW 2003).

These findings support prior research indicating that deficits in deep trunk muscle activation, particularly the transversus abdominis and multifidus, contribute to spinal instability and chronic pain (Stokes IA et. al. 2011). Individuals with LBP often exhibit delayed core muscle activation and compensatory movement patterns, further predisposing them to pain recurrence and functional impairments.

Effects of Core Stability Training on Pelvic Inclination and Pain

Following the 6-week core stability intervention, significant improvements were observed in the LBP group. Pain intensity, measured by the Numeric Pain Rating Scale

(NPRS), decreased from 6.3 ± 1.2 to 3.1 ± 1.0 ($p < 0.001$), and ODI scores improved from 42.7 ± 7.5% to 25.3 ± 6.8% ($p < 0.001$). Additionally, anterior pelvic tilt angle reduced from 16.4° ± 3.2° to 13.7° ± 2.9° ($p = 0.002$), suggesting that targeted core exercises effectively corrected pelvic alignment and improved postural control.

These improvements are consistent with existing literature demonstrating the benefits of core stability exercises in enhancing lumbar stability, reducing pain, and restoring functional movement patterns (Frizziero A et. al. 2021). A well-conditioned core enhances neuromuscular control, reduces excessive pelvic tilt, and prevents compensatory lumbar hyperlordosis, thereby decreasing mechanical strain on the lower back.

Furthermore, the increase in plank endurance (38.5 ± 8.2 sec to 55.6 ± 7.5 sec, $p < 0.001$) post-intervention indicates improved core muscle activation and endurance, which may contribute to sustained reductions in pain and disability over time (Van Dieën JH et. al. 2003). This reinforces the importance of incorporating dynamic core stabilization exercises in LBP rehabilitation programs to address underlying biomechanical deficits (Stokes IA et. al. 2011).

The findings of this study have important clinical implications for physiotherapists and rehabilitation specialists managing chronic LBP. The observed association between increased anterior pelvic tilt and LBP highlights the need for routine assessment of pelvic inclination and core stability in clinical practice. Incorporating targeted core stabilization exercises can significantly improve postural control, reduce excessive lumbar loading, and enhance functional outcomes in patients with LBP. Additionally, plank endurance tests and pelvic tilt measurements may serve as useful clinical markers for evaluating core stability deficits and monitoring rehabilitation progress. Given the significant improvements observed in pain, disability, and pelvic alignment following a 6-week core training intervention, these exercises should be a fundamental component of LBP rehabilitation programs.

Despite these promising findings, this study has certain limitations. The sample size was relatively small, which may limit the generalizability of the results to a broader population. Additionally, the study did not include a long-term follow-up, making it unclear whether the observed improvements in pain, disability, and pelvic inclination are sustained over time. Furthermore, although clinical assessments of core stability were used, objective measures such as electromyographic (EMG) analysis were not incorporated, which could have provided deeper insights into muscle activation patterns. Future research should focus on longitudinal studies with larger sample sizes to evaluate the long-term effects of core stability training on recurrent LBP episodes and postural adaptations, ensuring a more comprehensive understanding of its biomechanical benefits.

CONCLUSION

This study underscores the critical interplay between pelvic inclination, core stability, and low back pain. Individuals with chronic LBP demonstrated greater anterior pelvic tilt, poor core endurance, and higher pain and disability levels. A 6-week core stability intervention effectively reduced pain, improved pelvic alignment, and enhanced core muscle function, emphasizing the biomechanical significance of lumbopelvic stability in LBP rehabilitation.

Declaration by Authors

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