



BIOMECHANICAL CONSEQUENCES OF BODY MASS INDEX VARIATION ON LUMBAR LORDOSIS AND PELVIC TILT IN SPONDYLOLISTHESIS: A RADIOGRAPHIC ANALYSIS

Orthopaedics

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ABSTRACT

Degenerative spondylolisthesis is a common spinal condition characterized by the forward slippage of one vertebra over another due to degeneration of the intervertebral discs and facet joints. Body mass index (BMI) has been implicated in alterations of spinal alignment, yet its specific relationship with lumbar lordosis and pelvic tilt in degenerative spondylolisthesis patients remains unclear. This retrospective radiographic analysis included 60 adult patients diagnosed with degenerative spondylolisthesis. Data on BMI, lumbar lordosis, and pelvic tilt were collected from medical records and radiographic images. Descriptive statistics, bivariate analysis using Pearson correlation coefficient, and multivariate analysis via linear regression were employed. Subgroup analysis based on spondylolisthesis severity and BMI categories was conducted. A negative correlation was found between BMI and lumbar lordosis ($r = -0.42$, $p < 0.05$), indicating decreased lumbar lordosis with higher BMI. Conversely, a positive correlation was observed between BMI and pelvic tilt ($r = 0.38$, $p < 0.05$), suggesting increased pelvic tilt with higher BMI. Multivariate analysis confirmed the independent association of BMI with both lumbar lordosis ($\beta = -0.27$, $p < 0.05$) and pelvic tilt ($\beta = 0.21$, $p < 0.05$). Subgroup analysis by BMI categories revealed a significant gradient in radiographic parameters with increasing BMI. The study highlights the significant impact of BMI on spinal alignment parameters in degenerative spondylolisthesis patients. Addressing obesity as a modifiable risk factor may have implications for improving spinal biomechanics and patient outcomes in this population.

KEYWORDS

Degenerative Spondylolisthesis, Body Mass Index, Lumbar Lordosis, Pelvic Tilt

INTRODUCTION

Degenerative spondylolisthesis is a prevalent spinal pathology characterized by the anterior displacement of one vertebral body over the adjacent one, primarily affecting the lumbar spine. It is often associated with significant alterations in spinal alignment and biomechanics, leading to chronic low back pain, functional impairment, and decreased quality of life for affected individuals. Among the various factors influencing the biomechanics of the lumbar spine, body mass index (BMI) has emerged as a key determinant, particularly in the context of degenerative spinal conditions.

BMI, a measure of body fat based on height and weight, has been implicated in exacerbating the progression and symptoms of degenerative spondylolisthesis. Studies have shown that higher BMI is associated with increased mechanical stress on the lumbar spine, leading to alterations in spinal curvature and pelvic orientation (Smith et al., 2015; Schwab et al., 2005). Specifically, obesity has been linked to decreased lumbar lordosis and increased pelvic tilt, which may further contribute to spinal instability and symptom severity in individuals with degenerative spondylolisthesis.

Despite the growing recognition of the impact of BMI on spinal biomechanics, the precise relationship between BMI variation and specific parameters of spinal alignment, such as lumbar lordosis and pelvic tilt, in degenerative spondylolisthesis patients remains unclear. Understanding these biomechanical consequences is crucial for optimizing clinical management strategies, including conservative treatments and surgical interventions, aimed at improving patient outcomes.

Therefore, this study aims to conduct a comprehensive radiographic analysis to examine the biomechanical consequences of BMI variation on lumbar lordosis and pelvic tilt in individuals with degenerative spondylolisthesis. By investigating these biomechanical aspects, we can gain insights into the pathophysiology of spondylolisthesis, refine treatment algorithms, and potentially identify targeted interventions to mitigate the impact of BMI on spinal biomechanics and patient outcomes.

Methodology

Inclusion Criteria

- Patients diagnosed with degenerative spondylolisthesis based on radiographic imaging (e.g., X-rays, MRI)
- Age ≥ 18 years
- Availability of complete radiographic imaging including standing lateral lumbar spine radiographs.

- BMI data recorded within three months of radiogr

Procedure

This retrospective study investigated the relationship between body mass index (BMI), lumbar lordosis, and pelvic tilt in patients diagnosed with degenerative spondylolisthesis. Data from 60 adult patients with degenerative spondylolisthesis were collected from medical records and radiology databases. Radiographic images, including standing lateral lumbar spine radiographs, were analyzed to measure lumbar lordosis and pelvic tilt. Review of radiographic images were done by trained observers to measure lumbar lordosis and pelvic tilt using standardized methods i.e. Cobb angle for lordosis, pelvic incidence minus lumbar lordosis for pelvic tilt. Statistical analysis, including descriptive statistics, bivariate analysis using Pearson correlation coefficient, and multivariate analysis via linear regression, was conducted to assess associations and adjust for potential confounders such as age and gender. Subgroup analysis based on spondylolisthesis severity and BMI categories was also done.

Result

Descriptive Statistics

Table 1 Demographic Characteristics Of The Study Population

Variable	Mean ($\pm$ SD)	Range
Age (years)	55.3 (± 6.8)	40-70
BMI (kg/m^2)	29.6 (± 4.2)	25-35
Gender (M/F)	32/28	-
Lumbar Lordosis ($^\circ$)	45.7 (± 5.6)	35-55
Pelvic Tilt ($^\circ$)	12.3 (± 2.9)	8-16

Bivariate Analysis

The correlation analysis revealed a significant negative correlation between body mass index (BMI) and lumbar lordosis ($r = -0.42$, $p < 0.05$), indicating that higher BMI was associated with decreased lumbar lordosis. Conversely, there was a significant positive correlation between BMI and pelvic tilt ($r = 0.38$, $p < 0.05$), suggesting that higher BMI was associated with increased pelvic tilt.

Multivariate Analysis

Linear regression analysis was performed to adjust for potential confounders such as age and gender and determine independent predictors of lumbar lordosis and pelvic tilt. The results indicated that BMI remained a significant predictor of lumbar lordosis ($\beta = -0.27$, $p < 0.05$) and pelvic tilt ($\beta = 0.21$, $p < 0.05$) after adjusting for age and gender.

Subgroup Analysis

Subgroup Analysis by Spondylolisthesis Severity and BMI Category

Table 3: Radiographic Parameters Stratified by Spondylolisthesis Severity and BMI Category.

Spondylolisthesis Severity	Lumbar Lordosis (°)	Pelvic Tilt (°)
Mild	47.5 (±4.3)	11.8 (±2.5)
Moderate	45.1 (±5.1)	12.5 (±3.1)
Severe	43.2 (±5.9)	13.8 (±2.7)
BMI Category		
Normal Weight	47.2 (±4.5)	11.5 (±2.8)
Overweight	45.6 (±5.3)	12.2 (±3.0)
Obese	43.8 (±6.2)	13.5 (±2.6)

The subgroup analysis demonstrated a trend of decreasing lumbar lordosis and increasing pelvic tilt with greater severity of spondylolisthesis, although the differences were not statistically significant.

The subgroup analysis by BMI categories showed a gradual decline in lumbar lordosis and an increase in pelvic tilt with increasing BMI category, with statistically significant differences observed between normal weight and obese groups ($p < 0.05$).

These results provide insights into the association between body mass index, lumbar lordosis, and pelvic tilt in patients with degenerative spondylolisthesis, highlighting the impact of obesity on spinal alignment and biomechanics.

DISCUSSION

The results of this study offer valuable insights into the relationship between body mass index (BMI), lumbar lordosis, and pelvic tilt in patients with degenerative spondylolisthesis. The negative correlation observed between BMI and lumbar lordosis aligns with previous research highlighting the impact of obesity on spinal alignment. Higher BMI has been associated with decreased lumbar lordosis in various studies, indicating a flattening of the lumbar curvature (Smith et al., 2015; Schwab et al., 2005). This alteration in spinal alignment may predispose individuals to increased biomechanical stress and potentially exacerbate symptoms in those with degenerative spondylolisthesis.

Conversely, the positive correlation between BMI and pelvic tilt observed in this study is consistent with previous literature demonstrating that obesity contributes to alterations in pelvic orientation (Lazennec et al., 2018; Vaz et al., 2002). Higher BMI has been associated with increased anterior pelvic rotation, which may further exacerbate lumbar spine malalignment and instability (Itoi & Sinaki, 1994). These findings underscore the complex interplay between obesity and spinal biomechanics in patients with degenerative spondylolisthesis.

The multivariate analysis adjusting for potential confounders such as age and gender reaffirmed the independent association of BMI with both lumbar lordosis and pelvic tilt. This suggests that BMI may exert a direct influence on spinal alignment parameters, irrespective of other demographic factors. These findings are consistent with previous studies that have identified obesity as a significant predictor of altered spinal alignment in various populations (Jackson & McManus, 1994; Rajnics et al., 2002).

The subgroup analysis based on spondylolisthesis severity and BMI categories provided further insights into the variations in radiographic parameters across different subgroups. While no statistically significant differences were observed across spondylolisthesis severity groups, subgroup analysis by BMI categories revealed a significant gradient in radiographic parameters with increasing BMI. This highlights the importance of considering obesity as a modifiable risk factor in the management of degenerative spondylolisthesis, with implications for clinical decision-making and targeted interventions aimed at weight reduction.

Despite the valuable insights provided by this study, several limitations must be acknowledged. The retrospective design and reliance on available medical records may introduce selection bias and limit the generalizability of the findings. Future prospective studies with larger sample sizes and longitudinal follow-up are warranted to validate these findings and explore potential mechanisms underlying the observed associations.

CONCLUSION

This study contributes to our understanding of the complex interplay between obesity, spinal alignment, and degenerative spondylolisthesis. The results underscore the importance of considering BMI as a modifiable risk factor in the management of spondylolisthesis, with implications for clinical decision-making and targeted interventions aimed at optimizing spinal alignment and improving patient outcomes.

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