RESEARCH

# COMPARISON OF SPINOPELVIC PARAMETERS AMONG OLDER ADULTS WITH LUMBAR SPONDYLOSIS, LUMBAR FRACTURES AND LUMBAR SPINAL STABILIZATION

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## Abstract

**Introduction:** In elderly individuals, sagittal plane deformities may be iatrogenic due to aging. Fractures due to osteoporosis, as well as previous surgeries, can cause resistant lower back pain. As a result of pathologies, degeneration can occur in the spinal joints, excessive tension in the paravertebral muscles, and compensatory changes occur in the pelvis respectively. These changes were evaluated with spinopelvic parameters. Our aim was to compare the spinopelvic parameters in patients over 65 years of age who presented to the clinic with lower back pain.

**Materials and Methods:** Measurements of the angles for spinopelvic parameters characterizing the alignment of the sacrum (sacral slope), the pelvis (pelvic tilt, pelvic incidence) and the lumbar lordosis were calculated based on X-ray imaging analysis.

**Results:** The records of 122 patients were included. Their mean age was 73.5 ± 5.70 years. Patients were divided into three groups: as those with spondylosis, lumbar fractures and lumbar stabilization. While a significant decrease was observed in lumbar lordosis in the group with lumbar vertebral fractures ($p = 0.019$), no significant difference was observed between the groups in pelvic incidence, sacral slope and or pelvic tilt ($p > 0.05$). No gender differences in spinopelvic parameters was observed. No differences were detected in spinopelvic parameters between age groups below and above 75 years.

**Conclusion**: A remarkable decrease in lumbar lordosis was seen in patients with lumbar fractures. Careful evaluation of spinopelvic parameters before planning the treatment can increase the probability of successful treatment of resistant lower back pain in the elderly.

***Keywords:*** Geriatrics; Spinal Curvatures; Spinal Fractures; Fracture Fixation; Spondylosis.

## INTRODUCTION

An ideal spinal alignment allows for standing independently with minimal muscular energy expenditure. Pathologies occurring in the frontal and sagittal plane increase the energy used by the spine to maintain its posture together with the load on the vertebrae, muscles and ligaments (1). As a result, degeneration occurs in the spinal joints, excessive tension in the paravertebral muscles, and compensatory changes in the pelvis. These changes were evaluated with spinopelvic parameters (2). The pelvic tilt (PT) angle, which is closely related to pain and disability, is an indicator of the degree of retroversion of the pelvis (3). The PT and sacral slope (SS) are positional parameters that vary according to the position of the pelvis. SS is measured as the angle of the sacral plateau to the horizontal plane, which determines the position of the lumbar spine. Pelvic incidence (PI), called an anatomic parameter, plays a key role in achieving sagittal balance; it determines the relative position of the sacral plateau in relation to the femoral heads and does not change with the presence of fractures, degenerative changes or aging (1, 3-4).

Recent research has emphasized the key role of spinal sagittal balance and investigated spinopelvic parameters in healthy volunteers (5-9). Aging is an important factor that affects lumbosacral alignment (5-6, 10). Age-related changes in the vertebra, degeneration of disks and ligaments, and weakness of back muscle strength contribute to these variations (1, 10-11).

In elderly individuals, sagittal plane deformities may be iatrogenic due to aging; fractures due to osteoporosis, as well as previous surgeries, can cause resistant lower back pain (1, 10, 12-13). Additionally, patients change their postures while trying to cope with back pain (6, 10, 12).

The aim of the present study was to compare the spinopelvic parameters of geriatric patients with lower back pain due to posterior instrumentation, lumbar spinal spondylosis and/or lumbar fractures.

## MATERIALS AND METHOD

### Sample and study design

This retrospective cross-sectional study was approved by the Institutional Review Board (IRB approval no. 2018/218). The number of patients for the research—which had three independent groups, 80% strength, type 1 error (alpha) 0.005, and effect size 0.290—was calculated as a total of 120 samples. The records of 122 patients over the age of 65 who applied to a polyclinic with lower back pain between May 2018 and September 2018 were reviewed. The patients were divided into three groups: those with lumbar spondylosis, lumbar vertebral fracture and lumbar stabilization. Standing lateral lumbar radiographs were obtained from the electronic hospital database for the calculation of spinopelvic parameters. Patients who had a congenital spinal deformity, total hip arthroplasty, ≥ 2 lumbar fractures, or long-level spinal fusion (>4), scoliosis, who were below the age of 65, or who had inappropriate radiographs were excluded from the study.

The spinopelvic parameters (LL, PT, PI, SS) were calculated as shown in Figure 1. All measurements were carried out with the same angle meter by two experienced researchers.

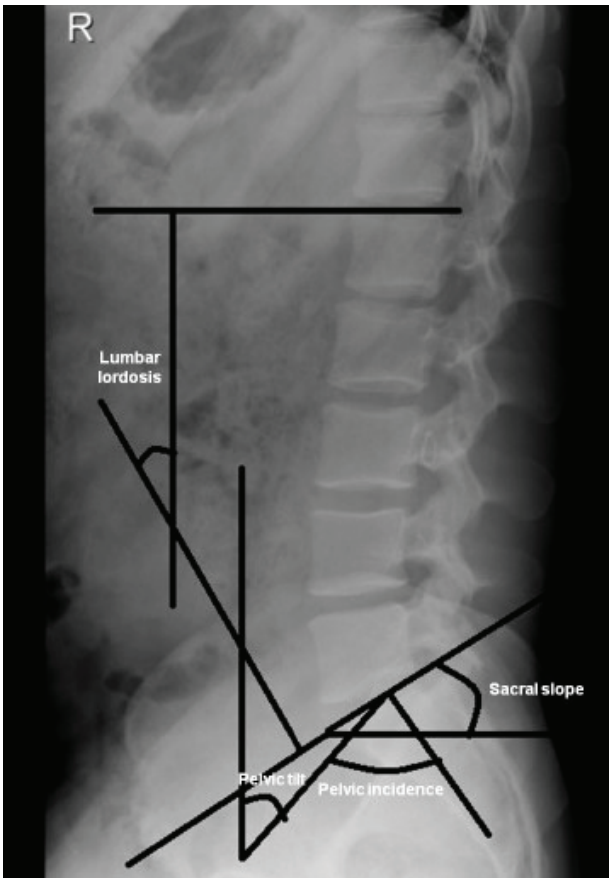
**LL** is defined as the angle between the line that passes through the upper-end plaque and the line drawn perpendicularly to the line that passes through the sacral-end plaque. The normal lumbar lordosis is between 40° and 70° when a distance of L3–4 is taken as the peak.

**PI** is the angle between the perpendicular line that passes through the midpoint of the upper sacral end-plaque and connects the femur head axis to this midpoint.

**SS** is the angle between the line that is drawn from the sacral-end plaque and the horizontal line that is drawn from the midpoint of the upper sacral-end plaque.

**PT** is the angle between the vertical line that passes through the femur head axis and the line

**Figure 1.** Radiographic image showing the reference line for measuring pelvic incidence (PI).




pelvic tilt (PT), lumbar lordosis (LL), sacral slope (SS)

that connects the sacral end-plaque midpoint of the femur head axis.

### Ethical approval

This study was conducted in compliance with the principles of the Declaration of Helsinki. It was approved by the Institutional Review Board (IRB approval number, 2018/218)

### Statistical analysis

Statistical analysis was performed using IBM SPSS 22.0 software. Descriptive statistics were calculated for age, gender, PI, SS, PT and LL [frequencies, percentages, mean ± SD, median ($25^{th}$%–$75^{th}$%)]. The normality of the data was evaluated using the Shapiro–Wilk and Kolmogorov–Smirnov tests. The Chi-square test was used to compare the qualitative data of gender and age in those over 75 years and those below. In comparing the quantitative data, to compare the lumbar spondylosis, lumbar vertebral fracture and lumbar stabilization groups for a normally distributed pelvic incidence, a one-way analysis of variance (ANOVA) test was employed. The Kruskal–Wallis test was employed to make the comparison among the parameter groups for non-normally distributed SS, PT and LL; the Tukey HSD test was used to determine the group that caused the difference and to compare gender and age in those above 75 and younger groups. Student's t-test was used for normally distributed PI, and the Mann–Whitney U test was used for non-normally distributed SS, PT and LL. A p value $< 0.05$ was considered statistically significant.

## RESULTS

A total of 357 patients aged 65 years and above were examined. The records of 122 patients (89 females, 33 males) were included. The mean values of PI, SS, PT and LL were 56.40 ± 14, 38.84 ± 11, 17.41 ± 9.2 and 39.84 ± 15.9, respectively (Table 1).

No differences were detected between genders in the measurements of PI, SS, PT and LL values (p

**Table 1.** Demographic data of the patients

| | N = 122 |
|---|---|
| **Age** | 73.53 ± 5.70; 73 (69–77) |
| **Gender (F/M) (%)** | 89/33 (73/27) |
| **Pelvic Incidence (PI)** | 56.40 ± 14; 57 (46–65) |
| **Sacral Slope (SS)** | 38.84 ± 11; 40 (32–46) |
| **Pelvic Tilt (PT)** | 17.41 ± 9.2; 16 (10–23) |
| **Lumbar Lordosis (LL)** | 39.84 ± 15.9; 43 (30–51.3) |

Values presented in mean ± SD, median (25th–75th%)

values: 0.458, 0.621, 0.793 and 0.084, respectively) (Table 2).

No differences were detected in spinopelvic parameters between the age groups below and above 75 (Table 3).

When the three groups were compared, the median age of those who had fractures was significantly higher (p = 0.007). There were no differences between PI, SS and PT measurements in the three groups (p > 0.05). Statistically significant differences were detected between the LL measurements (p = 0.019), and the angle of LL was significantly lower in the group with lumbar vertebral fracture (Table 4).

**Table 2.** Spinopelvic parameter measurements with respect to gender

| | Female (N = 89) | Male (N = 33) | p |
|---|---|---|---|
| **PI** | 59.98 ± 4.36 | 54.85 ± 13.04 | 0.458 |
| **SS** | 39.15 ± 11.20 | 38.03 ± 10.57 | 0.621 |
| **PT** | 16.0 (10.0–24.0) | 16.0 (10.0–20.0) | 0.793 |
| **LL** | 43.0 (32.0–51.5) | 34.0 (17.0–51.0) | 0.084 |

Values presented in mean ± SD, median (25–75), Significance of p < 0.05, Simple T test
PI (pelvic incidence), SS (sacral slope), PT (pelvic tilt), LL (lumbar lordosis)

**Table 3.** Spinopelvic parameter measurements with respect to age groups

| | Age < 75 (N = 76) | Age ≥ 75 (N = 46) | p |
|---|---|---|---|
| **PI** | 56.56 ± 13.95 | 56.13 ± 14.23 | 0.869 |
| **SS** | 39.13 ± 10.95 | 38.37 ± 11.19 | 0.712 |
| **PT** | 18.0 (12.0–22.8) | 15.0 (10.0–23.3) | 0.659 |
| **LL** | 43.0 (32.3–50.8) | 38.0 (23.8–52.0) | 0.420 |

Values presented in mean ± SD, median (25-75), Significance of p < 0.05, Simple T test
PI (pelvic incidence), SS (sacral slope), PT (pelvic tilt), LL (lumbar lordosis)

**Table 4.** Spinopelvic parameter measurements of the groups

| | Spondylosis | Those with fractures | Those undergoing stabilization | p |
|---|---|---|---|---|
| **N (%)** | 57 (46.7) | 31 (25.4) | 34 (27.9) | |
| **F/M(%)** | 44/13 (77.2/22.8) | 19/12 (61.3/38.7) | 26/8 (76.5/23.5) | 0.238 |
| **Age** | 73.0 ± 6.13;71 (68–77) | 76.16 ± 5.25; 74 (72–81) | 72.03 ± 4.58; 71.5 (68–76.3) | 0.007*$^{K}$ |
| **PI** | 57.14 ± 15.36; 59 (44–68) | 55.96 ± 13.2; 55 (48–64) | 55.56 ± 12.6; 55 (47.5–65) | 0.858 |
| **SS** | 39.0 ± 11.42; 40 (30–47) | 37.84 ± 10.14; 37 (31–44) | 39.5 ± 11.3; 40 (33.5–45.3) | 0.825 |
| **PT** | 18.14 ± 9.12; 16 (11–24) | 17.55 ± 9.57; 18 (10–20) | 16.06 ± 9.12; 15 (9.5–20.8) | 0.599$^{K}$ |
| **LL** | 42.23 ± 15.27; 43 (32–52) | 32.38 ± 17.9; 30 (20–48) | 42.62 ± 13.2; 44.5 (37.5–51.3) | 0.019*$^{K}$ |

Values presented in mean ± SD, median (25th–75th%), *Significance of p < 0.05; K: Kruskal–Wallis Test
PI (pelvic incidence), SS (sacral slope), PT (pelvic tilt), LL (lumbar lordosis)

## DISCUSSION

The present study represents a retrospective, cross-sectional analysis of spinopelvic alignment in older adults as studied through lateral standing lumbosacral radiographs. Based on our findings, a remarkable decrease in LL was seen in the lumbar fracture group. Gender differences were not detected in the measurements of spinopelvic parameters.

Few studies have been conducted on the spinopelvic parameter assessment of adults aged above 50 years. Most studies so far have been conducted on the surgical correction of spinal deformities in younger populations. LL is effective in maintaining a straight posture. Young adults decrease the thorasic kyphosis to compensate for changes in LL. As a result of non-flexible columns in older adults, this compensation is not sufficient and contributes to sagittal imbalance (10). In our study with a geriatric population, the LL values were significantly lower in the fracture group. Dai's study showed that those with low LL have a higher risk of vertebral fracture, and LL was determined to be low in postmenopausal women with fractures (14). Since the previous radiographs of the patients were not evaluated in our study, a low LL value may be a risk factor for lumbar fracture as well as a result of lumbar fracture.

Flatback syndrome is a postural disorder of the spine due to the loss or decrease in LL. Although generally defined as post-fusion LL loss, it may also be seen in pathologies such as ankylosing spondylitis without surgery, diffuse idiopathic skeletal hyperostosis and Scheuermann's disease (15). Although lumbar fusion relieves resistant lower back pain, it may cause acceleration in the degeneration in the segments that are adjacent to the segments fixed after instrumentation and may lead to flatback syndrome (16). Indeed, a study by Gottfried et al. found a reduction in LL in patients with iatrogenic flat backs (17). In our study, on the other hand, a significant decrease in LL was detected not in those who underwent stabilization but in the group with fractures. This may be because of the inclusion of patients who had short segment fusion in our study.

Different results were reported in previous studies that examined the relationship between age and spinopelvic parameters. In a study to describe changes in spinopelvic parameters in 132 Korean adult male volunteers over 50 years of age, similar spinopelvic parameters were observed, with a tendency for thoracic kyphosis to increase with age (18). Similarly, a study investigating age-related changes in spinal alignment in asymptomatic Japanese individuals found no correlation between lumbosacral parameters and aging (19). On the contrary, Kobayashi et al. reported a decrease in LL with age (20). Yukawa et al. showed that there was a decrease in LL with advancing age, while there was a remarkable decrease in LL from the 7$^{th}$ to the 8$^{th}$ decade (6). Ethnicity and different measurement methods and sample sizes may lead to these different results (13).

We found no relationship between gender and spinopelvic parameters. Similarly, few studies have found any differences in lumbosacral parameters between female and male asymptomatic volunteers (7-8). Contrary to our results, some studies have reported that female patients had higher lumbar lordosis (21, 22). These conflicting results may be a result of different sample sizes or selection bias.

The PT angle varies between 12.1–13.2° in the healthy population (9, 23). When LL decreases, an increase occurs in PT because of the backward rotation of the pelvis, and an increase in PT might occur as a compensatory mechanic to maintain sagittal balance (6). In our study, consistent with the literature, the mean value of PT was 17.41 ± 9.2.

Preoperative measurement of the spinopelvic parameters of patients who will undergo surgery for spinal deformity is particularly important. Lafarge et al. stated that patients who had high PI values had negative results following pedicle extraction osteotomy for thoracic kyphosis restoration and that patients who had low PI values were likelier to

be satisfied compared to patients who had high PI values (24). Since this is a retrospective study, the lack of preoperative spinopelvic parameters and the inability to question the postoperative satisfaction of the patients are the limitations of this study. Geometrically, PI is equal to the sum of PT and SS. PT changes inversely to SS, while PI remains constant and does not change with age. In a study that included an adult population over 60 years of age, the PI, PT and SS values were calculated as 51 ± 9, 16 ± 9 and 36 ± 9, respectively (25). In our study, PI was measured as 56.40 ± 14. This may be due to ethnic differences. The PI is considered to be an inherent value. A pelvis with a higher PI has a large anteroposterior axis; it is a large horizontal pelvis with a higher possibility of retroversion (1).

There were several limitations to our study. The body mass index affecting the lumbosacral alignment cannot be taken into account, since the study is based on retrospective records. Only symptomatic elderly patients were enrolled in this study. The fact that the female patients outnumbered the male patients presented a potential bias. We could not assess the clinical impacts of lumbosacral parameters. It seems that more attention being paid to other factors, such as the duration of symptoms, comorbidities and environmental or physical exposures could increase the value of the study's results.

Despite the aforementioned limitations, this study revealed the importance of sagittal alignment differences in geriatric populations for degenerative spinal disease, lumbar fracture or posterior fusion. A marked decrease in LL was seen in the lumbar fracture group. A recent meta-analysis demonstrated a strong relationship between lower back pain and decreased LL, especially when compared to age-matched healthy controls (12). Lumbosacral alignment, particularly LL, which affects sagittal balance, is pivotal to sustaining proper upright posture and reducing fall risk in elderly populations. For this reason, spinopelvic parameters should be evaluated carefully in older adults with lower back pain, and those with lumbar fractures should be referred to a surgeon in light of their medical condition.

In conclusion**,** a remarkable decrease in lumbar lordosis was seen in elderly individuals with lumbar fractures. Degenerative processes, iatrogenic causes and vertebral fractures affect spinal sagittal alignment. Patients with impaired sagittal alignment spend a lot of energy to stand up, and they also fight pain. Careful evaluation of spinopelvic parameters before planning the treatment can increase the probability of successful treatment of resistant lower back pain in the elderly.

### Conflict of Interest

The authors declare that they have no conflicts of interest.

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