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Original Article

Impact of thoracic kyphosis and lumbar lordosis changes on axial spine pain intensity: An epidemiological study

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Abstract

Objective: Adult spinal deformity is a common public health issue worldwide caused by changes in the normal curves of the spine, at times leading to axial spine pain. This study measures changes in the normal curves of the spine, especially thoracic kyphosis and lumbar lordosis, and correlates them with subjective axial pain scores to find how anatomic changes in thoracic and lumbar curves relate to the subjective pain.

Methods: This is a descriptive-analytical epidemiological study conducted in Ahvaz Golestan Hospital. In this study, 52 patients were selected by non-randomized convenience sampling of patients with axial spine pain referred to Golestan Hospital between October 2023 and June 2024. Thoracic kyphosis and lumbar lordosis were detected in the selected patients using long-standing radiographs. Then, using pelvic incidence, ΔTK and ΔLL were calculated, and their relation to axial spine pain was studied. We used the Pearson correlation coefficient to examine the relation between spine-related measurements and Visual Analogue Scale (VAS) scores. The distribution of the changes followed a normal distribution (Gaussian distribution) pattern, so Pearson correlation coefficient was employed.

Results: On average, lumbar lordosis in these people showed a mean decrease of 10 degrees compared to normal lumbar lordosis, and average thoracic kyphosis showed a mean increase of 15 degrees compared to the normal thoracic kyphosis. In the study of the global pain scale and comparing the intensity of pain with changes in thoracic kyphosis (ΔTK) and lumbar lordosis (ΔLL), axial pain was most associated with changes in thoracic kyphosis (ΔTK) ($P < 0.001$).

Conclusion: In the treatment of axial spine pain, the intensity of pain is more related to changes in thoracic kyphosis rather than lumbar lordosis. This can help researchers to propose further studies on correcting thoracic kyphosis to obtain better axial spine pain relief.

Keywords: Thoracic kyphosis, Lumbar lordosis, Axial spine pain

Introduction

Adult spinal deformity is a common public health issue worldwide and is on the increase with the aging of the population (1). Degenerative spinal sagittal imbalance is one of the common spinal deformities in adults. Its prevalence is between 20% and 40% worldwide (2). In general, adult spinal deformity has a wide diagnostic classification that includes idiopathic sclerosis as well as de novo or degenerative curves, which often lead to sagittal plane decompensation. Sagittal plane imbalance and malalignment are among the important and increasingly recognized causes of pain and disability (3-6). This front-back imbalance in the spine is the main radiographic driver of disability in spinal deformities (7). If one of the curves of the spine becomes either too pronounced or too flat, the balance of the spine is disturbed, and as a result, the center of gravity of the body moves forward (5,8).

Spinal sagittal balance is a state in which a person is capable of maintaining a stable standing position with minimal muscle expenditure. To maintain this balance, it requires the interaction of several factors, including bone morphology (spine and pelvis), disc and ligament mechanical behavior, muscle strength and resistance, and compensation. If one of these factors is disturbed, spinal sagittal imbalance occurs (9).

Sagittal alignment can be considered on a segmental, regional, or global basis. Segmental analysis refers to the relationships between two vertebral bodies and the intervening disc. Regional sagittal balance includes that of the cervical, thoracic, or lumbar spines; the thoracolumbar junction is often considered separately. Global spinal alignment is generally considered to be an indication of overall sagittal balance (10-12).

Overall spinal sagittal balance is determined by a plumb line dropped from the dens. This plumb line usually falls anterior to the thoracic spine, posterior to the lumbar

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spine, and through the posterior superior corner of S1 (12).

On the standing lateral long films generally used in spinal deformity evaluation, the dens is not easily seen. The plumb line, therefore, is usually dropped from the middle of the C7 vertebral body. This plumb line is called the sagittal vertebral axis or SVA (12) (Figure 1).

For a patient to have a severe positive sagittal imbalance, the SVA must be more than 50 mm (11). The overall sagittal balance is probably a more important measurement than regional and segmental measurements. In general, for sagittal balance to be maintained, lumbar lordosis should measure 20 to 30 degrees more than the kyphosis (10).

Patients with sagittal imbalance often complain of the inability to stand upright, unbearable pain, and fatigue with increasing activity, and a sense of imbalance (5). According to recent studies, plane sagittal imbalance causes gait disturbances, chronic lower back and leg pain, and a decrease in health-related quality of life (4,13).

Severe spinal deformity with sagittal imbalance may occur as a result of iatrogenic causes or as a result of genetic and metabolic diseases. The treatment of sagittal imbalance depends on the etiology, location, and severity of the deformity (3).

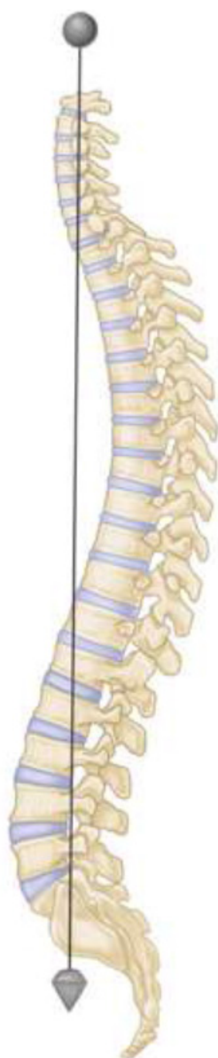

Figure 1. The C7 sagittal plumb line is a useful measurement of sagittal balance. A plumb line dropped from the middle of the C7 vertebral body falls close to the posterosuperior corner of the S1 vertebral body

Recently, the role of the pelvis in the sagittal spinal alignment has been described (14). Three pelvic parameters have been defined: Pelvic incidence is a constant morphological parameter that affects lumbar alignment, especially the degree of lumbar lordosis. Pelvic tilt and sacral slope are also dynamic pelvic parameters that evaluate pelvic version, a compensatory mechanism to help maintain an upright posture in the setting of sagittal malalignment (15). Other widely used spinopelvic parameters have also been identified in maintaining spinal sagittal balance (11,16-18).

Although previous studies have gathered information as a reference on how to correct lumbar lordosis and thoracic kyphosis without causing subsequent sagittal imbalance, there has been no study to evaluate the correlation between axial pain and sagittal kyphosis and lumbar lordosis to reduce axial pain and gain sagittal balance (9,19).

Methods

This is a descriptive-analytical epidemiological study that was conducted in Ahvaz Golestan Hospital. In this study, 52 patients were selected by non-randomized convenience sampling of patients with axial spine pain referred to Golestan Hospital between October 2023 and June 2024. An x-ray is the first tool to evaluate any patient with axial spine pain. We also kept the patients' information and data confidential. This study was ethically approved by the Medical Ethics Committee of Golestan Hospital, Ahvaz University of Medical Sciences (IR.AJUMS.HGOLESTAN.REC.1401.175).

The inclusion criteria were patients aged between 40 and 60 years with axial spine pain for six months or more who were referred to Golestan Hospital.

The exclusion criteria were radiating spine pain, any destructive spine injuries, malignancy, or medical conditions, such as ankylosing spondylitis, that affect the spine.

In this study, we evaluated and documented demographic and clinical factors, including pelvic incidence, thoracic kyphosis, lumbar lordosis, ΔTK and ΔLL, and pain intensity. To obtain these measurements, long standing radiographs of 52 patients with axial spine pain were taken. Then, using special anatomical positions that are visible in long-standing radiographs sagittal vertical axis, C7 plumb line, and vertical axis were drawn. By drawing these lines, we can calculate the β and δ angles, which help us measure TK and LL in each patient. As demonstrated in Figure 2, the β angle is equal to lumbar lordosis, and the δ angle (or Cobb angle between T5 and T12) is equal to thoracic kyphosis (Figure 2).

Each patient was given the global pain scale questionnaire or Visual Analogue Scale (VAS) to evaluate

the intensity of axial pain. The global pain questionnaire, or the VAS, is a simplified visual questionnaire that asks patients to subjectively score their pain from 0 (no pain) to 10 (the worst pain they have ever experienced). The VAS has demonstrated excellent test-retest reliability with an intra-class correlation coefficient (ICC) of 0.97. The standard error of measurement (SEM) was 0.03, and the minimum detectable change (MDC) was 0.08 (Figure 3).

All of the above measures were then calculated and documented for analysis. Two experienced specialists in the field of musculoskeletal diseases performed all measurements and documented their averages.

The relation between changes in thoracic kyphosis (ΔTK), lumbar lordosis (ΔLL), and axial pain scores was analyzed using the Pearson correlation coefficient. We used this method because we anticipated our data would have a normal distribution.

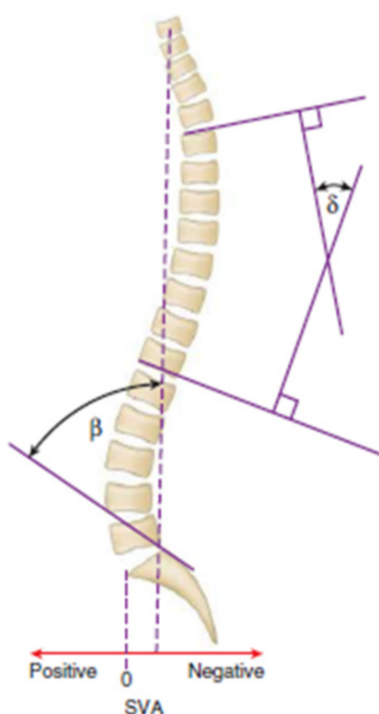

Figure 2. Method of measurement of various parameters of sagittal spinal alignment. The sagittal vertical axis (SVA) is the horizontal distance from the C7 plumb line to the front corner of the sacrum. Positive values indicate a position anterior to the sacrum; negative values indicate a position through or behind the sacrum. β, Angle of sacral inclination, is the angle subtended by the tangent to the posterior border of S1 and the vertical axis. δ, or the Cobb angle, is the angle between two vertebrae

A Pearson correlation coefficient closer to 1 indicates a stronger relation between the two factors that have been studied; for example, if the Pearson correlation coefficient is higher when we study the correlation between ΔTK and the VAS score, ΔTK is more related to the VAS pain score than ΔLL. In this study, we used SPSS version 22 to analyze the data we collected.

Results

Thoracic kyphosis measurements revealed that in patients participating in our study, the average thoracic kyphosis had increased by 15 degrees compared to the average thoracic kyphosis in the normal population (Table 1).

Lumbar lordosis measurement revealed that in patients participating in our study, the average lumbar lordosis had decreased by 10 degrees compared to the average lumbar lordosis in the normal population (Table 1).

In the next phase, the changes in thoracic kyphosis and lumbar lordosis were calculated as ΔTK and ΔLL. ΔTK and ΔLL were then correlated with the score obtained from the global pain scale questionnaire. Then, the relation between changes in thoracic kyphosis (ΔTK), lumbar lordosis (ΔLL), and axial pain scores was analyzed using the Pearson correlation coefficient.

A Pearson correlation coefficient closer to 1 indicates a stronger relation between the two factors being studied; for example, as the Pearson correlation coefficient between ΔTK and the VAS score was higher, ΔTK was more related to the VAS pain score than ΔLL.

This study shows that changes in thoracic kyphosis (ΔTK) are more related to higher axial pain scores compared to changes in lumbar lordosis (ΔLL) ($P < 0.001$) (Table 2).

Discussion

Adult spinal deformities are a common public health problem worldwide and are on the increase with the aging of the population.

As a result of this global problem, there are guidelines

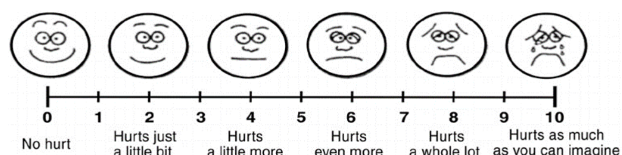

Figure 3. Global pain questionnaire or VAS

Table 1. Mean measurements of sagittal balance indices

	Sample size	Average measurements in patients	Unit of measurement	Standard deviation	*P* value
TK	52	55.2308	degrees	2.09215	<0.001
ΔTK	52	15.2308	degrees	2.09215	<0.001
LL	52	49.9423	degrees	1.75358	<0.001
ΔLL	52	-10.0577	degrees	1.75358	<0.001
According to previous studies, the mean TK in the normal population is 40 degrees.					<0.001
According to previous studies, the mean TK in the normal population is 60 degrees.					<0.001

Table 2. Calculated Pearson correlation coefficient between ΔTK, ΔLL, and VAS score

	Cases	*r* (Correlation coefficient)	*P* value
ΔTK	52	0.698	<0.001
ΔLL	52	0.522	<0.001

suggesting how to and how much to correct kyphosis and lordosis to obtain sagittal balance.

For example, Liang et al used guidelines suggesting that, as an objective goal, it is better to correct the SVA to under 50 mm and correct LL based on the formula LL = PI + /- 9 degrees (20).

Although these guidelines helped physicians manage this problem, the available guidelines and objective goals mentioned are mostly focused on structural correction of imbalance and do not consider the subjective aspect of the disease (21).

In our study, we showed that changes in TK (ΔTK) are more related to the intensity of axial pain than ΔLL.

Conclusion

In the treatment of axial spine pain, the intensity of pain is more related to changes in thoracic kyphosis rather than lumbar lordosis.

Although present guidelines suggest correcting thoracic kyphosis and lumbar lordosis based on the formula LL = PI + /-9, according to our findings, it seems to be necessary to make this formula more accurate.

This can help researchers propose further studies on correcting thoracic kyphosis more accurately to obtain better axial spine pain relief. However, further clinical research and examinations are needed to support our hypothesis. We recommend that future clinical trials focus more on correcting thoracic kyphosis than lumbar lordosis (in a manner that sagittal balance is not affected) to obtain better results on reducing axial spine pain.

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Competing Interests

The authors whose names are listed in this article certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria, educational grants, participation in speakers' bureaus, membership, employment, consultancies, stock ownership or other equity interests, expert testimony, or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical Approval

This study was ethically approved by the Medical Ethics Committee of Golestan Hospital, Ahvaz University of Medical Sciences (IR.AJUMS.HGOLESTAN.REC.1401.175). We respected every individual's willingness to participate in the study, informed them about the data we collected, and did not charge participants financially. We also kept patients' information and data confidential.

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