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Research Article

The Influence of Gender and Age on Lumbar Lordosis: A Magnetic Resonance Imaging Study

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ABSTRACT

Objective: The researchers aimed to verify the mean values and range of Cobb's angle to measure the lumbar lordosis on magnetic resonance (MR) images and to reveal any possible differences between genders or among age groups regarding the lumbar lordosis.

Methods: After exclusions, 527 patients, with a mean age of 48.73 ± 14.65 years, were measured for lumbar lordosis using the Cobb's angle of L1-S1 levels of the spine on MR images. A Kolmogorov-Smirnov test was performed to verify the data distribution properties. The comparison of the female and the male group was considered by the Mann-Whitney U test and the correlation with age was revealed using Spearman's Rho test.

Results: Cobb's angle measurements revealed a mean value of 51.45 ± 10.71 degrees. Regarding the angle measurement results, the female group had higher lordosis than the male group ($P < 0.001$). A low grade, positive, and significant correlation between age and the Cobb's angle was observed for the total study population and the male group. A moderate, positive, and significant correlation between age and lordotic angle measurement results was reached for the female group.

Conclusion: Females had higher lumbar lordosis than males and age is positively correlated with lumbar lordosis according to the results of this investigation. Many other scientific investigations are required to verify the outcome of this research to ensure the mean value and the normal ranges of Cobb's angle.

Keywords: Age, gender, lumbar lordosis, magnetic resonance

INTRODUCTION

Lumbar lordosis in an optimal anatomical range compensates for the sacral tilt, restores an upward orientation, and consequently enables one to avoid an excess forward inclination.[1] In the lateral lumbar X-rays or on the mid-sagittal planes of cross-sectional imaging modalities, it is observed as a convexity aligned anteriorly. Biomechanically, this curvature provides a certain resilience to the spine, and helps avoid compressive axial forces. If the spinal anatomic alignment was straight, compressive axial forces would be directly transferred via the bodies of the vertebrae and the discs between the vertebrae. Curvature of the lumbar spine, the axial compressive force is partially counteracted and absorbed by the anterior longitudinal ligaments.[2] The alterations of the physiological curvature of the lumbar spine may lead to low back pain and disabilities.

There have been various attempts to measure the lumbar lordosis in the literature using different modalities and several measurement techniques. Among the other methods, Cobb's angle, also known as the lordotic angle, is widely used as the gold standard of measuring lumbar lordosis.[3] Besides the radiographic measurements, other modalities are also used to evaluate the quantitative lordosis. Magnetic resonance (MR) imaging is a well-known modality in today's clinical practice. Low back pain, radiculopathies, disc herniations, degenerative diseases, scoliosis, and physiological alignment of the lumbar

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spine can easily be detected by MR imaging without radiation exposure. Not only radiologists, but also other clinicians and surgeons use this modality for the assessment of lumbar spinal diseases or pre-operative planning.

This study is planned to verify the mean values and range of Cobb's angle measurements of the lumbar lordosis on MR images, using a relatively large population. The gender differences and the influence of age are studied to reveal any significant differences in the lordotic angle.

MATERIAL AND METHODS

Patients

This study was approved by the institutional ethics committee of Erzincan Binali Yıldırım University Non-Interventional Clinical Research Ethics Committee (approval number: 2025-14/02, date: 24.07.2025). The requirement for informed consent from each patient participating in this study has been waived by the same ethics committee, regarding the methodology of the research. The investigation was conducted as a retrospective, cross-sectional study and all patients who had undergone lumbar MR imaging between 23rd of June 2025 and 22nd of July 2025 were scanned. There were 668 patients listed on the Picture Archiving and Communication System (PACS) of our institutional hospital. The study aimed to measure the lordotic angle of the skeletally mature individuals; therefore, the patients under 18 years old (n=5) were excluded. Any vertebral fracture in the field of view on lumbar MR imaging (n=19), 3 patients with sacralization of the L5 vertebra, 16 patients with high grade osteoarthritis (Kellgren-Lawrance type III or IV), patients with scoliosis (n=41), patients with spondylolisthesis (n=23), 3 patients with spondylodiscitis, 30 patients with postoperative fixation materials or history of operation, 1 patient with vertebral medullar signal alterations consistent with hemopoietic system involvement, totally 141 patients were excluded. Therefore, the lumbar MR images of 527 patients, without any biomechanical alterations, were included in the statistical calculations (Figure 1). All patients were measured by a radiology specialist with 7 years of experience, and the measurement results were noted with two decimals after the decimal. A PACS (Akgün PACS Viewer v7.5, Akgün Software, Ankara, Türkiye) was used in the re-assessment of the MR images and to perform measurements in standard Digital Imaging and Communication in Medicine Formats.

MR Imaging

The lumbar MR images were handled by standard protocol adjusted to the intervertebral disc pathologies. All lumbar MR images were acquired by a 1.5 T MR machine (Magnetom Aera, Siemens, Erlangen, Germany) using 32-channel lumbar coils. All patients were examined in the supine position during the scanning process. Sagittal plane T1-weighted images (TR: 646 ms, TE: 9 ms, average: 2, field of view: 280 mm, slice thickness: 4 mm, voxel size: 0.9 × 0.9 × 4 mm), sagittal plane T2-weighted images (TR: 4120 ms, TE: 104 ms, average: 2, field of view: 280 mm, slice thickness: 4 mm, voxel size: 0.9 × 0.9 × 4 mm), and axial plane T2-weighted images (TR: 5070 ms, TE: 88 ms, average: 1, field of view: 190 mm, slice thickness: 4 mm, voxel size: 0.7 × 0.7 × 4 mm) were acquired for each patient.

Measurement of Cobb's Angle

The midsagittal planes among the image series of the T1-weighted MR imaging sequence were used to measure Cobb's angle. T1 weighted images were used for measurements, which better delineate the anatomical borders and depict the endplates of the vertebral bodies. The line tangential to the upper endplate of the lumbar 1 (L1) and sacral 1 (S1) vertebral bodies was drawn.

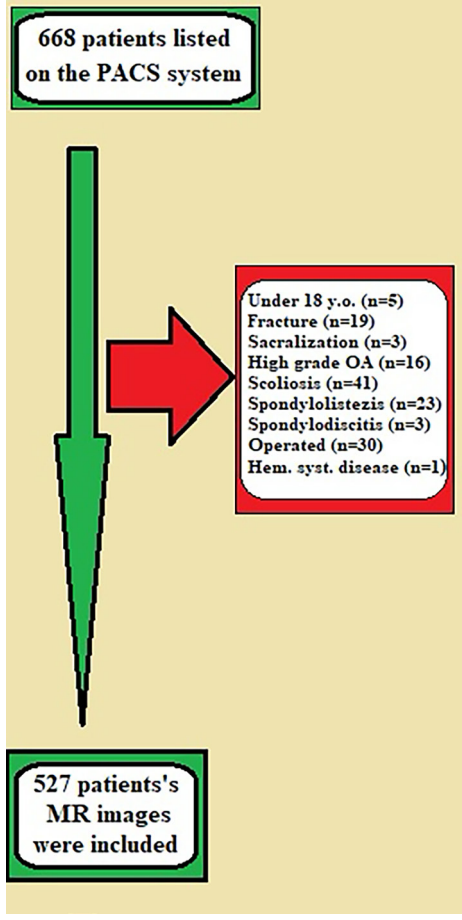

Figure 1. The workflow of the study

PACS, Picture Archiving and Communications System; y.o., years old; OA, osteoarthtiris; Hem. syst. disease; Heomopoetic system disease; MR, magnetic resonance

MAIN POINTS

- Cobb's angle measurement is widely used to measure lumbar lordosis.
- According to this study results, females had higher lumbar lordosis than males.
- Age shows a correlation with lumbar lordosis for the female and male groups, or the total study population in this current study.

The angle between the two lines, drawn perpendicular to each other, was determined as the Cobb's angle (Figure 2).

Statistical Analysis

The statistical calculations were carried out using IBM SPSS Statistics for Windows version 22.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was carried out to determine the property of the data distribution. The boxplot graphics were used to present the data distribution of angle measurement results for the total study population, females, and males. The independent samples t-test was used to compare the results of female and male groups. The correlation between age and Cobb's angle measurement results was analyzed using the Pearson correlation test. For all the statistical results, *P* values of < 0.05 were considered to represent statistical significance.

RESULTS

The lumbar MR images of 312 female and 215 male patients, for a total of 527, were re-assessed regarding Cobb's angle measurements. The mean age of the study population was 48.73 ± 14.65. There was no statistically significant difference between females and males regarding age (Table 1).

The data distribution was analyzed by the Kolmogorov-Smirnov test in the total study population, females, and the male group.

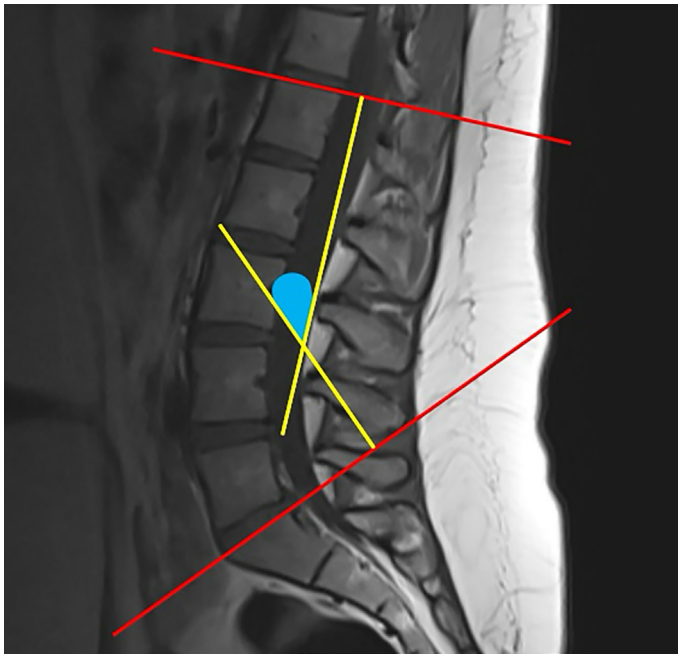

Figure 2. On the midsagittal plane of the T1-weighed lumbar magnetic resonance imaging series, the red lines tangential to the superior endplate of the L1 vertebra corpus and S1 vertebra corpus were drawn. Then the perpendicular lines to these red lines were drawn on the image (yellow-colored lines). Cobb's angle (presented with blue color) is formed in the intersection of the two perpendicular lines to these tangential lines.

Normal data distribution could not be reached according to the statistical results, however the skewness and kurtosis values of quantitative data were in a narrow enough range, and the researchers were able to use parametric tests (Independent Samples t-test) to compare the difference between female and male groups. The data distribution results were represented in boxplot analyses (Figure 3). Females had statistically higher Cobb's angle measurements than males ($P < 0.001$) (Table 2).

The correlation between age and angle measurements was calculated by Pearson correlation analysis. For the total study population, the female group, and the male group, the analyses indicated a low-grade, positive, and significant correlation between age and the Cobb's angle (Table 3).

DISCUSSION

This research was conducted on a relatively large population, determining the mean values and ranges of the Cobb's angle values regarding female and male groups. The current study results revealed that females had higher lordosis compared with males. Moreover, age shows a correlation with lumbar lordosis for the female and male groups, or the total study population.

A review mentioned that nine of the thirteen researchers reported a lower lumbar lordosis angle in patients with low back pain compared to healthy subjects, with a statistically

Table 1. The Study Population's Demographic Data

Gender (n)		Number		Percentage	
Females		312		59.2%	
Males		215		40.8%	
Total		527		-	
Age	**Mean**	**Std. Deviation**	**Min**	**Max**	***P***
Females	49.52	14.03	18	88	0.144
Males	47.59	15.48	18	80	
Total	48.73	14.65	18	88	-

Std. Deviation, standard deviation.

Table 2. Comparison of Cobb's Angle Between Females and Males

	Mean	**Std. Deviation**	***P* value**
Females	54.10	10.72	**<0.001**
Males	47.61	9.50	
Total	51.45	10.71	**-**

Std. Deviation, standard deviation.

Table 3. The Correlation (Pearson Correlation) Analysis Between Age and Cobb's Angle Measurement Results for Total Study Population, Females and Males

		Total	**Females**	**Males**
Age	**Correlation Coefficient**	0.303	0.246	0.379
	***P* value**	<0.001	<0.001	**<0.001**
	n	527	312	215

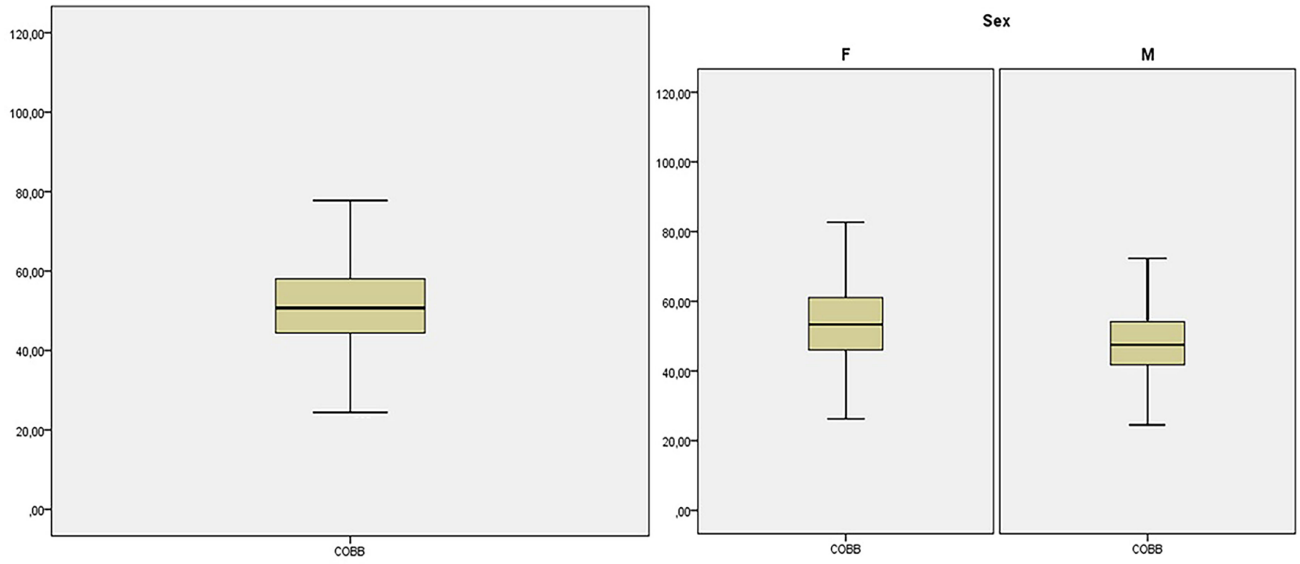

Figure 3. The data distribution for the total study population (on the left) and the specific data distributions for each gender (on the right). Female group had significantly greater lumbar lordosis than the male group.

significant difference. It is also mentioned that although statistically significant differences were not achieved, the remaining four studies also reported lower lumbar lordosis angle for patients with low back pain. In the same review, five factors were highlighted as the clinically significant determinants of the lumbar lordotic curve. The factors considered were the age, gender, of the participants, the severity of the lower back pain, and chronicity, and the spinal disease.[4]

To perform the most common version of the Cobb's angle measurement, a line is drawn through the upper endplate of the L1 vertebral body, and another line is drawn tangentially to the upper endplate of the sacral base (S1) or the inferior articular endplate of the L5 vertebral body. After demarcating these lines parallel to the endplates, two more lines are drawn perpendicularly to the initial lines. The angle formed at the intersection of these perpendiculars indicated the Cobb's angle.[3,5] The L1-S1 version of Cobb's angle measurement technique is generally recommended over other versions, due to the significant contribution of the L5-S1 disk to lumbar lordosis.[3,6]

Zhu et al.[7] have found a mean value of 48.2 ± 9.6 degrees of lumbar lordosis in 260 asymptomatic Chinese volunteers. Chanplakorn et al.[8] studied 100 healthy volunteers and one of the parameters measured was the angle formed by T12 inferior endplate and S1 superior endplate to reflect the lumbar lordosis. The mean value for the lumbar lordosis angle was 54.7 ± 9.9.[8] From the analysis of 60 asymptomatic adults, Janssen et al.[9] reported a mean value of 58.5 ± 9.6 degrees for lumbar lordosis. The mean value of lumbar lordosis measured using the superior articular plateaus of L1 and S1 was 51.45 ± 10.71 in the current research.

Gender differences in lumbar lordosis were another aspect of this study. No significant difference was observed between females and males regarding lumbar lordosis in some past studies.[10,11] Takao et al.'s[12] study was conducted on patients with spondylolisthesis, and the authors noted no sex difference in their research. However, some other studies found greater values for females than males regarding lumbar lordosis angles.[13,14] Some authors[4] considered that this situation may be explained by the greater buttock size of females. Our current study has also indicated higher lordosis angles in females than males in the study population.

The possible alterations in lumbar lordosis due to age-related degenerative changes of the musculoskeletal system were also discussed in the literature. Even though the lumbar spine is expected to flatten with degenerated changes as mentioned by some authors[14], there are many studies that could not indicate a relationship between age and lordosis in their investigations.[10,14] Kalichman et al.[15] revealed no association between age and wedging of vertebral bodies and intervertebral discs. Therefore, there is not enough evidence to support the common opinion that lordosis flattens with age. The correlation analysis of this study indicated a low-grade, positive, and significant correlation between age and the Cobb's angle for our total study population, directly opposite to this expectation.

Our research was based on the measurement of lumbar lordosis using Cobb's angle on MR images.

Study Limitations

There were important conditions to discuss along with the results of this study which can be considered the limitations of the research. First, many research results were discussed and compared with the current study results; however, many of them used radiological modalities other than MR imaging. Moreover, some of the measurement results obtained in this

study, where the results were acquired in patients with supine positions during MR scanning, were compared with those conducted in standing positions. There are studies indicating a significant difference in lumbar to pelvic parameters and the major curvature between the erect position and the supine position in patients with adult spinal deformity.[16] In another study, the researchers used positional MR imaging on healthy individuals and reported that the Cobb's angle decreased in the standing position.[17] With the evidence in the literature, it should be stated that, the effect of axial forces on lumbar lordosis angle was underestimated in this study. Although the angle measurements were performed meticulously for this research, the possibility of human error should also be considered for the study results. Repeated measurements or measurements with more than one interpreter can reduce potential measurement bias and enhance the generalizability of the findings.

CONCLUSION

To conclude, lumbar MR imaging is now a widely used technique, not only to reveal the altered signals of the soft tissue, bone marrow, causes of low back pain, radiculopathies, and intervertebral disc pathologies, but also and can easily be used to detect lumbar lordosis. Measuring Cobb's angle on MR images, is an easy way of determining the degree of lordosis on midsagittal planes. However, radiologists, clinicians and surgeons should be aware of the normal ranges of the lumbar lordosis and more research is required to verify its mean value and range for Cobb's angle measured on MR images of different age and gender groups.

Ethics

Ethics Committee Approval: This study was approved by the institutional ethics committee of Erzincan Binali Yıldırım University Non-Interventional Clinical Research Ethics Committee (approval number: 2025-14/02, date: 24.07.2025).

Informed Consent: The ethics committee has waived the need for informed consent due to the methodology of the study.

Footnotes

Author Contributions

Concept Design - B.K.; Data Collection or Processing - H.A.; Analysis or Interpretation - B.K., H.A.; Literature Review - B.K., H.A.; Writing, Reviewing and Editing - B.K.

Declaration of Interests: The authors declare that they have no competing interests.

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