RESEARCH ARTICLE

Radiographic analysis of the lumbar and sacral region angles in young Turkish adults

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Abstract

Objectives: To determine the normal angular ranges of the lateral spinal alignments in the lumbar and sacral regions.

Methods: This cross-sectional study was conducted at the Kilis State Hospital, Kahramanmaras Sutcu Imam University, Kahramanmaras, Turkey, from February to August 2017, and comprised patients aged 18-27 years who underwent standardised standing lateral lumbar radiography to eliminate hip and low back disorders. All radiographs were obtained from the hospital database as well as the demographic and contact information of each subject. Patients were invited for an interview and physical examination. Standard standing lateral radiographs of the lumbar spine were obtained from those who had no complaint of back pain and/or lower back problems. Sacro-horizontal angle, lumbosacral joint angle and sacral inclination angle were measured on the radiographic images. SPSS 22 was used to analyse data.

Results: Of the 150 subjects evaluated, 80(53.33%) were women and 70(46.77) were men. There was no statistically significant difference between women and men regarding lumbar lordosis angle, sacro-horizontal angle and lumbosacral angle ($p>0.05$). Sacral inclination angle and lower limb length in men were greater than in women ($p<0.05$). A positive correlation was observed between the lumbar lordosis angle, sacral inclination angle and sacro-horizontal angle values, while a negative correlation with the lumbosacral angle ($p<0.05$). There was no relationship observed between age, weight, height and body mass index, and sacral inclination, sacro-horizontal and lumbosacral angle values ($p>0.05$). Lumbar lordosis angle increased depending on the increase of the body mass index ($p<0.05$).

Conclusions: Values identified can be considered as reference values for young healthy Turkish adults.

Keywords: Lumbar spine, Lordosis, Radiography, Vertebrae, Angle. (JPMA 68: 1212; 2018)

Introduction

Columnavertebralis contains local curvatures in its structure in the sagittal plane in order to absorb impact, reduce its longitudinal stiffness, and intensify muscular function. These curvatures are located in the cervical, thoracic, lumbar and pelvic regions throughout the column avertebralis. Curvatures in the cervical and lumbar regions are termed physiological lordosis while ones in the thoracic region are physiologic kyphosis.[1] Lumbar lordosisis defined as an anteriorly convex curvature of the vertebral column.[2] Studies conducted on the functional and clinical significance of lumbar lordosis showed that variations of the curvatures that generate lordosis affect the postural balance and function of the body in the sagittal plane. Moreover, it has been indicated that pathologies such as spondylolisthesis, osteoarthritis and disk degeneration lead to alterations on the lumbar lordotic angle (LLA).[3] Regarding the importance of the lumbar region in body posture, angles between the sacral and lumbar regions are of clinical significance. One of the substantial angles of the sagittal plane contour is the sacral inclination. As a consequence of sacral inclination, one avoids the extreme angular changes that will occur in the sacrum with the lordotic curve that comes along with the lumbar vertebrae. Thus, vertical posture is conserved.[4] The lumbosacral angle (LSA) is one of such angles, and can be used in the investigation, treatment and follow-up of low back disorders. Different methods have been used to measure lumbar and sacral region angles, including goniometry,[5] radiography,[6] flexible rulers,[7] software methods,[8] spinal mouses[9] and inclinometers.[10] Radiography is accepted as the golden standard among all these methods.[11]

The current study was planned to be able to know the normal alignment of the lumbar and sacral vertebral bones in the sagittal plane so that guidelines and references for further studies may be generated.

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Patients and Methods

This cross-sectional study was conducted at Orthopaedics and Traumatology Department of Kilis State Hospital, Kahramanmaras Sutcu Imam University, Kahramanmaras, Turkey, from February to August 2017, and comprised patients aged 18-27 years who underwent standardised standing lateral lumbar radiography to eliminate hip and low back disorders. The study was approved by the institutional ethics committee and voluntary written informed consent was obtained from the participants before data collection. All radiographs which belonged to healthy young Turkish adults were obtained from the hospital's database. Demographic data, including age, gender, body weight, height, body mass index (BMI) and contact information of each subject were collected. The patients were invited for an interview and physical examination such as measurement of the lower limb length. Subjects with more than 1cm difference in their lower limbs' length, history of trauma, low back pain, who had undergone or planning to undergo a spinal surgery, disorder or abnormality or signs of hip disorder were excluded. Those who did not volunteer to take part in the study were also excluded. Subjects placed their right side closely to the cassette in relaxed standing position, while joining their hands behind their neck. All the X-ray images were taken with the beam focussed on third lumbar vertebrae (L3 V.) with an anode-film distance of 100cm. On all radiographs, we used the method for measuring sacro-horizontal, lumbosacral joint, sacral inclination angles as described in literature,[12] and the Cobb method[13] was used for LLA. Image J[14] for Windows application was used to analyse the alignment of the lumbar and sacral spine on the lateral radiographs.

Measurements were made on each lateral radiograph (Figure). These included the measurement of LLA for which the Cobb technique was used geometrically to measure the angle from the superior endplate of L1 V. to the inferior endplate of L5 V.[13] For the measurement of sacral inclination angle the highest point of the base of the sacrum was identified. From this point, a line was drawn towards the back of the sacrum. The angle between this line and the perpendicular line to the horizontal plane line was defined as the inclination angle of the sacrum.[12] For the measurement of LSA, the angle between the lines drawn along the highest point of the sacrum and the inferior endplate of the L5 V were measured.[12] For the measurement of sacro-horizontal angle, the angle between a line across the plane of the superior margin of the sacrum and a horizontal line were measured.[12]

All statistical analyses were performed using SPSS 22.0.

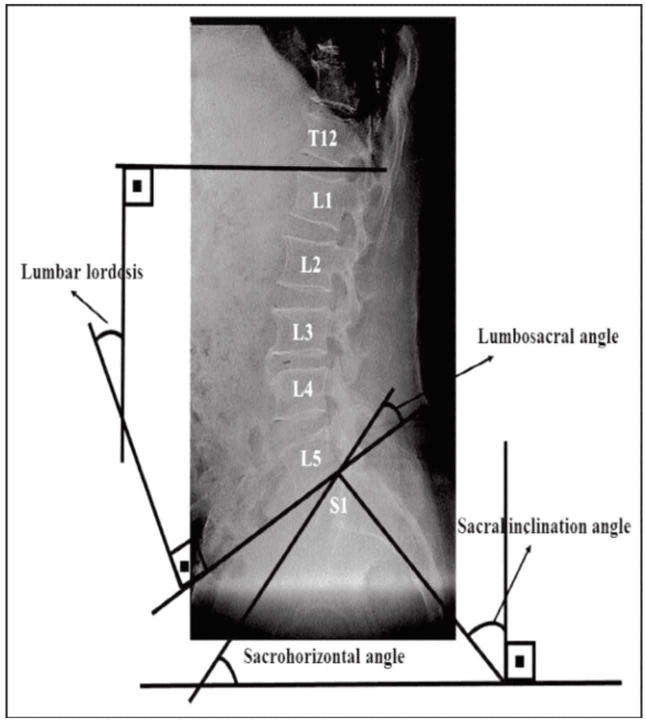

Figure: Schematic representation of measurements of lumbar and sacral region angles on lateral radiography.

The normality of the data was tested using Kolmogorov-Smirnov Test and the homogeneity of the variances was tested with Levene's Test of Homogeneity of Variance. The Pearson correlation coefficient was used to analyse the correlation between the parameters and T-test for independent samples for the analysis of data with normal distribution and homogeneous variances. The Spearman correlation coefficient was used to analyse the correlation between the parameters and Mann-Whitney U Test for the analysis of data with non-normal distributions and non-homogeneous variances. Test results were considered significant when $p<0.05$. All values were given as mean± standard deviation (SD).

Results

Of the 180 patients invited, 30(16.6%) were excluded. Of the 150 individuals, 80(53.33%) were women and 70(46.77%) were men. The overall mean age was 20.83±1.80 years (range: 18-27 years), mean height was 169.3±8.85cm (range: 151-190cm), mean weight was 63.76±12.15kg (range: 43-97kg), and mean BMI was 23.30±2.73kg/m^2 (range: 18.99-29.43kg/m^2). While there was no statistically significant difference between the ages of women and men ($p>0.05$), weight, height and BMI values of men were higher than women ($p<0.05$).

Mean angle values were determined as 42.73°±9.59° for

Table-1: Values of the lumbar and sacral region angles in both genders.

	Women (n=80)	Men (n=70)	P
Lumbar lordosis angle (o)[a]	43.16±9.17 (27-65)	42.23±10.11 (20-62)	0.570
Sacro-horizontal angle (o)[a]	36.96±0.05 (22-55)	38.19±8.31 (24-61)	0.551
Lumbosacral joint angle (o)[a]	16.51±4.38 (8-26)	15.48±4.55 (6-27)	0.179
Sacral inclination angle (o)[a]	45.62±5.27 (32-57)	48.83±6.71 (37-70)	0.007*
Lower limb length (cm)[b]	74.36±3.61 (65-86)	89.89±3.98 (83-99)	0.000 *

The values are means ± SD
[a]T test for independent samples,
[b]Mann-Whitney U Test,
*Difference is statistically significant.

Table-2: Correlation coefficients between the lumber lordosis angles and other angles.

	Lumbar lordosis angle	
	r	p
Sacro-horizontal angle (o)	0.585[a]	0.000*
Lumbosacral joint angle (o)	-0.334[a]	0.000*
Sacral inclination angle (o)	0.385[a]	0.000*
Lower limb length (cm)	-0.062[b]	0.471

[a]Pearson correlation coefficient,
[b]Spearman correlation coefficient,
*Correlation is statistically significant.

LLA, 37.53°±7.15° for sacro-horizontal angle, 16.04°±4.47° for LSA and 47.11°±6.17° for sacral inclination angle. There was no statistically significant difference between women and men regarding LLA, sacro-horizontal angle and LSA ($p>0.05$). Mean sacral inclination angle and lower limb length in men were greater than in women ($p<0.05$) (Table-1).

A positive correlation was observed between LLA and sacral inclination angle ($p=0.000$) and sacro-horizontal angle values ($p=0.000$), while a negative correlation was found with LSA ($p=0.000$) (Table-2). LLA values were significantly increased depending on the increase of sacral inclination and sacro-horizontal angle values, and decreased depending on the increase of the LSA values ($p<0.05$).

There was no relationship observed between age, weight, height and BMI, and sacral inclination, sacro-horizontal and LSA values. LLA was observed to be significantly increased depending on the increase of BMI ($p=0.013$). A negative correlation was observed between age and LLAs ($p=0.523$), and LLA values were lower with increased age.

There was no significant association between age and lower limb length ($p>0.05$). Lower limb length was significantly increased depending on the increase of height, weight and BMI ($p<0.05$) (Table-3).

Discussion

Lumbar lordosis is defined as a curvature that acts on balancing the curve between the lumbar vertebrae and the sacrum. It regulates the upward spinal direction from the sacrum and thus prevents forward inclination, thereby ensuring spinal stability.[13] Lumbar lordosis begins to develop as an infant starts to stand until the completion of spinal growth, between the ages of 13 and 18 years.[15] Radiological examinations performed in order to evaluate the spinal contours should be optimal, accurate and repeatable. However, due to the upper and lower vertebrae that are used for the assessment of lordosis, different studies reported various results and reference ranges. A study determined the LLA as 28.39° ± 0.47° in

Table-3: Correlation coefficients between demographic data and lumbar and sacral region angles.

	Age		Weight		Height		BMI	
	r	P	r	p	r	P	r	p
Lumbar lordosis angle (0)	-0.055[b]	0.523	0.056[b]	0.512	-0.125[a]	0.142	0.211[a]	0.013*
Sacro-horizontal angle (0)	0.088[b]	0.304	0.010[b]	0.911	-0.052[a]	0.546	0.063[a]	0.466
Lumbosacral joint angle (0)	0.147[b]	0.086	-0.126[b]	0.139	-0.139[a]	0.104	-0.089[a]	0.301
Sacral inclination angle (0)	0.038[b]	0.658	0.154[b]	0.071	0.153[a]	0.073	0.098[a]	0.250
Lower limb length (cm)	0.064[b]	0.452	0.771[b]	0.000*	0.934[b]	0.000*	0.366[b]	0.000*

[a]Pearson correlation coefficient, [b]Spearman correlation coefficient, *Correlation is statistically significant.

men and 28.59° ± 0.43° in women.[16] It did not find any significantly differ among men and women LLA as measured by Cobb's method. However, it stated that it significantly correlated with age. Another study[17] performed various measurements on the cervical, thoracic and lumbopelvic regions in healthy individuals including 30 men and 22 women with ages ranging between 22 and 50 years. It measured LLA from the superior endplate of L1 to the superior endplate of L5 and found it to be 30.3°±9.0°. It also reported that no statistical difference was observed between gender and LLA. Therefore, in our study, the Cobb measurement method was used to evaluate the LLA due to its accuracy and its prevalent usage in the literature. It is clear that the selection of such different levels in the literature differentiates the results. The reasons for choosing different vertebrae may be the inclusion of the entire curve and / or the use of the best visible vertebrae.[18] Parallel with all these studies, in the current study, the LLA was measured 43.16°±9.17° in women and 42.23°±10.11° in men, which indicates that there was no statistical difference in terms of LLA between genders. The anatomical relationships of the spine and the sacro-pelvis are related to each other. The correlation between lumbar lordosis, sacral inclination and pelvic incidence shows a balanced position. Since pelvic incidence is not affected by the posture of the body, sacral inclination plays a dominant role on lumbar lordosis.[19] Therefore, we conclude that evaluating the LLA together with the sacral inclination angle, sacro-horizontal angle and LSA would be a more accurate clinical approach rather than evaluating it alone. Another set of researchers calculated the lumbosacral region associated angle values in Lebanese adult women and determined the LLA as 71.8°±12.8°, LSA as 15.9°±5.7° and sacral inclination angle as 45.4°±10.7°.[18] Another study evaluated the LLA, LSA and sacral inclination angle values in Egyptian women, and all three of the angle values were found lower than Lebanese women with similar age.[20] In another study,[21] in which LLA, LSA and sacral inclination angles were investigated, mean LLA was measured as 40.40°±11.20°, LSA as 37.80°±9.20° and sacral inclination angle as 38.70o±8.9o. In the presented study, the mean LLA of the participants was measured 42.73°±9.59°, sacro-horizontal angle 37.53°±7.15°, LSA 16.04°±4.47° and the sacral inclination angle 47.11°±6.17°. The angle values in our study are in accordance with the normal physiological angle values and other studies in the literature. The main reason for the diversity in our findings from these two studies was determined as the differences in waist and hip circumferences, BMI, racial features and measuring methods. Theoretically, the axis of the chain comprised of the spine, pelvis, lower extremities, and their movable and immovable joints is thought to be the base of the body. The lumbar lordosis causes the sacrum to horizontalise, while the pelvic incidence angle explains this horizontalisation. This incidence angle showed parallelism with the LSA evaluated by some researchers and also was distinctive in lumbar lordosis.[22] In addition, during the occurrence of lumbar lordosis, it also happens with the sacrum becoming horizontal as a result of the effect of vertical muscles. In case of high pelvic incidences lumbar lordosis expands and femur heads slide forward with reference to the sacrum.[23] In standard posture, the vertebrae should have ideal curvatures and angles, and the lower extremity bones should be in ideal posture and order for weight bearing. In individuals with lumbar lordosis, the difference in height on the right and left side of the pelvis is due to variant lower limb lengths.[24] In our study, the difference between LLA, sacro-horizontal angle and LSA, and gender were not statistically significant ($p>0.05$). However, the mean sacral inclination angle and lower limb length of men were found to be higher than women ($p<0.05$). There was no significant relationship between lower limb length and age according to our findings, yet it was found increased significantly according to height, weight and BMI. Furthermore, a negative correlation was observed between age and LLA. In the light of these findings, it was determined that the LLA decreases due to increased age. There are limitations of the present study. The measurement of the parameters in the present study was performed on radiographs which rely on strict measures for obtaining standard views. The radiographs were obtained from one healthcare centre which can possibly restrict detection of variations among particular population. Lack of records for past medical history of the participants was compensated with questionnaire with regard to low back pain, history of trauma or spinal surgery.

Conclusion

It may be more appropriate to evaluate by taking the normal distribution width into account instead of the mean value for the measurements, since the normal limits of the angle values are wide. Thus we believe that the great differences due to reasons such as geography and race are better explained. However, the lumbar lordosis and other angle values we have identified can be considered as reference values for young healthy Turkish adults. These findings may be used as a guide in determining normal values for future studies and spinal surgeons.

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Conflict of Interest: None.

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