Original Research Article

Evaluation of Geometrical Angles in Lumbo-Sacral Spine on Digital Radiographs in North Indian Population

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Abstract

Objectives: The lumbo-sacral spine is the most important region of the vertebral column in terms of its mobility and weight-bearing functions. Measurement of geometrical angles has been used to evaluate the stability of this region. However, there is relative paucity of such data concerning the Indian population. We attempted to study the various angles on digital radiographs in the lumbo-sacral spine in the North-Indian population.**Methods:** This was a retrospective study in which digital radiographs (lateral view) of the lumbo-sacral spine in 500 subjects with low back pain were evaluated. Patients with history of trauma or radiographically detected bony spinal abnormality were excluded. The lumbar angles measured were lumbo-sacral angle (LSA), Lumbar lordosis angle (LLA), Sacral-inclination angle (SIA) and lumbo-sacral disc angle (LSDA). The demographics and anthropometric parameters were also recorded. **Results:** The mean values of the angles were: LSA=37.7±8.8; LLA=49.9±6.8; SIA=38.5±7.7and LSDA=12.0±3.9. The results revealed significant higher values for LSA and LLA in females whereas significantly higher values were obtained for LSDA in males. There was a significant correlation observed between the BMI and SIA of the subjects.**Conclusion:** The mean values of these angles may form the reference values for the North Indian population. Our results show variability when compared to other similar studies, which further strengthen the fact that normal variation in angles of lumbo-sacral region differs among different geographical region and races; hence results of the present study may be of use to for treating different spinal disorders of North Indian population.

Keywords: lumbar angles, lumbo-sacral region, evaluation, spinal disorders

Introduction

Background

The lumbosacral region is the most important region of the vertebral column in terms of its mobility and weight bearing function [1].The human vertebral column exhibits regional curvatures with the vertebral bones extending cranio-caudally down the sacrum and thus ensures resilience as it enables successive vertebrae bear and transfer weight, up to about three times that of a straight column [2].The spine is not a rigid body; rather it is a multi-joint with non linear geometry, so this should be considered in biomechanical models of the lumbar spine. The geometrical angles in the lumbo-sacral spine may be used to assess the condition of spine. The angles can be used in the investigation, treatment and follow up of patients with low back disorders. The geometry of the lumbar spine can be evaluated by imaging techniques like radiography, computed tomography or magnetic resonance imaging [3].There are various factors which can influence the lumbo-sacral curvature such as age, posture, degenerative changes, stature, trauma or surgery, race and ethnicity [4]. The geometric angles of the lumbosacral spine which can be evaluated radiologically are lumbosacral angle (LSA) or Ferguson's angle; lumbar lordosis angle (LLA), sacral inclination angle (SIA) or sacral tilt angle and lumbosacral disc angle (LSDA) or sacrovertebral disc angle. have suggested that low lumbosacral angle (LSA) may be associated with pains in the lower back and increased vulnerability of sufferers to disc herniation [5,6]. There has been paucity of data about the normal values of these angles, their anthropometric correlates and clinical significance in North Indian population. Additionally, the evaluation of these angles may be useful in identifying individuals who are at risk of developing mechanical low back pain as well as in the design of population-specific spinal instrumentations and implants. The objective of the present study is to measure lumbar angles in North Indian population and find its correlation with age, gender and BMI.

Patients and Methods

This retrospective study was done in the North Indian population (Himachal Pradesh). The data was obtained from the 500 patients who came into the department of Radiology, SLBS GMCH Mandi at NerChowk. The patients with complaint of low back pain without radio graphically detected abnormality were considered in the part of this study. The lower age limit was 18 years to ensure that only subjects who had attained spinal maturity to be studied. The upper age limit was set at 45 years to ensure that subjects with osteoporotic changes commonly seen in elderly persons to be excluded. The

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patients with past fracture and traumatic injury were also excluded from the study.

Technique:The data collection included the age, sex, and occupation of the subject. The X-ray imaging of the lumbosacral region in the patients with low back pain was done in lateral position using the Allengers D500 Digital X Ray system in the department of Radiology, SLBS GMCH Mandi at NerChowk. The criteria for normality of the radiographs were as follows:

1. Presence of 5 lumbar and 5 sacral vertebrae.
2. Preservation of lumbar lordosis.
3. The intervertebral disc spaces increase in thickness from L1 to L5.
4. No radiographic evidence of congenital abnormality or disease.

The lumbar angles were measured using the RaDiant DICOM software.

1. Lumbo-sacral angle (LSA): The angle between the sacral base and the horizontal plane (Figure1).
2. Lumbar lordosis angle (LLA): The angle formed by the intersection of two lines drawn through the superior end plates of L1and S1 (figure 2).
3. Sacral inclination angle (SIA): The angle between a vertical plane and a tangential line to the posterior border of S1vertebra (figure 3).
4. Lumbo-sacral disc angle (LSDA): The angle formed by the intersection of two lines drawn through inferior end plate of L5 and the superior end plate of S1(figure 4).

The Lumbar angles were measured using RaDiantDicom Viewer Software. The angles were read by two authors with no significant inter- observer error.

- The statistical analysis was done using SPSS Version 20. ANOVA test and student –t test unpaired was used to analyse the data. P-value to ≤ 0.05 was considered as significant value.

Results

The data of 500 subjects who met the eligibility criteria were analyzed. There were 169 males (33.8%) and 331 females (66.2%).the distribution of subjects by gender is shown in table 1.

The mean age, BMI and weight in the study population was found to be 38.3, 23.6, 64.4respectively. This is shown in fig 1.

Table 1: Distribution of Subjects by Gender (N= 500)

Gender	Number	%age
Male	169	33.8
Female	331	66.2

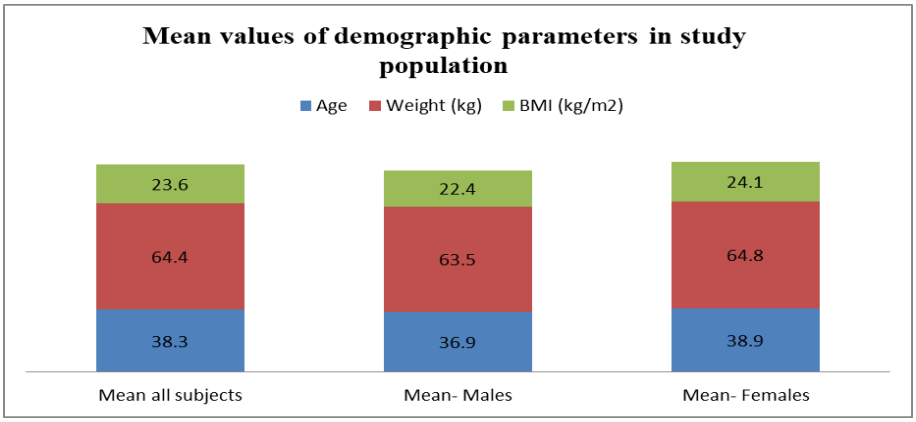

Fig 1 a-d: digital radiographic images-lateral view of the lumbosacral spine depicting the measurement of various angles a) LSA-Lumbo-sacral angle b) LLA- Lumbar lordotic angle c) SIA-Sacral inclination angle d) LSDA- Lumbo-sacral disc angle

Table 2: Summary of age and demographic characteristics of the subjects

Variables	Mean all subjects	Mean- Males	Mean- Females	P value
Age	38.3	36.9	38.9	**0.001**
BMI ($kg/m^{2)}$	23.6	22.4	24.1	**0.000**
Weight (kg)	64.4	63.5	64.8	**0.026**

Table 3 shows the mean of the lumbar angles in study population and the comparison of the lumbar angles between males and females.The mean LSA was found to be 37.7 in the study population.With a range of 19.2-67.1.However the LSA in females was significantly more than the males.

Table 3: Distribution of mean lumbar angles by sex

Lumbar angles	Mean total population	Mean-males	Mean- Females	P value
LSA	37.7	36.6	38.3	**0.049**
LLA	49.9	48.6	50.6	**0.003**
SIA	38.5	37.7	39.0	0.072
LSDA	12.0	12.8	11.7	**0.003**

The mean LLA of the subjects was 49.9 with a range of 31.3-75.9. The values for LLA in females were significantly higher than males.

The SIA in the study population was 38.5 with a range of 21-57.7. The value of SIA in females and males were 39.0 and 37.7 respectively. No significant result was observed in the values of this angle.The mean LSDA in the population was 12.0 with a range of 4.1-24.8. Unlike the LSA and LLA, LSDA was significantly low in females.On comparison of mean lumbar angles with BMI in table 4 resulted to the findings that BMI has positive co relation with the mean lumbar angles and significant result has been obtained with SIA.

Table 4: Cross tabulation of mean lumbar angles and BMI of subjects

Geometric angles	Underweight (n=1)	Normal (n=359)	Over-weight (n=138)	Obese(n=2)	P value
LSA	21.5	37.4	38.5	40.4	0.164
LLA	43.5	49.6	50.8	50.6	0.250
SIA	26.9	38.3	39.5	25.7	**0.016**
LSDA	16.6	11.9	12.4	12.0	0.430

The further comparison of mean lumbar angles with age in table 5 revealed the fact that LSA,SIA and LSDA increased with age whereas subsequent decline was seen in LLA, however findings were not significant.

Table 5: Cross tabulation of mean lumbar angles and Age-groups of subjects

Geometric angles	15-24 years(n=26)	25-34 years(n=108)	35-45 years(n=366)	P value
LSA	39.0	39.1	37.1	0.090
LLA	51.4	49.6	49.9	0.506
SIA	38.4	38.7	38.5	0.811
LSDA	11.6	12.0	12.1	0.973

Discussion

The following table (Table 6) gives a comparative analysis of the average lumbo-sacral angle (LSA) in various studies. In the present study, the overall average LSA of all 500 subjects was 37.7^{0}.

Table 6: LSA reported by various authors in various study population

S No.	Author's Name	Mean LSA
1	Von – Lackum (1924)[7]	42.5^{0}
2	Friedman (1946)[8]	43^{0}
3	Ferguson (1949)[9]	34^{0}
4	Splithoff (1953)[10]	$40\text{-}44^{0}$
5	Blackburne (1977)[11]	32^{0}
6	Fernard (1985)[12]	42.05^{0}
7	Present study	37.7^{0}

The mean LSA angle in our study population was 37.7^{0} and thus shows great difference from the other studies [7-12].The mean LSA in the present population was significantly higher than the mean LSA reported by Blackburne [11], Kim HS et al [13] and Chung HJ et al [14] which was 32º, 31.7 and 32.4 respectively. In the present study, the average LSA in female population was greater than the males. This finding is similar to many other studies [1,15-17]. The mean LSA reported by Agichani et al in males and females found positive co relation with age which is coherent with present study population till 45 years. Greater LSA in females could be due to evolutionary changes adapted to assist pregnancy and hormonal changes during reproductive age [16].The study done by Okpala [17], the average LSA for males was 43.4° and for females was 45.5°. The wide range of difference in lumbosacral angles explain the fact that LSA has a racial variation being higher in Caucasians and lower in the Asian population and may be explained by the difference in stature of the different races.

The mean LLA in our study population was 49.9. Similar results have been reported by Lord MJ et al [18] andChernukha KV et al [19] which were 49 and 52 respectively and in contrast with the mean value of 42 reported by Farfan HF et al [20]. The present study found significant variation in the mean LLA between male and female subjects which is in agreement to reports by some authors who also noted a greater LLA in female subjects [12,21]. However in the study reported by Onyemachi [5] didn't find any variation in the difference of mean LLA between female and male subjects. The mean SIA in the present population was 38.5 .The values of mean SIA in females was 39 and in males was 37.7 with a significant difference which was found to be coherent with the study reported by Onyemachi [5]. The SIA reported in Lebanese population was 45.4° ± 10.7° significantly more than the present population [6]. The above findings suggest that age may be a determinant of SIA as study conducted in Lebanese population constituted subjects with younger age group.The mean LSDA in the present population was 12^{0}. Unlike the rest of lumbar angles LSDA was found to be significantly higher in males. The mean LSDA was found to increase with age till 45 years. The study did not coincide with the other studies on gender variation aspect as LSDA was found to be higher in males with significant difference. However present study is in agreement to the fact that age can be the determinant of LSDA. The increased LSDA angle with increasing age could be the causative factor for facet joint syndrome.

On comparison of mean lumbar angles with BMI, LSA, LLA, SIA were found to be increased with BMI but significant results were obtained only for SIA. However LSDA showed marked declination with BMI.

Conclusion

The mean LSA in our study was 37.7. The mean values of the LLA, SIA and LSDA were 49.9, 38.5 and 12 respectively and found that women have significantly higher values for LSA, LLA and SIA than men, whereas the mean values for LSDA was significantly higher in males. The present study shows the positive correlation of age with the lumbar angles till 45 years of age. The lumbar angles are also influenced by BMI and significant results were obtained for SIA.

The evaluation of these angles may be useful in identifying individuals who are at risk of developing low back pain and values be used in the design of spinal instrumentations and implants.

What is already known on this topic:

- Mean values of the lumbar angles in various population
- Various anthropometric factors determining the angles
- Guidance to clinicians for the evaluation and treatment of low back pain

What this study adds:

- Database for the mean lumbar angles in the present study population, holding the medico legal significance.
- Mean LSDA significantly higher in males
- Mean values of the lumbar angles obtained from the present study may be of use in the formation of spinal implants**.**

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