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Research Article

Evaluation of lumbar angles and their clinical correlates in a Nigerian population

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ABSTRACT

Background: There is paucity of data on the geometric angles of the lumbosacral spine in Nigeria and other African countries. The objective was to study the lumbar angles in our population and causes of variations if any.
Methods: The lateral views of the lumbosacral spine radiographs of 300 Nigerian subjects were studied. The lumbar angles measured were lumbosacral angle (LSA), Lumbar lordosis angle (LLA), Sacral inclination angle (SIA) and lumbosacral disc angle (LSDA). The demographics and anthropometric measurements of the subjects such as weight, height, body mass index (BMI), hip circumference (HC), waist circumference (WC) and waist-hip ratio (WHR) were also recorded.
Results: The mean values of the angles were as follows: LSA=$37.8^0 \pm 9.2^0$; LLA=$40.4^0 \pm 11.2^0$; SIA=$38.7^0 \pm 8.9^0$ and LSDA=$14.6^0 \pm 3.4^0$. There was a positive correlation between the weight, BMI, HC and WC of the subjects and LSA. A significant association was noted between the height, weight, BMI, HC, WC and WHR of the subjects and LLA. Whereas SIA was significantly affected by sex, weight, BMI, HC and WC of the subjects, LSDA was determined by age, BMI, WC and WHR.
Conclusion: The mean values of these angles may form the reference values for the Nigerian population. Overweight and obesity were associated with increased lumbar angles.

Keywords: Lumbar angles, Evaluation, Anthropometry, Nigeria

INTRODUCTION

The vertebral spine presents regional curves on sagittal plane designed to absorb impact, reduce its longitudinal stiffness and intensify muscular function.[1] Values of sagittal curve measurements of the spine present great variability in normal individuals often with a wide range of variation. The lumbosacral region is the most important region in the vertebral column in terms of mobility and weight bearing. The vertebral column is lordotic in the cervical and lumbar regions and kyphotic in the thoracic and sacral vertebrae. The human lumbar vertebrae support the weight of the upper body. It is the main load-bearing region of the entire vertebral column and its abnormality contributes to the development of an array of pathological symptoms such as low back pain.

The geometric angles of the lumbosacral spine (lumbar angles) are of clinical importance. The correlation between lumbar angles and the incidence of low back pain has been described.[2-4]

The shape and geometry of the lumbosacral spine has been reported to be of importance in the occurrence of low back pain.[5-7] The sacral inclination also has a considerable clinical significance. As a result of the sacral inclination, an individual maintains an erect posture by developing a lordotic curve in the lumbar spine in order to compensate for the angulations of the sacrum.[7,8] There is paucity of data on normal values of lumbar lordosis angle for the Nigerian population. Consequently, values that constitute hypo-/hyper-lordosis in clinical practice are based on studies from other races.

The lumbosacral curvature could be affected by conditions such as age, posture, degenerative changes, stature, trauma or surgery, race and ethnicity.[1,2] Therefore, knowledge of racial differences in the lumbosacral spine geometry is of global importance. Measurement of the lumbar spine geometric angles is useful in the investigation of low back pain and in the design and development of spinal implants and instrumentation.[9,10] This is particularly important in Nigeria and other African countries where spinal implants and instrumentations from other climes are used without due consideration of such racial variation. Furthermore, lumbosacral lordosis plays an important role in spine surgery. Loss of lordosis after spinal instrumentation often results in loss of sagittal spine balance and persistent back pain, so-called flat-back syndrome.[11] Measures must be put in place to preserve the lordosis during spine surgery. 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. Ageing, posture and obesity have been identified as factors that influence these angles.[5,9,12,13]

Little is known about the normal values of these angles, their anthropometric correlates and clinical significance in our 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 this study was to measure lumbar angles in our study population and causes of variations if any.

METHODS

The study was a prospective, cross-sectional study over a one year period. The data were obtained from the lumbosacral radiographs, anthropometric and demographic data of selected subjects in Enugu, Nigeria. Subjects who were younger than 18 years or older than 65 years were excluded. The lower age limit was 18 years to ensure that only subjects who had attained spinal maturity were studied. The upper age limit was set at 65 years to ensure that subjects with osteoporotic vertebral fractures commonly seen in elderly persons and which may affect the angles were eliminated. Subjects who sustained macro-trauma to the low back region or who had clinically detectable scoliosis or kyphosis of the lumbar spine were also excluded. Subjects who had spinal disorders or deformities were not included. Pregnant women and subjects who have had any spine surgery or instrumentation were not part of the study.

The research and ethics committee of National Orthopaedic Hospital Enugu approved the study protocol. Informed consent was obtained from prospective subjects. The demographic profile of the subjects and certain anthropometric measurements were documented using a proforma. The data collected included: age, sex, occupation, weight, height, waist circumference (WC), hip circumference (HC), body mass index (BMI) and waist hip ratio (WHR). X-ray imaging of the lumbosacral vertebrae was done in erect position using a Siemens D500 Digital X ray system. The lateral projections of the lumbosacral spine radiographs were evaluated. The criteria for normality of the radiographs were as follows: 1. Presence of 5 lumbar and 5 sacral vertebrae. 2. Progressive increase in vertebral height from L1 to L5. 3. Preservation of lumbar lordosis. 4. Posterior margins of the lumbar vertebral bodies form a smooth curved line. 5. The intervertebral disc spaces increase in thickness from L1 to L5. 6. No radiographic evidence of congenital abnormality or disease.

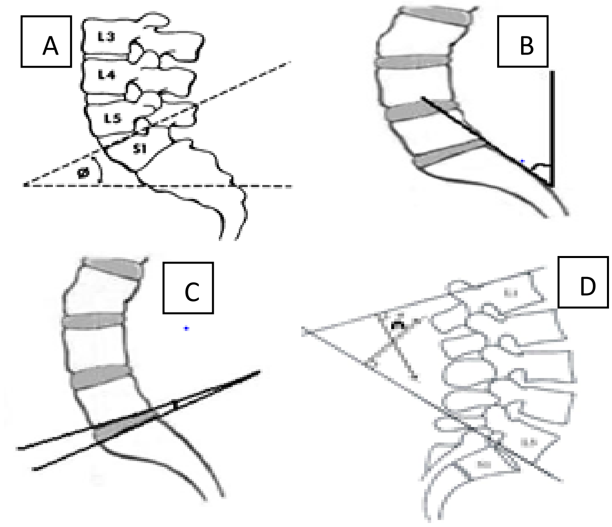

Figure 1: Measurement of geometric angles of the lumbosacral spine.

The lumbar angles measured using an x-ray viewing box and a transparent goniometer included: 1. Lumbosacral angle (LSA): The angle between the sacral base and the horizontal plane (Figure 1A). 2. Lumbar lordosis angle (LLA): The angle formed by the intersection of two perpendiculars to lines drawn through the superior end plates of L_1 and S_1 (Figure 1D). 3. Sacral inclination angle (SIA): The angle between a vertical plane and a tangential line to the posterior border of S_1 vertebra (Figure 1B). 4. Lumbosacral disc angle (LSDA): The angle formed by the intersection of two lines drawn through inferior end plate of L_5 and the superior end plate of S_1 (Figure 1C). The angles were read by the three authors with no significant inter-observer error.

Statistical analysis was done using SPSS version 17.0 (Chicago IL, USA). Prior to analysis, we verified the normality of continuous variables distributions, and tested the homogeneity of their variances with the Levene's test. Quantitative data were expressed as mean and standard deviation. Comparison of quantitative measurements was done using Student's t-test. Prediction formulae were derived using regression analysis. Statistical significance was set at p value <0.05.

RESULTS

Out of 315 subjects who were recruited, 15 were excluded due to incomplete records and abnormal radiographs. The data of 300 subjects who met the inclusion criteria were analyzed. The mean age was 48±12 years. The age distribution of the subjects is shown in Figure 2. There were 141 (47%) male subjects and 159 (53%) female subjects. The summary of the mean age and anthropometric characteristics of the subjects is shown in Table 1. While 41.3% of the subjects had a normal BMI, 36% were overweight, 22% were obese and 0.7% was underweight.

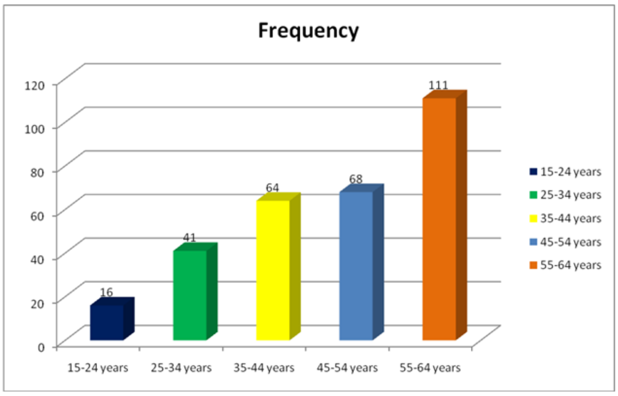

Figure 2: Distribution of the subjects by age groups.

Table 1: Summary of age and anthropometric characteristics of the subjects.

	Mean-all subjects (n=300)	Mean – males (n=141)	Mean – females (n=151)	P value
Age (years)	48	47.6	48.3	0.25
Weight (kg)	73	72.5	73.5	0.40
Height (cm)	164	167.4	161.1	**0.001**
BMI (kg/m^2)	27.2	25.9	28.4	**0.02**
Waist circumference (cm)	91.8	89.3	94.1	**0.012**
Height circumference (cm)	102.5	99.8	104.9	**0.001**
WHR	0.90	0.89	0.89	0.70

BMI = body mass index; WHR = waist-hip ratio

The LSA of the subjects ranged from 22–64^0 with a mean of 37.8^0±9.2^0. There was no correlation between LSA and age, sex or occupation or height of the subjects. However, a significant correlation was noted between LSA and weight, BMI, WC and HC (P=0.001). No association was noted between the WHR of the subjects and LSA (p=0.12).

Table 2: Distribution of mean lumbar angles by sex.

	Mean – total population	Mean - males	Mean - females	P value
LSA	37.8	37.1	38.3	0.27
LLA	40.4	39.4	41.2	0.14
SIA	38.7	37.6	39.87	**0.03**
LSDA	14.6	14.7	14.3	0.33

Table 2 shows the distribution of the mean lumbar angles by sex. The mean LLA of the subjects was 40.4^0±11.2^0 with a range of 10–72^0. A negative association was noted between LLA and height (P= 0.01). There was a positive correlation between weight (p=0.01); BMI (p=0.001); WC (p=0.001); HC (p=0.004) and WHR (p=0.008) with LLA.

The mean SIA was 38.7^0±8.9^0 with a range of 18–65^0. The difference between the mean SIA in males and females was significant (P=0.03).

There was a positive correlation between the weight, BMI, WC, HC and SIA (P=0.001). No association was noted between SIA and WHR (P=0.36). The mean LSDA was 14.6^0±3.4^0 with a range of 9–26^0. LSDA increased with age up to 55 years (P=0.01). There was positive correlation between BMI (p=0.001); WC (p=0.01); WHR (p=0.001) and LSDA. Table 3 shows the cross tabulation of mean lumbar angles and BMI.

Table 3: Cross tabulation of mean lumbar angles and BMI of subjects.

Geometric angles	Under – weight (n=2)	Normal (n=124)	Over– weight (n = 108)	Obese (n = 66)	P value
LSA	32.5	34.6	39.3	41.1	**0.001**
LLA	42.0	37.3	41.4	44.4	**0.001**
SIA	30.5	36.1	38.7	44.1	**0.001**
LSDA	13.5	14.0	14.5	15.6	**0.03**

A linear regression analysis of the lumbar angles reveals that in males, the major determinants of LSA and SIA were the WC, HC and BMI.

The LLA was predicted by the height and WHR while the LSDA was determined by the WHR. In the females, the determinants of the LSA, SIA and LLA were the weight, WC, HC and BMI, while the LSDA was predicted by weight, WC, HC, BMI and WHR.

The regression (prediction) formulae were derived as follows:

Males:
LSA = 0.14WC+0.05HC+0.02BMI+19.21^0
SIA = 0.06WC+0.08HC+0.10BMI+21.92^0
LLA = - 0.19Height+27.09WHR+46.97^0
LSDA = 15.75WHR+0.65^0

Females:
LSA=-0.09Weight+0.14WC+0.03HC+0.48BMI+15.75^0
SIA=0.24Weight+0.18WC+ 0.03HC–0.22BMI+8.19^0
LLA=-0.01Weight+0.16WC–0.15HC+0.75BMI+22.16^0
LSDA=-0.05Weight+0.23WC–0.19HC+0.26BMI–13.8WHR+21.94^0

A comparison was done with a one sample t-test between the predicted values and the actual values of the lumbar angles. The p values were greater than 0.05 indicating that there was no significant difference between the predicted and actual values, thus validating the use of the regression (prediction) formulae.

DISCUSSION

The mean values of the height, HC, BMI and WHR were similar to the study by Andrews R et al.[12] These values were higher than the values in the studies by Naidoo M and Miyamoto M, et al et al and may be explained by the fact that Africans as represented in this study and the study by Andrews R et al are bigger in stature than Asians as reported in the studies by Naidoo M and Miyamoto M, et al.[12-14]

The LSA in this study had a wide range and this may explain the difference in mean angles from various studies.[6,8,13,15,16] The mean LSA of our subjects was significantly higher than the mean value of 31.7^0 reported by Kim HS et al and 32.4^0 reported by Chung HJ et al.[15,16] It was however significantly lower than the mean values in the studies by Fernard R et al (46.5^0) and Middleditch A et al (42.5^0).[6,8]

These findings suggest 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. There is paucity of studies correlating LSA and anthropometric indices, therefore the effects of anthropometry on LSA have not been thoroughly investigated. The association noted between LSA and weight in females may be due to the effects of female sex hormones. This finding had earlier been reported by Middleditch A et al.[8] The BMI of the subjects had a significant correlation with LSA in both sexes. This was similar to the report by Ridola C et al and Braunaugh J et al.[17,18] It is believed that in overweight and obese subjects, the weight of the trunk displaces the base of the sacrum anteriorly thus increasing the LSA. This may also explain the finding that LSA increased with the waist and hip circumference of the subjects.

The mean LLA in our study was similar to the mean value of 42^o reported by Farfan HF et al. However, Lord MJ et al and Chernukha KV et al reported significantly higher values of 49^0 and 52^0 respectively.[5,19,20] The method of measurement and differences in the vertebral levels from which the lordotic angles were measured may explain these variations. We did not observe any variation in the mean LLA between male and female subjects. This is in contrast to reports by some authors who noted a greater LLA in female subjects.[6,9,21] The explanation for these observations is not clear but may be attributed to the greater curve of the buttocks in females and may not have a radiological confirmation.

The negative association observed between LLA and height of the subjects suggests that taller subjects have a straighter lumbar spine than shorter ones. The possible explanation is that since the body's centre of gravity is affected by height, the shorter individuals maintain their centre of gravity by assuming a more lordotic posture in the lumbar region.

The positive correlation between LLA and weight, BMI and WHR may be due to increased loading of the lumbar spine due to increase in weight resulting in increased lordotic angle. Vonlackum HL et al reported that increase in lordotic angle is associated with increased shearing strain and stress in the lumbar spine which may lead to increased incidence of low back pain.[22] The reduced LLA observed in subjects with LBP is usually due to muscle spasms which is a protective mechanism.

The mean SIA of our subjects was lower than reports by Nakipoglu GF et al and Yochum TR et al who reported 45^0 and 46^0 respectively.[23,24] The reason for this observation is not very clear but may be due to racial differences. The difference between the mean SIA in male and female subjects was significant (p = 0.03).

The position of the sacrum affects the pelvic inlet and outlet diameters. In females, the sacrum is slightly more inclined to create a larger pelvic outlet diameter which is important during child birth. This may explain the higher SIA in female subjects. Although, SIA has been reported to be age-dependent no difference in the mean SIA between younger and older subjects was noted.[9,25]

There was a significant correlation between BMI and SIA. This corroborates earlier reports by Guo JM et al and Hirano K et al.[26,27] Guo JM et al reported that BMI exceeding 24kg/m^2 increases SIA. Increased loading of the sacrum caused by increased weight and BMI may have caused anterior tilting of the sacrum, thus assuming a more horizontal shape with an increased SIA. No association between WHR, height and SIA could be established.

The mean LSDA in this study was similar to that reported by other authors.[13,28,29] LSDA did not have any gender variation but increased with age up to 55 years. Since increased LSDA increases the impaction of the facet joints, this observation may explain the increased incidence of facet joint syndrome with increasing age. The association observed between BMI, WHR and LSDA suggests that obese individual's particular those with truncal obesity may have an increased risk of facet syndrome due to increased shearing force at the L_5/S_1 facet joint. [29,30]

CONCLUSION

The mean LSA in our study was = 37.8^0. The mean values of the LLA, SIA and LSDA were 40.4^0, 38.7^0 and 14.6^0 respectively. The study demonstrated that women had a significantly greater SIA than men. No gender variation was observed in the other lumbar angles.

LSDA increased with age up to 55 years. Overweight and obesity were associated with increased lumbar angles. The regression formulae for the lumbar angles derived from the anthropometric indices proved to be valid. Thus, the value of these angles can be derived from an individual's anthropometric data.

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