# Evaluation of the lumbar-sacral configuration: A radiographic study of young adults in Southern Nigeria

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## Abstract

**Introduction:** Compared with other populations, African spines, have not been adequately studied and consequently, surgical interventions on the spine rely on assumptions and data from studies done on non-Nigerians. **Materials and Methods:** Lateral lumbosacral X-ray films of 120 informed volunteers who met relevant inclusion criteria were studied. Three parameters frequently employed to characterize the lumbosacral region in the assessment of spinal health; Lumbar Lordotic Angle (LLA), Lumbar Lordotic Depth (LLD) and Lumbosacral Angle (LSA),were measured using standard radiographic procedures. **Statistical Analysis:** Data were analyzed using SPSS version 17. Confidence interval was set at 95% defining $P \leq 0.05$ of statistical significance. **Results:** On the average, the subjects were 27 years old (males 28 and females 24). Mean (SE) of weight was 66.59 (1.06) kg; males 65.71 (1.18) kg, females 67.80 (2.04) kg. Mean (SE) of height was 1.66 (0.01) m, females 1.6 (0.01) m, males 1.69 (0.01). Mean (SE) of BMI was 24.32 (0.41); males 23.04 (0.39), females 26.45 (0.79). Mean (SE) of LSA was 31.12 (0.46) 0; females 32.04 (0.91) 0, males 30.56 (0.50) 0.Mean (SE) LLA 51.34 (0.76) 0; females 49.84 (1.23) 0, males 52.24 (0.96) 0.Mean (SE) LLD 3.23 (0.04) cm; males 3.15 (0.05) cm, females 3. 36 (0.07) cm. Significant associations were found between the following variables; age and LLA ($r^2$= 0.158, $P < 0.001$), age and LLD ($r^2 = 0.224$, $P < 0.001$), LSA and LLA ($r^2 = 0.034$, $P = 0.044$), LSA and LLD ($r^2 = 0.042$, $P = 0.024$), LLA and LLD ($r^2 = 0.555$, $P < 0.001$). **Conclusion:** This study is probably the first to be carried out on living subjects in Nigeria and the data it provides will be useful for further research and will also add to existing knowledge on African spines.

**Key words:** Adults, Cobb, Ferguson's method, lumbar lordotic depth, lumbosacral angle

## INTRODUCTION

The human vertebral column exhibits regional curvatures with the vertebral bones spreading out cranio-caudally down the sacrum. This arrangement ensures resilience as it enables successive vertebrae bear and transfer weight, up to about three times that of a straight column.[1,2] The regional curvatures do not only enable the spine to bear weight, but also act as shock absorbers within certain limits. However, excessive angulation of the spine to the right or left side of the body, in a backward or forward direction, will cause derangement.[2-4] Studies based on non-African populations have sought to establish a relationship between angle dimensions of the spine and back disorders. Some of these[1-3,5] have suggested that low lumbosacral angle (LSA) may be associated with pains in the lower back and increased vulnerability of sufferers to disc herniation.

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In Nigeria, not much is known about ergonomics and mechanized system of farming. Consequently, majority of the civil servants, those employed in the construction industries and farmers, perform job tasks with outdated tools and in postures that are harmful to the spine. This has resulted in the observed increase in the prevalence of low back pain in this country.[4,6] Apart from a few studies,[7-11] metric analysis of the relationship between anatomical structures of the back has not been sufficiently explored. We aimed in this study to evaluate the anatomical characteristics of the lumbosacral segment of the spine in a population of healthy adult Nigerians to provide normal reference values of the LSA, lumbar lordosis angle, and the lumbar lordotic depth (LLD).

## MATERIALS AND METHODS

This study was conducted in accordance with Nigerian National Code of Health Ethics.[12] Accordingly, institutional approval was obtained from the Ethics Review Committee of the Faculty of Basic Medical Sciences, College of Health Sciences of the University of Port Harcourt. Subjects who satisfied the conditions laid out in the inclusion criteria were adequately informed and voluntarily signed the consent forms.

Measurements were taken following the standard protocol as described by previous studies;[13-19] X-ray viewing box, lateral X-ray films of the lumbosacral spine, transparent goniometer; Chicago electric, Harbor freight tools, and Pittsburgh were used to obtain the anatomical parameters of the lumbosacral segment of the spine. Plastic collapsible stadiometer (Leicester heights; 40 Barn street, Birmingham, UK) and electronic weighing scale (model: ZT-1504A, Ocean Med+, England) were used to take the height and weight measurements, respectively, the body mass index (BMI) was calculated by dividing the weight by the squared height (kg/m$^2$).

The study was carried out in the outpatient department of the University of Port Harcourt Teaching Hospital, Image Diagnostics Center, Ashford and Patrice Clinic, all in Port Harcourt, a multi-ethnic commercial city, in Southern Nigeria. The study involved 120 resident healthy adult male and female volunteers, aged 18–55 years. Participants in this study were not patients; these centers were chosen based on the availability of imaging facilities and personnel, their location, proximity to the subjects, as well as their willingness to willingly report at these centers at specified time periods.

### Selection criteria

Participants were required to be Nigerians with no history and clinical evidence of back pain or musculoskeletal disease. They were also required to be mentally fit to provide written informed consent. Subjects with radiographic evidence of scoliosis, kyphosis, degenerative changes such as spondylosis, presence of osteophytes, or of disc space narrowing were excluded from the study.

### Sampling method

Purposive and convenience sampling methods were employed so as to ensure adequate representation with regards to age, sex, and occupation.

### Sample size

Minimum sample size was determined using the following formula:

$n = (A + B)^2 \times 2 \times (SD)^2/D^2$ $(0.84 + 1.96)^2 \times 2 \times (7.75)^2/5^2$, based on the research by Chen and Lee[2], Yochum and Rowe[3] and Sayed *et al.*[20]

where $n$ = minimum sample size

A = (0.84) probability equivalence of statistical power of 80%, at 0.05 level of significance
B = (1.96) critical value at the level of significance
SD = (7.75) standard deviation (SD) from a previous study[9]
D = Acceptable difference in mean values of clinical significance = 5°[3,4,6-10,21]

Commonly, it is difficult to achieve remarkable voluntary participation in human clinical studies involving the usage of X-rays. In particular, response from women is usually poor because of the additional caution and protection required for them.[12] As a result, more male volunteers (75) were involved in the study as compared to the female subjects (45). To reduce the probable negative effect of this, data were stratified and analyzed separately with respect to sex.

### Techniques of measurements

Measurements were performed in accordance with the established protocol.[12] A film cassette of 35 cm × 43 cm was used for the lumbosacral spine, with a minimum subject image distance of 100 cm. We used the Ferguson's method of measurement for the LSA[3,5,14-16] as described below.

#### Measurement of the lumbosacral angle

*End-plate lines*

The five lumbar vertebrae (L1–L5) were examined and the two end-plates (superior end plate [SEP] and inferior end plate) were noted. The first sacral vertebra (S1) was identified and its SEP is noted. Using a small safety pin, two marks were made on the sacral end plate; one at the anterior end and another at the posterior extremity. A thin flat sheet of transparent rubber material was placed over the film. On the transparency, a line (CD) was drawn horizontally and parallel to the edge of the table and a second line (AB) was drawn through and parallel to the SEP (sacral base) of the sacrum, the two lines were extended to their point of intersection [Figure 1].

*Goniometry*

The transparent special-sized goniometer was placed with the zero mark at the point of intersection of lines AB and CD. The long axis of the stationary arm was placed on the horizontal line, while the movable arm (angle finder) was placed with its long axis along the second line drawn tangent to the superior border of the sacral end plate. The lumbosacral angle is the angle between lines AB and CD. It was read from the 360° protractor fixed on the goniometer, and the result was noted.

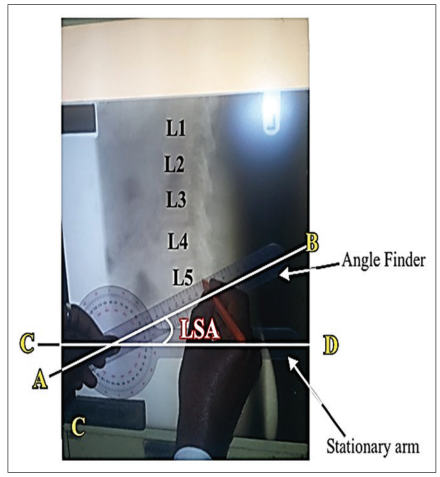


**Figure 1:** Measurement of the lumbosacral angle

### Measurement of the lumbar lordotic angle COBB 4-LINE method

*End-plate lines*

The X-ray film was placed in the viewing box, and the five lumbar vertebrae as well as the SEP of the first sacral vertebra were identified. Three marking points were placed on the anterior, middle, and posterior extremities of the L1 SEP and another set of three points was placed on the SEP of S1. A piece of natural paper cut to fit the viewing box end to end was then placed on the film. Using cosmetic pencils, the points on L1 were joined with a straight line AB and extended posteriorly to the end at the pediculo-laminar junction. Another line BC was drawn in a similar way on S1.

Two perpendicular lines, i.e. AM and CQ were drawn from the ends of AB and CD until their intersection as shown in Figure 2.

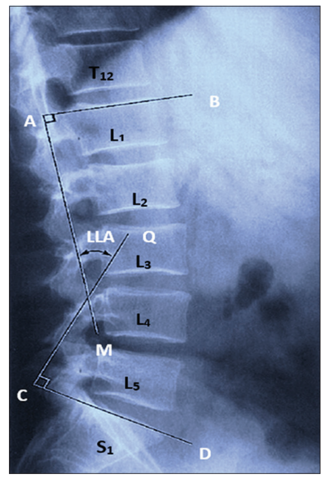


**Figure 2:** Measurement of the lumbar lordosis angle – lumbar lordotic angle ($\alpha$)

*Goniometry*

The transparent goniometer was placed on the transparent paper with the 0 point at the intersection of the two perpendiculars. The axis of the stationary arm of the equipment was placed on line CQ, while the movable arm was then used to locate the line AM. The angle subtended between the two lines is the lumbar lordosis angle and was measured with the aid of a 360° protractor fixed at the end of the goniometer [Figure 2].

### Measurement of the lumbar lordotic depth

The five lumbar vertebrae were identified. The third lumbar vertebra L3 is the apex of the lordotic curve. Transparent paper was then placed on the film. Diagonals were drawn from each of the four angles of the third lumbar vertebra (L3) to identify the midpoint of the vertebra body. Two marks were made, one at posterior superior angle of L1 and another one at the posterior inferior angle of L5. These two points were joined with a straight vertical line. Another line BE was drawn from the midpoint of the back of L3 vertebra to meet the vertical line AC. Line BE was measured with a transparent ruler in millimeters and the value was recorded as the lumbo-lordotic depth in centimeters [Figure 3].

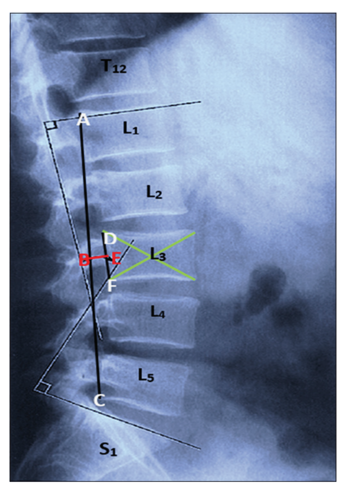


**Figure 3:** Measurement of the lumbar lordosis depth – lumbar lordotic depth (B-E)

## Data analysis

Statistical analysis was done using SPSS version 17.0 (SPSS Inc., Chicago, IL) and protocol provided by Zar[17] was followed. Homogeneity of variance was analyzed using the Levente test. The independent *t*-test was used for comparing difference in mean values between male and female angles.

Pearson's correlation analysis was also employed to determine the relationship between measured variables.[18] The confidence level was set at 95%; hence, $P \leq 0.05$ was considered to be statistically significant.

## RESULTS

The mean ± SD, standard error, and range of the measurements are presented in graphs and tables. The general characteristics of the sample studied are shown in Figure 4 and Tables 1-3. Analysis involving mean difference, correlation, and linearity test is shown in Tables 4-8.

Subjects were neither obese nor underweight, and except for LLD, the measured spine parameters were within the accepted range of normal for body size [Table 2].

An increase in lumbar lordotic angle (LLA) was observed with advancing age, beginning from age 28. The parameter LLD decreased with advancing age until age 42 whereas on the average, LLA and LSA were observed to increase steadily after age 32 [Table 1]. Average values of LSA and LLD were higher for female subjects compared with males, while LLA was larger for males [Table 3].

Correlation analysis (Spearman's rho) showed a statistically significant proximity between measured parameters. Age showed a significant positive correlation with LLA ($r = 0.397$, $P < 0.001$), but negatively correlated with LLD (r=-0.473, $P < 0.001$). LSA was negatively correlated with LLA ($r = -0.184$, $P < 0.05$) and correlated positively with LLD ($r = 0.206$, $P < 0.05$). LLA showed a negative correlation with both LSA and LLD ($r = -0.184$, $P < 0.05$ and $r = -0.745$, $P < 0.001$), respectively [Table 4]. Results of the test for linearity between the measured parameters using regression analysis are summarized in Table 5. The relationship between age and LSA was not statistically significant ($P > 0.05$).

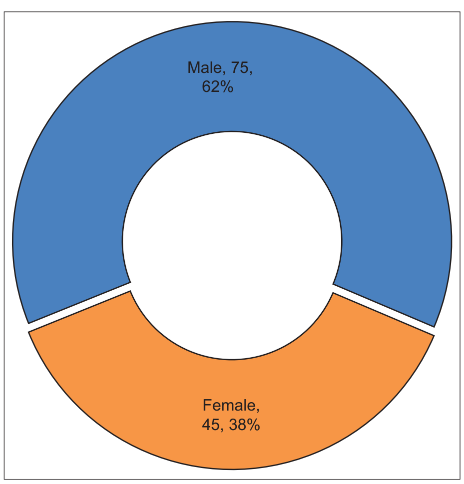


**Figure 4:** Distribution of the study sample based on sex (males = 75, females = 45)

However, significant linear relationships were observed between age and LLA ($r^2 = 0.129$, $P < 0.001$) and between age and LLD ($r^2 = 0.172$, $P < 0.001$). In addition, LSA showed a weak but statistically significant linear relationship with LLD ($r^2 = 0.035$, $P < 0.05$) and LLA ($r^2 = 0.052$, $P < 0.05$). Whereas, LLA and LLD showed a strong linear relationship ($r^2 = 0.579$, $P < 0.001$) [Table 5].

Mean LSA and LLD were higher in females than in males while males had a higher LLA value. No significant

**Table 1: Distribution of subjects and parameters in the study sample according to age (*n*=120)**

| Age group (years) | *n* | Mean LSA (°) | Mean LLA (°) | Mean LLD (cm) |
|---|---|---|---|---|
| 18-22 | 38 | 31.58 | 47.18 | 3.50 |
| 23-27 | 43 | 30.12 | 52.47 | 3.18 |
| 28-32 | 15 | 32.67 | 50.67 | 3.21 |
| 33-37 | 5 | 28.60 | 54.00 | 2.98 |
| 38-42 | 13 | 30.39 | 56.54 | 2.83 |
| >43 | 6 | 35.17 | 57.83 | 2.97 |

LSA=Lumbosacral angle; LLA=Lumbar lordotic angle; LLD=Lumbar lordotic depth

**Table 2: Descriptive statistics of all measured parameters in the study sample (*n*=120)**

| Parameters | Mean±SD | SE | Minimum | Maximum |
|---|---|---|---|---|
| Age | 27.20±8.22 | 0.75 | 18.00 | 55.00 |
| Weight | 66.49±11.61 | 1.06 | 40.10 | 110.00 |
| Height | 1.66±0.09 | 0.01 | 1.30 | 1.83 |
| BMI | 24.32±4.484 | 0.41 | 16.71 | 37.87 |
| LSA | 31.12±5.09 | 0.46 | 22.00 | 60.00 |
| LLA | 51.34±8.35 | 0.76 | 31.00 | 71.00 |
| LLD | 3.23±0.45 | 0.04 | 2.40 | 4.50 |

LSA=Lumbosacral angle; LLA=Lumbar lordotic angle; LLD=Lumbar lordotic depth; BMI=Body mass index; SD=Standard deviation; SE=Standard error

**Table 3: Descriptive statistics of parameters by sex (*n*=120)**

| Parameters | Sex | Mean±SD | SE | Minimum | Maximum |
|---|---|---|---|---|---|
| Age | Female | 24.44±5.94 | 0.89 | 18 | 54 |
| | Male | 28.85±8.96 | 1.04 | 18 | 55 |
| Weight | Female | 67.8±13.67 | 2.04 | 45 | 110 |
| | Male | 65.71±10.19 | 1.18 | 40.1 | 92 |
| Height | Female | 1.6±0.09 | 0.01 | 1.3 | 1.79 |
| | Male | 1.69±0.07 | 0.01 | 1.53 | 1.83 |
| BMI | Female | 26.45±5.3 | 0.79 | 16.71 | 37.87 |
| | Male | 23.04±3.35 | 0.39 | 16.85 | 32.21 |
| LSA | Female | 32.04±6.07 | 0.91 | 23 | 60 |
| | Male | 30.56±4.34 | 0.5 | 22 | 45 |
| LLA | Female | 49.84±8.26 | 1.23 | 33 | 70 |
| | Male | 52.24±8.33 | 0.96 | 31 | 71 |
| LLD | Female | 3.36±0.45 | 0.07 | 2.5 | 4.3 |
| | Male | 3.15±0.43 | 0.05 | 2.4 | 4.5 |

LSA=Lumbosacral angle; LLA=Lumbar lordotic angle; LLD=Lumbar lordotic depth; BMI=Body mass index; SD=Standard deviation; SE=Standard error difference was observed in the mean LSA and LLA between the sexes ($P > 0.05$). However, the average values of LLD were significantly wider in female subjects, suggesting sexual dimorphism [Table 6].

### Interdependence of spine parameters and their relationship with age

#### Female subjects

A negative significant correlation was found to exist between LSA and LLA ($r = -0.39$, $r^2 = 0.15$, $P = 0.01$) and a positive significant correlation was found to exist between LSA and LLD ($r = 0.38$, $r^2 = 0.14$, $P = 0.01$). A negative significant correlation was found between LLA and LLD ($r = -0.86$, $r^2 = 0.75$, $P < 0.001$) [Table 7].

A positive significant correlation was observed between age and LLA ($r = 0.49$, $r^2 = 0.24$, $P = 0.001$). The opposite (negative significant correlation) occurred between age and LLD ($r = -0.58$, $r^2 = 0.34$, $P = 0.001$). A positive but nonstatistically significant correlation was observed between age and LSA ($r = 0.043$, $P = 0.781$).

#### Male subjects

A negative significant correlation was found between LLA and LLD ($r = -0.66$, $r^2 = 0.435$, $P < 0.001$) [Table 8].

A positive significant correlation was found between age and LLA ($r = 0.34$, $r^2 = 0.12$, $P = 0.003$) and a positive but insignificant correlation was found between age and LSA ($r = -0.06$, $P = 0.574$). A negative significant correlation was found between age and LLD ($r = -0.42$, $r^2 = 0.18$, $P < 0.001$) [Table 8].

## DISCUSSION

This study was carried out to investigate the anatomical characteristics of the lumbosacral spine in a population of normal Nigerians to determine normal reference values of three known spine parameters; the LSA, LLA, and LLD.

From Table 4, it has been observed that two participants on the average had weight, height, and BMI within the range considered normal.[18,19,22] Normal values of LSA

**Table 4: Tests of association between age and lumbar spine parameters (*n*=120)**

| Parameters | Spearman's rho | | | Inference | Null hypothesis |
|---|---|---|---|---|---|
| | *R* | $r^2$ | *P* | | |
| Age (years)/LSA (°) | 0.012 | 0.0001 | 0.896 | NS | Failed to reject |
| Age (years)/LLA (°) | 0.397 | 0.158 | <0.001 | S | Reject |
| Age (years)/LLD (cm) | −0.473 | 0.224 | 0.000 | S | Reject |
| LSA (°)/LLA (°) | −0.184 | 0.034 | 0.044 | S | Reject |
| LSA (°)/LLD (cm) | 0.206 | 0.042 | 0.024 | S | Reject |
| LLA (°)/LLD (cm) | −0.745 | 0.555 | 0.000 | S | Reject |

LSA=Lumbosacral angle; LLA=Lumbar lordotic angle; LLD=Lumbar lordotic depth; NS=Not significant; S=Significant

**Table 5: Summary of linear regression analysis**

| Variables | | Model summary | | Coefficients | | *P* | Inference |
|---|---|---|---|---|---|---|---|
| Dependents | Predictors | *R* | $r^2$ | Constant | Predictor's value | | |
| Age | LSA | 0.066 | 0.004 | 23.880 | 0.107 | 0.474 | NS |
| LLD | LSA | 0.188 | 0.035 | 2.715 | 0.017 | 0.040 | S |
| Age | LLA | 0.359 | 0.129 | 9.061 | 0.353 | <0.001 | S |
| LLA | LLD | 0.761 | 0.579 | 97.322 | −14.239 | <0.001 | S |
| LSA | LLA | 0.227 | 0.052 | 38.222 | −0.138 | 0.013 | S |
| Age | LLD | 0.414 | 0.172 | 51.861 | −7.637 | <0.001 | S |

LSA=Lumbosacral angle; LLA=Lumbar lordotic angle; LLD=Lumbar lordotic depth; NS=Not significant; S=Significant

**Table 6: Tests of association between sex and lumbar spine parameters**

| Parameter | Sex (male=75, female=45) | Mean±SD | SE | *t*-test (*P*) | Inference | Null hypothesis |
|---|---|---|---|---|---|---|
| LSA (°) | Male | 30.56±4.34 | 0.50 | 0.122 | NS | Failed to reject |
| | Female | 32.04±6.07 | 0.91 | | | |
| LLA (°) | Male | 52.24±8.33 | 0.96 | 0.129 | NS | Failed to reject |
| | Female | 49.84±8.26 | 1.23 | | | |
| LLD (cm) | Male | 3.15±0.43 | 0.05 | 0.016 | S | Rejected |
| | Female | 3.36±0.45 | 0.07 | | | |

LSA=Lumbosacral angle; LLA=Lumbar lordotic angle; LLD=Lumbar lordotic depth; SD=Standard deviation; SE=Standard error; NS=Not significant; S=Significant

**Table 7: Spearman's rho correlation analysis of parameters of females in the study sample ($n$=45)**

| | Age | LSA | LLA | LLD |
|---|---|---|---|---|
| Spearman's rho | | | | |
| Age | | | | |
| Correlation coefficient | 1.000 | 0.043 | 0.493** | −0.575** |
| Significant (two-tailed) | | 0.781 | <0.001 | <0.001 |
| LSA | | | | |
| Correlation coefficient | 0.043 | 1.000 | −0.393** | 0.380* |
| Significant (two-tailed) | 0.781 | | 0.008 | 0.010 |
| LLA | | | | |
| Correlation coefficient | 0.493** | −0.393** | 1.000 | −0.856** |
| Significant (two-tailed) | 0.001 | 0.008 | | 0.000 |
| LLD | | | | |
| Correlation coefficient | −0.575** | 0.380* | −0.856** | 1.000 |
| Significant (two-tailed) | <0.001 | 0.010 | <0.001 | |

Bolded values are statistically significant at: *$P$<0.05 level (two-tailed), **$P$<0.01 level (two-tailed). LSA=Lumbosacral angle; LLA=Lumbar lordotic angle; LLD=Lumbar lordotic depth

**Table 8: Spearman's rho correlation analysis of parameters in males ($n$=75)**

| | Age | LSA | LLA | LLD |
|---|---|---|---|---|
| Spearman's rho | | | | |
| Age | | | | |
| Correlation coefficient | 1.000 | 0.066 | 0.339** | −0.418** |
| Significant (two-tailed) | | 0.574 | 0.003 | <0.001 |
| LSA | | | | |
| Correlation coefficient | 0.066 | 1.000 | −0.037 | 0.034 |
| Significant (two-tailed) | 0.574 | | 0.749 | 0.769 |
| LLA | | | | |
| Correlation coefficient | 0.339** | −0.037 | 1.000 | −0.661** |
| Significant (two-tailed) | 0.003 | 0.749 | | <0.001 |
| LLD | | | | |
| Correlation coefficient | −0.418** | 0.034 | −0.661** | 1.000 |
| Significant (two-tailed) | <0.001 | 0.769 | <0.001 | |

Bolded values are statistically significant at: *$P$<0.05 level (two-tailed), **$P$<0.01 level (two-tailed). LSA=Lumbosacral angle; LLA=Lumbar lordotic angle; LLD=Lumbar lordotic depth

and LLA in the current study were lower,[23-26] but were within the range accepted as normal for studies employing radiographic morphometry. The observed measurement though consistent with previous studies was also lower compared with previously reported values for Africans and Nigerians.[10,11,15,23-26]

As shown in Tables 5 and 6, age- and sex-related differences and similarities were observed between LSA, LLA, and LLD in the current study. This is in contrast with previous reports[15,24,27] that between Africans and non-Africans (African-Americans and European-Americans), differences in anatomical dimensions of the structures that make up the spine are not statistically significant. Notably, a number of authors[10,23,24] used samples that comprised all male subjects and particularly in the study by Jonk,[24] subjects were older compared with the mixed sex sample in the current study. In a related study by Okpala[11] who used sacral based horizontal angle method as used in this study, failed to make clarifications between lumbar lordosis angle which can only be measured using the Cobb two line or 4-line method, and the LSA. The author worked on X-rays selected from film libraries stored for about 7 years, and subjects were indeed much older patients, 15–74 years with a mean age of 35 years, compared with the mean age of 27 years for subjects in the current study. Therefore, differences in demographic characteristics, measurement techniques as well as interpretation of results may be responsible for some of the observed differences.

Average values of LLA and LSA increased as age increased beginning, respectively, from age 33 and 28. Similar observation was made by Peleg and Gali[27] and Lang-Tapia.[28] LLA was found to increase significantly with advancing age, in agreement with previous reports,[10,26,29-31] Okpala,[11] Ferguson,[14] Farfan,[32] Milne and Lauder.[33] The observed differences may be due to inclusion of much older subjects in these previous studies. Also, in the study by

Mac-Thiong *et al*.,[30] the mean lumbar lordosis was 48.5° and there was a weak but significant correlation with age. Whereas an increase in LLA was observed for older subjects, a decrease in LLD indicating straightening of the spine with advancing age was observed. Similar findings were reported by Maduforo[10] and Peleg *et al*.[27]

Mean values of LSA were higher in female subjects, while that of LLA was higher in male subjects. However, using Student's *t*-test, the differences did not show statistical significance.

Mean values of LLD were, however, significantly higher in females (3.39 cm), when compared to the male subjects (3.26 cm). These findings suggest that in young to middle age adult Nigerians, the LLD can be used in sex determination using vertebral column skeleton.

In agreement with, Cailliet[21] and in contrast with, Silva[15] and Gelb *et al*.[34] LLD was observed to decrease as the lumbar lordosis increased suggesting that these parameters are interdependent. The inclusion of individuals at the extremes of life; maximum age of 17 years in the study by Silva[15] and the criterion of minimum age of 45 years in the study by Gelb *et al*.[34] may have accounted for the differences observed.

From the correlation analysis, an increase in LLD was observed to occur in association with a decrease in LLA; whereas a strong positive relationship was observed between LLA and LSA. Although the correlation between LLD and LLA was a weak one, it was, however, statistically significant. This is clinically significant considering that to produce the normal physiological curves of the vertebral column, sacral orientation determines the angle of lumbar lordosis which in turn depends on the wedge angles.

## CONCLUSION

Results from this study suggest that age and sex are among the individual factors that significantly influence spine morphology. On the average, values of radiographically determined lumbosacral curve dimensions of Nigerians fall within the range considered normal in accordance with the previous research. Lumbosacral curve angles are interdependent and significantly influenced by age and to a lesser extent by sex.

### Recommendations

There is a need for additional studies with the scope enlarged to provide a wider range of country-specific data capable of improving better understanding of the relationship between vertebral column morphology and the individual factors that influence its configuration such as age, sex, posture, occupation, and ethnicity.

To make imaging investigations of the lower back more accurate and meaningful, radiologists need to quantify observed deviations from normal, while paying attention to among others, the modifying effect of age and sex.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

## REFERENCES

1. Pate D. Stability of the lumbar Spine. Dyn Chiropr 1991;9:1.
2. Chen YL, Lee YH. A non-invasive protocol for the determination of lumbosacral vertebral angle. Clin Biomech (Bristol, Avon) 1997;12:185-9.
3. Yochum TR, Rowe JL. Essential of Skeletal Radiology. 3rd ed. Philadelphia USA: Williams and Wilkins; 2005. p. 217-20.
4. Birabi BN, Dienye PO, Ndukwu GU. Prevalence of low back pain among peasant farmers in a rural community in South South Nigeria. Rural Remote Health 2012;12:1920.
5. Bogduk N. Clinical Anatomy of the Lumbar Spine and Sacrum. 4th ed. USA: Elsevier Churchill Livingstone Limited; 2005. p. 51-8.
6. Igbinedion BO, Akhigbe A. Correlations of radiographic findings in patients with low back pain. Niger Med J 2011;52:28-34.
7. Iruo A, Ogungbo B. Surgical treatment for spine diseases in Abuja: Early outcome study. Niger J Gen Pract 2013;11:3.
8. Jaja BN, Didia BC, Ekere AU. Rotation of spinal curvatures of patients with structural scoliosis. West Afr J Med 2008;27:111-3.
9. Oyakhire OM, Didia BC. Metric analysis of the lumbosacral angle in a population of asymptomatic Nigerians. Afr J Med Sci 2011;5:99-105.
10. Maduforo C, West O, Nwankwo N, Onwuchekwa R, Etawo US, Ogbulu D. Study of the lumbosacral angles of males in Port Harcourt, South-South, Nigeria. Niger Health J 2012;12:1.
11. Okpala F. Measurement of lumbosacral angle in normal radiographs: A retrospective study in southeast Nigeria. Ann Med Health Sci Res 2014;4:757-62.
12. Federal Ministry of Health, Research Ethics Committee, National Code of Health Research Ethics; 2007. Available from: http://www.nhrec.net. [Last assessed on 2015 Jan 15].
13. Torsten BM, Emil R. Pocket Atlas of Radiographic Anatomy. 2nd ed. New York: Stugart; 2000. p. 53-5.
14. Ferguson AB. The clinical and roentgenographic interpretation of lumbosacral anomalies. Radiology 1934;22:548.
15. Silva HM. Sagittal Spine lumbosacral angles: View from a sample from adolescents. Chil J Anat 2001;19:1-13.
16. Wiltse LL, Newman PH, Macnab I. Classification of spondylolysis and spondylolisthesis. Clin Orthop Relat Res 1976;1:23-9.
17. Zar JH. Biostatistical Analysis. 3rd ed. New Jersey, USA: Prentice Hall, Inc.; 1996. p. 213-50.
18. Centre for Disease Control (CDC). National Health and Nutrition Examination Survey. Anthropometry Procedure Manual; 2007. p. 13-5.
19. Odenigbo UM, Odenigbo UC, Oguejiofor OC, Adogu PO. Relationship of waist circumference, waist hip ratio, and body mass index as predictors of obesity in adult Nigerians. Pak J Nut 2011;10:15-8.

20. El-Sayed S, Ibtissam M S, Mohamed El S, Khodor HH. Morphometric study of the lumbosacral spine and some of its related angles in Lebanese adult females. Ital J Anat Embryol 2014;119:92-105.
21. Cailliet R. Low back pain Syndrome. 3rd ed. Philadelphia: FA Davis Company; 1985. p. 11-21.
22. World Health Organization (WHO). Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation on Obesity. [WHO/NUT/NCD/98.1.1997]. Geneva, Switzerland: World Health Organization; 1997.
23. Ananiadis C. The Effect of Scuba Diving Cylinder on Static Lumbar Spine Posture {MSc. Dissertation}. Kwazulu Natal Institute of Technology; 2001. Available from: http://www.ir.dut.ac.za/bitstream/handle/10322/277/Ananiadis_2002. [Last accessed on 2012 Jun 10].
24. Jonk LM. The influence of weight bearing on lumbar spine: A radiological study. South Afr J Radiol 1964;2:25-9.
25. Hoseinfar M, Ghiasi F, Akbari A. The relationship between lumbar and thoracic curves with body mass index and low back pain in students of Zahedan University of medical sciences. J Med Sci 2007;7:984-90.
26. Melanee N. The Evaluation of Normal Radiographic Measurements of the Lumbar Spine in Young Middle aged Indian Females in Durban; 2008. Available from: http://www.ir.ac.za:8080/xmlui/bitstream/handle/10321/378/Naidoo_2008. [Last accessed on 2011 Oct 29].
27. Peleg S, Dar G, Medlej B, Steinberg N, Masharawi Y, Latimer B, *et al.* Orientation of the human sacrum: Anthropological perspectives and methodological approaches. Am J Phys Anthropol 2007;133:967-77.
28. Lang-Tapia M, España-Romero V, Anelo J, Castillo MJ. Differences on spinal curvature in standing position by gender, age and weight status using a noninvasive method. J Appl Biomech 2011;27:143-50.
29. Vialle R, Dauzac C, Khouri N, Wicart P, Glorion C, Guigui P. Sacral and lumbar-pelvic morphology in high-grade spondylolisthesis. Orthopedics 2007;30:642-9.
30. Mac-Thiong JM, Labelle H, Berthonnaud E, Betz RR, Roussouly P. Sagittal spinopelvic balance in normal children and adolescents. Eur Spine J 2007;16:227-34.
31. Ferreira EA, Duarte M, Maldonado EP, Bersanetti AA, Marques AP. Quantitative assessment of postural alignment in young adults based on photographs of anterior, posterior, and lateral views. J Manipulative Physiol Ther 2011;34:371-80.
32. Farfan HF, Huberdeau RM, Dubow HI. Lumbar intervertebral disc degeneration: The influence of geometrical features on the pattern of disc degeneration – A post mortem study. J Bone Joint Surg Am 1972;54:492-510.
33. Milne JS, Lauder IJ. The relationship of kyphosis to the shape of vertebral bodies. Ann Hum Biol 1976;3:173-9.
34. Gelb DE, Lenke LG, Bridwell KH, Blanke K, McEnery KW. An analysis of sagittal spinal alignment in 100 asymptomatic middle and older aged volunteers. Spine (Phila Pa 1976) 1995;20:1351-8.