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Original Research Article

Radiographic Morphometry of the Lumbosacral Region in a Population of Normal Adult Female Volunteers in Port Harcourt Nigeria. Normal Values, Implication for Depth of Epidural Space in Spinal Anesthesia

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Abstract

Background: The L5/S1 intervertebral foramen which houses the largest nerve trunk in the lumbosacral region is the smallest in the vertebral column, and studies on spinal health has revealed that certain clinical conditions of the lower back and the predisposition to them such as spondylosis, spondylolysis and lower back pain may be associated with anatomical variations in the size of the bony components in this region. The study seeks to evaluate normal measurement values of the LSA, LSA and LLD of the spine of healthy female Nigerians, and find out if there exists significant associations between these normal values and with respect to age. A secondary purpose is to provide an indirect method for estimating the epidural space by measuring the depth of lumbar lordosis (LLD). ***Materials and Methods:*** Lateral x-ray films of the lumbar and lumbosacral spine of 45 informed volunteers who met the inclusion criteria were studied with respect to the LLD, LLA and LLA using standard radiologic procedures. ***Results and Discussion:*** Lumbosacral parameters were 32.04 ± 6.08^0, 49.84 ± 8.26^0 and 3.36 ± 0.45cm for LSA, LLA and LLD respectively. Average values of spine parameters varied significantly with age; except for LSA, significant differences were found between age groups. Mean LLA was significant between age group 18-22 and 23-27 years, while mean LLD was significant between age group 18-22 and 23-27, as well as 18-22 and 33-37 years. Statistically significant correlation (at $P < 0.05$) was found between LLA and age and also between LLD and age. On the average, the size and shape of lumbosacral curve dimensions as determined by lateral x-ray in healthy female Nigerians, fall within the range considered normal and are significantly influenced by age. ***Conclusion:*** The findings of this research will be helpful to physicians in the management of low back and also in drawing treatment plans for other back related conditions.

Keywords: Lumbosacral angle, Lumbar lordotic angle, Lumbar lordotic depth, laterals x-ray.

INTRODUCTION

The human lumbosacral region lies at the lower portion of the vertebral column between the trunk above and the pelvis below [1]. It influences the maintenance of spino-pelvic balance and normal erect posture of the bipedal human [2-7].

A number of factors make the lumbosacral portion of the spine ontogenically active in terms of mobility and weight bearing [8, 9, 2, 10-12]. These includes normal angulation between the fifth lumbar and the first sacral vertebrae (L5/S1).

According to (Cailliet [9]; Yochum and Rowe [10]; Peleg *et al.* [13]; Nakipoglu and Nese [14]; Vialle and Cyril [15]) measurement values of lumbosacral angle utilizing lateral X-rays fall within the range of 35-50º. Also, Carlos and Jose [16] reported that LSA increased with advancing age. Other authors have reported variations in the association between age and Lumbosacral angle; Peleg *et al.* [13], reported that LSA first increases with age and around age 21-40 years

decreases. Many others (Norman [17]; Farfan *et al.* [18], Milne and Lauder [19], Lang-Tapia *et al.* [20], Korovesis *et al.* [21] and Yi-Liang *et al.* [22]) failed to establish any statistically significant relationship between age and lumbosacral angle particularly for persons aged 20-49 years.

In the study by Jean *et al.* [23]; Nakipoglu and Nese [14] mean lumbosacral angle of 41.90 and 38.20 for males and females respectively were observed, showing sexual dimorphism (significantly wider in females). On the other hand, Silva [24] reported mean lumbosacral angle of 40.020 for females aged 13-17 years, while Melanee [25], measured the lumbar lordotic angle of sixty healthy young to middle aged Indian females and reported lumbar lordosis of 490. Similar observations have been reported by many research groups including Chen and Lee [26]; Vialle and Cyril [15]; Norton *et al.* [27] and Jean *et al.* [23], but in contradistinction Korovesis *et al.* [21], did not find any significant correlation between angle of lordosis and sex.

Also, statistically significant difference in lumbar lordosis was found between Africans, Americans and European Americans [7, 28].

Most of the occupational activities of women (females) require bending and stooping, and Wiwat *et al.* [29] have produced substantial evidence linking such activities with speedy degeneration of the lower spine IVDs often with terminal consequences. Studies by Jimoh *et al.* [30]; Megan and Tulikang [31], have shown that women with Utero-vaginal prolapse had narrow Lumbar lordotic angulation compared with control sample population who did not have the condition. In addition, Hen riques *et al.* [32], in a comparative study investigated the lumbosacral region of Post-menopausal women with and without osteoporosis and musculoskeletal status; women with osteoporosis had LLA -1170 and in those without the condition LLA was $53.1^{0.}$

More recently, Femal *et al.* [33] in lateral X-rays using 100 female volunteers aged 8-49 years, reported mean LSA in the range (34-50)0, and a significant positive correlation between LSA and LLA.

It can be concluded from these previous studies that the size, shape and angulation the lumbosacral configuration vary with age, gender, body proportion, occupation as well as among individuals of the same age [1, 9, 2, 10, 11, 34, 35, 36]. For the normal Female Nigerian, the nature of these relationships, as well as the underlying mechanisms have not been sufficiently explored.

MATERIALS AND METHODS

About one hundred and twenty (120) females presented themselves to the centers (Ashford and Patrice Clinic LTD, D-line, Port Harcourt and the radiology department of the University of Port Harcourt Teaching Hospital) and were given health education and detailed information on the aim as well as the objectives of this study. Demographic data were obtained and additional relevant information sourced from present and past medical history.

A total number of 45 Nigerian female volunteers, aged between 18 and 55years who had voluntarily signed consent form and subsequently passed the physical screening exercise conducted, participated in the study.

Subjects were thereafter clothed in light under wear, with the gonads shielded with lead apron. They were placed on the table top in the left lateral position with the hips and knees in slight flexion. A padded wooden slab was placed in the depression just cranial to the iliac crest, and a small pillow placed between the knees to ensure proper alignment. Lateral X-ray of the lumbosacral spine was taken at an anode film distance of 90 cm, with breath held in expiration [37].

Ferguson's method of measurement for the angles of the lumbosacral region as described by Yochum and Rowe [10]; Bogduk [11]; Ferguson [38] and Silva [24] was used to obtain the Lumbosacral Angle (LSA), Lumbar Lordosis Angle (LLA) and Lumbar Lordotic Depth (LLD).

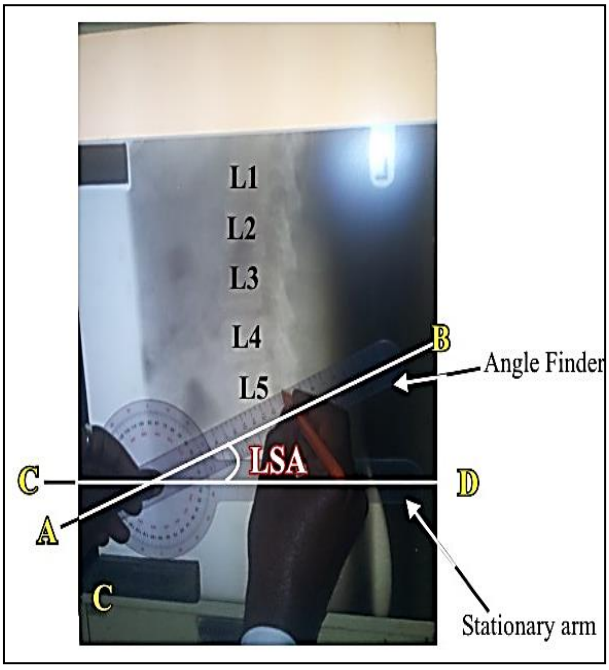

Fig-1: Measurement of the lumbosacral angle

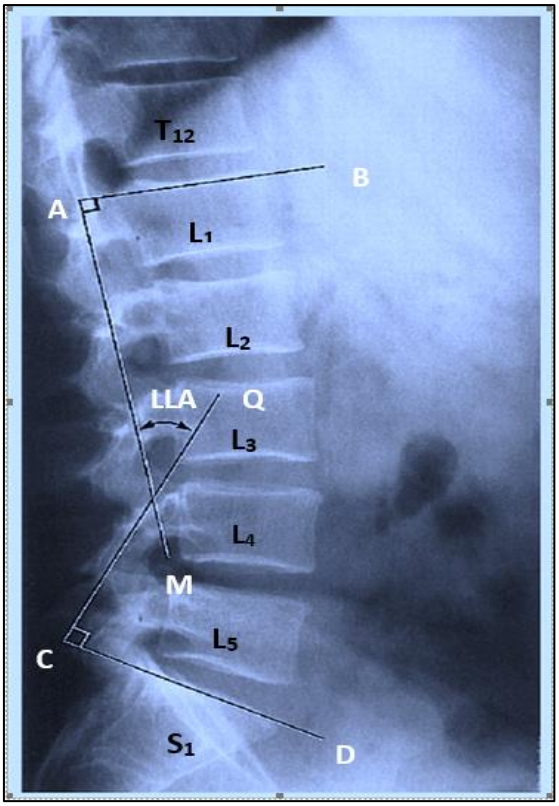

Fig-2: Measurement of the lumbar lordosis lordosis depth – LLD (B-E)

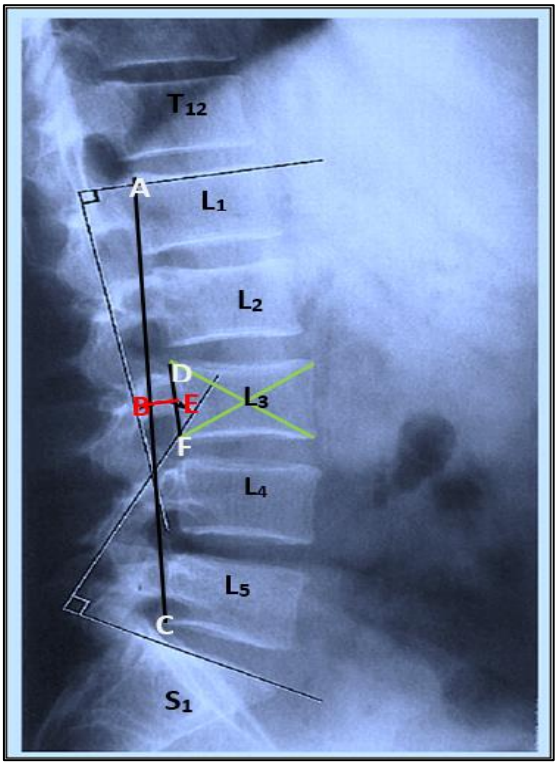

Fig-3: Measurement of the lumbar lordotic angle – LLA (□)

RESULTS

Results are as presented in tables 1−11, with categorical data being in frequency distribution tables, while the measures of central tendency [mean and range (minimum and maximum)] were used to establish cutoff values of spine parameters; [Lumbosacral angle (LSA), Lumbar lordotic angle (LLA) and Lumbar lordotic depth (LLD)]. The age of subjects was stratified into 6 groups; group 1 (18-22years), group 2 (23-27years), group 3 (28-32years), group 4 (33-37years), group 5 (38-42years) and group 6 (> 42years). Significant differences between spine parameters among various age groups was established using t-test, while Spearman's rho correlation was used to correlate age and spinal parameters as well as individual spinal parameters against others. Significance level was set at $p < 0.05$.

Distribution of the subjects by occupation is presented in Figure 1, while distribution of subjects by age is presented in Figure 2.

Distribution of the subjects according to age is presented in Table 1. As distributed, more subjects were 18 -22 years old, while the least is above 42 years old.

Socio-demographic characteristics of the study sample is presented in Table 2. Mean age is 24.44±5.94 years, weight 67.8±13.67 kg, height 1.6±0.09 m and BMI 26.45 ± 5.3kg/m^2. Subjects in the study were neither obese nor underweight; these parameters were within the accepted range of normal for body size.

Descriptive statistics of spine parameters is presented in Table 3. Mean LSA is 32.04±6.08°, LLA 49.84±8.26° and LLD 3.36±0.45cm. On the average LSA and LLD was higher, compared to LLA.

Socio-demographic characteristics of study sample by age groups was categorized according to age group in Table 4. Age 33 -37 has the highest mean value for weight, while subjects above 42 years has the least. Subjects above 42 years has the highest mean value for height, while 33 – 37 years has the least value. For BMI, 28 – 32 years old has the highest value, those between 18 – 22 years old has the least value.

In Table 4, Lumbo-Sacral angle of subjects by age groups is presented. A non-linear relationship in LSA was observed with advancing age, with no difference in LSA after age 33, while an increase decrease pattern was observed in LLA across all age groups (Table 6).

Mean LLD of subjects by age groups is presented in Table 7. An increase decrease pattern was observed in LLD across all age groups. Subjects between 18 – 22 years has the highest mean value (3.61±0.45°), while 33 – 37 years old has the least (2.75±0.35°).

In Table 8, 9 and 10, LSA, LLA and LLD were compared between age groups using *T*- test. For LSA, significant differences were not observed at $P < 0.05$. While for LLA significant differences were not observed between age groups, except between 18 – 22 and 23 – 27 years ($T = -2.78$; $P = 0.01$). And for LLD, significant differences were also not observed except for age 18 – 22 and 23 – 27 ($T = 3.56$; $P = 0.00$) as well as 18 – 22 and 33 – 37 ($T = 2.6$; $P = 0.02$).

In Table 11, age showed a significant positive correlation with LLA ($r = 0.493$, $p < 0.01$), but negatively correlated with LLD ($r = -0.575$, $p < 0.01$). LSA showed a significant negative correlation with LLA ($r = -0.393$, $p < 0.01$) but positively correlated with LLD ($r = 0.380$, $p = 0.01$). While LSD showed a significant negative correlation with LLA ($r = -0.856$, $p < 0.01$).

Table-1: Distribution of subjects by age

AGE GROUPS	N
18-22	21
23-27	15
28-32	6
33-37	2
38-42	0
> 42	1
Total	**45**

Table-2: Socio-demographic characteristics of the study sample (N = 45)

PARAMETERS	Min	Max	Mean	SD	SE
AGE (years)	18	54	24.44	5.94	0.89
WEIGHT (kg)	45	110	67.8	13.67	2.04
HEIGHT (m)	1.3	1.79	1.6	0.09	0.01
BMI (kg/m^2)	16.71	37.87	26.45	5.3	0.79

Min & max *=minimum & maximum value,* ***S.D*** *=standard deviation,* ***S.E*** *= Standard error of mean,* ***N*** *= Sample size of group*

Table-3: Descriptive statistics of spine parameters of the subjects

PARAMETERS	Min	Max	Mean	SD	SE
LSA (^{0})	23	60	32.04	6.08	0.91
LLA (^{0})	33	70	49.84	8.26	1.23
LLD (cm)	2.5	4.3	3.36	0.45	0.07

Min & max *=minimum & maximum value,* ***S.D*** *=standard deviation,* ***S.E*** *=Standard error of mean, LSA = Lumbosacral angle, LLA = Lumbar lordotic angle, LLD = Lumbar lordotic depth*

Table-4: Socio-demographic characteristics of study sample by age groups

Parameters	Age (years)	N	Mean	SD	SE	Min	Max
WGT (kg)	**18-22**	***21***	65.38	15.33	3.34	45	110
	23-27	***15***	65.33	11.39	2.94	55	93
	28-32	***6***	76.5	8.02	3.27	64	87
	33-37	***2***	82	15.56	11	71	93
	38-42	**-**	-	-	-	-	-
	> 42	***1***	75	-	-	75	75
	Total	**45**	**67.8**	**13.65**	**2.04**	**45**	**110**
HGT (m)	**18-22**	***21***	1.62	0.09	0.02	1.45	1.79
	23-27	***15***	1.58	0.06	0.02	1.44	1.71
	28-32	***6***	1.58	0.15	0.06	1.3	1.73
	33-37	***2***	1.64	0.08	0.06	1.58	1.7
	38-42	-	-	-	-	-	-
	> 42	***1***	1.68	-	-	1.68	1.68
	Total	**45**	**1.6**	**0.09**	**0.01**	**1.3**	**1.79**
BMI (kg/m^2)	**18-22**	***21***	24.78	4.99	1.09	16.71	34.33
	23-27	***15***	26.4	4.81	1.24	20.86	37.25
	28-32	***6***	30.95	4.8	1.96	23.72	37.87
	33-37	***2***	30.91	8.97	6.34	24.57	37.25
	38-42	**-**	-	-	-	-	-
	> 42	***1***	26.57	-	-	26.57	26.57
	Total	**45**	**26.45**	**5.3**	**0.79**	**16.71**	**37.87**

WGT = Weight, HGT= Height, BMI = Body mass index, Min & max = minimum & maximum value, SD = standard deviation, SE = Standard error of mean, N = Sample size of group

Table-5: Lumbo-Sacral angle of subjects by age groups

Age (years)	N	Mean	SD	SE	Min	Max
18-22	21	31.62	5.08	1.11	24	46
23-27	15	30.6	3.72	0.96	23	37
28-32	6	36.67	12.21	4.98	27	60
33-37	2	33	1.41	1	32	34
38-42	-	-	-	-	-	-
> 42	1	33	-	-	33	33
Total	**45**	**32.04**	**6.08**	**0.91**	**23**	**60**

Min & max = minimum & maximum value, S.D =standard deviation, SE= Standard error of mean, N = Sample size of group

Table-6: Mean LLA of subjects by age groups

Age (years)	N	Mean	SD	SE	Min	Max
18-22	21	46.19	7.75	1.69	33	60
23-27	15	53.13	6.86	1.77	40	70
28-32	6	52	10.58	4.32	35	65
33-37	2	56	5.66	4	52	60
38-42	-	-	-	-	-	-
> 42	1	52	-	-	52	52
Total	**45**	**49.84**	**8.26**	**1.23**	**33**	**70**

Min & max =minimum & maximum value, S.D =standard deviation, SE= Standard error of mean, N=Sample size of group

Table-7: Mean LLD of subjects by age groups

Age (years)	N	Mean	SD	SE	Min	Max
18-22	21	3.61	0.45	0.1	2.6	4.3
23-27	15	3.13	0.3	0.08	2.5	3.7
28-32	6	3.23	0.37	0.15	2.9	3.8
33-37	2	2.75	0.35	0.25	2.5	3
38-42	-	-	-	-	-	-
> 42	1	3.4	-	-	3.4	3.4
Total	45	3.36	0.45	0.07	2.5	4.3

Min & max = minimum & maximum value, S.D = standard deviation, SE = Standard error of mean, N = Sample size of group

Table-8: T-test of significance in LSA between age groups

Age (years)		Mean diff	S.E.M diff	df	*t*-value	*p*-value
18-22	23-27	1.02	1.55	34	0.66	0.51
	28-32	-5.05	3.29	25	-1.53	0.14
	33-37	-1.38	3.68	21	-0.38	0.71
	38-42	-	-	-	-	-
	> 42	-1.38	5.2	20	-0.27	0.79
23-27	28-32	-6.07	3.4	19	-1.79	0.09
	33-37	-2.4	2.72	15	-0.88	0.39
	38-42	-	-	-	-	-
	> 42	-2.4	3.84	14	-0.62	0.54
28-32	33-37	3.67	9.11	6	0.4	0.7
	38-42	-	-	-	-	-
	> 42	3.67	13.19	5	0.28	0.79
33-37	38-42	-	-	-	-	-
	> 42	0	1.73	1	0	1
38-42	> 42	-	-	-	-	-

***Diff** = difference, **S.E.M** = Standard error of mean, df = degree of freedom, * = represents significant difference*

Table-9: T-test of significance in LLA between age groups

Age (years)		Mean diff	S.E.M diff	df	*t*-value	*p*-value
18-22	23-27	-6.94	2.5	34	-2.78	*0.01
	28-32	-5.81	3.89	25	-1.5	0.15
	33-37	-9.81	5.67	21	-1.73	0.1
	38-42					
	> 42	-5.81	7.93	20	-0.73	0.47
23-27	28-32	1.13	3.87	19	0.29	0.77
	33-37	-2.87	5.11	15	-0.56	0.58
	38-42					
	> 42	1.13	7.09	14	0.16	0.88
28-32	33-37	-4	8.11	6	-0.49	0.64
	38-42					
	> 42	0	11.43	5	0	1
33-37	38-42					
	> 42	4	6.93	1	0.58	0.67
38-42	> 42					

***Diff** = difference, **S.E.M** = Standard error of mean, df = degree of freedom, * = significant at P < 0.05*

Table-10: T-test of significance in LLD between age groups

Age (years)		Mean diff	S.E.M diff	df	*t*-value	*p*-value
18-22	23-27	0.48	0.13	34	3.56	*0.00
	28-32	0.38	0.2	25	1.87	0.07
	33-37	0.86	0.33	21	2.6	*0.02
	38-42	-	-	-	-	-
	> 42	0.21	0.46	20	0.45	0.65
23-27	28-32	-0.1	0.15	19	-0.65	0.53
	33-37	0.38	0.23	15	1.67	0.12
	38-42	-	-	-	-	-
	> 42	-0.27	0.31	14	-0.86	0.41
28-32	33-37	0.48	0.3	6	1.62	0.16
	38-42	-	-	-	-	-
	> 42	-0.17	0.4	5	-0.42	0.69
33-37	38-42	-	-	-	-	-
	> 42	-0.65	0.43	1	0.58	0.37
38-42	> 42	-	-	-	-	-

***Diff** = difference, **S.E.M** = Standard error of mean, df = degree of freedom, * = significant at P < 0.05*

Table-11: Spearman's rho correlation analysis

Parameters		AGE	LSA	LLA	LLD
AGE	**Correlation Coefficient**	1.000			
	Sig. (2-tailed)	.			
LSA	**Correlation Coefficient**	0.043	1.000		
	Sig. (2-tailed)	0.781	.		
LLA	**Correlation Coefficient**	**0.493****	**-0.393****	1.000	
	Sig. (2-tailed)	0.001	0.008	.	
LLD	**Correlation Coefficient**	**-0.575****	**0.380***	**-0.856****	1.000
	Sig. (2-tailed)	<0.001	.010	<0.001	.

** = correlation is significant at P < 0.01 (2-tailed), *LSA = Lumbosacral angle, LLA = Lumbar lordotic angle, LLD = Lumbar lordotic depth*

DISCUSSION

The study evaluated three known parameters of the lumbosacral spine in a sample of normal female Nigerians, using standard radiographic anthropometry.

Age related differences and similarities were observed between spine parameters measured in the current study compared with values obtained in the literature. Much significant difference was not observed in spine parameters across age groups, except for age 23−27 in LLA and 23 −27 as well as 33−37 in LLD (Table 4, 5 and 6). These findings will be considered to agree with those of Silva [24]; Nakipoglu and Nese [14]

who are of the opinion that there is no difference in Rachic index between Blacks and Whites.

With the exception of LLA, average values of LSA and LLD in the current study were much lower compared with previously reported values for Africans; by Hoseinfar *et al.* [39] and Sungsoo *et al.* [40] and Nigerians (Hoseinfar *et al.* [39] and Melanee [25]). Differences in measurement techniques as well as demographic distribution may be responsible for some of the observed differences.

An increase decrease relationship was observed between age and mean values of LSA. Statistical analysis showed there was no significant association between LSA and age despite the observed higher mean values of LSA (Table 4 and 9). Previous investigations did not arrive at the same conclusion (Maduforo *et al.* [41]; Melanee [25] and Klineberg *et al.* [42]). Because of the consistency observed in LSA in female subjects, LSA may be an efficient diagnostic screening tool either for pre-employment or in the evaluation of low back pain.

A decrease increase relationship was observed between age and LLA, which on the average was found to increase with advancing age up to 42years. Age related differences in LLA were observed between the younger age groups; 18-22 and 23-27 (Table 4). This was in agreement with previous reports (Maduforo *et al.* [41]; Melanee [25] and Vialle and Cyril [15]) but contradicts the conclusions by Ferguson [38]; Carlos and Jose [16]; Norman [17]; Farfan *et al.* [18] and Lang-Tapia *et al.* [20]). The dissimilarities may be due to the inclusion of much older subjects as reported by the Authors. In the study by Farfan *et al.* [18], the mean lumbar lordosis was 48.5°, and there was a weak but significant correlation with age. The observed relationship between age and the size of the lumbar curve in this study supports the argument that the skeletal adaptation for obstetric reasons develops around the immediate post pubertal period. The results are relevant in the design and manufacture of such equipment as anatomical plates, casts and lumbosacral corsets. Findings will also be helpful in the planning and design of programs of rehabilitation in many situations involving the elderly as seen frequently in cerebrovascular accidents (stroke syndromes) and in conditions such as continuous ambulatory peritoneal dialysis.

An increase decrease relationship was also observed between LLD and age. While an increase in LLA was observed for older subjects compared to the younger, significant increase in LLD indicating weakening of the spine was observed between age groups 23−27 and 33−37 indicating the influence of child bearing (Table 8). These changes were found to be statistically significant, and in agreement with report by Peleg *et al* [13]; Maduforo *et al* [41] and Milne and Lauder [19].

Thus, in the period before, during and after any surgical intervention of the spine, the age and preoperative LLD of each patient should be properly documented.

Also, the observed relationship can act as a guide in the design of corsets, trunk brace and other ergonomic tools for individuals with back problems who require back support, as well as patients with chronic conditions requiring long periods of confinement in bed.

A positive significant correlation was observed between age and LLA in females (R = 0.49, R2 = 0.24, P = 0.001). The opposite (negative significant correlation) was found to exist between age and LLD (r = -0.58, R2 = 0.34, P = 0.001). A positive but non-statistically significant correlation was observed between age and LSA (r = 0.043, P = 0.781).

A negative significant correlation was found to exist between LSA and LLA (r = -0.39, R2 = 0.15, P = 0.01) and a positive significant correlation between LSA and LLD (r = 0.38, R2 = 0.14, P = 0.01).

A negative significant correlation was found between LLA and LLD (r = -0.86, R2 = 0.75, P < 0.001) (Table 11).

A wider LSA was observed in females, which implies that the foundation for obstetric lordosis is established at the level of the sacral base, whereas curvatures in the spine cranial to the LSA is compensatory as a result of postural stabilization and bone remodeling. This is in agreement with previous findings (Lang-Tapia *et al.* [20] and Torsten and Emil [37]), but not at par with the conclusion by Silva [24] and Nakipoglu and Nese [14], who in an earlier study had shown there was no significant correlation between angle of lordosis in either male or female. This also implies that in the management of young women with problems of the lumbar spine, the LLA may need to be combined with other diagnostic tools to produce better results.

CONCLUSION

Results from this study suggest that age is among the individual factors that significantly influence spine morphology in female Nigerians. The LSA, LLA and LLD exhibit an increase decrease relationship, except for LSA that becomes constant after the age of 32.

Thus, LLA, LSA and LLA can be used to correctly quantify deviations from normal and a case can be made for current radiology reports to indicate

numerical values of these parameters as it is the practice in many areas of laboratory medicine.

REFERENCES

1. Standring, S. (Ed). (2005). Gray's Anatomy: The Anatomical basis of Clinical Practice. 3rd ed. London UK: Elsevier Churchill Livingstone.
2. Levangie, P.L., Norkin, C.C. (2005). Joint Structure and Function: a comprehensive analysis. 4th ed. Philadelphia USA: FA Davis Company.
3. Chapman, M., Szabo, R., Kelly, V.R., Lay, M., Mclan, R., & Rab, G., (Editors). (2001). Chapman's orthopedic surgery.3rd ed. California: Lippincott Williams and Wilkins Publishers.
4. MacLean, J. G., Tucker, J. K., & Latham, J. B. (1990). Radiographic appearances in lumbar disc prolapse. *The Journal of Bone and Joint Surgery. British volume*, *72*(5), 917-920.
5. Pate, D. (1991). Stability of the lumbar Spine. Dynamic Chiropractic, *9*(11)
6. Danhert, W. (1999). Radiology review manual {CD ROM}. ISILO TM for Windows®, 4th ed. Version 5.20 USA: Lippincot Williams and Willkins.
7. Labelle, H., Roussouly, P., Berthonnaud, É., Dimnet, J., & O'Brien, M. (2005). The importance of spino-pelvic balance in L5–S1 developmental spondylolisthesis: a review of pertinent radiologic measurements. *Spine*, *30*(6S), S27-S34.
8. Moore, K.L., Arthur, F.D. (2000). Clinically oriented Anatomy. 5th ed. Philadelphia: Lippincott Williams and Wilkins.
9. Cailliet, R. (1985). Low back pain Syndrome. 3rd ed. Philadelphia: FA Davis Company.
10. Yochum, T.R., & Rowe, J.L. (2005). Essential of Skeletal Radiology. 3rd ed. Philadelphia USA: Williams and Wilkins.
11. Bogduk, N. (2005). Clinical Anatomy of the lumbar spine and sacrum. 4th ed. USA: Elsevier Churchill Livingstone limited.
12. Stuart Mc Gill. (2007). Low back disorders: evidence-based prevention and rehabilitation. 2nd ed. USA: Sheridan books.
13. Peleg, S., Dar, G., Medlej, B., Steinberg, N., Masharawi, Y., Latimer, B., ... & Hershkovitz, I. (2007). Orientation of the human sacrum: anthropological perspectives and methodological approaches. *American Journal of Physical Anthropology: The Official Publication of the American Association of Physical Anthropologists*, *133*(3), 967-977.
14. Nakipoglu, G. F., Karagoz, A., & Ozgirgin, N. (2008). The biomechanics of the lumbosacral region in acute and chronic low back pain patients. *Pain Physician*, *11*(4), 505-511.
15. Vialle, R., Dauzac, C., Khouri, N., Wicart, P., Glorion, C., & Guigui, P. (2007). Sacral and lumbar-pelvic morphology in high-grade spondylolisthesis. *Orthopedics*, *30*(8), 642.
16. Giglio, C. A., & Volpon, J. B. (2007). Development and evaluation of thoracic kyphosis and lumbar lordosis during growth. *Journal of children's orthopaedics*, *1*(3), 187.
17. Sekiguchi, M., Yabuki, S., Satoh, K., & Kikuchi, S. (2004). An anatomic study of the sacral hiatus: a basis for successful caudal epidural block. *The Clinical journal of pain*, *20*(1), 51-54.
18. Farfan, H. F. (1972). Huberdeau RM, Dubow HI. *Lumbar intervertebral disc degeneration. J Bone Joint Surg [Am] l972*, 492-5.
19. Milne, J. S., & Lauder, I. J. (1976). The relationship of kyphosis to the shape of vertebral bodies. *Annals of Human Biology*, *3*(2), 173-179.
20. Lang-Tapia, M., España-Romero, V., Anelo, J., & Castillo, M. J. (2011). Differences on spinal curvature in standing position by gender, age and weight status using a noninvasive method. *Journal of applied biomechanics*, *27*(2), 143-150.
21. Korovessis, P. G., Stamatakis, M. V., & Baikousis, A. G. (1998). Reciprocal angulation of vertebral bodies in the sagittal plane in an asymptomatic Greek population. *Spine*, *23*(6), 700-704.
22. Kuo, Y. L., Tully, E. A., & Galea, M. P. (2009). Video analysis of sagittal spinal posture in healthy young and older adults. *Journal of manipulative and physiological therapeutics*, *32*(3), 210-215.
23. Mac-Thiong, J. M., Labelle, H., Berthonnaud, E., Betz, R. R., & Roussouly, P. (2007). Sagittal spinopelvic balance in normal children and adolescents. *European Spine Journal*, *16*(2), 227-234.
24. Silva, H. M. (2001). Sagittal Spine Lumbosacral Angles: view from a sample from Adolescents. *Chilean Journal of Anatomy*, *19*(3), 1-13.
25. Naidoo, M. (2008). *The evaluation of normal radiographic measurements of the lumbar spine in young to middle aged Indian females in Durban* (Doctoral dissertation).
26. Chen, Y. L., & Lee, Y. H. (1997). A non-invasive protocol for the determination of lumbosacral vertebral angle. *Clinical Biomechanics*, *12*(3), 185-189.
27. Norton, B. J., Sahrmann, S. A., & Van Dillen, L. R. (2004). Differences in measurements of lumbar curvature related to gender and low back pain. *Journal of Orthopaedic & Sports Physical Therapy*, *34*(9), 524-534.

28. Von Lackum, H. L. (1924). The lumbosacral region: an anatomic study and some clinical observations. *Journal of the American Medical Association*, *82*(14), 1109-1114.
29. Wajanavisit, W., Woratanarat, P., Wattanawong, T., & Laohacharoensombat, W. (2009). Floor activities and degenerative spinal diseases. *Journal of the Medical Association of Thailand= Chotmaihet Thangphaet*, *92*, S88-94.
30. Jimoh, A.A.G., Balogun, O.R., Abegunde, A., Akunwale, G.S., Anjorin, O., U.(2004). Physiotherapy in obstetrics and gynecology: A Review. *Medilink Journal*, *5*(6):28-25.
31. Megan, Schimpf, Æ Pau, l., Tulikang, A.S. (2005). Evolution of the female pelvis and relationships to pelvic organ Prolapse. *Int Urogynecol J, 16*; 315–320 DOI 10.1007/s00192-004-1258
32. Cunha-Henriques, S., Costa-Paiva, L., Pinto-Neto, A. M., Fonsechi-Carvesan, G., Nanni, L., & Morais, S. S. (2011). Postmenopausal women with osteoporosis and musculoskeletal status: a comparative cross-sectional study. *Journal of clinical medicine research*, *3*(4), 168.
33. Findikcioglu, K., Findikcioglu, F., Ozmen, S., & Guclu, T. (2007). The impact of breast size on the vertebral column: a radiologic study. *Aesthetic plastic surgery*, *31*(1), 23-27.
34. Cho, M., Lee, Y., Kim, C. S., & Gong, W. (2011). Correlations among sacral angle, lumbar lordosis, lumbar ROM, static and dynamic lumbar stability in college students. *Journal of physical therapy science*, *23*(5), 793-795.
35. Hojat, B., & Mahdi, E. (2011). Effect of different sitting posture on pulmonary function in students. *Journal of Physiology and Pathophysiology*, *2*(3), 29-33.
36. Harold, E. (1986). Clinical Anatomy: Revision and Applied Anatomy for Clinical Students.7th ed. Summerset Great Britain: Blackkwell Scientific Publication.
37. Torsten, B.M., Emil, R. (2000). Pocket Atlas of Radiographic Anatomy, 2nd ed. Stugart: New York, 53-55
38. Ferguson, A.B. (1934). The clinical and roentgenographic interpretation of lumbosacral anomalies. Radiology, 22:548.
39. Hoseinifar, M., Ghiasi, F., & Akbari, A. (2007). 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*, *7*(6), 984-90.
40. Kim, H. J., Chung, S., Kim, S., Shin, H., Lee, J., Kim, S., & Song, M. Y. (2006). Influences of trunk muscles on lumbar lordosis and sacral angle. *European Spine Journal*, *15*(4), 409-414.
41. Maduforo, C., West, O., Nwankwo, N., Onwuchekwa, R., Etawo, U. S., & Ogbulu, D. (2012). Study of the lumbosacral angles of males in Port Harcourt, South-South, Nigeria. *Nigerian Health Journal*, *12*(1), 22-24.
42. Klineberg, E., Schwab, F., Smith, J.S., Gupta, M.C., Lafage, V., Bess, S. (2013). *Neurosurg Clin N Am, 24*(2013) 157–162 http://dx. doi. org/10.1016/j. nec