

Lumbo-Sacral Angle Evaluation Among Lebanese Population

Khawli Loubaba, Haidar Hassan Khodor, and Kheir Eddine Hassane

ABSTRACT

Background: Lumbar lordosis is an essential postural element that has gained the interest of both clinicians and researchers for several years. It is the inward curvature made by the wedging of the vertebrae of the lumbar spine. Since there is paucity of data on the lumbar lordosis in the Lebanese population, most of the data used in clinical practice to classify hypo- and hyper-lordosis are based on studies from other races.

Aim: To identify the normal LSA in a Lebanese population, then see if there is a difference between the races and determine if this angle is affected by the gender or age.

Methods: A retrospective study established to measure lumbar lordosis using LSA technique. Lateral supine lumbosacral radiographs of 128 Lebanese subjects, aged between 19 and 84 years, were analyzed. Statistical analysis was done using SPSS version 20.0.

Results: The mean value (SD) of LSA was 38.980 (+9.90) with a min 15.70 and max 64.20. A significant difference was found between LSA and gender. However, there was no significant variation between this angle and age.

Conclusion: The mean value of this angle 38.980 (+9.90) may form a reference for the Lebanese population. The study demonstrated that lumbar lordosis is affected by race and gender, with females having a greater LSA than males. Whereas the latter was not affected by age.

Keywords: Lumbar lordosis, Lebanese population, lumbosacral angle, radiography.

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I. INTRODUCTION

Lumbar lordosis is an essential postural element that has gained the interest of both clinicians and researchers for several years. It is the inward curvature made by the wedging of the vertebrae of the lumbar spine [1]. Since it plays an important role in the weight-bearing of the entire upper part, abnormal changes in this curve leads to occurrence of low back pain or functional impairments [2].

Low back pain (LBP) is the 5th most common cause for doctor visits; approximately 60-80% of people suffer from LBP through their lifetime [3], [4]. The relationship between lumbar lordosis and low back pain has a huge clinical importance since it acts as the base of therapeutic exercises for low back pain treatment and prevention [5].

Many techniques have been utilized to evaluate lumbar angles, including goniometry, radiography, flexible rulers, software methods, spinal mouse, and inclinometers. Among all these techniques, radiography remains as the golden standard method for the evaluation of these angles [6]. Many radiologic methods have been used to evaluate the lordosis angle on two-dimensional radiographs such as lumbosacral angle (LSA), tangential radiologic assessment of lumbar

lordosis (TRALL), Cobb's angle and lumbar lordosis angle (LLA) [7].

Considering the treatment, the main target is to put the body in a physiologic position; so, it can keep its balance with minimal effort. The treatment might be non-operative or operative. The first one uses bracing to maintain the structural support or physiotherapy to strengthen the muscles. The second one includes various levels of invasive procedures or bony removal to realign the spine [8].

According to the literatures, several factors influence the angle of lumbar lordosis such as ethnicity, age, gender, obesity, posture, activity, muscular strength and flexibility of the spine and lower limbs; making it hard to know the optimal range of this angle [1], [2].

The majority of studies concerning the effect of age on the spine show that lumbar lordosis decreases or stays constant with ageing; just few have shown an increase in the latter. Studies examining gender differences in lumbar lordosis show that it is slightly larger in women or there is no significant dependency on gender. However, some of these studies, where age and sex were examined, were limited in sample size, and did not distinguish between men and women and subjects with or without back pain [9].

It is well known that good assessment led to good plan of treatment; that's why it is important to assess the lumbar lordosis in order to plan for a good treatment. There is paucity of data on values of lumbar lordosis angle in the Lebanese population; accordingly, values that represent hypo/hyper lordosis in clinical practice are established on studies from other races.

The first aim of this study is to identify the mean value of LSA in the Lebanese population, which may form a reference value for physicians, physiotherapists, and researchers in Lebanon.

The second aim is to compare the mean values obtained in this current study with other studies and determine if there's difference between the races.

The third aim is to identify if the LSA is affected by the gender or age.

Additionally, the measurement of these angles may be helpful first, in recognizing persons at risk of developing LBP as well as in the design of spinal instrumentations and implants that are specific for the population.

II. MATERIALS AND METHODS

In this chapter we aim to describe several methodological steps used to filtrate the data, evaluate the radiographic images using LSA method and finally using T-test and ANOVA to analyze the data obtained then compare it with other results.

A. Design and Participants

This study is a retrospective study established to measure LSA using 152 radiographs of lateral lumbo-sacral spine in supine position collected from CEMA center in Beirut, Lebanon: after obtaining an IRB approval and ethical clearance from the center. Taking it as retrospective was for many reasons for example avoiding ethical issues like patient irradiation and the high cost of the examination. The 152 radiographs were collected on June 2020 as images on a CD. Each image contains patient's records including age and gender. The aim of using one source of data was to increase the accuracy and narrowing the bias in the data, since using the same device and protocol contributes to better homogeneity in the results.

The following inclusion and exclusion criteria were used to filtrate the data (Table 1).

TABLE I: THE ELIGIBILITY CRITERIA FOR THE PARTICIPANTS

Inclusion Criteria	Exclusion Criteria
- Lebanese nationality	- Incomplete records (age or gender not recorded)
- Age > 18 years	- Poor resolution/quality radiographs
- Normal radiographs*	- Radiographs with spinal abnormality
- Age and gender must be recorded	- (anterolisthesis, abnormal curvature, sacrum in abnormal position)
	- Patients < 18 years (to assure that only those who have reached spinal maturity are studied)

*The criteria for normal radiographs were:

1. The spine must include 5 lumbar and 5 sacral vertebrae.
2. The height of vertebrae from L1 to L5 should increase progressively or remain the same.

3. The lumbar curvature should be anteriorly convex with a concave curve in the sacral region.
4. The intervertebral disks increase progressively in thickness from L1 to L5.
5. Absence of abnormality in the lumbo-sacral spine [10].

Statistical analysis was done using SPSS version 20.0 (Chicago, USA). Quantitative data were expressed as mean and standard deviation. Comparison of quantitative measurements was done using Sample t-test and ANOVA test. Statistical significance was set at p value <0.05.

B. Measurement of Lumbo-sacral Angle

The steps of the LSA method are (Fig. 1):

a) Over the plane of the superior margin of the sacral vertebra, a straight line is drawn.

b) A horizontal line is then drawn to form the lumbo-sacral angle.

c) The LSA formed can be measured using a protractor; in this study a software called "ImageJ" was used to measure it, which is an open source image processing program designed for scientific multidimensional images.

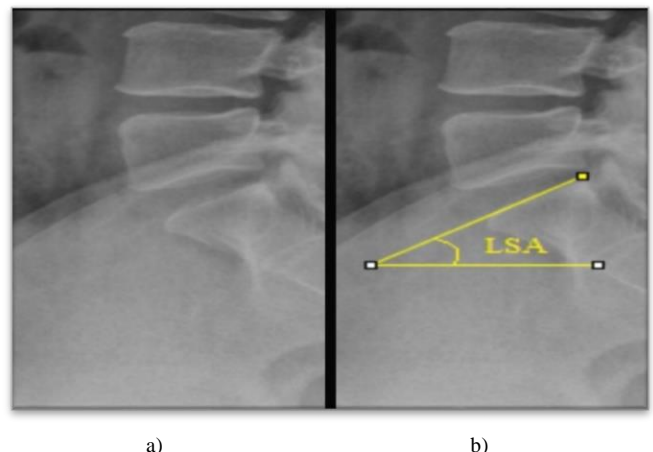


Fig. 1. (a) Radiograph of normal lateral lumbo-sacral spine. (b) measurement lines for the normal lumbo-sacral angle.

III. RESULTS AND STATISTICAL ANALYSIS

In this chapter we intend to show the results obtained after analyzing the data. LSA and the derivative method means and standard deviations for the Lebanese population are calculated using SPSS.

A. Data Selection and Distribution

1. Filtration of data

Out of the 152 radiographs collected, 24 were excluded (as shown in Fig. 2). The reasons of exclusion are incomplete records (no gender or age), abnormal radiographs (pathologies of spine or abnormal shape of vertebrae) and duplicated file (same image for the same subject is repeated twice). The radiographs of 128 subjects who met the inclusion criteria were analyzed.

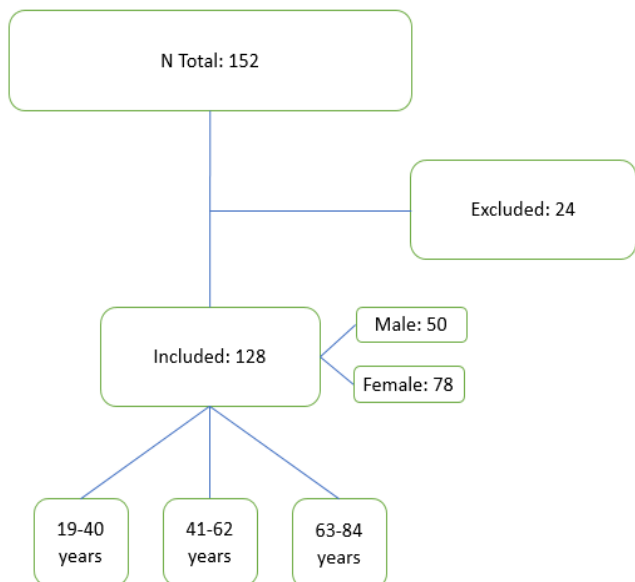


Fig. 2. Flow chart showing the selection and filtration of data.

2. Distribution of data

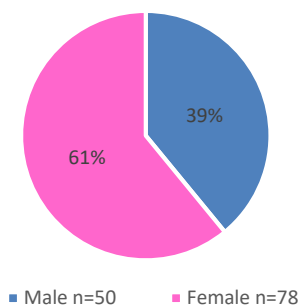


Fig. 3. Pie chart of the distribution of subjects according to gender.

Among the 128 participants, there were 50 (39%) males and 78 (61%) females (as shown in Fig. 3).

The mean value of age was 49 years with +/- 17.4 SD (age ranged between 19 and 84 years).

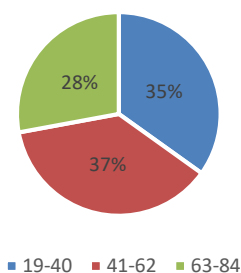


Fig. 4. Pie chart of the distribution according to the age groups.

As shown in Fig. 4, the age was divided into three groups: 1st group: 19-40 years which compromise 38% of the population, 2nd group: 41-62 years (37%) and 3rd group: 63-84 years (28%).

The mean value of LSA is 38.98 +/- 9.9 with a min 15.70 and max 64.20.

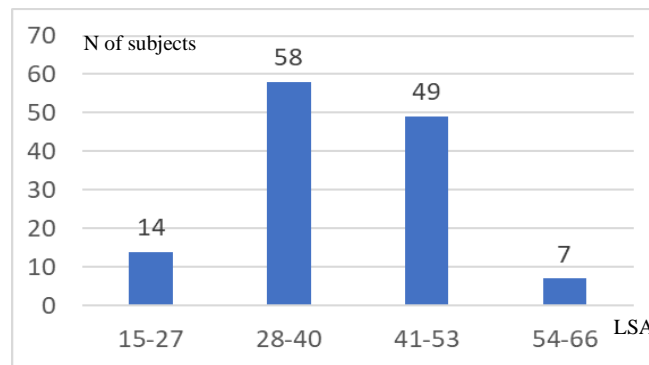


Fig. 5. Bar chart of subjects' distribution according to LSA.

The results in Fig. 5 show that only 7 participants out of 128 had a lumbo-sacral angle between 54-66. In addition, only 14 had it between 15-27. Whereas 58 subjects had it between 28-40 and 49 with a range of 41-53.

B. Statistical Tests

A sample T-test was used to analyze the LSA between gender.

TABLE II: SAMPLE T-TEST BETWEEN LSA MEAN OF MALE AND FEMALE

ONE-SAMPLE TEST						
Test Value = 0						
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Male	29.688	50	.000	38.93333	36.2993	41.5674
Female	33.992	78	.000	39.22848	36.9310	41.5260

The results of Table 2 show that the LSA mean of males (N=50) is 38.9⁰ lower than the females' (N=78) which is 39.2⁰. The difference between the LSA mean of male and female is significant (p value less than 0.05).

ANOVA test was used to analyze the LSA between the three age groups.

TABLE III: ANOVA TEST BETWEEN THE THREE AGE GROUPS

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	366.692	2	183.346	1.898	.154
Within Groups	12073.194	125	96.586		
Total	12439.886	127			

The results of Table 3 show no significant difference between the 3 age groups since p value is 0.154 which means there is no correlation between LSA and age.

IV. DISCUSSION

Lumbar lordosis is the inward curvature made by the wedging of the vertebrae of the lumbar spine [1]. It has been linked to the occurrence of low back pain or functional impairments [2] and the relationship between both has a huge clinical importance since it acts as the base of therapeutic exercises for low back pain treatment and prevention [5].

Ethnicity, age, gender, obesity, posture, activity, muscular strength and flexibility of the spine and lower limbs; all these factors may influence the angle of the lordosis, where some studies did not find any correlation between age, gender and LSA [9].

Ferguson's angle, sacro-horizontal angle, the sacral angle, are different name for the lumbo-sacral angle or LSA which

is the angle formed between a line across the plane of the superior margin of the sacrum and a horizontal line [11].

The aim of our study is to identify the normal LSA in the Lebanese population, then compare the mean value with other studies to see if there's difference between the races, and finally determine if this angle is affected by the gender or age.

The LSA in our study ranged between 15-64° with a mean value (SD) of 38.98° ($\pm 9.9^\circ$); The SD in our study is high since the age range is wide (19-84 years). The range of LSA is wide and this may explain the difference in the mean angle compared to other studies by Chung HJ et al., Fernand R et al., Kim HS et al., and Middleditch A et al. [13]. The mean value of LSA in our study was significantly higher than the mean value reported by Kim HS et al. [14] of 31.70° and by Chung HJ et al. [15] 32.40°. However, it was significantly lower than that of Fernand R et al. [12] (46.50°) and Middleditch A et al. [13] (42.50°). These findings suggest that there is a racial variation in LSA being lower in the Asian and higher in Caucasian population which may be due to the different stature of the various races.

To begin with, there is evidence that the females have greater lumbar lordosis according to the literature [9], [16], [17]. Moreover, in this study there is a significant difference between the LSA of male and female, possibly because females have a larger sacral slope than males [18]. Other studies showed that lumbar lordosis does not differ between the genders. One study by Kalichman et al. [19], evaluated lordosis in a supine position. However, in his study Kalichman did not use Xray nor LSA in the measurement, he used CT Scan and Cobb angle; maybe that is why our results are not compatible with his.

According to Okpala, in a study done retrospectively measuring supine lateral lumbo-sacral radiographs of 100 females and 100 males, aged 15 years and above; the LSA was 44.2° (10.0°) and there was not a significant difference in gender. These results are not compatible with ours, maybe due to the difference in race since this study by Okpala is done in Nigeria; and as previously stated, race is a factor that may affect the LL as claimed by many authors.

However, our results are similar to many studies; Fernand et al. [12], Gelb et al. [20], Murrie et al. [21], Vialle et al. [22], and Youdas et al. [23], [24] that showed that females have greater lordosis angle than males. As mentioned, this difference might be due to the reason that females have a larger sacral slope than the males and they usually have greater buttock size, that is why they have greater lumbar lordosis. In addition, history of pregnancy could influence LL; females considerably gain weight during pregnancy, go through biomechanical and hormonal changes such as the adaptation of LL possibly due to weak abdominal muscles or postpartum joint laxity; thus, increasing lumbar lordosis.

Furthermore, the commonly held view is that LL decreases with subsequent age-related degenerative changes and spinal problems. However, many studies, by Kalichman et al. [19], Murrie et al. [21], Youdas et al. [23], [24] and Naido [25] did not find any association between lordosis and age. According to our results, the LSA is not affected by age since p value was 0.154 (more than 0.05).

A study by Tuzun et al. [26], claimed that lumbar lordosis increases with age; maybe because the age of the subjects of Tuzun's study ranged between 20 and 63 years which is

different than our range (19-84 years) and the majority of their patients were women. We already assumed that females have larger lumbar lordosis, that is why there is difference in our results and theirs. Another one done by Amonoo-Kuofi [27], showed that it decreases after the 6th decade; maybe due to degenerative disc disease or increasing kyphosis that pushes the body's center of gravity forward with compensatory straightening of the lumbar spine which causes decreased lordosis.

Okpala's study in 2014, which is a retrospective study of lumbo-sacral angle in normal lateral supine radiographs of 274 Nigerians aged between 15 and 74 years, showed that there is no significant variation of the LSA between the various age groups which is similar to our results. LSA was not affected by age, since at spinal maturity, the development of lumbar lordosis hits a plateau [13], [28].

Another reason is, in our current study and the study done by Okpala, we only included the normal radiographs and excluded the radiographs that did not follow the normal criteria which include: the height of vertebrae from L1 to L5 should increase progressively or remain the same, the intervertebral disks increase progressively in thickness from L1 to L5 and absence of abnormality in the lumbo-sacral spine; therefore, excluding the subjects with disc degenerative disease. While other studies when studied the effect of age and found affecting the LSA, mentioned that the reason behind these changes was due to the degeneration of discs (which was excluded in our study). Therefore, no correlation was found between age and LSA.

V. LIMITATIONS

The main limitation in this study, since it was a retrospective study, was the inability to collect more information about each subject including weight, height, address, and profession. The weight and height would be necessary to calculate the BMI thus analyzing if obesity affects the LSA as claimed by many authors. The address is also important to compare the results between the regions for example south and north of Lebanon and see if there is any significant difference which might be due to genetic factors. In addition, the profession or activity are useful since they also might affect the LSA.

Another limitation was the delay in getting the radiographs from the center. The reason behind it was the current situation due to COVID-19, which caused delay in getting the data therefore interruption of the study since there was a mandatory quarantine.

In this study, we tried to make an equation to find a correlation between LSA and age, but it was not applicable since the distribution of the 2 variables wasn't graphically correlated.

VI. CONCLUSION

In this study, evaluation of lumbar lordosis was done on 128 radiographs in a Lebanese population. The range of the LSA was 15-64° with a mean value (SD) of 38.98° ($\pm 9.9^\circ$). The study demonstrated that lumbar lordosis is affected by race and gender, and the difference between the LSA of female and that of male is significant; with females having a

greater LSA than males. However, no association was found between age and LSA.

This angle $39.98^\circ (\pm 9.9^\circ)$ may form a reference value of lumbar lordosis for physicians, physiotherapists, and researchers in the Lebanese population.

VII. RECOMMENDATIONS

To be more ideal, this study would have been done prospectively using a greater number of patients distributed on all the Lebanese region not only Beirut. However, if further studies were to be done prospectively, it is recommended to collect more information about each subject including BMI and history of low back pain to analyze if these factors do affect the LSA as claimed by many authors.

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