LUMBAR LORDOSIS: A STUDY OF ANGLE VALUES AND OF VERTEBRAL BODIES AND INTERVERTEBRAL DISCS ROLE

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SUMMARY

The angular value of lumbar lordosis and the role of vertebral bodies and intervertebral discs in its constitution were studied in normal individuals. X-Ray images of lumbar spine were studied in 350 normal and asymptomatic individuals, ages ranging from 18 to 50 years old (average 29.0 years old ± 8.24), being 143 males and 207 females. The lumbosacral (L1S1) and the lumbolumbar (L1L5) curves were measured. Measurements for lumbar curves and their components presented a large variation. Average values of -61º were seen for lumbosacral curve and of -45º for lumbolumbar curve. Vertebral bodies measurements presented kyphotic values for L1, neutral for L2, and progressively lordotic for L3 – L5. Intervertebral discs presented a progressive lordotic angulation from L1-L2. Caudal elements of curvature, intervertebral discs L4-L5 and L5-S1 and the vertebral body L5 accounted for nearly 60% of the angular measurement of lumbosacral curvature. A significant difference was seen between males and females for lumbar curvature measurements, and for vertebral bodies L2 and L4, with females presenting higher values. Age-related differences were found in lumbar curvature and vertebral bodies measurements.

Keywords: *Lumbosacral region; Lordosis; Lumbar vertebrae; Intervertebral disc*

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 curves measurements on spine present great variability in normal individuals, with a wide variation range for those, within normality limits. That great measurements variation must be considered as physiological, indicative, but not normative [2].

Lumbar lordosis has long been studied, and its curvature is associated with various factors, such as thoracic curvature, age, gender, pelvic bend, among others. Studies have been conducted intending to measure lumbar and spinal segments curvatures. The participation of vertebral bodies and intervertebral discs on lumbar lordosis formation has not been considered. The objective of this study was to measure lumbar curvature, and vertebral bodies and intervertebral discs angles in normal individuals, aiming to observe lumbar lordosis values and also the role of vertebral bodies and intervertebral discs in its composition, also considering a potential age and gender bias.

MATERIALS AND METHODS

X-ray images at lateral plane of 350 asymptomatic individuals, both genders (143 men and 207 women), ages ranging from 18 to 50 years old (mean age = 29.0 ± 8.24) were studied. X-ray images used in the study were part of the admission medical tests of employees of Ribeirão Preto Medical College's Hospital das Clínicas. X-ray images were taken according to a standard technique with patients in orthostatic position and with arms laid on a support in front of the body. 25 x 30 cm films were used, with the X-ray equipment ampoule placed 1.0 m away from the patient, and with rays focused on lumbar region. X-ray images were randomly selected for the study at the Medical Files Service (SAME) at the very hospital. Exclusion criteria established for the study were: previous lumbar pain (described in medical files), previous spinal surgery, presence of degenerative disease or congenital abnormality of lumbar spine as seen on X-ray images.

Lumbar, vertebral bodies and intervertebral discs curvature angles measurement was manually performed, directly on lateral plane X-ray images, using as reference the upper and lower edges of vertebral bodies L1-L5 and S1 upper edge. Those measurements were performed by two surgeons who were experienced with the method. Consistently with other studies, it was established that negative angle values indicated lordosis and positive values indicated kyphosis [3].

Initially, the lumbosacral curvature (L1S1) - angle between L1 upper edge and S1 upper edge - and the lumbolumbar curvature (L1L5) - angle between L1 upper edge and L5 lower edge - were measured (Figure 1 A and B). Then, the angle of each vertebral body (angle between each vertebra's upper and lower edges from L1 to L5) and the angle of each intervertebral disc (angle between upper vertebra's lower edge

Study conducted at Hospital das Clínicas, Ribeirão Preto Medical College - USP.

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and lower vertebra's upper edge on disc spaces, from L1-L2 to L5-S1) were measured (Figure 1).

Percentage share of the measurement in each vertebral body and each intervertebral disc was calculated from the ratio between the measurement of each element of lumbar region by the measurement of lumbosacral curvature observed for each individual.

Measurements for lumbar curvatures (L1S1 and L1L5), vertebral bodies and intervertebral discs were compared, considering gender and age. For the study of age bias, two groups were constituted, one consisting of individuals whose ages ranged from 18 to 30 years old (n=207), and the other with individuals whose ages ranged from 31 to 50 years old (n=143).

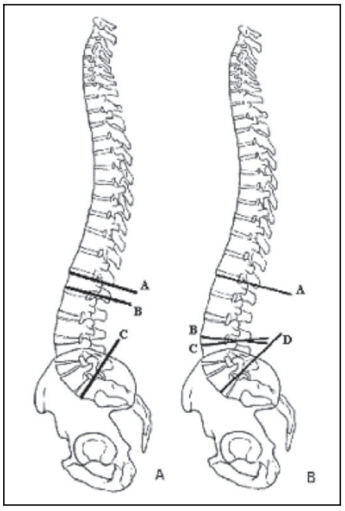

Figure 1 - *Schematic illustration of measurements performed in the study. A: representation of lumbosacral curvature measurement (angle between lines A and C) and vertebral body L1 angle measurement (lines A and B). B: representation of lumbolumbar curvature measurement (angle between lines A and D) and intervertebral disc L3-L4 angle measurement (lines B and C).*

	Mean Angle (°)	Standard Deviation	Range (°)	% participation in curvature L1S1 (range)
L1	2.15 *	3.25	14.0 to -9.0	-3.86 (-22.58 to 15,0)
L2	-0.36 *	3.0	7.0 to -8.0	0.22 (-13.46 to 14.29)
L3	-1.56 *	2.93	8.0 to -10.0	2.37 (-12.12 to 14.08)
L4	-2.89 *	3.08	4.0 to -14.0	4.55 (-10.81 to 22.58)
L5	-9.23 *	3.59	0.0 to -19.0	15.34 (0.00 to 33.33)

(*) Averages different from each other with p<0.001

Table 1 - *Vertebral bodies' measurements and participation percent in lumbosacral curvature.*

	Mean Angle (°)	Standard Deviation	Range (°)	% participation in curvature L1S1 (range)
L1-L2	-4.99 *	2.9	4.0 to -12.0	8.16 (-8.57 to 24.00)
L2-L3	-6.89 *	2.73	0.0 to -15.0	11.35 (0.00 to 27.27)
L3-L4	-9.25 *	2.54	-2.0 to -20.0	15.38 (3.03 to 30.95)
L4-L5	-12.29 *	3.39	-2.0 to -26.0	20.43 (3.81 to 42.86)
L5-S1	-15,58 *	5,43	-4,0 a -35,0	26,07 (5,80 a 56,52)

(*)Averages different from each other with p<0.001

Tabela 2 - *Intervertebral discs measurements*

Measurements were assessed for distribution normality by means of Kolmogorov-Smirnov's test. The evaluation of variances homogeneity was performed by means of Levine's test. Comparisons between groups were performed by means of variance analysis (followed by *Student-Newman-Keus – SNK test) or Student's t-test* whenever applicable. When data distribution was not normal in the groups, or when variances were not homogenous, comparisons were made by means of Kruskal-Wallis' test, Friedman's test or Mann-Whitney's test whenever applicable. We considered p<0.05 as indicative of significance.

Measurements reproducibility was assessed in a subgroup of twenty X-ray images, in which studied parameters were assessed by means of intra-class correlation coefficient (ICC). Measurements reliability was also assessed by means of comparisons between measurements achieved for lumbar curvatures and values obtained from the summation of their components (vertebral bodies and intervertebral discs), compared by Pearson's correlation test, considering p<0.05 as indicative of significance.

	Age	Sample	Average (°)	Standard Deviation	Range (°)	Significance
Curvature L1S1	Group 1	207	-59.33	10.57	-33.0 to -88.0	p<0.001 *
	Group 2	143	-63.19	10.38	-34.0 to -89.0	
Curvature L1L5	Group 1	207	-43.39	10.93	-15.0 to -78.0	p<0.0001 *
	Group 2	143	-47.57	10.14	-21.0 to -77.0	
L1	Group 1	207	2.32	3.10	14.0 to -9.0	p=0.279
	Group 2	143	1.92	3.46	11.0 to -9.0	
L2	Group 1	207	0.019	2.96	7.0 to -8.0	p=0.008 *
	Group 2	143	-0.9161	2.99	7.0 to -8.0	
L3	Group 1	207	-1.40	3.04	8.0 to -10.0	p=0.265
	Group 2	143	-1.80	2.78	5.0 to -10.0	
L4	Group 1	207	-2.71	3.04	4.0 to -11.0	p=0.228
	Group 2	143	-3.16	3.12	4.0 to -14.0	
L5	Group 1	207	-8.88	3.47	0.0 to -18.0	p=0.042 *
	Group 2	143	-9.74	3.70	-2.0 to -19.0	
L1-L2	Group 1	207	-5.02	2.92	3.0 to -12.0	p=0.829
	Group 2	143	-4.94	2.87	4.0 to -11.0	
L2-L3	Group 1	207	-6.79	2.78	0.0 to -14.0	p=0.413
	Group 2	143	-7.03	2.67	-1.0 to -15.0	
L3-L4	Group 1	207	-8.97	2.62	-2.0 to -20.0	p=0.008 *
	Group 2	143	-9.65	2.38	-3.0 to -15.0	
L4-L5	Group 1	207	-12.23	3.40	-3.0 to -26.0	p=0.423
	Group 2	143	-12.38	3.39	-2.0 to -21.0	
L5-S1	Group 1	207	-15.56	5.54	-4.0 to -35.0	p=0.879
	Group 2	143	-15.62	5.28	-5.0 to -30.0	

Group 1 – ages between 18 and 30 years old; Group 2 – ages between 31 and 50 years old. * Significant difference.

Table 3 - *Angle values for lumbosacral, lumbolumbar, vertebral bodies, and intervertebral discs curvatures in both age groups.*

RESULTS

The values obtained for lumbosacral curvature measurements (L1S1) ranged from –33.0° to –89.0° (average –60.9° ± 10.65). The values for lumbolumbar curvature (L1L5) ranged from –15.0° to –78.0° (average –45.1° ± 10.8). Vertebral bodies showed kyphotic bent in L1, tended to neural in L2, and then showed progressive lordotic bent, with a statistically significant difference between measurements (Table 1). Intervertebral discs showed progressive lordotic bent from L1-L2 to L5-S1, also showing statistically

significant differences between values (Table 2).

Vertebral bodies, as well as intervertebral discs, presented a progressively more lordotic participation on head-tail direction of the lumbosacral curvature. The only lumbar curvature element presenting medium kyphotic participation was the vertebral body L1 (negative percent participation). It was observed that the percent participation range for vertebral bodies L1 to L4, as well as for intervertebral disc L1-L2 showed negative percent values in some individuals (Tables 1 and 2). That observation is attributed to the finding of individuals presenting kyphotic bent in those vertebral bodies and intervertebral discs. It was observed that only vertebral body L5 and intervertebral discs L2-L3 to L5-S1 showed lordotic bent in all individuals.

	Gender	Sample	Average	Standard Deviation	Range	Significance
Curvature L1L5	male	143	-43.02	10.77	-15.0 to -78.0	p=0.003*
	female	207	-46.53	10.61	-20.0 to -77.0	
Curvature L1S1	male	143	-59.3	10.74	-33.0 to -88.0	p=0.019*
	female	207	-62.01	10.46	-33.0 to -89.0	
L1	male	143	2.45	3.36	14.0 to -9.0	p=0.213
	female	207	1.95	3.17	11.0 to -9.0	
L2	male	143	0.06	2.83	7.0 to -7.0	p=0.035*
	female	207	-0.65	3.09	7.0 to -8.0	
L3	male	143	-1.2	3.02	8.0 to -10.0	p=0.052
	female	207	-1.82	2.86	5.0 to -10.0	
L4	male	143	-2.4	2.84	4.0 to -11.0	p=0.013*
	female	207	-3.23	3.2	4.0 to -14.0	
L5	male	143	-8.81	3.67	0.0 to -19.0	p=0.069
	female	207	-9.52	3.51	-1.0 to -19.0	
L1-L2	male	143	-5.07	3.13	3.0 to -12.0	p=0.748
	female	207	-4.93	2.73	4.0 to -12.0	
L2-L3	male	143	-7.2	2.68	0.0 to -15.0	p=0.104
	female	207	-6.67	2.75	0.0 to -13.0	
L3-L4	male	143	-9.14	2.71	-2.0 to -20.0	p=0.404
	female	207	-9.33	2.43	-3.0 to -15.0	
L4-L5	male	143	-12.33	3.5	-3.0 to -26.0	p=0.958
	female	207	-12.27	3.32	-2.0 to -21.0	
L5-S1	male	143	-15.75	5.05	-5.0 to -27.0	p=0.57
	female	207	-15.47	5.68	-4.0 to -35.0	

Table 4 - *Comparison of lumbar curvatures, vertebral bodies and intervertebral discs between individuals of different genders.*

The comparison of both subjects groups according to age group showed a statistically significant difference between lumbosacral curvature measurements ($p<0.01$) and lumbolumbar curvature measurements ($p<0.001$) (Table 3). Only the angle values for vertebral bodies L2 and L5 and for intervertebral disc L2-L3 showed a statistically significant difference (Table 3).

Lumbosacral and lumbolumbar curvatures measurements showed statistically significant differences between male and female subjects. A statistically significant difference was also seen between the measurements for vertebral bodies L2 and L4. No statistically significant difference was found between angle values for intervertebral discs (Table 4).

The assessment of male subjects as a separate subgroup showed no statistically significant difference between values for lumbosacral curvature, lumbolumbar curvature, vertebral bodies, or intervertebral discs among individuals within both age groups studied (Figures 2 and 3).

The assessment of female subjects divided into both age groups showed a statistically significant difference between measurements for lumbosacral curvature, lumbolumbar curvature and vertebral body L5. There was no significant difference between values for other vertebral bodies and intervertebral discs (Figures 4 and 5).

The results of reliability tests showed a good reliability between intra- and inter-observer measurements for studied parameters (Table 5), showing an acceptable consistency between measurements.

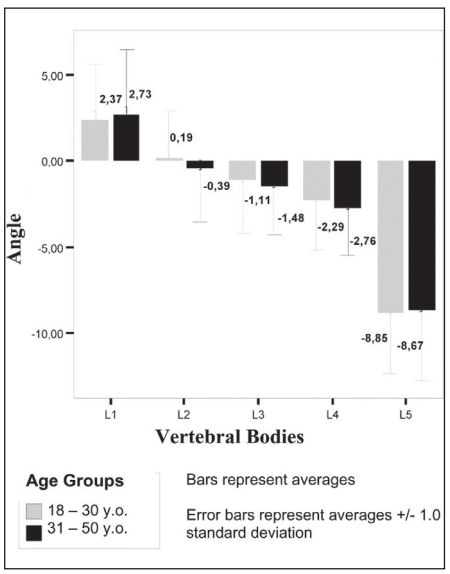

Figure 2 - *Angle measurement values or vertebral bodies in male subjects according to age.*

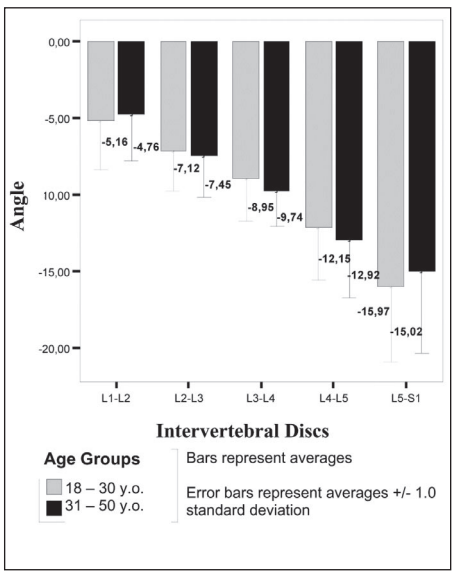

Figure 3 - *Angle measurement values or intervertebral discs in male subjects according to age.*

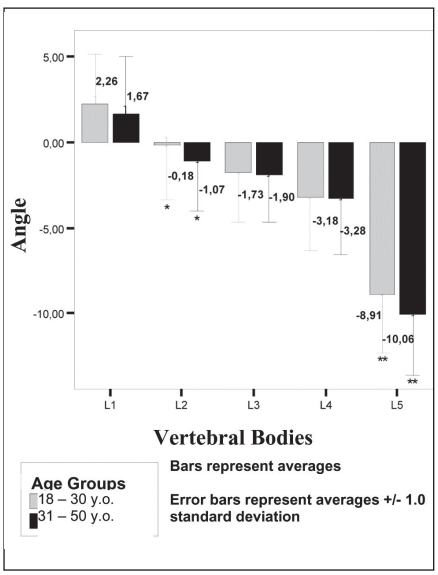

Figure 4 - *Angle measurement values for vertebral bodies in female subjects according to age.*

Another method employed for assessing the reliability of performed measurements was the comparison between angle values measured on lumbosacral curvature (L1S1) and values found by the sum of angle measurements for vertebral bodies and intervertebral discs, which are integral part of the lumbosacral curvature. Measurements found for lumbosacral curvature ranged from –33° to –89° (average –60.9° ± 10.65) for measurements of the sum of vertebral bodies and intervertebral discs ranged from –31° to –89° (average –60.9° ± 10.78), with a correlation of 0.98 (Pearson $p<0.0001$), showing an almost perfect correlation.

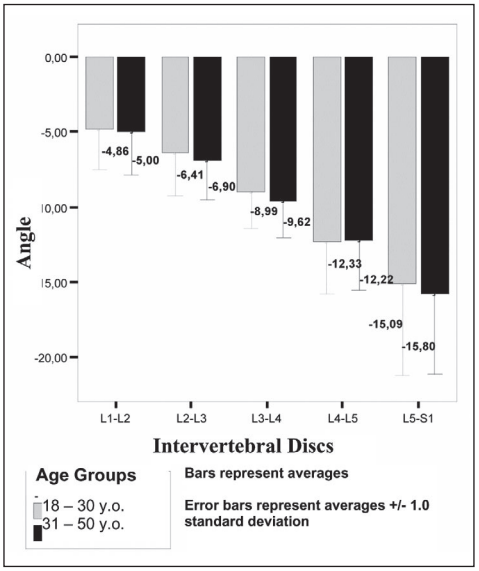

Figure 5 - *Angle measurement values for intervertebral discs in female subjects according to age.*

DISCUSSION

Physiological spinal curvatures occur as a result of the trapezoidal shape of vertebral bodies and intervertebral discs [4]. Literature described numerous ways to measure lumbar curvature[5-9]. In our study, we assessed lumbar lordosis measurement considering two different methods: the lumbosacral curvature measurement and the lumbolumbar curvature measurement [10]. Those curvatures are different from each other only for the presence of L5-S1 disc. With the purpose of better describing lumbar curvature features, we also studied vertebral bodies and intervertebral discs measurements, which constitute the lumbar curvature. Harrison et al.[11] compared the different lumbar lordosis measurement methods and concluded that the reliability and relative uncertainty degree were similar to each other. In this study, we used a modified Cobb's method, because of the ease and speed in measuring lumbar curvatures, achieving an excellent reliability in measuring lumbar curvatures and their components with this method.

Lumbar lordosis measurement shows a great variation between asymptomatic individuals. Jackson and McManus[12] described values ranging from -31° to -88° for lumbosacral curvature, and Guigui et al.[13] described values ranging from -13.6° to -69° for lumbolumbar curvature. The observed values similar to other authors' when the same age group was evaluated (Table 6).

We measured vertebral bodies and intervertebral discs angles individually, which have been poorly mentioned in literature, and we noticed that the values mentioned by other authors are similar to ours (Table 7). Vertebral bodies showed kyphotic bent in L1; tended to neutral in L2; and showed lordosis bent from L3 on. This trend to a higher participation towards tail segments was also described by Gelb et al.[1]. Those very authors also reported that the thoracolumbar segment tends to be straight, because this is a transition area between thoracic kyphotic curvature and lumbar lordotic curvature. This transition may explain our findings of kyphotic participation of the vertebral body L1. Intervertebral discs presented progressive lordotic bent at the head-tail direction, similar to those observed by other authors (Table 7).

Many methods have been described for assessing segments of the lumbar curvature. Some authors consider lumbar segment as the one composed by a vertebral body and its subjacent intervertebral disc; others consider it as the segment composed by two vertebra bodies and the intervertebral disc interposed to them[1,2, 12-15,18-22,].

We performed the summation of vertebral bodies and intervertebral discs measurements to compare our findings to those of other authors who assessed vertebral segments' angles measurements. A similarity was found between values described in literature and those that may be assumed in our study (Table 8).

Percent participation of intervertebral discs and vertebral bodies on lumbosacral curvature has also increased at head-

	OBSERVER 1		OBSERVER 2		INTER-OBSERVERS	
	CCIntraclasses (95%)	α	CCIntraclasses (95%)	α	CCInterclasses (95%)	α
Curvature L1S1	0.9624 (0.9105 - 0.9845)	0.0000	0.8069 (-0.0535 – 0.9533)	0.0000	0.9773 (0.8941 – 0.9926)	0.0000
Curvature L1L5	0.9650 (0.9169 - 0.9856)	0.0000	0.8619 (-0.321 – 0.9685)	0.0000	0.9839 (0.9280 – 0.9946)	0.0000
L1	0.6572 (0.3178 - 0.846)	0.0006	0.6513 (0.3144 – 0.8423)	0.0006	0.9306 (0.8650 – 0.9688)	0.0000
L2	0.7236 (0.4355 - 0.8776)	0.0001	0.7383 (0.4599 – 0.8847)	0.0001	0.9483 (0.8997 – 0.9767)	0.0000
L3	0.6739 (0.3616 - 0.8522)	0.0002	0.6831 (0.3735 – 0.8572)	0.0002	0.9359 (0.8762 - 0.9711)	0.0000
L4	0.7515 (0.4778 - 0.8916)	0.0000	0.7123 (0.3573 – 0.8787)	0.0000	0.9472 (0.8918 – 0.9768)	0.0000
L5	0.6493 (0.1786 - 0.8575)	0.0000	0.5518 (-0.0607 – 0.8313)	0.0000	0.9081 (0.7374 – 0.964999)	0.0000
L1-L2	0.7496 (0.4831 - 0.8897)	0.0000	0.7495 (0.4757 – 0.8905)	0.0000	0.9253 (0.9076 – 0.9785)	0.0000
L2-L3	0.7883 (0.5542 - 0.9077)	0.0000	0.6743 (0.2016 – 0.8706)	0.0000	0.9456 (0.8819 - 0.9767)	0.0000
L3-L4	0.7845 (0.5441 - 0.9063)	0.0000	0.8033 (0.5819 – 0.9147)	0.0000	0.9614 (0.9251 – .,9826)	0.0000
L4-L5	0.6365 (0.2904 - 0.8350)	0.0003	0.6929 (0.3796 – 0.8632)	0.0002	0.9319 (0.8678 – 0.9694)	0.0000
L5-S1	0.6863 (0.3657 - 0.8603)	0.0003	0.5994 (0.2119 – 0.8192)	0.0005	0.9253 (0.8528 – 0.9666)	0.0000

α – significance. CCI between 0.4 and 0.75 – reliability: fair to good; CCI above 0.75 = excellent reliability.

Table 5 - *Interclass correlation coefficient intra- and inter-observers for lumbar, vertebral bodies, and intervertebral discs curvature measurements.*

tail direction (Tables 1 and 2). Due to a kyphotic bent, L1 body has a negative participation on lumbosacral curvature. Lumbosacral curvature components with the highest level of participation were discs located at the most caudal portion - the L4-L5 and L5-S1 discs - both contributing to more than 40% of the lumbosacral curvature. If L5 body is included, more than 60% of the lumbosacral curvature occurs at that distal portion of the curvature. Other authors found the same participation level of caudal segments at lumbar curvature[1,12,24,25].

Lumbar curvature	Damasceno et al.	Jackson and McManus, 1994[12]	Jackson et al., 1998[14]	Korovesis et al., 1998[15]	Cheng et al., 1998[6]	Tüzin et al., 1999[16]	Tsuji et al., 2001[17]	Guigui et al., 2003[13]
	n=350	n=100	n=50	n=99	n=387	n=150	n=489	n=250
L1S1	-60.9° (-33 to –89)	-60.9° (-31 to –88)	-62.1° (-41 to –86)				-54.2°	-59°
L1L5	-45.1° (-15 to -78)			-45.7°	-41.95°	-45.85°		-43° (-13.6 to –69)

Table 6 - *Lumbar lordosis measurement values found in this study and those described in literature by other authors.*

	Damasceno et al..	Stagnara et al., 1982[2]	Wambolt and Spencer, 1987 [23]	Guigui et al., 2003 [13]	Vialle et al., 2005 [22]
Sample	n=350	n=100	n=50	n=250	n=300
L1	2.15° (14 to –9)	5° (12 to –3)	3°	4°	9.8°
L2	-0.36° (7 to –8)	3° (11 to –5)	1°	1.25°	1.2°
L3	-1.56° (8 to –10)	1° (10 to –7)	-2°	-0.52°	-0.6°
L4	-2.89° (4 to –14)	-1° (8 to –10)	-4°	-2.65°	-2.6°
L5	-9.23° (0 to –19)	-8° (5 to –27)	-10°	-8°	-8°
L1-L2	-4.99° (4 to –12)	-8° *	-6°	-5.6° *	4.55° *
L2-L3	-6.89° (0 to –15)	-10° *	-7°	-7.9° *	5.4° *
L3-L4	-9.25° (-2 to –20)	-10° *	-9°	-9.7° *	9.8° *
L4-L5	-12.29° (-2 to –26)	-14° *	-11°	-14° *	14° *
L5-S1	-15.58° (-4 to –35)	-13° *	-11°	-16° *	15.3° *

* measurement values for intervertebral discs assumed from measurements of vertebral segments, because they were not shown in the original study.

Table 7 - *Vertebral bodies and intervertebral discs measurements found in this study and those described by other authors.*

We found a significant difference at lumbosacral and lumbolumbar curvatures measurements between genders, of about 4°. Fernand and Fox[10] found lumbar curvature measurements (upperL2lowerS1) of – 43.25° in men and -47.19° in women. Amonoo-Kuofi[26] evaluated lumbar lordosis (upperL1upperS1) in a number of age groups and in all of them measurements were higher for females. Guigui et al.[13] also found a difference between genders for lumbosacral lordosis measurements (5.5°) and maximum lordosis (3.6°), with women showing greater curvatures. However, Gellb et al.[1] did not observe differences between curvatures measurements in both genders, but did observed differences between segments at the middle curvature (L2L3, L3L4, and L4L5) with women showing higher values compared to men. In our study, we saw higher average values in females for vertebral bodies' measurements, with a significant difference between vertebral bodies L2 and L4. But for intervertebral discs measurements, we found men showing slightly greater measurements for the majority of intervertebral discs, although not showing a significant difference. We couldn't find in literature similar findings by other authors, because those who performed vertebral bodies measurements have not compared genders[2,13,23]. It seems that there is a biological difference leading women to show a greater angle in some lumbar curvature components, but more rigorous anthropometric studies are required for coming to that conclusion, because our results may be correlated to sample variation.

We observed significant differences between age-related lumbar curvatures measurements, with older individuals showing higher values. Some authors also evaluating individuals in wide age groups [13,16,17,25,] described an increased age-related lumbar curvature when compared to adult individuals. We noticed that, in general, measurements of all lumbar curvature components showed higher average values in the older individuals subgroup compared to the younger ones, however, we found significant differences only for vertebral bodies L2 and L5 and intervertebral disc L2-L3. Guigui et al.[13] observed a correlation between lumbar curvature and age when individuals of both genders were studied in conjunction, but this correlation became inexistent when male and female individuals were studied separately.

	Damasceno et al..	Stagnara et al.., 1982[20].	Jackson and McManus, 1994[14].	Gelb et al.., 1995[6].	Jackson et al.., 1998[15].	Vedantan et al.., 1998[24].	Guigui et al.., 2003[9].	Hammerberg and Wood, 2003[10].
Sample	n=250	n=100	n=200		n=50	n=88	n=250	n=100
ASL1	-2.8		-1.7		1.9			-3.4
ASL2	-7.2		-7.0		-7.2			-6.6
ASL3	-10.8		-11.3		-12.0			-10.0
ASL4	-15.2		-16.5		-17.0			-13.1
ASL5	-24.8	-21.0	-24.6		-24.0			-24.4
MSL12	-3.2	0.0		-4.0		-4.0	-0.33	
MSL23	-8.8	-6.0		-10.0		-9.0	-7.2	
MSL34	-13.7	-12.0		-14.0		-13.0	-12.9	
MSL45	-24.4	-21.0		-24.0		-20.0	-24.6	
MSL51	-24.8			-24.0		-25.0	-24.0	

AS (angular segment): segment constituted of vertebral body and subjacent intervertebral disc. MS (motor segment): segment constituted of adjacent vertebral bodies and intervertebral disc.

Table 8 - *Vertebral segments values found in this study and those described in literature*

By assessing male subjects separately, we found that the differences between lumbar curvature measurements and its components' at the different age groups were subtler, with no significant difference being found. By assessing female subjects separately, we observed the occurrence of a significant difference between lumbar curvature measurements and that some components tended to show higher values in the older subjects subgroup, with a significant difference being found between measurements for vertebral bodies L2 and L5. Probably, those differences seen in different age groups from the initial group are due to women's participation in this group, but our data are not enough to explain the cause of differences found between lumbosacral curvature's components, which are higher for older women. We consider that those differences on body and intervertebral disc bending may be the result of spondylosis occurrence or due to a sample finding.

CONCLUSIONS

The measurement of lumbar lordosis, as well as of its components (vertebral bodies and intervertebral discs) showed a high variation in studied subjects. There was a progressive increase of percent participation of more caudal elements of the lumbosacral curvature, with distal segment constituted of vertebral body L5 and intervertebral discs L4-L5 and L5-S1 accounting for 60% of lumbar curvature magnitude. Differences were seen between measurements for lumbar curvature between genders, and those differences seem to be related to differences between measurements for lumbar curvatures' components. We observed the occurrence of differences between lumbar curvatures measurements and for some of their components in individuals belonging to different age groups, with older individuals showing higher values. Those differences observed seem to be a result of women's participation in the study, since no significant difference was found between men belonging to different age groups, but just in women belonging to different age groups.

REFERENCES

1. Gelb DE, Lenke LG, Bridwell KH, Blanke K, McEnery KW. An analysis of sagittal spinal alignment in 100 asymptomatic middle and older aged vonluteers. Spine. 1995; 20:1351-8.
2. Stagnara P, De Mauroy JC, Dran G, Gonon GP, Costanzo G, Dimnet J et al. Reciprocal angulation of vertebral bodies in a sagittal plane: approach to references for the evaluation of kyphosis and lordosis. Spine. 1982; 7:335-42.
3. Panjabi MM, White III AA, Brand Jr RA. A note on defining body parts configurations. J Biomech.1974; 7:385-7.
4. Kuslich SD. Surgical treatment of lumbar degenerative disc disease: axial low back pain. In: Vacaro AR, Betz RR, Zeidman SM editors. Principles and practice of Spine. surgery: Philadelphia: Mosby; 2003. p.365-75.
5. Chen Y. Vertebral Centroid Measurement of lumbar lordosis compared with the Cobb technique. Spine. 1999; 24:1786-90.
6. Cheng XG, Sum Y, Boonen S, Nicholson PHF, Brys P, Dequeker J et al. Measurements of vertebral shape by radiographic morphometry: sex differences and relationships with vertebral level and lumbar lordosis. Skeletal Radiol. 1998; 27:380-74.
7. Chernukha KV, Daffner RH, Reigel DH. Lumbar lordosis measurement: a new method *versus* Cobb technique. Spine. 1998; 23:74-80.
8. Harrison DD, Cailliet R, Janik, TJ, Troyanovich S, Harrison DE, Holland B. Elliptical modeling of the sagittal lumbar lordosis and segmental rotation angles as a method to discriminate between normal and low back pain subjects. Spine. 1998; 11:430-9.
9. Troyanovich SJ, Cailliet R, Janik TJ, Harrison DD, Harrison DE. Radiographic mensuration characteristics of the sagittal lumbar Spine. from a normal population with a method to synthesize prior studies of lordosis. J Spinal Dis. 1997; 10:380-6.
10. Fernand R, Fox DE. Evaluation of lumbar lordosis: a prospective and retrospective study. Spine. 1985;10:799-803.
11. Harrison DE, Harrison DD, Cailliet R, Janik TJ, Holland B. Radiographic analysis of lumbar lordosis – Centroid, Cobb, TRALL, and Harisson posterior tangent methods. Spine. 2001; 26:E235-E242.
12 - Jackson RP, McManus AC. Radiographic analysis of sagittal plane alignment and balance in standing volunteers and patients with low back pain matched for age, sex, and size: a prospective controlled clinical study. Spine. 1994; 19:1611-8.
13. Guigui P, Levassor N, Rillardon L, Wodecki P, Cardine L. Valeur physiologique des paramètres pelviens et rachidiens de l'equilibre sagital du rachis – analyse d'une série de 250 volontaires. Rev Chir Orthop. 2003; 89:496-506.
14. Jackson RP, Peterson MD, McManus AC, Hales C. Compensatory spinopelvic balance over the hip axis and better reliability in measuring lordosis to the pelvic radius on standing lateral radiographs of adult volunteers and patients. Spine. 1998; 23:1750-67.
15. Korovessis PG, Stamatakis MV, Baikousis AG. Reciprocal angulation of vertebral bodies in the sagittal plane in an asymptomatic Greek population. Spine. 1998; 23:700-5.
16. Tüzün C, Yorulmaz I, Cindas A, Vatan S. Low back pain and posture. Clin Rheum. 1999; 18:308-12.
17. Tsuji T, Matsuyama Y, Sato K, Hasegawa Y, Yimin Y, Iwata H. Epidemiology of low back pain in the elderly: correlation with lumbar lordosis. J Orthop Sci. 2001; 6:307-11.
18. Cil A, Yazici M, Uzumcugil, Kandemir U, Alanay A, Acaroglu E et al. The evolution of sagittal segmental aligniment of the spine during childhood. Spine. 2005; 30:93-100.
19. Hammerberg EM, Wood KB. Sagital profile of the elderly. J Spinal Dis Tech. 2003; 16:44-50.
20. Jackson RP, Kanemura T, Kawakami N, Hales C. Lumbopelvic lordosis and pelvic balance on repeated standing lateral radiographs of adult volunteers and untreated patients with constant low back pain. Spine. 2000; 25:575-86.
21. Vedantam R, Lenke LG, Keeney JA, Bridwell KH. Comparison of standing sagittal spinal alignment in asymptomatic adolescents and adults. Spine.1998; 23:211-5.
22 . Vialle R, Levassor N, Rillardon L, Templier A, Skalli W, Guigui P. Radiographic analysis of the sagittal alignment and balance of the spine in asymptomatic subjects. J Bone Joint Surg Am. 2005; 87:260-7.
23. Wambolt A, Spencer DL. Analyses of the distribution of the lumbar lordosis in the normal Spine. Orthop Trans. 1987; 11:92-3.
24. Bernhardt M, Bridwell KH. Segmental analysis of the sagittal plane alignment of the normal thoracic and lumbar spine and thoracolumbar junction. Spine. 1989; 14:717-21.
25. Korovesis P, Stamatakis M, Baikousis A. Segmental roentgenographic analysis of vertebral inclination on sagittal plane in asymptomatic versus chronic low back pain patient. J Spinal Dis. 1999; 12:131-7.
26. Amonoo-Kuofi HS. Changes in the lumbosacral angle, sacral inclination and the curvature of the lumbar Spine. during aging. Acta Anat.1992; 145:373-7.