Effect of Aging and Lumbar Spondylosis on Lumbar Lordosis

Francis Osita Okpala
Department of Radiology, Federal Teaching Hospital Abakaliki, Abakaliki, Ebonyi State, Nigeria

Abstract

Background: Lumbar lordosis (LL), the anterior convexity of the lumbar spine in the mid-sagittal plane, gives the spine some resilience and helps in protecting it from compressive forces because some of the force is taken by the anterior longitudinal ligaments. In aging and lumbar spondylosis, the intervertebral discs undergo the same degenerative changes though at different rates, and in both, while some authors reported a straightening of LL, others reported no significant change. This morphologic information would hopefully influence therapeutic decision-making, particularly in lumbar spondylosis, which though usually asymptomatic, is a common cause of low back pain. **Aim:** The aim of the study was to investigate the effect of aging and lumbar spondylosis on LL. **Subjects and Methods:** Lumbosacral joint angle (LSJA), an angular measure of LL, was retrospectively measured in 252 normal and 329 spondylotic adolescent and adult supine lateral lumbosacral spine archival radiographs, and data were analyzed with IBM SPSS Statistics 23.0 (New York, USA). **Results:** Normal LSJA range was 5°–39°; the mean was 18.7° and showed insignificant variation with gender and aging. Spondylotic range was 5°–40° and the mean (20.8°) differed from the normal mean by about 2°, which probably have inconsequential effect on the lumbar curvature, suggesting that the normal and spondylotic mean values are essentially equal. The spondylotic mean also showed insignificant variation with aging and inconsequential 1° gender difference in favor of females. **Conclusion:** LL is substantially maintained in aging and lumbar spondylosis.

Keyword: Aging, change, lumbar lordosis, lumbar spondylosis

Introduction

Lumbar lordosis (LL), the anterior convexity of the lumbar spine in the midsagittal plane,[1] gives the spine some resilience and helps in protecting it from compressive forces because some of the force is taken by the anterior longitudinal ligaments.[2] Although it can be measured by radiographic and nonradiographic (e.g., goniometry,[3] flexible rulers,[4] software,[5] spinal mouse,[6] spinal pantograph,[7] and inclinometer[8]) methods, a supine lateral lumbosacral spine radiograph accurately measures LL, and this radiographic method is still the gold standard.[9-11]

The reported factors that may influence the degree of LL include sex, age, position (recumbent, sitting, and standing), footwear (i.e., high-heeled shoes), and pathological disorders (e.g., muscle spasm or pain and mechanical joint lesions such as lumbar spondylosis).[2,12] Aging and lumbar spondylosis are two very similar processes involving the degeneration of intervertebral disc (IVD) though at different rates;[13] aging discs, and degenerative discs have the same low water and proteoglycan content.[14] Due to the similarity in the pathological changes in the lumbar IVD in aging and degenerative disc disease, this study was designed to assess the possible effect of aging and lumbar spondylosis on the degree of LL.

Some authors have reported that, in old age, the LL often becomes flattened (i.e., straightened),[2,12] while some reported no significant variation.[15] In lumbar spondylosis, a flattening of the LL has also been reported by some authors,[16] while some reported no significant variation.[17] Therefore, whether the LL flattens with aging, and with lumbar spondylosis, is debatable.

The aim of this study was to investigate the effect of aging and lumbar spondylosis on LL; this morphologic information would hopefully influence therapeutic decision-making, particularly in lumbar spondylosis, which though usually asymptomatic, is a common cause of low back pain.[18,19]

Access this article online	
Quick Response Code:	**Website:** www.actamedicainternational.com
	DOI: 10.4103/ami.ami_64_17

Address for correspondence: Dr. Francis Osita Okpala, Department of Radiology, Federal Teaching Hospital Abakaliki, P.M.B 102 Abakaliki, Abakaliki, Ebonyi State, Nigeria. E-mail: frankokp@yahoo.com

How to cite this article: Okpala FO. Effect of aging and lumbar spondylosis on lumbar lordosis. Acta Med Int 2018;5:14-9.

Subjects and Methods

The archival lateral lumbosacral spine radiographs of 252 normal and 329 spondylotic adolescent and adult patients of two tertiary health institutions in the Southeastern part of Nigeria were retrospectively reviewed over a period of 5 years: 1996–2000. Ethical approval was obtained from one of them. The two institutions routinely take their lateral lumbar radiographs in supine position, using the standard radiographic imaging technique. Thus, in positioning for imaging, (i) patient would normally be laid in true lateral position in the center of the X-ray couch; (ii) head supported with a pillow; (iii) nonopaque sponge roll placed under the thoracolumbar spine (to make the long axis of the spine parallel to the film); (iv) arms raised to the head; (v) hips and knees flexed, and the legs placed comfortably using padding; and then, (vi) entire body immobilized. After positioning the patient, (a) anatomical marker would be inserted; (b) over-couch X-ray beam collimated and centered to the midline at the level of lower costal margin (corresponding to L3 spinous process), and the central X-ray vertical at 90° to the film; and then, (c) X-ray exposure done in arrested respiration using appropriate exposure factors.

Inclusion criteria were (a) patients aged 15 years and above (the choice of this age was to ensure that almost all have attained spinal maturity); (b) normal appearances [Figure 1]; and (c) signs of lumbar spondylosis. The signs were vertebral body osteophytosis (bony overgrowths especially at the anterior, lateral, and less commonly, posterior aspects of the superior and inferior margins of vertebral bodies)[19] as the only finding,[20] or in addition[16] with decreased IVD height, and subarticular sclerosis [Figure 2].[21-23] Radiographs showing additional pathologies (other than the lumbar spondylotic signs mentioned above) or belonging to patients <15 years of age were excluded from the study.

Patient's age, sex, and citizenship of Southeast region of Nigeria were recorded from the request form, usually enclosed in the film jacket. The radiographs were mounted on a well-illuminated viewing screen, measurement lines were drawn (using a pencil and a 30 cm long transparent ruler), and the lumbosacral joint angle (LSJA), one of the angular measures of LL, measured in degrees with a protractor. The LSJA is the angle formed by two lines; the first is across the plane of the inferior endplate of L_5 and the second line is across the superior endplate of S_1 [Figure 3].[2,24] All measurements were made by the author to avoid interobserver error and great effort was made to avoid repeating the measurement of any radiograph by documenting the patients' name, age, and sex with the recorded angles and also making a mark in the film jacket of all reviewed radiographs. Patients' names were, however, not revealed in the analyses.

The radiographs were grouped into age groups with a class interval size of 10. The age groups, in years, were (1) 11–20, (2) 21–30, (3) 31–40, (4) 41–50, (5) 51–60, (6) 61–70, (7) 71–80, and (8) 81–90. As determined by the data, in the normal group, the male age group stopped at Group 5, and the female at Group 6; in the spondylotic group, the male age group stopped at Group 8 and the female at Group 7.

Data were analyzed with SPSS (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.), and $P < 0.05$ was considered statistically significant. The statistical methods employed included mean, standard deviation, test of significance, and graphical display.

Results

The mean age (standard deviation) of 252 patients with normal radiographs was 35.0 (11.3) years (range = 15–69 years), while that of the 329 spondylotic patients was 52.1 (13.7) years (range = 17–90 years) [Table 1].

In the normal patients, the mean (standard deviation) of the LSJA was 18.7 (5.7)° (range = 5°–39°) and showed insignificant

Figure 1: Normal supine lateral lumbosacral spine plain radiograph showing normal vertebral bodies, intervertebral disc height, and posterior elements

Figure 2: Spondylotic supine lateral lumbosacral spine plain radiograph showing vertebral body osteophytes (anterior and posterior in L4 and L5), decreased L4/L5 intervertebral disc height, and subarticular sclerosis of adjacent L4/L5 vertebral bodies

Table 1: Mean age (male, female, and total) of the normal and spondylotic patients

Variable	*n*	Age (years)				Variance	*t*-test of mean age: Male versus female
		Minimum	Maximum	Mean	SD		
a. Normal male	122	15	59	33.84	10.5	109.9	a versus b: t=2.179, P=0.03, P<0.05
b. Normal female	130	15	69	36.11	11.9	140.9	
c. Normal total	252	15	69	35.01	11.3	126.6	
d. Spondylotic male	195	17	90	52.55	14.6	214.0	d versus e: t=−1.005, P=0.32, P>0.05
e. Spondylotic female	134	17	80	51.49	12.2	148.3	
f. Spondylotic total	329	17	90	52.12	13.7	187.0	

SD: Standard deviation

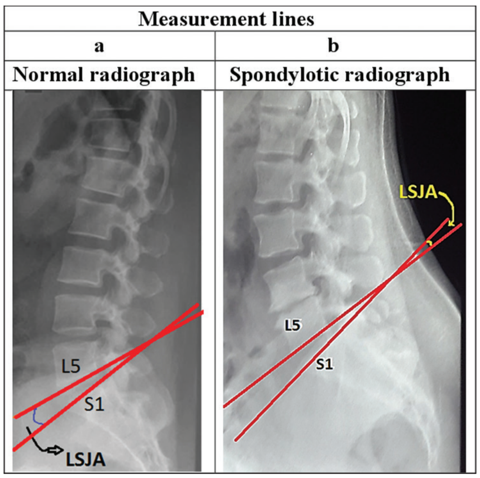

Figure 3: Lumbosacral joint angle measurement lines in normal (a) and spondylotic (b) supine lateral lumbosacral spine plain radiographs. The lumbosacral joint angle is the angle between a line across the plane of the inferior endplate of L5 and a second line across the superior endplate of S1

variation with gender (t = 1.354; P = 0.18) [Table 2] and age groups (i.e., aging) [Table 3 and Figure 4a, b].

In the spondylotic patients, the LSJA range was 5°–40°. The mean (standard deviation) was 20.8 (5.5)°, and this mean differed from the normal mean by only 2.1° (t = 6.767, P = 0.001) [Table 2 and Figure 5c]. Although this slight difference was statistically significant, the effect it will have in the degree of lumbar curvature is most probably inconsequential, suggesting that the normal and spondylotic mean values are essentially equal. The spondylotic mean also showed insignificant variation with age groups (i.e., aging) [Table 3 and Figure 4c, d] and inconsequential 1.1° gender difference in favor of females (t = 2.065; P = 0.04); the female was 21.4 (5.8)° and the male was 20.3 (5.2)° [Table 2].

Discussion

In this study, the mean LL showed an insignificant variation with aging [Table 3 and Figure 4a, b). This finding is similar to those of Murrie *et al*. (who measured the LL in supine lumbar spine Magnetic Resonance Images of Caucasians, in Cambridge, the United Kingdom)[15] and Okpala (who quantified the LL in supine lateral lumbar radiographs, using the lumbosacral angle (LSA), in a retrospective study in Nigeria).[25] This finding, however, contradicts the report by Schmorl and Junghanns (who reported flattening of LL in old age in Michigan, USA)[2] and Amonoo-Kuofi (who, in Saudi Arabia, used the LSA to measure the LL and reported that the LL varied steadily with age and showed a tendency to decrease after the sixth decade).[12] This contradiction might partly be due to the fact that, in the angular measurement of LL, investigators have used different parameters.

Furthermore, in spondylotic patients in the current study, the mean LL showed no significant variation with age groups (i.e., aging), just like what was observed in the normal patients [Table 3 and Figure 4c, d). This is probably due to the fact that lumbar spondylosis and aging are very similar processes involving the degeneration of the IVD though occurring at different rates.[13]

Furthermore, in this study, the mean LL of spondylotic patients differed from that of normal patients by about 2° [Table 2 and Figure 5a-c]. This very slight difference is, however, probably of little clinical importance because the effect it will have on the lumbar curvature is most probably inconsequential, suggesting that the normal and spondylotic values are essentially equivalent, and that, in lumbar spondylosis, the spine still significantly maintains its natural morphology of within-normal LL. This finding contradicts some literature reports, but it is in agreement with some others. It contradicts the report by Schafer,[16] Jackson and McManus,[26] and Harrison *et al*.,[27] all in the USA, who reported reduced LL in lumbar spondylosis. Jackson and McManus did a prospective study in erect position, using a variant of the Cobb method (L1–S1) in Missouri, while Harrison *et al*. did their study in erect position, using software to measure the LL by another variant of the Cobb method (T12–S1) and LSA method in Alabama. Perhaps the use of different parameters by these investigators might partly account for this contradiction.

On the other hand, the finding in this study that, in lumbar spondylosis, the spine still significantly maintains its natural morphology of within-normal LL is in agreement with the reports by Schmorl and Junghanns,[2] Papadakis *et al*.,[17] Lin *et al*.,[28] Łebkowski *et al*.,[29] Tüzün *et al*.,[30] and Esmailiejah *et al*.[31] The studies by these investigators involve different racial groups, different angular measures of LL, with some in erect posture, and some of the studies' prospective.

Table 2: Mean lumbosacral joint angle of the normal and spondylotic patients by gender

Variable	*n*	LSJA (°)				Variance	*t*-test of mean LSJA: Male versus female
		Minimum	Maximum	Mean	SD		
Normal male (1)	122	5	39	18.38	5.7	32.6	1 versus 2: t=5.277, P=0.001, P<0.05
Spondylotic male (2)	195	5	35	20.34	5.2	27.1	
Normal female (3)	130	5	37	19.05	5.6	31.5	3 versus 4: t=4.634, P=0.001, P<0.05
Spondylotic female (4)	134	8	40	21.38	5.8	34.0	
Normal total (5)	252	5	39	18.72	5.7	32.0	5 versus 6: t=6.767, P=0.001, P<0.05
Spondylotic total (6)	329	5	40	20.77	5.5	30.1	
Normal male (1)	122	5	39	18.38	5.7	32.6	1 versus 3: t=1.354, P=0.178, P>0.05
Normal female (3)	130	5	37	19.05	5.6	31.5	
Spondylotic male (2)	195	5	35	20.34	5.2	27.1	2 versus 4: t=2.065, P=0.041, P<0.05
Spondylotic female (4)	134	8	40	21.38	5.8	34.0	

SD: Standard deviation, LSJA: Lumbosacral joint angle

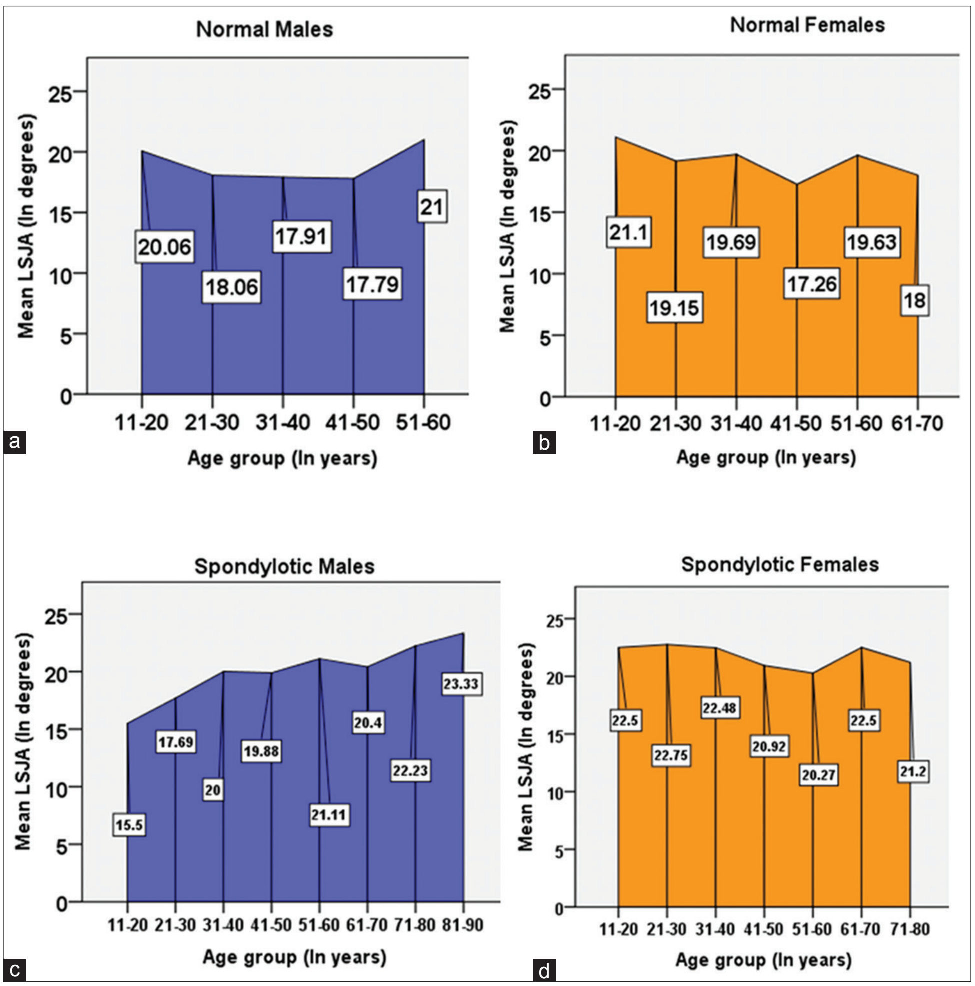

Figure 4: Variation of normal (a, b) and spondylotic (c, d) mean lumbosacral joint angles with age groups (i.e., aging).

Papadakis *et al*. did a cross-sectional study and used software to study the LL with the Cobb method in erect lateral lumbar radiographs of Greek females.[17] Lin *et al*. measured the lumbar lordotic angle, LSA, and sacral inclination angle in their study in Taiwanese adults.[28] Łebkowski *et al*. studied Polish adults with radiography.[29] Tüzün *et al*. used a variant of the Cobb (L1–S1) and LSA methods, in erect radiographs, in their prospective study in Turkey.[30] Esmailiejah *et al*. did a prospective study in Tehran, Iran, in erect posture, and the LSJA was one of the methods they used to evaluate the LL.[31] According to Schmorl and Junghanns, the curve of the lumbar spine gives it certain resilience and helps to protect the spine from compressive forces;[2] a flattened or straightened LL would, therefore, seem unnatural.

Table 3: Summary of *t*-tests (using Bonferroni correction) of mean lumbosacral joint angles (male, female, and total) by age groups (i.e., aging)

t-tests of mean LSJAs	Age group (years)							
	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90
Normal patients								
Male	20.06_a	18.06_a	17.91_a	17.79_a	21.00_a			
Female	21.10_b	19.15_b	19.69_b	17.26_b	19.63_b	18.00_b		
Total	20.44_c	18.68_c	18.75_c	17.51_c	20.21_c	18.00_c		
Spondylotic patients								
Male	15.50_d	17.69_d	20.00_d	19.88_d	21.11_d	20.40_d	22.23_d	23.33_d
Female	22.50_e	22.75_e	22.48_e	20.92_e	20.27_e	22.50_e	21.20_e	
Total	19.00_f	18.70_f	21.24_f	20.38_f	20.78_f	21.23_f	21.94_f	23.33_f

NB: Values in the same row and subtable sharing the same subscript are not significantly different at $P<0.05$

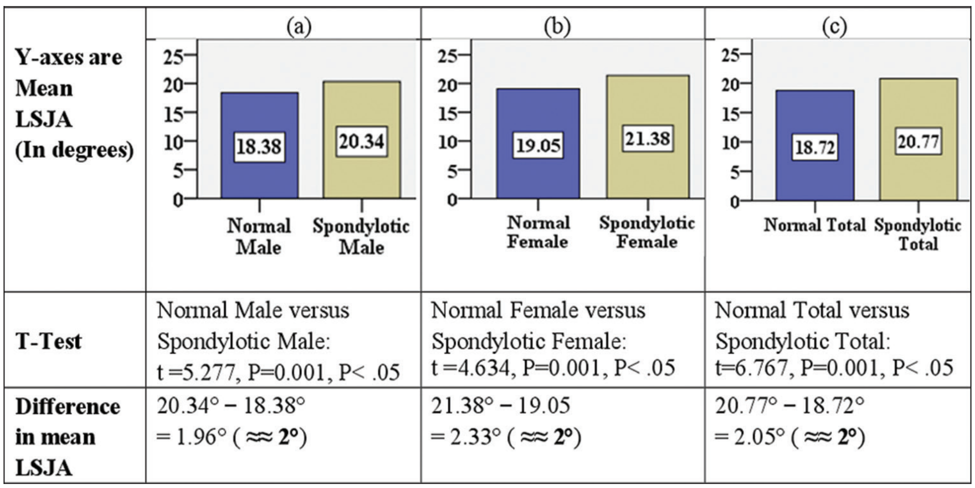

Figure 5: Normal versus spondylotic patients: *t*-test of mean lumbosacral joint angles according to gender (a=Males; b=Females; c=Total)

In this study, normal and spondylotic patients were not matched for age. Attainment of spinal maturity was the primary consideration in patients' selection. This is because the development of LL stops at spinal maturity, usually between 13 and 18 years.[25,32,33] Supine lateral lumbosacral spine radiographs were used in this study because it accurately measures LL and is still the gold standard;[9-11] furthermore, it has a standard radiographic imaging technique which guarantees the reproducibility of the spine curvature measurements. Therefore, the findings in this study that aging and lumbar spondylosis do not result in significant change in LL is most likely reliable. Although erect radiographs would have been preferable due to some concerns about posture and its possible effect on spine curvature, some authors have shown that the LL is not significantly different in the erect and recumbent positions.[25,34]

The limitations in this study include: (a) possible noninclusion of few normal patients (aged 13–14 years) that could have attained spinal maturity because the studied minimum age was 15 years and (b) few of the radiographs could have been taken in the erect position, though the two study centers routinely take their lateral lumbosacral spine radiographs in the supine position. In (a) and (b), however, the very small number of radiographs involved makes them statistically irrelevant. Furthermore, some authors have shown that the LL is not significantly different in the erect and recumbent positions.[34]

A prospective longitudinal study (with either the radiographic or magnetic resonance techniques) of two individual groups (normal aging and lumbar spondylosis) aged 15 years and above, with follow-up every 5–10 years until 90 years of age or death, whichever comes first, is recommended as further study.

Conclusion

The normal mean LL showed no significant change with aging, but in lumbar spondylosis, there was a very slight change of about 2°, which is probably of little clinical significance, suggesting that the normal and spondylotic mean values are essentially equal. Therefore, LL is significantly maintained in aging and lumbar spondylosis.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Bogduk N, Twomey LT. Clinical Anatomy of the Lumbar Spine. 2nd ed. New York: Churchill Livingstone; 1991. p. 45-7.
2. Schmorl G, Junghanns H. The Human Spine in Health and Disease. 2nd American ed. New York: Grune and Stratton; 1971. p. 43.
3. Burdett RG, Brown KE, Fall MP. Reliability and validity of four instruments for measuring lumbar spine and pelvic positions. Phys Ther 1986;66:677-84.
4. de Oliveira TS, Candotti CT, La Torre M, Pelinson PP, Furlanetto TS, Kutchak FM, *et al.* Validity and reproducibility of the measurements obtained using the flexicurve instrument to evaluate the angles of thoracic and lumbar curvatures of the spine in the sagittal plane. Rehabil Res Pract 2012;2012:186156.
5. Babai E, Khodamoradi A, Mosavi Z, Bahari S. An innovative software method for measuring lumbar lordosis. Ann Biol Res 2012;3:204-13.
6. López-Miñarro PA, Muyor JM, Belmonte F, Alacid F. Acute effects of hamstring stretching on sagittal spinal curvatures and pelvic tilt. J Hum Kinet 2012;31:69-78.
7. Willner S. Spinal pantograph – A non-invasive technique for describing kyphosis and lordosis in the thoraco-lumbar spine. Acta Orthop Scand 1981;52:525-9.
8. Macintyre NJ, Bennett L, Bonnyman AM, Stratford PW. Optimizing reliability of digital inclinometer and flexicurve ruler measures of spine curvatures in postmenopausal women with osteoporosis of the spine: An illustration of the use of generalizability theory. ISRN Rheumatol 2011;2011:571698.
9. Fernand R, Fox DE. Evaluation of lumbar lordosis. A prospective and retrospective study. Spine (Phila Pa 1976) 1985;10:799-803.
10. Vrtovec T, Pernus F, Likar B. A review of methods for quantitative evaluation of spinal curvature. Eur Spine J 2009;18:593-607.
11. Salisbury PJ, Porter RW. Measurement of lumbar sagittal mobility. A comparison of methods. Spine (Phila Pa 1976) 1987;12:190-3.
12. Amonoo-Kuofi HS. Changes in the lumbosacral angle, sacral inclination and the curvature of the lumbar spine during aging. Acta Anat (Basel) 1992;145:373-7.
13. Resnick D, Niwayama G. Degenerative Disease of the Spine. Philadelphia, Pa: Saunders; 1995. p. 1372-462.
14. Lipson SJ, Muir H. 1980 Volvo award in basic science. Proteoglycans in experimental intervertebral disc degeneration. Spine (Phila Pa 1976) 1981;6:194-210.
15. Murrie VL, Dixon AK, Hollingworth W, Wilson H, Doyle TA. Lumbar lordosis: Study of patients with and without low back pain. Clin Anat 2003;16:144-7.
16. Schafer RC. Lumbar and sacral areas. Symptomatology and Differential Diagnosis. Ch. 12. Available from: http://www.chiro.org/ACAPress/Lumbar_and_Sacral_Areas.html. [Last accessed on 2017 Oct 23].
17. Papadakis M, Papadokostakis G, Kampanis N, Sapkas G, Papadakis SA, Katonis P, *et al.* The association of spinal osteoarthritis with lumbar lordosis. BMC Musculoskelet Disord 2010;11:1.
18. Hesselink JR. Spine imaging: History, achievements, remaining frontiers. AJR Am J Roentgenol 1988;150:1223-9.
19. Medscape. Lumbar Spondylosis. Available from: http://www.emedicine.medscape.com/article/249036-overview#showall. [Last accessed on 2017 Oct 23].
20. van der Kraan PM, van den Berg WB. Osteophytes: Relevance and biology. Osteoarthritis Cartilage 2007;15:237-44.
21. Muraki S, Oka H, Akune T, Mabuchi A, En-Yo Y, Yoshida M, *et al.* Prevalence of radiographic lumbar spondylosis and its association with low back pain in elderly subjects of population-based cohorts: The ROAD study. Ann Rheum Dis 2009;68:1401-6.
22. Fardon DF, Milette PC; Combined Task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology. Nomenclature and classification of lumbar disc pathology. Recommendations of the Combined Task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology. Spine (Phila Pa 1976) 2001;26:E93-113.
23. Binder AI. Cervical spondylosis and neck pain. BMJ 2007;334:527-31.
24. Wiltse LL, Winter RB. Terminology and measurement of spondylolisthesis. J Bone Joint Surg Am 1983;65:768-72.
25. Okpala F. Measurement of lumbosacral angle in normal radiographs: A retrospective study in Southeast Nigeria. Ann Med Health Sci Res 2014;4:757-62.
26. 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 (Phila Pa 1976) 1994;19:1611-8.
27. Harrison DD, Cailliet R, Janik TJ, Troyanovich SJ, Harrison DE, Holland B, *et al.* Elliptical modeling of the sagittal lumbar lordosis and segmental rotation angles as a method to discriminate between normal and low back pain subjects. J Spinal Disord 1998;11:430-9.
28. Lin RM, Jou IM, Yu CY. Lumbar lordosis: Normal adults. J Formos Med Assoc 1992;91:329-33.
29. Łebkowski WJ, Łebkowska U, Niedźwiecka M, Dzieciol J. The radiological symptoms of lumbar disc herniation and degenerative changes of the lumbar intervertebral discs. Med Sci Monit 2004;10 Suppl 3:112-4.
30. Tüzün C, Yorulmaz I, Cindaş A, Vatan S. Low back pain and posture. Clin Rheumatol 1999;18:308-12.
31. Esmailiejah AA, Qoreishy M, Keipourfard A, Babaei S. Changes in lumbosacral angles in patients with chronic low back pain: A prospective study. Am J Med Case Rep 2017;5:163-5.
32. Oliver J, Middleditch A. Lumbar spine. In: Functional Anatomy of the Spine. Oxford: Butterworth-Heinemann; 1998. p. 36-58.
33. Chernukha KV, Daffner RH, Reigel DH. Lumbar lordosis measurement. A new method versus Cobb technique. Spine (Phila Pa 1976) 1998;23:74-9.
34. Bogduk N, Macintosh JE, Pearcy MJ. A universal model of the lumbar back muscles in the upright position. Spine (Phila Pa 1976) 1992;17:897-913.