

ORIGINAL ARTICLE

Correlations of Radiographic Findings in Patients with Low Back Pain

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ABSTRACT

Background: Low back pain can cause severe debilitating pain that may lead to loss of productivity. The pain is usually non-specific and imaging request protocols varies. However, physicians may order lumbo-sacral x-ray in the initial radiologic assessment of the patient. This study aims to determine the frequency of occurrence of radiographic findings in patients reporting low back pain including the presence of osteophytes, spondylolisthesis and degenerative disc diseases and determine the relationship with patients' features including age, sex, marital status, level of education, body mass index and other radiographic findings. **Method:** Patients who presented at our department for radiographic assessment of the lumbo-sacral spine were voluntarily recruited. Their radiographs were reviewed and questionnaire administered. Height and weight were measured. The radiographic findings were documented and data analysis using Chi square with significant level set at $p < 0.05$. **Result:** Lumbo-sacral x-rays of 337 patients were reviewed with more females than males, ratio 1:1.4. Osteophytes were demonstrable in 73.6%; spondylolisthesis, 13.4%; and disc degeneration, 28.2%. Disc degeneration correlated with age, educational status, osteophytosis, osteopenia and spondylolisthesis. Osteophytosis correlated with age, BMI and educational level. While spondylolisthesis correlated with educational level and sex. **Conclusion:** Osteophytosis was the commonest finding in patients presenting with LBP. Disc degeneration shows a strong association with osteophytosis and spondylolisthesis and it is reported to herald these changes. Radiography still shows some correlations between the findings in LBP and patients' characteristics.

KEY WORDS: Low Back Pain, spondylosis, osteophytosis, spondylolisthesis, radiographic findings.

INTRODUCTION

Low back pain (lumbago) is a common musculoskeletal disorder complaint that can originate from many spinal structures including ligaments, facet joints, the vertebral periosteum, the paravertebral musculature and fascia, blood vessels, the annulus fibrosus and spinal nerve root. The pain can be severe enough to cause debilitation. The incidence of LBP is such that over 80% of people will have complain of LBP over a life time.^{1,2,3} Non-specific LBP is the most common cause of LBP and is generally due to a sprain or strain in the muscle of the back and soft tissues. In Africa the average life-time prevalence of LBP among the adolescents was

36% and adult 62% while the mean LBP point prevalence among adolescents was 12% and adults 32%.⁴

The investigative management for LBP range from radiography, CT, MRI, myelography, radionuclide imaging. Other more invasive methods include epidural venography, vertebroplasty, discography, laser disk decompression, percutaneous nerve root blocking and percutaneous injection of the facet joint are used in some centers and are usually performed by radiologists.³ Plain radiographs of the lumbar spine are routinely ordered in patients with acute mechanical and neurogenic pain of the lower back. Despite the availability of CT and MRI in some centers in Nigeria, it is the authors' observation that the use of plain radiography in the evaluation of LBP is very high. Unfortunately the yield is low, for instance disc herniation (the commonest surgically remediable cause of LBP) cannot be diagnosed

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on plain film.³

The diagnosis and treatment of LBP are complicated by the difficulty in precisely identifying the cause and by the non-specificity of the pain in many cases.⁵ Leading to a wide variation in patient care, a fact that suggests there is professional uncertainty about the optimal approach.^{6,7} Hence, some authors advocate that conservative management is effective and radiological investigation is unnecessary.³ Conservative management may be disastrous in cases of spinal stenosis from disc prolapse or herniated nucleus pulposus and radiology play a prudent role in the evaluation.

Modern neuroimaging techniques such as CT and MRI have improved the diagnosis and detection of the cause of LBP. These are expensive imaging modalities that are not usually available in several communities. As such physicians tend to use radiography at least in the initial assessment of LBP. It is therefore crucial to evaluate patients with LBP and assess for possible relationship between the findings and patients' characteristics.

MATERIALS AND METHOD

The study is a cross-sectional descriptive analysis of the lumbosacral radiographs of 337 patients referred for lumbosacral x-ray by their physicians after complaining of low back pain. The radiographs were reviewed by the researchers who are trained radiologists. Those that volunteered to be recruited into this study were accepted on a consecutive basis from August 2009 to June 2010. The radiographs were reviewed and questionnaires administered. The patients then had their heights and weights measured. The data was then entered and analyzed using SPSS (statistical package for scientific solution) version 15. Chi square analysis was done with p value less than or equals to 0.05 considered as significant.

Standard radiographic positioning was maintained in all the radiographs. All the radiographs were taken in the erect position with centering at the L3 level, at the level of the lower costal margin. To minimize radiation dose lumbosacral x-ray for LBP were routinely limited to anteroposterior and lateral views. Hence oblique views were not routinely done except if indicated by the examining radiologist. The usage of oblique view to detect spondylolysis

tremendously increases the radiation dose and its detection rate for spondylolysis is only 5% to 10%.^{8,9} Consequently attempt to categorize spondylolisthesis into its subtypes was not made as presence of fracture of the pars interarticularis, better appreciated on oblique view, is a feature of Wiltse's type II spondylolisthesis (see discussion).

Alignment pattern was judged by trained radiologists. The presence of osteophytosis, spondylolisthesis and disc degeneration were documented for the vertebra(e) involved. The locations of the osteophytes were entered as anterior, lateral and posterior where present. Spondylolisthesis was graded using the Meyerding's classification (grade I – 0 to 25% displacement; grade II – 26 to 50%; grade III – 51 to 75%; grade IV – 76 to 100%) and also categorized as anterior or posterior shift of the superior vertebra over the inferior one. The presence of disc space narrowing, end plate sclerosis and irregularity, and vacuum phenomenon were documented as features of disc degeneration.

RESULTS

The lumbosacral radiographic examinations of 337 patients with LBP were reviewed; 138(40.9%) were for males and 199(59.1%) for females giving a M:F ratio of 1:1.4. In all these patients only a small proportion, 15(4.5%), had normal radiographic findings. The frequencies of the alignment patterns are shown in figure 1. Reduced lumbar lordosis was the most common observed pattern. Scoliosis was noted in 10.7% and right concavity occurred more commonly.

The frequency of patients with disc degeneration was 95(28.2%) while the occurrence of disc degeneration components were; vacuum phenomenon, 51(15.1%); end plate sclerosis and irregularity, 62(18.4%); and reduced disc space, 29(8.6%). Table 1 shows the distribution of disc degeneration components among the lumbar vertebral spaces. The older the patient, the lower the educational status, osteophytosis, osteopenia and spondylolisthesis the higher the chance of developing degenerative disease of the inter-vertebral disc space, $p < 0.001$ for all (table 2). BMI and sex did not show statistically significant correlation with lumbar spine disc degeneration, $p = 0.908$ and $p = 0.775$ respectively.

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Osteophytosis was demonstrable in about 73.6% of patients with LBP. It is the most common degenerative change in these patients. It can involve the anterior, lateral and posterior margins of the vertebral body. The anterior margin of L4 is the commonest site of osteophytosis while the least involved site is the posterior margin of L1 – table 3. In general, posterior osteophytes were the least common. Only a small proportion, 2.6% of the 21 to 30 years age group and 6(2.4%) of 248 patients who had osteophytes, were below 30 years of age – table 4. The others with osteophytes were above 30 years but below 80 years. Advancing age, increasing BMI and lower educational level increases the chances of developing osteophytosis. It was also found that being married or divorced increased the likelihood of developing osteophytes ($p < 0.001$) but confounding variables like age limits the credibility of this observation. Similarly confounding variable(s) also affected the credibility of the significant correlation of marital status with spondylolisthesis and intervertebral disc degeneration. Sex had no significant correlation with the development of osteophytes ($p = 0.058$).

Spondylolisthesis was demonstrable in 45(13.4%) of the cases, most of which were anteriorly located and at L4/L5 and L5/S1 disc spaces (table 5). Grade I spondylolisthesis was observed the most constituting 42 cases (93.3%) while grade II was seen in 3 cases (6.7%). No case of grade III or IV spondylolisthesis was seen. Lower educational level and female sex increases the chances of developing spondylolisthesis (table 6). There was no significant relationship between spondylolisthesis with age ($p = 0.071$) and BMI class ($p = 0.062$). Patients with disc degeneration were more likely to develop spondylolisthesis whereas there was no significant correlation between spondylolisthesis and osteophytosis – table 6. We note that unlike osteophytosis, all the patients with spondylolisthesis were aged between 31 and 80 years.

Transition vertebrae was seen in 109(32.3%) of the patients of which 20(5.9%) had lumbarization and 89(26.4%) sacralization. There were 8(2.4%) males and 12(3.6%) females with lumbarization and 53(15.7%) males and 36(10.7%) females with sacralization. There was no statistical

correlation between transitional vertebrae with sex, age group, BMI, osteophyte formation, vacuum phenomenon, disc degeneration and spondylolisthesis.

Figure 1: Alignment pattern distribution.

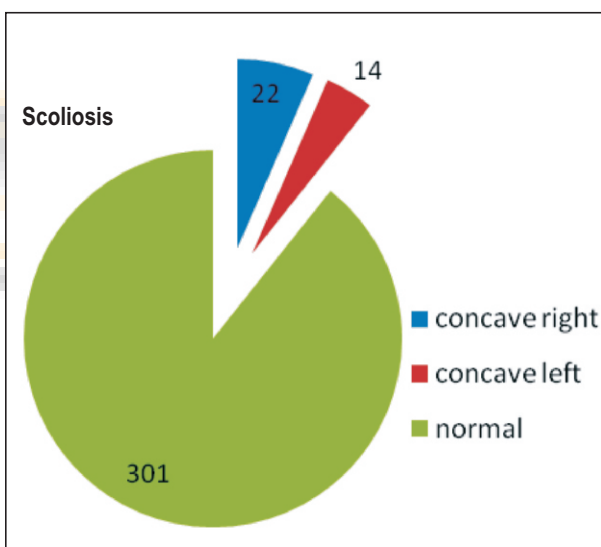
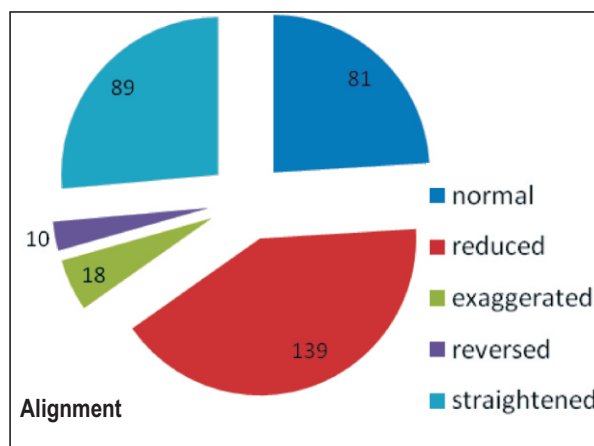


Table 1: The distribution of observed vertebral disk space changes.

	Vertebral disk space				
	L1/L2	L2/L3	L3/L4	L4/L5	L5/S1
Vacuum phenomenon	14(4.2)	24(7.1)	22(6.5)	34(10.1)	8(2.4)
Disc sclerosis/irregularity	6(1.8)	24(7.1)	24(7.1)	34(10.1)	14(4.2)
Reduced disk space	2(0.6)	2(0.6)	2(0.6)	17(5.0)	6(1.8)

NB: Values are in n(%).

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Table 2: Cross-tabulations of vertebral disc degenerative changes with age, educational level, osteophytosis, osteopenia and spondylolisthesis.

	Disc degeneration		
	Present	Absent	Total
Age 11 - 20	0(0)	4(100)	4(100)
21 - 30	1(2.6)	37(97.4)	38(100)
31 - 40	4(8.2)	45(91.8)	49(100)
41 - 50	16(19.8)	65(80.2)	81(100)
51 - 60	22(36.1)	39(63.9)	61(100)
61 - 70	40(51.3)	38(48.7)	78(100)
71 - 80	8(36.4)	14(63.6)	22(100)
81+	4(100)	0(0)	4(100)
Total	95(28.2)	242(71.8)	337(100)

$\chi^2=59.720$, $p<0.001$, values are in n(% within age group).

Educational level	Disc degeneration		
	Present	Absent	Total
None	31(64.6)	17(35.4)	48(100)
Primary	27(30.3)	62(69.7)	89(100)
Secondary	24(27.6)	63(72.4)	87(100)
Tertiary	13(11.5)	100(88.5)	113(100)
Total	95(28.2)	242(71.8)	337(100)

$\chi^2=47.165$, $p<0.001$, values are in n(% within educational level).

Osteophytes	Disc degeneration		
	Present	Absent	Total
Present	84(33.9)	164(66.1)	248(100)
Absent	11(12.4)	78(87.6)	89(100)
Total	95(28.2)	242(71.8)	337(100)

$\chi^2=14.972$, $p<0.001$, values are in n(% within osteophytosis).

Spondylolisthesis	Disc degeneration		
	Present	Absent	Total
Present	32(71.1)	13(28.9)	45(100)
Absent	63(21.6)	229(78.4)	292(100)
Total	95(28.2)	242(71.8)	337(100)

$\chi^2=47.263$, $p<0.001$, values are in n(% within spondylolisthesis).

Table 3: The distribution of osteophytes amongst the vertebral bodies

Osteophyte	Vertebral body involvement					
	L1	L2	L3	L4	L5	S1
Anterior	91(27.0)	151(44.8)	208(61.7)	222(65.9)	162(48.1)	20(5.9)
Lateral	54(16.0)	90(26.7)	139(41.2)	200(59.3)	75(22.3)	2(0.6)
Posterior	0(0)	6(1.8)	8(2.4)	10(3.0)	8(2.4)	-

Total number of patients with lumbosacral osteophytes 248(73.6)
NB: Values are in n(%).

Table 4: Cross-tabulations of osteophyte formation with age group, BMI class and educational level. Osteophyte Vs. age cross-tabulation.

Age (in yrs)	Osteophytes		
	Present	Absent	Total
11 - 20	0(0)	4(100)	4(100)
21 - 30	6(15.8)	32(84.2)	38(100)
31 - 40	28(57.1)	21(42.9)	49(100)
41 - 50	67(82.7)	14(17.3)	81(100)
51 - 60	49(80.3)	12(19.7)	61(100)
61 - 70	72(92.3)	6(7.7)	78(100)
71 - 80	22(100)	0(0)	22(100)
80+	4(100)	0(0)	4(100)
TOTAL	248(73.6)	89(26.4)	337(100)

$\chi^2 = 111.58$, $P = <0.001$; values are in n(% within age group).

Osteophyte vs. BMI classification cross-tabulation.

BMI class	Osteophytes		
	Present	Absent	Total
Underweight	6(75.0)	2(25.0)	8(100)
Normal	75(62.5)	45(37.5)	120(100)
Overweight	99(79.2)	26(20.8)	125(100)
Obese	68(81.0)	16(19.0)	84(100)
TOTAL	248(73.6)	89(26.4)	337(100)

$\chi^2 = 11.969$, $P = 0.007$; values are in n(% within BMI class).

Osteophyte vs. educational level cross-tabulation

Educational level	Osteophytes		
	Present	Absent	Total
None	42(87.5)	6(12.5)	48(100)
Primary	67(75.3)	22(24.7)	89(100)
Secondary	64(73.6)	23(26.4)	87(100)
Tertiary	75(66.4)	38(33.6)	113(100)
TOTAL	248(73.6)	89(26.4)	337(100)

$\chi^2 = 7.939$, $P = 0.047$; values are in n(% within educational level).

Table 5: The distribution of spondylolisthesis amongst the involved vertebral disk spaces.

Spondylolisthesis	Vertebral disk space				
	L1/L2	L2/L3	L3/L4	L4/L5	L5/S1
Anterior shift	0(0)	2(0.6)	6(1.8)	17(5.0)	16(4.7)
Posterior shift	2(0.6)	2(0.6)	2(0.6)	4(1.2)	6(1.8)

Total number of patients with spondylolisthesis; 45(13.4).
NB: Values are in n(%).

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Table 6:
Cross-tabulations of spondylolisthesis with educational level, sex and disc degeneration. Cross-tabulation of spondylolisthesis with educational level.

Educational level	spondylolisthesis		Total
	Present	Absent	
None	10(20.8)	38(79.2)	48(100)
Primary	21(23.6)	68(76.4)	89(100)
Secondary	8(9.2)	79(90.4)	87(100)
Tertiary	6(5.3)	107(94.7)	113(100)
Total	45(13.4)	292(86.6)	337(100)

$\chi^2=5.851$, $p<0.001$, values are in n(% within educational level).

Cross-tabulation of spondylolisthesis with sex.

Sex	spondylolisthesis		Total
	Present	Absent	
Male	11(8.0)	127(92.0)	138(100)
Female	34(17.1)	165(82.9)	199(100)
Total	45(13.4)	292(86.6)	337(100)

$\chi^2=18.009$, $p=0.016$, values are in n(% within sex).

Cross-tabulation of spondylolisthesis with disc degeneration.

D. Dg.	spondylolisthesis		Total
	Present	Absent	
Present	18(29.0)	44(71.0)	62(100)
Absent	27(9.8)	248(90.2)	275(100)
Total	45(13.4)	92(86.6)	337(100)

$\chi^2=16.144$, $p<0.001$, values are in n(% within sex), D. Dg=disc degeneration.

Discussion

Radiographic evaluation of LBP plays an important role in the management of patients even when its yield is reputed to be low. Common causes of LBP are muscular and ligamentous injuries and age-related degenerative processes in the intervertebral disks and facet joints. Other problems include spinal stenosis and disk herniation. Acute mechanical pain accounts for over 90% of the causes of LBP.³ Leading to various range of alignment anomaly like reduction in lumbar lordosis and scoliosis. Reduction of the lumbar lordosis is the most frequently observed malalignment accounting for about 41.2% in these cases. In patients with exaggerated lumbar lordosis the spinous processes of adjoining vertebrae may entrap muscles thereby causing LBP. In patients with scoliosis the concavity is usually to the side of the pain. Congenital anomaly of the spine, other pathological lesion and psychological anomaly may cause patients

to present with LBP. No morphological vertebral anomaly was demonstrable in these patients with scoliosis. We could not exclude the fact that some of these scoliosis may actually be positional.

Disc degeneration occurs from a variety of contributory factors. Apoptosis, collagen abnormality, aging, vascular supply anomaly, mechanical stress, inflammation, abnormal proteoglycan and possible genetic factor all contribute to disc degeneration.¹⁰ Consequent herniation of the disc with radiculopathy and chronic discogenic pain may arise from disc degeneration. We observed that radiographic features of disc degeneration correlated with age, low education status, osteophytosis and spondylolisthesis. All the patients above 80 years of age in this study had features of disc degeneration. In the study by Pye *et al*¹¹ disc space degeneration was reported to be associated with LBP, and disc space narrowing shows the strongest association. Degenerative changes of the lumbar spine occur most frequently in the L4/L5 disc space seconded by the L5/S1 disc space. These disc spaces are the point of maximal force of transmission of the weight of the upper part of the body to the pelvic girdle.

Intervertebral disc degeneration is known to herald osteophytosis by increasing flexibility between the vertebral bodies and consequent mechanical stress on the ossification centers of bones under the cartilage of the vertebral body leading further to sclerotic or hyperplastic changes at the edge of the vertebral body (osteophytes).^{12,13,14} These osteophytes help in the stabilization of the spine. Osteophytes are age-related phenomenon occurring with increasing frequency with advancing age. This study shows a strong correlation between advancing age and osteophyte formation. Watanabe *et al*¹⁵ documented that the size of osteophyte increases with advancing age, thereby increasing the likelihood of exit foramina impingement by osteophytes with advancing age with consequent LBP and neurological deficit.

Anterior osteophytes are more common than lateral and posterior osteophytes. This is because the anterior part of the vertebral body is the most mobile and therefore the most unstable part of the vertebrae. The most likely sites of osteophyte location in this study are the anterior

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margins of L3 and L4 vertebral bodies. This observation was similarly reported in other studies.^{13,16} Osteophyte formation was observed to have correlated with BMI signifying that obese patients tend to develop osteophytes more frequently. Some authors documented this relation between obesity and osteophytosis.^{17,18} Obesity results in increased stress on the weight bearing spine with consequent osteophyte formation (a stabilization reaction). Heavy physical activity is known to result in increased incidence of osteophyte formation.¹³ We observed that osteophytes were more common in the less educated groups which may be attributed to the likelihood of people with lower education taking up more strenuous and tasking jobs. It is noteworthy that the frequency of osteophyte is remarkable from 31 years of age where most of the working population and elderly falls into. This observation may arise from a constellation of age, weight, physical activity amongst other factors.

Osteophytes were demonstrable in 73.6% of these patients presenting with LBP. This high prevalence of osteophytes in our patients with LBP calls to reason that there may be a causal relationship between the two. Some researchers state that the frequency of symptoms and signs among individuals with osteophytes is no greater than among those without osteophytes.¹³ However bulging degenerated intervertebral disc as well as posterior and some exuberant lateral osteophytes may impinge on the intervertebral foramina or cause spinal stenosis leading to radicular pain and neurologic deficit in severe cases. The chance of this occurring is higher as the frequency of disc degeneration and osteophytosis increases. Several authors have documented the association between spondylosis (osteophytosis) and LBP.¹⁹⁻²³ O'Neill *et al*¹³ reported that osteophytosis affecting the lumbar spine are associated with LBP in men and those with more severe osteophytes were more likely to report back pain. Therefore we opined that osteophytosis share some relationship with LBP despite the contrary opinion of other authors.²⁴

Spondylolisthesis is not as common as osteophytosis in patients with LBP. It was demonstrable in 13.4% of our cases. The etiologies of spondylolisthesis can be categorized into type I – congenital (dysplastic); type II – isthmic; type III – degenerative; type IV

– traumatic; type V – pathologic and iatrogenic.²⁵ The isthmic type is the commonest below 50 years while degenerative type is the commonest above 50 years and has a predilection for females. Isthmic spondylolisthesis is believed to arise from biomechanical stress while degenerative spondylolisthesis from chronic disc degeneration and facet incompetence leading to segmental instability and slippage. We observed that most (75.2%) of the spondylolisthesis in this study occurred at the L4/L5 and L5/S1 disc spaces (the commonest sites of degenerative spondylolisthesis). In addition degenerative spondylolisthetic patients have significantly greater baseline lumbar lordosis, pelvic incidence, vertebral inclination angle and smaller vertebral size.²⁶ Degenerative disease of the facets and the posterior elements are also known causes of chronic mechanical pain and sciatica.²⁷ Note that anterior shift of the superior vertebra over the inferior one occurs more commonly.

Certain high risk activities like gymnastics, rowing, tennis, weightlifting, wrestling and football create mechanical stresses that can cause spondylolisthesis. These activities are more common in less educated people, corresponding with the observation in this study of a significant relation between educational level and spondylolisthesis. We also observed that females were more likely to develop spondylolisthesis which is the common pattern reported.^{30,31,32} Spondylolisthesis was reported to be more common in African American women (60%) than elderly whites (19%).^{31,32}

Transition vertebrae involved the downward migration of L5 (sacralization) or upward migration of S1 (lumbarization). Transition vertebrae cause low back pain. In this study there was no significant correlation between its presence and the formation of osteophytes, spondylolisthesis, BMI, sex, age or educational level.

Conclusion

Degeneration of the vertebral disc show strong relation with the other findings in LBP and it is said to be the initiator of these other findings. Osteophytosis is age-related and associated with strenuous activities with anterior osteophyte been the most common. Spondylolisthesis and disc degeneration occur commonly in L4/L5 and L5/S1 disc spaces.

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Finally, age and physical activities/lumbar stress play a crucial role in LBP.

CONFLICT OF INTEREST: There is none to declare.

REFERENCES

1. Urquhart DM, Hoving JL, Assendelft WW, Roland M, van Tulder MW. Antidepressants for non-specific low back pain. *Cochrane Database Syst Rev*; 1: CD001703. DOI: 10.1002/14651858.CD001703.
2. Walker B. The prevalence of low back pain; a systematic review of the literature from 1966 to 1998. *Journal of spinal disorder* 2000; 13(3): 719 – 740.
3. Pelz DM, Haddad RG. Radiologic investigation of low back pain. *CMAJ* 1989; 140: 289 – 295.
4. Louw QA, Morris LD, Grimmer-Somers K. The prevalence of low back pain in Africa: a systematic review. *BMC musculo-skeletal disorders* 2007; 8: 105.
5. Scientific approach to the assessment and management of activity-related spinal disorders. A monograph for clinicians. Report of the Quebec Task Force on Spinal Disorders. *Spine* 1987; 12(1): S1 – S59.
6. Hart LG, Deyo RA, Cherkin DC. Physician office visits for low back pain: frequency, clinical evaluation, and treatment patterns from a US national survey. *Spine* 1995; 20: 11 – 19.
7. Anderson GBJ. Epidemiologic features of chronic low back pain. *Lancet* 1999; 354: 581 – 585.
8. Haughton VM, Eldevik OP, Magnaes B, et al. A perspective comparison of computed tomography and myelography in the diagnosis of herniated lumbar discs. *Radiology* 1982; 142: 103 – 110.
9. Gehweiler JA, Daffner RH. Low back pain: the controversy of radiologic evaluation. *AJR* 1983; 140: 109 – 112.
10. Martin MD, Boxell CM, Malone DG. Pathophysiology of lumbar disc degeneration: a review of the literature. *Neurosurg focus* 2002; 13(2): 1 – 6.
11. Pye SR, Reid DM, Smith R, Adams J, Nelson K, Silman AJ, O'Neill TW. Radiographic features of lumbar disc degeneration and self-reported back pain. *The journal of Rheumatology* 2004; 31(4): 753 – 758.
12. Nathan H. Osteophytes of the vertebral column. *J Bone Joint Surg Am* 1962; 44: 243 – 268.
13. O'Neill TW, McCloskey EV, Kanis JA, et al. The distribution, determinants and clinical correlates of vertebral osteophytosis: a population based survey. *J Rheumatol* 1999; 26(4): 842 – 848.
14. Wada E, Ebara S, Saito S, Ono K. Experimental spondylosis in rabbit spine. Overuse could accelerate the spondylosis. *Spine* 1992; 17: S1 – 6.
15. Watanabe S, Terazawa K. age estimation from the degree of osteophyte. *Legal medicine* 2006; 8: 156 – 160.
16. Pate D, Goobar J, Resnick D, Haghghi P, Sartoris DJ, Pathria MN. Traction osteophytes of the lumbar spine: radiographic pathologic correlation. *Radiology* 1988; 166: 843 – 848.
17. Cvijetic S, McCloskey E, Korsic M. Vertebral osteophytosis and vertebral deformities in an elderly population sample. *Wien Klin Wochenschr* 2000; 112(9): 407 – 412.
18. Oishi Y, Shimizu K, Katoh T, Nakao H, Yamaura M, Faruko T, Narusawa K, Nakamura T. Lack of association between lumbar disc degeneration and osteophyte formation in elderly Japanese women with back pain. *Bone* 2003; 32: 407 – 412.
19. Lamer TJ. Lumbar spine pain originating from vertebral osteophytes. *Reg Anaesth Pain Med* 1999; 24(4): 347 – 351.
20. Jandric S, Antic B. low back pain and degenerative disease. *Med Pregl* 2006; 59(9-10): 456 – 461.
21. Frymoyer JW, Newberg A, Wilder DG, Clements J, MacPherson B. Spine radiographs in patients with low back pain. An epidemiological study in men. *J Bone Joint Surg Am* 1984; 66: 1048 – 1055.
22. Rives PA, Douglas AB. Evaluation and treatment of low back pain in family practice. *J Am Board Fam Prac* 2004; 17: S23 – 31.
23. Borenstein D. does osteoarthritis of the lumbar spine cause chronic low back pain? *Curr Rheumatol Rep* 2004; 6(1): 14 – 19.
24. van Tulder MW, Assendelft WJ, Koes BW, Bouter LM. Spinal radiographic findings and nonspecific low back pain. A systematic review of observational studies. *Spine* 1997; 22(4): 427 – 434.
25. Wiltse LL, Newman PH, Macnab I. classification of spondylosis and spondylolisthesis. *Clin Ortho* 1976; 117: 23 – 29.
26. Aono K, Kobayashi T, Jimbo S, Atsuta Y, Matsuno T. Radiographic analysis of newly developed degenerative spondylolisthesis in a mean twelve-year prospective study. *Spine* 2010; 35(8): 887 – 891.
27. Carrera GF, Haughton VM. Computed tomography in sciatica. *Radiology* 1980; 137: 433 – 437.
28. Horikawa K, Kasai Y, Yamakawa T, Sudo A, Uchida A. prevalence of osteoarthritis, osteoporotic vertebral fractures and spondylolisthesis among the elderly in a Japanese village. *J Ortho Surg* 2006; 14(1): 9 – 12.
29. Voght MT, Rubin DA, Palermo L, et al. Lumbar spine listhesis in older African American women. *Spine J* 2003; 3: 255 – 261.
30. Kauppila LI, Eustace S, Kiel DP, Felson DT, Wright AM. Degenerative displacement of lumbar vertebrae. A 25 year follow-up study in Framingham. *Spine* 1998; 23: 1868 – 1874.