ORIGINAL ARTICLE

UDC: 616-057:616.711-02
DOI: https://doi.org/10.2298/VSP151112306P

Relation between grades of intervertebral disc degeneration and occupational activities of patients with lumbar disc herniation

Povezanost stepena degeneracije intervertebralnih diskusa i radnih aktivnosti kod bolesnika sa lumbalnom diskus hernijom

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Abstract

Background/Aim. Intervertebral disc degeneration (IDD) occurs as consequence of combined effects of genetic, age-related, environmental and occupational factors. Lumbar disc herniation (LDH) develops mostly due to IDD. The aim of this study was to investigate whether the frequency of LDH is higher at the level of the most pronounced IDD, and whether a category of physical workload influences higher IDD on level L3-L4, L4-L5 and L5-S1 separately. **Methods**. The research included 60 patients with permanent employment, hospitalized due to LDH. A grade of IDD was assessed by lumbosacral preoperative magnetic resonance imaging (MRI), according to Pfirmann's MRI classification system. Occupational factors were determined by a specific questionnaire. **Results.** Out of the 60 patients participating in the study, 33.3% had jobs with easy workload, 23% had moderate workload, while 43% had heavy workload. Herniated discs were found at level L3-L4 in 8.3%, at level L4-L5 in 46.7% and at level L5-S1 in 45% patients. The symptomatic discs at level L5-S1 showed statistically significant frequency of degenerative changes of grades IV and V. Binary logistic regression results showed that the strongest predictor of IDD grade for examined levels was physical workload. Positive association of physical workload and IDD grade was observed in all cases. Higher grades of IDD are more likely for patients with both higher TE and heavier physical workload (OR 2.011) at level L3-L4. At levels L4-L5 and L5-S1 higher degree of IDD was more likely for females with heavier physical workload (OR 1.978 and 2.433 respectively). **Conclusion**. Symptomatic discs show higher frequency of higher grades of IDD but herniation does not occur solely at the disc of the most prominent degenerative changes. The results suggest importance of inter-influence of physical workload and the years of employment and the inter-influence of physical workload and gender, on degeneration of lumbar discs.

Key words:
lumbosacral region; inervertebral disc degeneration; occupational exposure; intervertebral disc displacement.

Apstrakt

Uvod/Cilj. Degeneracija intervertebralnog diskusa (DID) nastaje kao posledica udruženog dejstva genetskih, starosnih faktora kao i faktora iz životne i radne sredine. Lumbalna diskus hernija (LDH) je najčešće posledica DID. Cilj rada bio je da se istraži da li je učestalost LDH viša na nivou najizraženijih degenerativnih promena intervertebralnog diskusa i da li kategorija fizičkog opterećenja na radnom mestu ima uticaj na stepen DID na nivou L3-L4, L4-L5 i L5-S1 pojedinačno. **Metode.** Istraživanjem je obuhvaćeno 60 bolesnika u stalnom radnom odnosu, hospitalizovanih zbog LDH. Stepen DID utvrđen je na osnovu preoperativnog nalaza pregleda lumbosakralne kičme magnetnom rezonancom (MRI) prema Firmanovom MRI sistemu klasifikacije. Profesionalni faktori su određeni pomoću specifičnog upitnika. **Rezultati.** Od 60 bolesnika koji su učestvovali u istraživanju, 33.3% obavljalo je lak fizički rad, 23% srednje težak, a 43% bolesnika težak fizički rad. Hernijacija diskusa na nivou L3-L4 nađena je kod 8,3%, na nivou L4-L5 kod 46,7%, a na nivou L5-S1 kod 45% bolesnika. Simptomatski diskusi na nivou L5-S1, su pokazali statistički značajno veću učestalost degenerativnih promena IV i V stepena. Rezultati binarne logističke regresije pokazali su da je fizičko opterećenje najjači prediktor stepena DID na svim ispitivanim nivoima. Pozitivna veza između fizičkog opterećenja i stepena

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DID je uočena u svim slučajevima. Viši stepen DID je verovatniji kod bolesnika sa dužim radnim stažom i teškim fizičkim opterećenjem (OR 2.011) na nivou L3-L4. Na nivoima L4-L5 i L5-S1 viši stepen DID je verovatniji kod žena koje obavljaju težak fizički rad (OR 1,978 i 2,433 respektivno). **Zaključak**. Simptomatski diskusi imaju veću učestalost degenerativnih promena višeg stepena, ali se hernijacija ne dešava isključivo na nivou diskusa sa najizraženijim degenerativnim promenama. Rezultati ukazuju na značaj interaktivnog uticaja kategorije fizičkog opterećenja i dužine radnog staža kao i interakcije kategorije fizičkog opterećenja i pola, na degeneraciju lumbalnih diskusa.

Ključne reči:
lumbosakralni predeo; diskus degeneracija; profesionalna izloženost; hernija diskusa.

Introduction

The degenerative process of intervertebral discs (IVD) includes many biochemical and pathoanatomical alterations, leading to changes in its biomechanical characteristics. It is the result of combined effects of genetic, age, mechanical, chemical, and autoimmune factors [1]. Degeneration of IVD is clinically significant if its pathogenesis, directly or indirectly, causes the low back pain (LBP), and in cases of lumbar disc herniation (LDH), leads to the compression of neural and vascular elements in the surrounding tissue [2]. Low back pain occurs more often when combined with the existence of degenerative alterations in IVD [3]. However, intervertebral disc degeneration (IDD) in itself does not need to be the cause of pain [1].

Low back pain is usually related to the factors from occupational environment, such as exposure to vibrations, nonphysiological position of a body during the work (extreme forward bending, trunk twisting), carrying and lifting heavy weights [3–5]. Therefore, the LBP is regarded as an occupation related disease [6]. Low back pain is caused by pathological changes in lumbar spine and surrounding tissue, commonly due to IDD [1, 2, 7].

Although the effect of physical workload on the occurrence of the LBP has been extensively investigated, only a few quantitative studies have examined the morphological changes visualized via magnetic resonance imaging (MRI) in relation to occupational variables [8].

The aim of this study was to investigate whether the frequency of LDH is higher at the level of the most pronounced IDD, and whether a category of physical workload in the patient's working position influences higher IDD at the most common level L3-L4, L4-L5 and L5-S1, separately.

To the best of our knowledge, this is the first research about relation between physical workload and the grade of IDD changes in patients with LDH for each level separately, and similar studies has not been published at the national level.

Methods

This study included 60 patients with permanent employment who were hospitalized for operative treatment due to the LDH on one level, marked as symptomatic level. Study was conducted on the Clinic of Neurosurgery of the Clinical Centre of Vojvodina in Novi Sad, Serbia, in the period between January 2013 and December 2014. The study excluded patients with spinal trauma consequences, spinal deformities, associated rheumatic and degenerative conditions of musculoskeletal system, and metabolic disorders with manifestations on the locomotor system, oncological diseases, infective and inflammatory diseases of the spinal column.

Lumbosacral preoperative MRI was analyzed. The standard protocol included the imaging of spinal segments between Th10 and S5, with T1-weighted (T1W) and T2-weighted (T2W) sequences in sagittal projections, T2W sequence in axial projections of the lower three levels of the lumbar segment parallel to the intervertebral disc, as well as Short Tau Inversion Recovery (STIR) sequence in coronar projections. Additional axial projections also included levels where suspect protrusions; radiculopathies and spinal stenosis were detected on sagittal projections. If needed, more T2W sequences in sagittal projections were taken with the obliteration of fat tissue signal. The images were processed on an MRI scanner and obtained in a digital form. On the basis of this examination, the grade of IDD was assessed (levels L3-L4, L4-L5 and L5-S1), according to Pfirmann's magnetic MRI classification system [9].

Assessment of the IDD was performed independently by a single radiologist, blind for the patients' demographic, occupational and clinical characteristics. Using self-evaluation questionnaires in the preoperative evaluation we collected the following basic demographic and occupational data: gender, age, number of years of employment in total, number of years of service in the workplace where patients were currently employed. By measuring the weight and height of participants we calculated body mass index (BMI). Demands of the physical load at work place of participants were determined by self-assessment, using "Workload Assessment Questionnary" (Table 1). This questionnaire was specially designed for the purpose of assessing physical activity in the workplace. As a part of the questionnaire, participants provided information on the length of work activities in relation to the eight-hour day, expressed as: 0% absence of load, < 30% of the eight-hour working time, > 30% of the eight-hour working time. Work activities that we assessed were related to: static load, dynamic load, sitting, standing, lifting and carrying loads, the presence or absence of whole body vibration, bending and rotation of the trunk. Based on data collected from this questionnaire, an independent specialist in occupational medicine, licensed to perform risk assessments in the workplace, blind for clinical status, neurological status of participants, and their MRI findings, determined the category of physical workloads of each participant, according to the recomended methodology for "Grading System for Physical Workload" (Table 2). For statistical analysis we grouped a category of hard and very hard work as the same group.

Table 1

Workload Assessment Questionnary of the Institute of Occupational Medicine "Dr Dragomir Karajović", Belgrade, Serbia, designed for the purpose of assessing physical activity in the workplace.

Physical workload	0%	< 30%	Above 30%
Dynamic work			
Static work			
Sitting			
Standing			
Walking			
Forced position			
bending			
trunk twisting			
Lifting and carrying weights			
The amount of weight (kg)			

Table 2

Grading System for Physical Workload of the Institute of Occupational Medicine "Dr Dragomir Karajović", Belgrade, Serbia, for determination of the category of physical workloads

Category	Description of workload
I – Easy	Sitting type of work with limited walking and standing (0%); mostly easy manual work (using arms and hands), without forced body position, without lifting and carrying weights and without static work.
II – Medium	Alternation of sitting, standing and walking (< 30%) including carrying and lifting light and medium heavy weights (women 5 kg and men 12 kg) without forced body position and with little static work.
III – Hard	Alternation of mostly standing and walking including lifting and carrying heavy weights (women 5–10 kg and men 12–25 kg), occasionally (up to 8%) forced body position and static work.
IV – Very hard	Alternation of mostly standing and walking; whole body work with constant lifting (> 30%), (women over 10 kg and men over 25 kg), forced body position and very often (> 30%) static work.

Summary statistics was presented as a mean ± SD for metric variables and as percentages for categorical variables. Analysis of disk degeneration was based on the following classification of the patients: the first group consists of patients whose grade of IDD was II or III, while the second one consists of patients with grade IV or V which is considered as a higher grade of IDD. Differences between groups were tested using χ^2 test and binomial test. The tested proportion in binomial test was 0.5. Crosstab procedure and χ^2 test were used to examine differences in characteristics between groups for nominal variables. Binary logistic regression models were built to discover which factors were affecting grades of degeneration on levels L3-L4, L4-L5 and L5-S1 including symptomatic and asymptomatic levels. The dependent variables for all three levels were coded using the same classification of the patients according to their grade of the IDD mentioned above. All models were built on the basis of carefully chosen independent variables which can be divided into two categories: basic characteristics of patients (gender, age, BMI) and the patient's occupational characteristics [total years of employment (TE), years on the actual working position (AWP), sitting, standing, walking, presence of vibrations at work place, nonphysiological position of a body during the work (extreme forward bending, trunk twisting), carrying and lifting of heavy weight and variable that describe the patient's workload]. Models were presented with the regression coefficients (B), standard errors (S.E), *p* values (Sig.) and odd ratios (OR) for sets of statistically significant variables. The level of significance in all tests was set to ($p < 0.05$). All calculations were performed using standard statistical packages (R CRAN and SPSS, version 20).

Results

Thirty-one male and 29 female patients aged between 35 and 60 years (average age was 46.22 ± 7.71) participated in the study. Average employment period for the actual professional position was 16.47 ± 8.66 years (ranging between 5 and 38 years) while the total period of employment was on average 21.10 years (ranging between 5 and 38 years). As for the physical workload, 33.3% of the patients had jobs with easy workload, 23% had moderate workload, while 43% had heavy workload. No statistically significant difference was found between different categories of the physical workload ($\chi^2 = 3600$, df = 2, $p = 0.165$).

Herniated discs were found at level L3-L4 in 8.3% patients, at level L4-L5 in 46.7% and at level L5-S1 in 45% patients. Frequency of LDH on level L3-L4 is statistically significant lower comparing with other two examined levels. ($\chi^2 = 16.900$, df = 2, $p = 0.000$).

The differences in frequencies of IDD grades (Figure 1) on symptomatic discs were not statistically significant (χ^2 = 2.341, df = 2, p = 0.310) for each level. A majority of the patients had higher grade of IDD. However, the difference in number of patients with grades II and III and patients with grades IV and V of IDD was only statistically significant at level L5-S1 (test. prop. = 0.5, exact sig. = 0.000).

Contrary to the symptomatic discs, on asymptomatic discs at level L3-L4 (Figure 2), the Binomial test showed statistically significant difference between frequency of patients with IDD changes grades II and III and patients with grades IV and V (test. prop. = 0.5, exact sig. = 0.000).

The patients were more likely to have higher grade of IDD, if they had longer TE, AWP and sitting during working time. (Table 3) Precisely, patients with higher TE have 1.371 higher chances to have higher grade of IDD in comparison to the patient with lower TE. When it comes to AWP, the chance for the patients with higher AWP to have higher grade of IDD was 1.147. Furthermore, patients who were sitting more during working time were 1.873 times likely to have higher grade of IDD. The patients with both higher TE and heavier physical workload are 2.011 times likely to have higher grade of IDD.

For level L4-L5, the patients are more likely to have higher grade of IDD if their TE was higher (Table 4). The patients with higher TE were 0.512 times likely to have higher grade of IDD. Physical workload in interaction with gender and TE increases chances for higher grade of IDD. Females with heavier physical workload were 1.978 likely to have higher grade of IDD. Moreover, patients with both higher TE and heavier physical workload are 1.151 times likely to have higher grade of IDD.

The results for level L5-S1 indicated that patients with the presence of vibrations at work place were likely to have higher grade of IDD (Table 5). Physical workload and lifting and carrying, but both in interaction with gender were likely to have higher grade of IDD. Females with heavier physical workload were 2.433 times likely to have higher grade of IDD, while females who lift and carry more than 30% were 2.502 times likely to have higher grade of IDD.

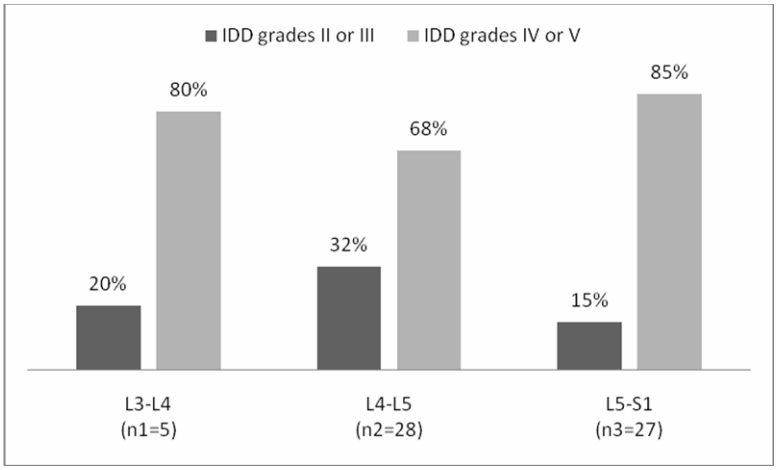

Fig. 1 – The frequencies of intervertebral discs degeneration (IDD) grade II and III (dark gray column) and grade IV and V (light gray column) according to Pfirmann's magnetic resonance imaging (MRI) classification system, for symptomatic discs (n = 60) in 60 patients, at level L3-L4, L4-L5, L5-S1.

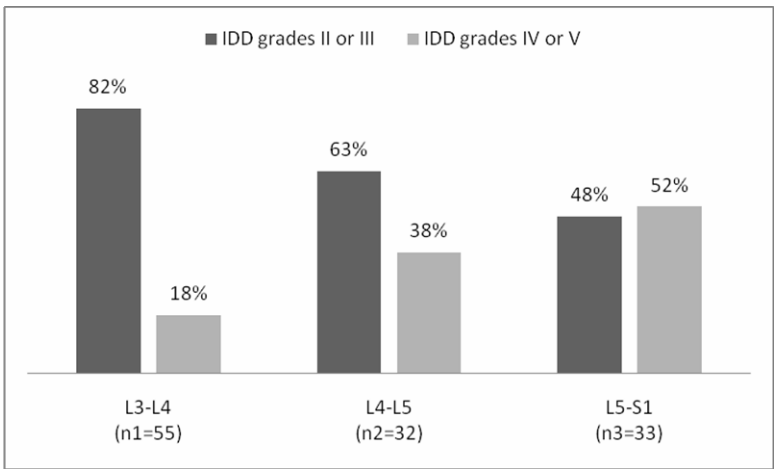

Fig. 2 – The frequencies of intervertebral disc degeneration (IDD) grade II and III (dark gray column) and grade IV and V (light gray column) according to Pfirmann's magnetic resonance imaging (MRI) classification system, for asymptomatic discs (n = 120) in 60 patients, at level L3-L4, L4-L5, L5-S1.

Table 3

Statistically significant results of binary logistic regression analysis that represent relation between grades of intervertebral disk degeneration (IDD) and patients occupational characteristics for level L3-L4

Occupational characteristics	B	SE	Sig.	OR
TE	0.316	0.107	0.045	1.372
AWP	0.137	0.001	0.020	1.147
Sitting	0.628	0.038	0.004	1.873
TE by physical workload	0.698	0.004	0.020	2.012

TE – total years of employment; AWP – years on the actual working position.
SE – standard error; OR – odds ratio.

Table 4

Statistically significant results of binary logistic regression analysis that represent relation between grades of intervertebral disk degeneration (IDD) and basic characteristics of patients and the patients occupational characteristics for level L4-L5

Occupational characteristics	B	SE	Sig.	OR
TE	0.234	0.547	0.040	0.512
Physical workload by gender (1)*	0.682	0.418	0.046	1.978
TE by physical workload	0.141	0.783	0.020	1.151

TE- total years of employment; SE – standard error; OR – odds ratio; *reference category for gender was male (0), where gender (1) denotes females.
SE – standard error; OR – odds ratio.

Table 5

Statistically significant results of binary logistic regression analysis that represent relation between grades of intervertebral disk degeneration and basic characteristics of patients and the patients occupational characteristics for level L5-S1

Occupational characteristics	B	SE	Sig.	OR
Vibration (1)	-0.669	0.339	0.033	0.009
Physical workload by gender (1)*	0.889	0.543	0.027	2.433
Lifting and carrying by gender (1)*	0.917	0.594	0.035	2.502

***reference category for gender was male (0), where gender (1) denoted females; SE – standard error; OR – odds ratio.**

Discussion

Lumbar disc herniation is the most common cause of surgical treatment of active working population [10]. Most commonly, it occurs between 40 and 50 years of age [1] with a predominance of intervertebral discs herniation at the L4-L5 and L5-S1 level [11], as it was shown in our study.

Degenerative changes on symptomatic intervertebral disc

Degeneration of intervertebral discs usually preceded LDH [12]. Studies that have examined the degenerative diseases of IVD show that the herniated disc is not mandatory degeneratively changed [13]. Modic et al. [14] and Jacob et al. [15] showed that in 60% of cases disc was degenerated, and in 8% of cases degeneration did not preceded herniation. Our research confirmed that the herniated discs showed higher degree of degeneration (IV and V) on all three analyzed levels, in 68–85% cases. Herniated discs at level L4-L5 in 32% cases showed lower degree of degeneration. However, significantly higher frequency of higher degree degenerative changes was revealed only at the herniated disc at level L5-S1. Cross-sectional study by Vardhan et al. [16] also showed that in the lumbar region maximum degenerative changes (Modic type end plate degenerative change, disc contour abnormalities and disc inflammation and infiltration) were seen at L5-S1 level. This points out possible interactions of the anatomical, biomechanical factors at L5-S1 level with other factors that lead to faster progression of degenerative changes, as well as that pathogenetic mechanisms of disc herniation and degeneration of intervertebral discs are somewhat different.

Degenerative changes at asymptomatic level

Asymptomatic discs have a lower incidence of higher degree degenerative changes compared to symptomatic discs at all three analyzed levels. Asymptomatic discs at the L3-L4 in 82% of cases have a lower degree of degenerative changes (grade II and III), while the discs on other two analyzed levels represent degenerative changes even lower and higher grades. The fact that the discs at the L4-S1 levels are more degenerated than at the L1-L4 level indicates that there are other unresolved variables that play a role in the pathogenesis of disc degeneration, and that they affect the lower levels of the lumbar segment more than the upper ones [1].

Is the physical load associated with the degeneration of intervertebral discs?

The potential impact of physical activity as the etiologic cause of the IVD degeneration is still being discussed. Several experimental sudies suggest that compressive forces can

lead to structural changes in IVD (decreased disc thickness) as well as to changes in the IVD metabolism [17–19].

Results of German multicenter case control study support a clear dose-response relation between cumulative lumbar load and lumbar disc herniation as well as symptomatic lumbar disc narrowing [8]. However, Elfering et al. [20] in their prospective MRI study failed to detect any association between exposure to heavy physical load and the development of degeneration of intervertebral discs. Another group of authors who investigated the morphological changes visualized by MRI examination also found that exposure to physical load was not necessarily associated with the presence of degeneration and narrowing of the disc, but a higher degree to such an exposure was directly associated with a higher degree of degeneration [21]. Based on this association of professional factors and degeneration of intervertebral discs, in some countries as Germany, France, and Denmark, it was decided to include lumbar disc diseases in the list of occupational diseases [8].

Our study demonstrated a significant interaction effect of the category of heavy physical loads and other factors, on the occurrence of degenerative changes at a higher degree at all three levels. For the level of L3-L4 and L4-L5 model of binary logistic regression showed association of hard physical labor and the years of exposure to such work which coincides with the study of Hung et al. [22], which has proven connection between degeneration of intervertebral discs and cumulative workload.

A study conducted in the group of women gave results that lumbar disc degeneration are not associated with the job type and characteristic physical loadings [23]. Our results revealed the significant influence of hard physical labor in women on the occurrence of higher grade of IDD at the level L4-L5 and particularly at level L5-S1. Precisely, our results indicate that women with heavier physical workload have more chances to have higher grade of IDD than men with the same workload on both levels L4-L5 and L5-S1. Additionally, women who lift and carry more than 30% during working time have more chances to have higher grade of IDD than men on level L5-S1.

However, studies that investigated the cumulative load of the lumbar spine in women found a positive relation between the dose of physical activity and the occurrence of LDH [22].

A cross-sectional study, however, showed a significant association between performing sedentary activities in females and the number of degenerative intervertebral discs changed at the level of L5-S1 [24].

Current studies indicate that lumbar intradiscal pressure in sitting is unlikely to pose a threat to non-degenerate discs, and sitting is no worse than standing for disc degeneration or low back pain incidence. If sitting is a greater threat for development of low back pain than standing, the mechanism is unlikely to raise lumbar intradiscal pressure [25].

In our group of patients we found an association between prolonged sitting for over 30% working hours and a higher degree of degenerative changes at the level L3-L4. Namely, patients who are sitting more during working time have increased chances to have higher grades of IDD than patients who sit less.

In our study, the effect of whole body vibrations on discs at L5-S1 level proved to be significant because it gave higher degree of degenerative changes, compared to those in subjects subjects who were not exposed to general vibrations in the workplace. The association between whole body vibration and degeneration of IVD has confirmed in a study carried out earlier [26]. Vibrations at or near the spine's intrinsic resonance frequency cause abnormal pressure-dependent fluid shifts in the intervertebral disc. The combination of certain postures of the spine with vibrations in the resonance range leads to increased energy consumption, probably because of the 2.5-fold increase in axial stress, that experimental studies have shown, to arise with vibrations in this range [2].

Potential limit, or the specificity of our study in the research of degenerative changes in the discs of lumbar region is that our study group represents only those with diagnosed LDH without including subjects who do not have LDH. Being unable to precisely measure the dose of physical activity in interaction with other occupational hazards during work time and their relations with degenerative changes of IVD, adds a strong suspicion of a causal association.

Conclusion

Symptomatic discs show higher frequency of higher grades of IDD, but herniation does not occur solely at the disc with the most prominent degenerative changes. The results suggest the importance of inter-influence of physical workload and the years of employment, and the inter-influence of physical workload and gender, as well as on degeneration of the lumbar discs.

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Received on November 12, 2015.
Revised on April 23, 2016.
Accepted on April 27, 2016.
Online First October, 2016.