Scientific Research Publishing

Health, 2026, 18(1), 82-93
https://www.scirp.org/journal/health
ISSN Online: 1949-5005
ISSN Print: 1949-4998

The Association between Cigarette Smoking and Lumbar Disc Herniation Using MRI, Correlation with Occupation and Duration of Smoking

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How to cite this paper: Abdelrahim, E. (2026) The Association between Cigarette Smoking and Lumbar Disc Herniation Using MRI, Correlation with Occupation and Duration of Smoking. *Health*, **18**, 82-93.
https://doi.org/10.4236/health.2026.181006

Received: December 2, 2025
Accepted: January 19, 2026
Published: January 22, 2026

Abstract

Background: Lumbar intervertebral disc herniation (LDH) is a major contributor to low-back pain. It is unknown how cigarette smoking duration and occupation combine to increase LDH risk in Sudanese males. Objectives: Quantify MRI-confirmed LDH patterns in male smokers and determine if long-term smoking (>10 years) and manual employment independently predict pathology. Methods: A prospective cross-sectional study of 56 male smokers (mean age 46 ± 12 years). Smoking history, occupation, and MRI data were analyzed using χ^2 tests. Variables with $p < 0.10$ were incorporated into a multivariable logistic-regression model (backward likelihood-ratio) to yield adjusted odds ratios (AORs, 95 % confidence interval). The analyses were done using SPSS v29. Sample size justification: G*Power 3.1 shows that n = 56 has 80% power to detect an OR ≥ 2.8 at $\alpha = 0.05$. Results: LDH was found to be independently predicted by smoking for more than 10 years and manual labor (AOR = 3.2, 95% CI = 1.4 - 7.1 and AOR = 2.7, 95% CI = 1.1 - 6.5, respectively; both $p < 0.01$). Longer smoking duration and occupational load increase LDH risk. Integrated smoking cessation and ergonomic programs may reduce this burden.

Keywords

Low-Back Pain, Smoking, Lumbar Disc Herniation, MRI

1. Introduction

While traumatic injuries can certainly cause lumbar disc herniation, it's far more common for the condition to develop gradually due to a combination of factors.

Cigarette smoking is a significant and well-established risk factor, independent of trauma. The link isn't fully understood in all its complexities, but several mechanisms contribute [1]. Studies on the relationship between tobacco smoking and disc herniation have shown a consistent association, with smokers exhibiting a significantly increased risk compared to non-smokers. However, the exact mechanisms and strength of association remain areas of ongoing research and debate. Smoking constricts blood vessels, reducing blood flow to intervertebral discs. This hypoxia (lack of oxygen) impairs the disc's ability to heal and repair itself, making it more vulnerable to injury and herniation. This is considered a major contributing factor. Smoking accelerates degenerative process in the intervertebral discs, leading to earlier onset and more severe disc degeneration [2]. This weakened disc is more prone to herniation. Smoking affects collagen synthesis and degradation, weakening the disc's structural integrity and increasing the risk of rupture. Smoking can modulate the inflammatory response within discs, potentially contributing to the development of herniation. Studies suggest smokers are more likely to require surgery for disc herniation due to slower healing and higher recurrence rates. In summary, cigarette smoking is a significant independent risk factor for lumbar disc herniation due to its multifaceted negative effects on disc health and integrity. Quitting smoking is a crucial step in reducing the risk of developing this condition [2].

A major socioeconomic burden on working-age populations, low-back pain caused by lumbar intervertebral disc herniation continues to rank among the world's leading causes of disability [3]. When annular integrity is compromised by degeneration or mechanical stress, nucleus pulposus material can protrude or extrude into spinal canal, compressing neural components and resulting in lumbar disc herniation [2]. Despite a fact that magnetic resonance imaging (MRI) has improved identification and description of these lesions, there are currently few effective preventive measures available, mostly due to incomplete definition of modifiable risk factors.

Through nicotine-induced microvascular constriction, persistent hypoxia-mediated matrix breakdown, and accelerated cellular senescence within the annulus fibrosus and nucleus pulposus, cigarette smoking is a biologically plausible contribution to disc degeneration [4]. According to meta-analyses, smokers have a higher risk of lumbar disc herniation [5]. However, majority of studies use self-reported symptoms or plain radiography instead of MRI-confirmed pathology, and few look at possible relationships between cumulative smoking exposure and physically demanding jobs.

The projected daily smoking prevalence among adult males in Sudan is still high [6], but there are hardly any MRI-based studies examining connection between smoking and lumbar disc disease. There was a significant knowledge gap regarding the joint effects of smoking duration and job-related mechanical stress on disc health since previous regional studies frequently excluded smokers, combined smokers and non-smokers, or lacked thorough occupational classification.

In this study, MRI-confirmed lumbar disc herniation in male Sudanese smokers is prospectively evaluated, its distribution across lumbar levels is quantified, and the independent and combined effects of smoking duration and occupational class are assessed. This work intends to inform ergonomic guidelines and targeted smoking cessation campaigns to reduce disc-related disability in Sudan and similar countries by providing population-specific evidence [7].

2. Material and Methods

This study used a prospective cross-sectional analytical design with 56 male Sudanese smokers referred for lumbar spine MRI. There was no intervention, and all data were gathered by observation at a single time point. The data collected according to (age, smoking history, symptoms) from private centres in the duration from November 2023 to November 2024. Ages of patients range between 27 to more than 55 years. MRI data were analyzed using χ^2 tests. Variables with $p < 0.10$ were incorporated into a multivariable logistic-regression model (backward likelihood-ratio) to yield adjusted odds ratios (AORs, 95 % confidence interval). The analyses were done using SPSS v29. Sample size justification: G*Power 3.1 shows that n = 56 has 80% power to detect an OR ≥ 2.8 at $\alpha = 0.05$. The term "history of disease" related to the duration of self-reported low-back complaints previous to MRI evaluation, which recorded as a continuous variable and measured in years. This measure was included to determine whether the chronicity of symptoms was associated with MRI-confirmed lumbar disc disease. The study focused on cigarette smokers with duration of smoking more than 5 years to 25 years. Patient's symptoms were lower back pain, lower limbs (pain, Numbness, weakness). The data collected by data collection sheets which were designed by the researcher include all variables needed in this study. All patient scanned by MRI lumbar spine with same lumbar spine protocols. A senior radiologists interpreted different patient's images from sagittal, axial, myelography projections and wrote a final report. The study was prospective, analytical, and cross-sectional. Inclusion criteria were male smokers aged ≥ 18 years with lumbar discomfort referred for MRI, excluding prior lumbar surgery or malignancy. For analytical purposes, "manual labor" was defined according to ISCO standards as jobs that required repetitive lifting, carrying, bending, extended standing, or a high mechanical spinal load (for example, soldiers, construction workers, drivers, and heavy-duty workers). This operational definition is consistent with occupational health literature, which shows that labor demanding repetitive lifting, awkward postures, and continuous mechanical load increases spinal stress and the likelihood of lumbar disc diseases [8] [9]. Teachers, despite being substantially represented in the sample, were classed as non-manual workers since their job duties did not fit biomechanical criteria. Their high prevalence in the sample reflects referral patterns rather than being classified as manual labor. This statement resolves apparent conflict between observed occupational frequencies and corrected regression results.

Occupations were coded using the International Standard Classification of Oc-

cupations and divided into manual and non-manual categories for analysis.

3. Results

The study found that most common age group of male smokers affected by disc problems were in the age group 46 - 55 years (42.9%) and 36 - 45 years (30.4%).

Table 1 demonstrates that LDH was most prevalent among participants aged 46 - 55 years (42.9%), followed by those aged 36 - 45 years (30.4%). Together, these two categories accounted for more than 73% of all cases, demonstrating that LDH in smokers primarily affects middle-aged people. 27 - 35-year-old group had the lowest prevalence (10.7%), indicating that age-related degenerative changes combined with cumulative smoking exposure may contribute considerably to LDH risk.

Table 1. Frequency distribution of age group.

Age group	Frequency	Percent	Valid Percent	Cumulative Percent
27 - 35	6	10.7	10.7	10.7
36 - 45	17	30.4	30.4	41.1
46 - 55	24	42.9	42.9	83.9
More than 55	9	16.1	16.1	100.0
Total	56	100.0	100.0	

Table 2 shows that the average cigarette smoking duration was 10.7 ± 5.5 years, indicating long-term nicotine exposure for most subjects. The sample's average BMI of 25.18 kg/m^2 indicates overweight, potentially increasing mechanical pressure on lumbar spine. The average duration of low-back symptoms (history of disease) was 3.56 ± 2.56 years, indicating that most participants had chronic problems before MRI scan. The mean age, weight, height, BMI, Duration, and history of smoking was 46.82 years, 82.37 kg, 180.82 cm, and 10.71, 3.56 years respectively.

Table 2. Descriptive statistics for age, duration of smoking, history, height, weight, BMI Among the smokers.

Variables	N	Minimum	Maximum	Mean	Std.Deviation
Age	56	27	64	46.82	9.525
Duration of Cigarette Smoking/Years	56	4.0	23.0	10.714	5.5456
History of disease	56	.10	9.00	3.5679	2.56479
Weight in Kg	56	65.0	115.0	82.375	10.4578
Height in cm	56	173.0	195.0	180.821	4.9363
BMI	56	20.52	31.86	25.1860	2.92974
Valid N (listwise)	56				

Figure 1 shows that teachers (35.7%) and soldiers (12.5%) were the most common jobs among impacted people. Teachers were not classed as manual labor, although their significant representation is likely due to referral practices rather than occupational biomechanical stress. Soldiers, who engage in repetitive lifting and severe physical activity, accounted for highest proportion of actual manual labor-related LDH patients, confirming occupational risk trends identified in the regression analysis.

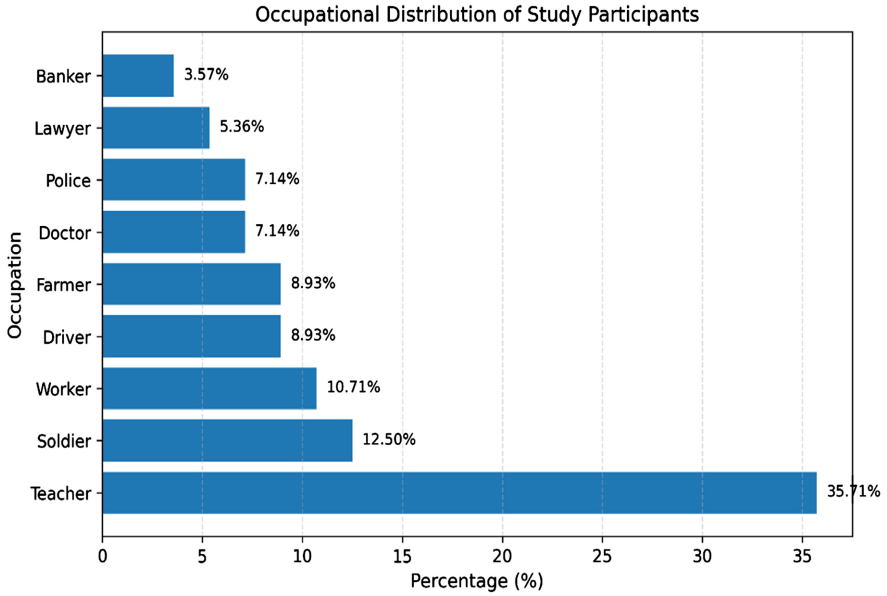

Figure 1. The occupation of the participants.

Table 3 shows that 67.9% of participants smoked for 4 - 10 years, with approximately one-third smoking for more than 11 years. Longer smoking duration was associated with more severe MRI results, which is consistent with nicotine's degenerative effects on disc vascularity and metabolism. Furthermore, 55.4% of subjects reported symptom duration between 0.1 - 3 years, indicating that LDH frequently develops after several years of chronic smoking exposure.

Table 3. Frequency distribution of duration and history.

Variables	Frequency	Percent	Valid Percent	Cumulative Percent
		Duration		
4 - 10	38	67.9	67.9	67.9
18 - 23	11	19.6	19.6	87.5
11 - 17	7	12.5	12.5	100.0
		History		
0.1 - 3	31	55.4	55.4	55.4
3.1 - 6	16	28.6	28.6	83.9
6.1 - 9	9	16.1	16.1	100.0
Total	56	100.0	100.0	

The majority of individuals (85.7%) reported lower back pain as their primary complaint, with 58.9% reporting lower limb symptoms such numbness or radiculopathy. This pattern corresponds to the anatomical distribution of nerve compression in LDH, specifically at L5-S1, which was the most usually affected level (Figure 2).

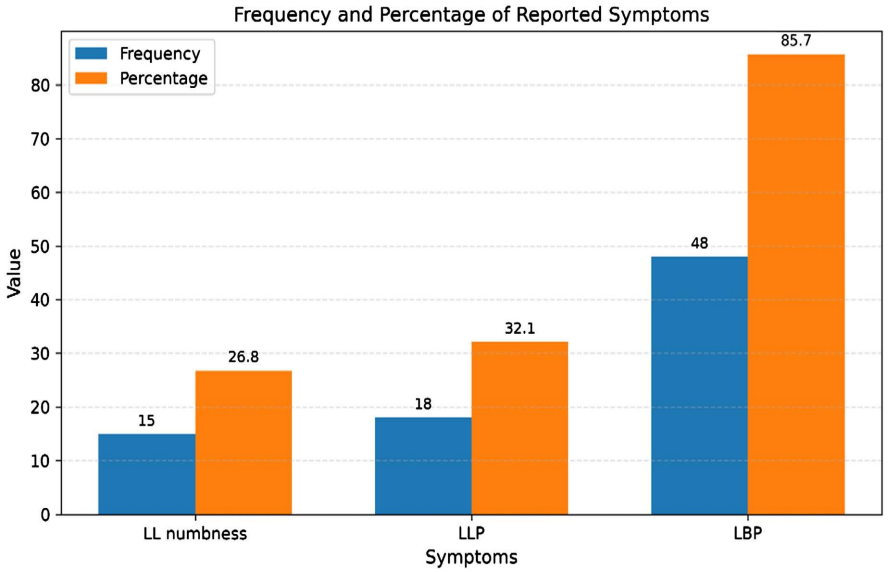

Figure 2. Frequency distribution of sign and symptoms.

Table 4 cross-tabulation to assess the correlation between age groups and the degree of disc prolapse demonstrates a statistically significant relationship between age group and degree of disc prolapse (p = 0.005). Severe prolapse occurred primarily in the 36 - 45 and 46 - 55 age ranges, while mild prolapse was more common among younger participants. These data support the concept that both aging and chronic smoking exposure contribute synergistically to disc degeneration.

Table 4. Cross-tabulation to assess the correlation between age groups and the degree of disc prolapse.

Age groups	Degree of the Disc Prolapse			Total
	Mild	Moderate	Severe	
27 - 35	4	2	0	6
36 - 45	4	6	7	17
46 - 55	5	14	5	24
More than 55	0	9	0	9
Total	13	31	12	56
P value 0.005				

Figure 3 shows that the most common pathology was L5-S1 disc prolapse (33.9%), followed by mixed L4-L5/L5-S1 involvement (16.7%). A smaller number

of patients showed multilevel degenerative disc degeneration. The prominence of L5-S1 participation is consistent with its biomechanical load-bearing role and sensitivity to degenerative alterations.

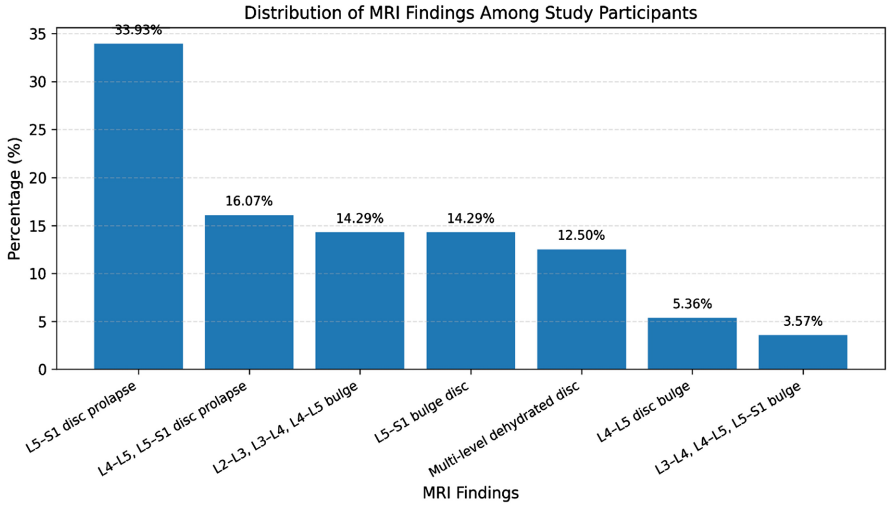

Figure 3. MRI findings.

Figure 4 shows that overweight individuals (BMI ≥ 25) had higher levels of disc prolapse, albeit this trend was not statistically significant. This observation implies that greater body weight may contribute to increasing lumbar mechanical stress.

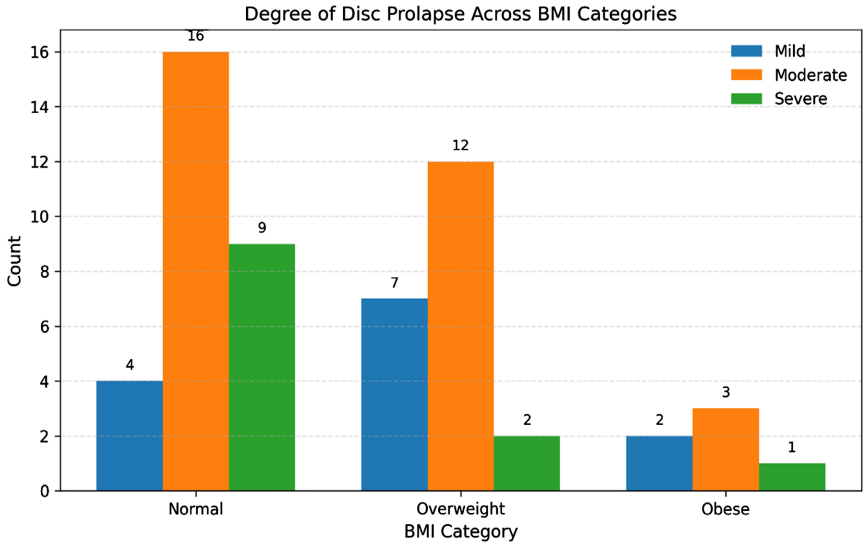

Figure 4. Cross-tabulation to assess the correlation between BMI and degree of disc prolapse.

Figure 5 demonstrates that participants who had smoked for more than ten years had a larger proportion of moderate and severe MRI abnormalities than those who smoked for less than ten years. This pattern supports the regression findings that longer smoking time independently predicts LDH severity.

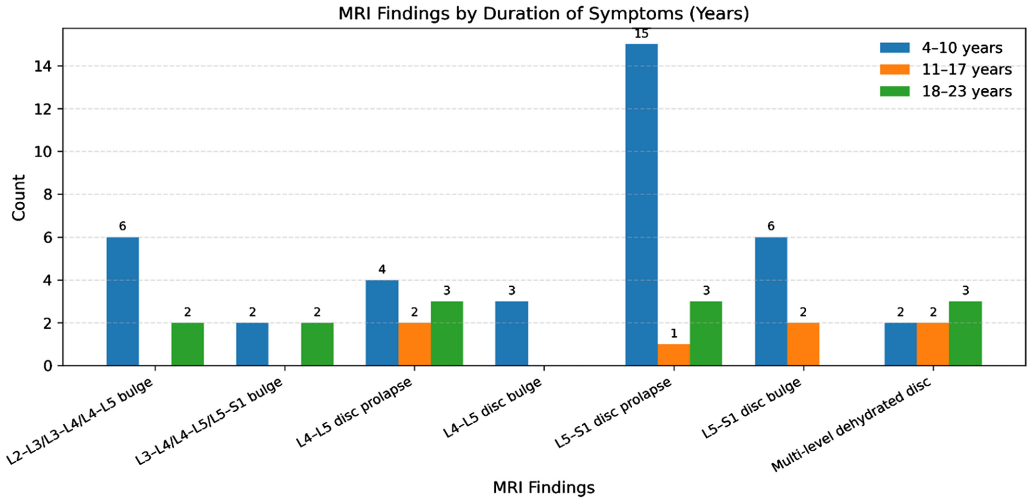

Figure 5. Cross-tabulation to assess the correlation between the duration of smoking and MRI findings.

4. Discussion

Our main principle is that smoking duration and occupational loading are independent but synergistic risk factors for LDH in this Sudanese group. Strengths include prospective data acquisition and MRI confirmation. Limitations include lack of a non-smoking control, a male-only sample, and self-reported smoking exposure. Future studies should validate smoking exposure with serum cotinine levels and recruit female individuals to ensure generalizability.

A few key findings from this study indicate that the age range of 46 - 55 years (42.9%) and 36 - 45 years (30.4%) was the most common among male smokers with disc difficulties. According to **Table 1** This age range corresponds with normal timeframe for the beginning of degenerative disc disease. As we age, discs in our spine naturally deteriorate, losing their suppleness and moisture, this degenerative process is accelerated by smoking. The combined effects of years of smoking and age-related degeneration probably raise the chance of disc issues by time a person is 36 to 55 years old **Table 1**. These age groups' members have probably smoked for a significant amount of their adult lives; a study by G. Livshits et al. confirmed this finding, which indicates that age and cigarette smoking history are significant risk factors for disc degeneration disease [10].

A latency interval between initiation of smoking and development of clinically severe disc issues may be the cause of highest occurrence in 46 - 55 age range. According to a thorough analysis by Niharika Rajesh a. et al. on smoking and degenerative spinal illness, the harm produced by smoking may not become apparent for years until symptoms start to show [11]. In addition to being in the prime of their working lives, these age groups may work in physically demanding occupations or partake in other activities that further strain their spines, exacerbating negative consequences of aging and smoking. The increased prevalence may be explained by combination of smoking-induced disc health impairment and physical strain [11]. In conclusion, the evidence points to a significant interplay between aging, chronic smoking, and the emergence of disc issues in males aged 36 - 55 [12].

These factors—height, weight, and BMI—are frequently connected to spinal stress and likelihood of back issues. Increased strain on spine is linked to higher weight and BMI **Table 2**.

Disc degeneration may be more severe in older smokers with longer smoking histories. The claim that "Most smokers were in 4 - 10 years' duration (67.9%), and more than half of participants with duration history of 1 month to 3 years (55.4%)" Many participants had likely been smokers for a considerable period of time, as indicated by high percentage in 4 - 10 years range **Table 3** [13].

The occupational distribution reported in this study needs to be regarded with caution. Although teachers were the largest occupational group, current research does not identify teaching as a high-mechanical-load profession, and there is no link in the literature between ordinary teaching activities and an elevated risk of lumbar disc herniation. Their increased representation most likely reflects referral patterns rather than genuine biomechanical risk. Soldiers, on the other hand, perform tasks that require repetitive lifting, load carriage, prolonged standing, and exposure to whole-body vibration, all of which have been linked to spinal mechanical stress and lumbar disc degeneration (Costa & Vieira, 2010; Dolan & Adams, 1998; Punnett & Wegman, 2004). Future research with larger, occupation-stratified samples is required to evaluate whether occupational differences reported in this study reflect actual risk variance or sampling factors **Figure 1** [14]. Spinal discomfort can also result from lifting and carrying objects like books and supplies. Muscle strain may be indirectly caused by high-stress atmosphere of teaching, raising possibility of disc issues [15]. Poor posture and a lack of awareness of body mechanics can result from stress. Although there is some movement involved in teaching, it frequently lacks the variety and intensity of exercise required to keep back muscles that support spine strongly [16]. Awkward postures, frequent bending, carrying heavy objects (materials, equipment), and reaching overhead are all common when soldering. These activities increase risk of disc herniation by placing a great deal of strain on the spine, particularly lower back. Intervertebral discs may also deteriorate because to the continuous pressure and vibration caused by tools. Workspaces used for soldering may not always be ergonomically constructed, which might result in bad posture and more spinal strain. Lack of proper support and prolonged periods in uncomfortable positions exacerbate the risk. Usage of certain soldering tools can cause significant vibration, which is transmitted to the spine and can contribute to disc degeneration and eventual prolapse **Figure 2** [17].

For a number of reasons, lumbar 5-Sacrum 1 (L5-S1) disc prolapse is most typical site for a slipped disc **Figure 3**. The lowest and most heavily loaded disc in lumbar spine is the L5-S1 disc. It is the junction of more rigid sacrum and comparatively flexible lumbar spine. It becomes more vulnerable to damage as a result of this transition, which concentrates biomechanical stress. Increased stress on this specific disc is also a result of L5 vertebra's tilt with respect to sacrum. Numerous movements, such as flexion (bending forward), extension (bending backward), lat-

eral bending (side-to-side), and rotation, are performed by L5-S1 joint [9].

A high average BMI could suggest obesity as a contributing factor to the disc issues, alongside smoking [18]. Multiple regression analyses controlling for occupation, history of driving, smoking, and back injuries found that persistently being overweight (body mass index (BMI) > or = 25 kg/m (2) at both ages) was strongly associated with an increased risk of the number of lumbar discs with decreased nucleus signal intensity **Figure 4** [19].

The risk of disc injury is increased when weight-bearing and heavy movement are combined. This area is subjected to significant stress from a variety of daily tasks, including lifting and twisting [20]. L5-S1 disc may be significantly more vulnerable due to inherent structural features, even though all intervertebral discs are prone to degeneration. Its size, the angle of spinal endplates, or other minute anatomical details may be related to this. A prolapsed disc is most likely to crush nerve roots that exit at L5-S1 level **Table 4**. Because nerve roots supplying leg are squeezed at L5-S1 disc prolapse, sciatica, or pain spreading down leg, is a common complaint. The higher probability of observable symptoms may contribute to higher frequency of reported L5-S1 prolapses **Figure 5** [21].

5. Conclusion

The study reveals that increasing duration of cigarette smoking, heavy lifting and long-time sitting jobs are predisposing factors of lumber disc herniation, MRI is golden investigation of choice in diagnosing lumbar disc herniation.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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