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Distribution of the Pfirrmann Classification by BMI and Age in a Mexican Population

Distribución de la clasificación de Pfirrmann según IMC y edad en una población mexicana

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ABSTRACT. This study aimed to delineate trends in intervertebral disc degeneration among Mexican patients, specifically focusing on the distribution and correlation between BMI and Pfirrmann classification results within the Mexican population. Conducted using the public health database of Mexico City. The study involved 51 patients sampled via convenience sampling, with exclusive utilization of internal MRI data from L4-L5 and L5-S1 discs. Data encompassed gender, age, height, weight, BMI, and radiographic findings. The dataset was stratified by gender and BMI categories, with analyses including measures of distribution and association, notably employing the Dunn test to compare BMI groups. Visualization tools such as violin plots and box-and-whisker charts were employed to elucidate the relationships between BMI, age, and Pfirrmann classification results. In both female and male groups, increasing BMI exhibited a positive correlation with disc degeneration severity, particularly

RESUMEN. Este estudio tuvo como objetivo delinear las tendencias en la degeneración del disco intervertebral entre pacientes mexicanos, centrándose específicamente en la distribución y correlación entre el IMC y los resultados de la clasificación de Pfirrmann dentro de la población mexicana. Se llevó a cabo utilizando la base de datos de salud pública de la Ciudad de México. El estudio involucró a 51 pacientes seleccionados mediante muestreo de conveniencia, con uso exclusivo de datos internos de resonancia magnética de los discos L4-L5 y L5-S1. Los datos abarcaron género, edad, altura, peso, IMC y hallazgos radiográficos. El conjunto de datos se estratificó por género y categorías de IMC, con análisis que incluyeron medidas de distribución y asociación, en particular empleando la prueba de Dunn para comparar grupos de IMC. Se emplearon herramientas de visualización como gráficos de violín y diagramas de caja y bigotes para dilucidar las relaciones entre el IMC, la edad y los resultados de la clasificación de Pfirrmann. En los gru-

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pronounced in the obesity category. Statistical analyses revealed differences between normal BMI and overweight/obesity groups. Furthermore, there is also an increase in severity between overweight and obesity groups. The odds ratios (ORs) for disc degeneration severity, comparing different BMI categories, reveal significant associations. Among women, overweight individuals have 3.333 times higher odds of presenting a Pfirrmann classification result ≥ 4 at L4-L5, and 6.545 times higher odds at L5-S1, compared to those with normal BMI. Similarly, women with obesity have 8 times higher odds of disc degeneration at both levels. For men, the ORs were 1.6 and 2.222 at L4-L5 and L5-S1, respectively, comparing normal BMI to overweight individuals, the ORs were 5 at L4-L5 and 4.166 at L5-S1 when comparing normal BMI to obesity. This study offers persuasive evidence that, among Mexican patients, body mass index (BMI) is probably correlated with the severity of lumbosacral degenerative disc degeneration (DDD). Acknowledging limitations in sample size, future investigations should delve into elucidating the underlying mechanisms driving this correlation. Multi-center studies with larger, diverse cohorts are warranted to validate and enhance the generalizability of our findings. We promote the focus on early detection and prevention, marking a paradigm change in the treatment of degenerative spine disorders and opening the door for creative methods of patient care and public health campaigns.

Keywords: intervertebral disc degeneration, BMI, Pfirrmann classification, Lumbar degenerative disc disease, low back pain.

pos de mujeres y hombres, el aumento del IMC exhibió una correlación positiva con la gravedad de la degeneración del disco, particularmente pronunciada en la categoría de obesidad. Los análisis estadísticos revelaron diferencias entre los grupos de IMC normal y sobrepeso/obesidad. Además, también hay un aumento de la gravedad entre los grupos con sobrepeso y obesidad. Los *odds ratios* (OR) para la gravedad de la degeneración discal, comparando diferentes categorías de IMC, revelan asociaciones significativas. Entre las mujeres, los individuos con sobrepeso tienen 3.333 veces más probabilidades de presentar un resultado de clasificación de Pfirrmann ≥ 4 en L4-L5, y 6.545 veces más probabilidades en L5-S1, en comparación con aquéllos con IMC normal. De manera similar, las mujeres con obesidad tienen 8 veces más probabilidades de degeneración discal en ambos niveles. Para los hombres, los OR fueron 1.6 y 2.222 en L4-L5 y L5-S1, respectivamente, comparando IMC normal con individuos con sobrepeso, los OR fueron 5 en L4-L5 y 4.166 en L5-S1 cuando se compara IMC normal con obesidad. Este estudio ofrece evidencia convincente de que, entre los pacientes mexicanos, el índice de masa corporal (IMC) probablemente esté correlacionado con la gravedad de la degeneración discal degenerativa lumbosacra (DDD). Reconociendo las limitaciones en el tamaño de la muestra, las investigaciones futuras deben profundizar en la elucidación de los mecanismos subyacentes que impulsan esta correlación. Se justifican estudios multicéntricos con cohortes más grandes y diversas para validar y mejorar la generalización de nuestros hallazgos. Promovemos el enfoque en la detección temprana y la prevención, lo que marca un cambio de paradigma en el tratamiento de los trastornos degenerativos de la columna vertebral y abre la puerta a métodos creativos de atención al paciente y campañas de salud pública.

Palabras clave: degeneración del disco intervertebral, IMC, clasificación de Pfirrmann, enfermedad degenerativa del disco lumbar, dolor lumbar.

Introduction

The increasing population weight is a public health issue in Mexico to the extent that, at the national level, in 2018, the percentage of adults aged 20 and over, with overweight or obesity was 75.2% (39.1% overweight and 36.1% obesity), a 3.9% increase since 2012. This not only indicates an increase in the population with risk factors but also an increase in the severity of the population already within these ranges.[1] In the United States alone, $147 billion is spent annually to treat disorders attributable to obesity.[2]

Lumbosacral degenerative disc disease and, consequently, low back pain, represent a serious public health issue and a significant occupational problem in national centers. It represents the fifth most common cause of consultation, with patients experiencing long-lasting pain and movement difficulties in 10% of all cases.[3] As reported by the Mexican Social Security Institute, more than 300,000 consultations for low back pain were provided in the year 2017, making it the most common ailment among workers and the second leading cause of hospital consultations in the field of Traumatology and Orthopedics.[1] It can lead to work-related disability for up to 10 days, and chronic suffering is associated with a reduced quality of life.[4]

There are multiple theories of disc degeneration at the lumbosacral level. Among them, genetic, mechanical, and metabolic theories stand out, the latter focusing on the metabolism of fatty tissue and the production of inflammatory mediators in the area.[5] According to the genetic theory of disc degeneration, genetics has an essential effect on the biochemical and structural integrity of intervertebral discs. Numerous theories have been put forth to account for this phenomenon. First, variations in genetics may affect the dimensions and morphology of spinal structures, which in turn may alter the spine's mechanical characteristics and how susceptible it is to outside influences. Furthermore, genetic predetermination may exist for biological processes that synthesize and

degrade the disc's biochemical components and structural elements.[6] The mechanical theory of disc degeneration implies that inappropriate loading circumstances, including overload and immobility, can cause tissue stress and adaptive changes in the intervertebral disc, which in turn can lead to disc degeneration. A thorough literature analysis has demonstrated that structural defects, including endplate fractures, radial fissures, and herniation, are unmistakable markers of intervertebral disc failure. Its structure is harmed by an excessive mechanical load, which sets off a series of cell-mediated reactions that exacerbate the damage and accelerate the degenerative process.[7] Lastly, changes in the intervertebral discs' biochemical makeup are at the center of the metabolic theory of disc degeneration. More specifically, degeneration has been associated with an elevation in collagen fiber and a decrease in the quantity of proteoglycans. These modifications cause the nucleus pulposus's chemical composition to change, shifting it from a fluid-like substance to a more solid one. Simultaneously, the water content of the annulus fibrosus tissue becomes altered by changes in its material qualities, which are directly impacted by the proteoglycan content. Reduced proteoglycan content in the nucleus pulposus is thought to be a key component affecting the disc's dynamic viscoelastic features.[8] Nevertheless, asymptomatic disc degeneration also occurs. There is a systematic literature review where thirty-three articles reporting imaging findings for 3,110 asymptomatic individuals were appraised. The prevalence of disk degeneration in asymptomatic individuals increased from 37% of 20-year-old individuals to 96% of 80-year-old individuals (Brinjikji et al., 2015).[9] Therefore, there is a need to look for a relationship between disc degeneration and potential variables that may serve as screening methods to assess the population's health.

Magnetic resonance imaging had become one of the primary methods for studying the lumbar spine, calling for the development of a morphological classification system and standardization of data collection. This led Pfirrmann and colleagues to create a straightforward algorithm and a universal classification system to facilitate data comparison. This classification is called the Pfirrmann classification. It is a classification of disc degeneration that grades the structure from I to V according to the severity, being I the least severe.[10,11]

Overweight and obesity are associated with multiple comorbidities, such as osteoarthritis, hypertension, diabetes mellitus, depression, and sleep apnea.[12] This condition tends to increase in both number and severity in the Mexican population.[1] There are weight-related implications with local changes in the lumbosacral column, and in addition to intervertebral disc degeneration, other conditions such as low back pain, radiculopathy, and an increased incidence of spinal surgery are known.[13] At the disc level, there is an increase in multidirectional mechanical load, coupled with chronic inflammation in the affected area and a decrease in blood supply, all of which, collectively lead to ischemic changes in the region.[14] Among the areas of axial load, the most important is the lumbosacral junction, which is the transition zone between lumbar lordosis and sacral kyphosis, making it a biomechanically weak point. This area is prone to degenerative changes when the normal body weight is exceeded.[15]

The objective of this study is to identify trends in degenerative changes in intervertebral discs and to describe the distribution and association between BMI (Body Mass Index) and Pfirrmann classification results within the Mexican population.

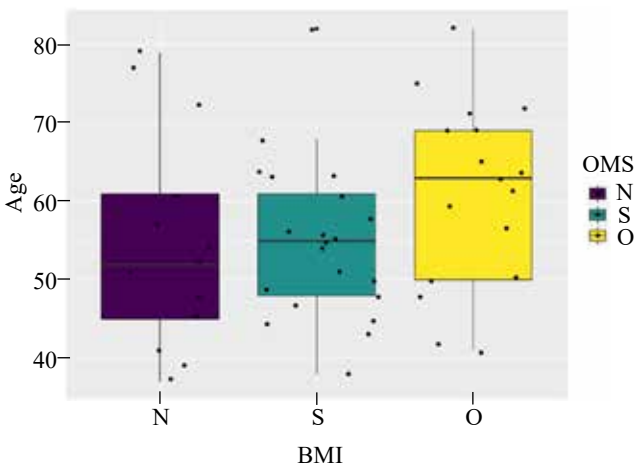

Figure 1: Box Plot. Population distribution according to their BMI and age. N = normal (BMI < 24.0 kg/m^2), S = overweight (BMI 25.0 - 29.9 kg/m^2), O = obese (BMI > 30 kg/m^2). BMI = Body Mass Index.

Material and methods

We conducted an observational retrospective transversal study. The study assesses data from January to July 2020 from the public health database of the High Specialty hospital of Mexico City. There were 51 patients sampled using a convenience sampling method. Patients' age ranges from 35 to 83 years old.

Data obtained included gender, age, height, weight, body mass index (BMI), and MRI data of L4-L5 and L5-S1 (1.5 Tesla General Electric nuclear magnetic resonator). The data of the patients was indirectly obtained, we used the hospital's stored information in the Carestream View Motion (Carestream Health, Inc. 2008) software. The BMI measurements used in this study were obtained within 12 months before the MRI scan, ensuring the data's relevance to the imaging analysis. We obtained 102 intervertebral spaces from 51 magnetic resonances.

Inclusion criteria comprised ages 35 to 83 years who are registered in the hospital's internal magnetic resonance imaging (MRI) software. Patients were selected in ascending alphabetical order. Additionally, patients' MRI data must have been obtained between January and July 2020. The study included a total of 51 patients, with 31 women and 20 men, for a total of 102 intervertebral spaces recorded.

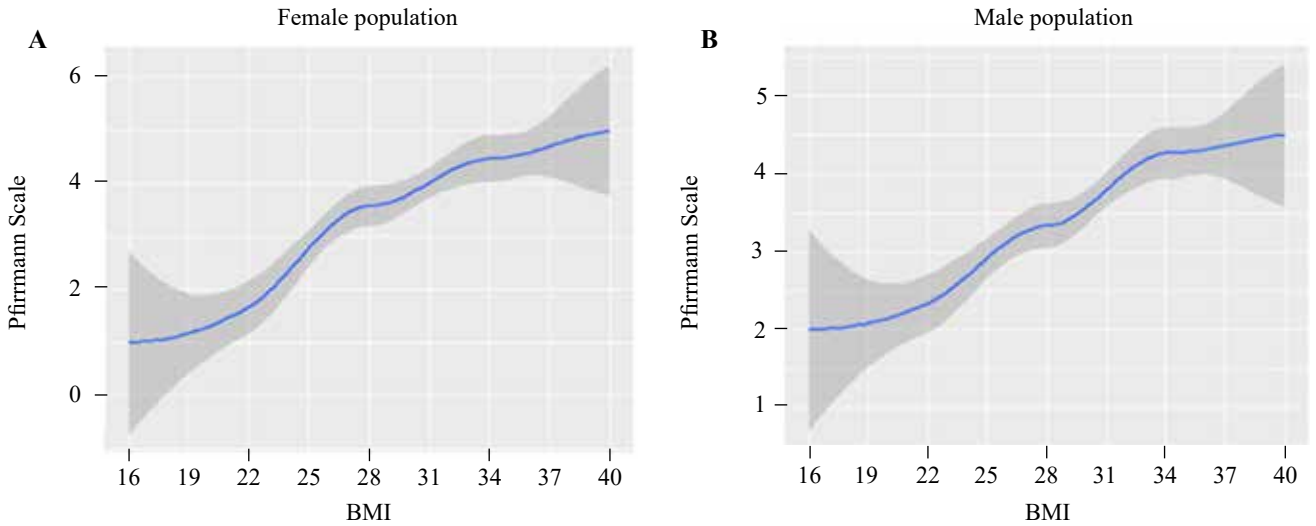

Figure 2: Smooth Scatter Plots of the female and male population Pfirrmann classification result with BMI as independent variable. BMI = Body Mass Index.

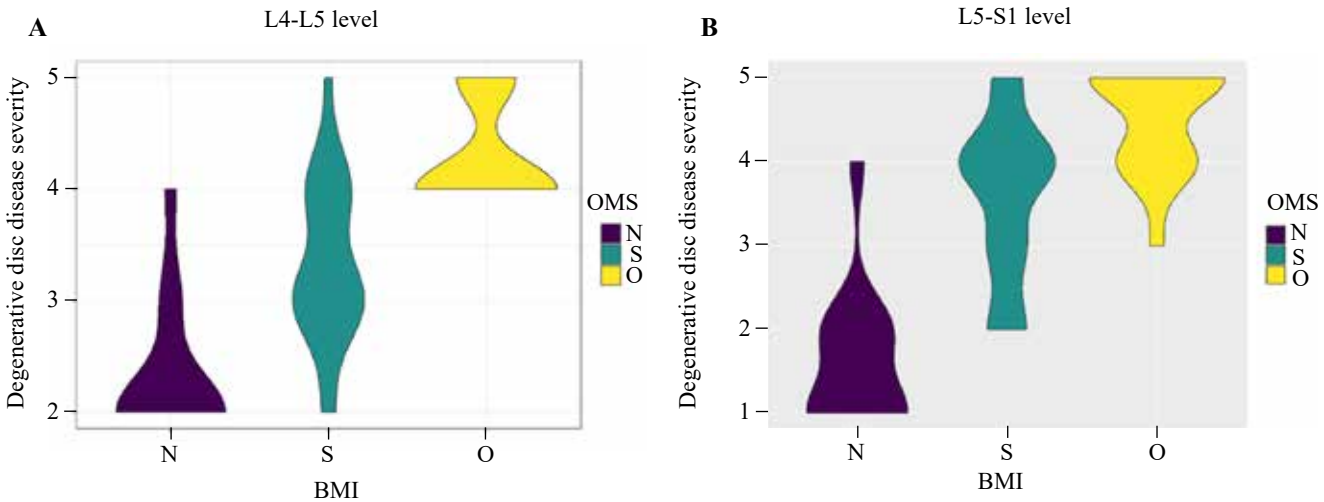

Figure 3: Violin Plots.L4-L5 and L5-S1 disc disease severity distribution in normal, overweight, and obesity groups. N = normal (BMI < 24.0 kg/m^2), S = overweight (BMI 25.0 - 29.9 kg/m^2), O = obese (BMI > 30 kg/m^2). BMI = Body Mass Index.

Exclusion criteria included previous spinal surgery, transpedicular instrumentation, any vertebral fracture, scoliosis, vertebral agenesis, spina bifida, acute extrusions of disc herniation, and previous bariatric surgery. The dataset was separated and sorted by gender. Each group was categorized in ascending order based on the body mass index in three other groups: normal BMI, overweight, and obesity. The data was analyzed using R-Studio.

We established the sample´s distribution according to BMI and age.

Results

In the female group, the mean age was 56.93 years, height was 1.6 meters, weight was 73.09 kilograms, and BMI was 27.51 kg/m^2. Similarly, in the male group, the mean age was 56.8 years, height was 1.68 m, weight was 78.135 kg, and BMI was 27.51 kg/m^2. *Figure 1* displays the population stratified by BMI and age.

In females, the mean Pfirrmann classification result was 2.125 points for the normal weight group, 3.541 for the overweight group, and 4.454 for the obesity group. In males, the mean severity was 1.7 points for the normal weight group, 3.33 for the overweight group, and 4.33 for the obesity group. *Figures 2A-2B* illustrate a positive correlation between higher BMI and increased severity on the Pfirrmann classification.

The Dunn test results revealed significant differences between groups. The comparison between the normal BMI group and the overweight group yielded a p-value < 0.05.

Similarly, the overweight group versus the obesity group showed a p-value < 0.05. Furthermore, the comparison between the normal BMI group and the obesity group resulted in a p-value < 0.05.

To improve data visualization and ease comprehension, we decided against gender-specific subdividing our population for additional analysis due to our small sample size. Using the violin plot tool, which improves visibility over box-and-whisker plots, we evaluated the data distribution. *Figure 3A* illustrates the distribution of disc disease severity in L4-L5 categorized by each study group, demonstrating a predominance of low-grade lesions in patients with a normal BMI. In the overweight group, a bimodal distribution was found, encompassing moderate and severe lesions, while the distribution in the obesity group was characterized entirely by severe lesions. Similarly, in *Figure 3B*, L5-S1, mild lesions were more prevalent in the normal BMI group, while the overweight group exhibited a majority of grade 4 lesions, and the group with obesity showed a bimodal distribution of lesions with a predominance of severe lesions.

When compared to age, it was found that degenerative disc disease affecting levels L4-L5 *(Figure 4A)* had a more severe presentation as age increased. Grade 2 lesions were more prevalent in patients in the fifth decade, while grade 5 lesions were frequently seen in patients in the seventh decade of life. Respectively, L5-S1 *(Figure 4B)* lesions demonstrated a partially homogenous distribution, showing a similar tendency to manifest an increasing severity with age, whereas grade 5 lesions had a median exceeding the sixth decade of life.

Disease severity, in association with BMI, was found to increase as BMI increased. At the L4-L5 level *(Figure 5)*, grade 2 lesions exhibited a median BMI of 25, grade 3 lesions a median BMI of 27, grade 4 lesions a BMI of 31 IMC, and finally the highest-grade lesion presented with a median BMI of 33. On the other hand, at the L5-S1 level *(Figure 5)*, grade 1 lesions are presented with a median BMI of 24, grade 2 lesions with a BMI of 25, grade 3 lesions with a BMI of 28, grade 4 lesions with a BMI of 28, and finally grade 5 lesions presented with a median BMI of 32.5.

We performed a linear regression with the data from L4-L5 levels, which illustrates that patients with normal weight tend to have a lower average in disc degeneration severity compared to those in the overweight group, and in turn, the overweight group has lower averages than the obesity group *(Figure 6)*.

We conducted tests of associative strength measures, and dichotomous tests, and 2 × 2 tables were utilized, considering patients with obesity and overweight as the exposed group, and those with normal weight as the unexposed group. Cases were defined as those exhibiting severe lumbar degeneration, encompassing Pfirrmann grades 4 and 5. The odds ratio test was employed using the formula: M = (P1 / (1-P1)) / (P2 / (1-P2)). This provided us with a proportion of the odds for the expression of a disease compared to its absence. We chose to use the odds ratio instead of relative risk due to the retrospective nature of the study.

In the comparison of normal BMI females versus overweight individuals, the odds of presenting a Pfirrmann classification result ≥ 4 were 3.333 times higher at L4-L5 and 6.545 times higher at L5-S1. Similarly, the odds of presenting a Pfirrmann classification result ≥ 4 were 8 times higher for normal BMI females versus individuals with obesity at both L4-L5 and L5-S1. For the male population, the odds of presenting a Pfirrmann classification result ≥ 4 were 1.6 times higher for those with normal BMI versus overweight individuals at L4-L5, and 2.222 times higher

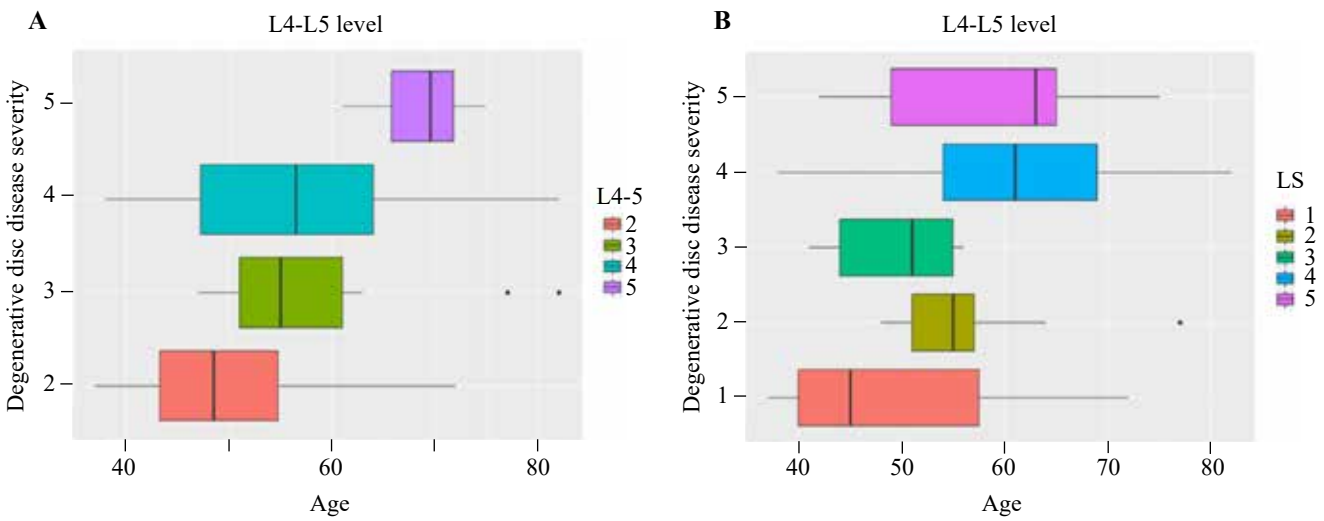

Figure 4: Box Plots. Disc disease severity distribution in L4- L5 and L5- S1 levels according to age. Pfirrman classification result used for disc disease severity (1, 2, 3, 4, 5).

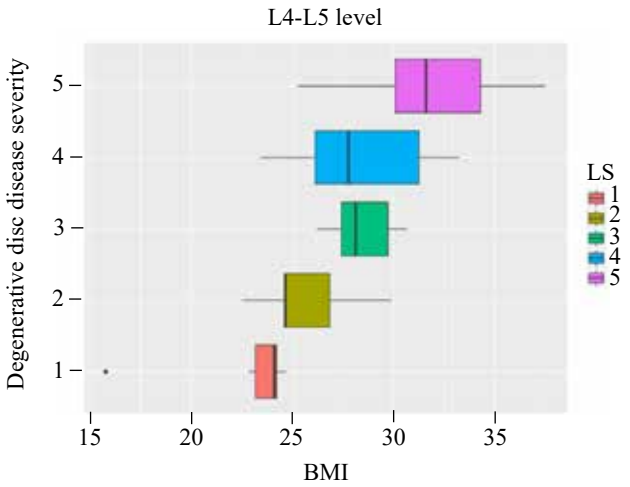

Figure 5: Box Plot. Disc disease severity distribution in L4- L5 and L5-S1 levels according to BMI. Pfirrman classification result used for disc disease severity (1, 2, 3, 4, 5).
BMI = Body Mass Index.

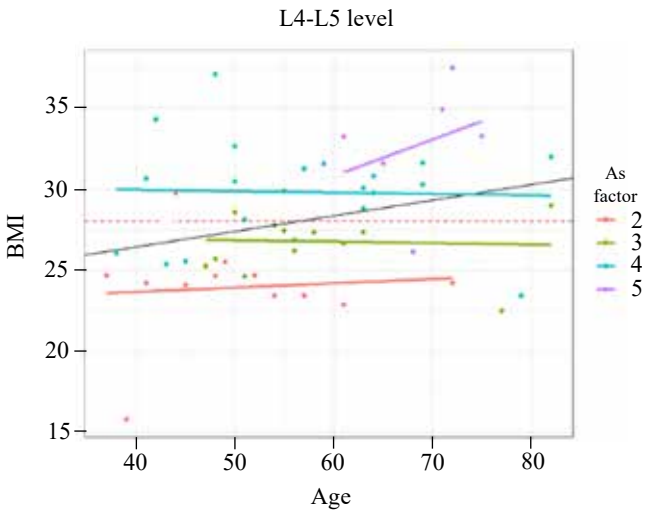

Figure 6: Scatter plot showing the relationship between age and BMI in relation to the Pfirrmann classification result (2, 3, 4, 5). Each point represents an individual (linear regression in black, disc degeneration shown in colors).

at L5-S1. Additionally, the odds of presenting a Pfirrmann classification result ≥ 4 were 5 times higher for normal BMI males versus those with obesity at L4-L5, and 4.166 times higher at L5-S1.

Discussion

Significant information gathered from our investigation and statistical studies reinforces our conclusions. Pfirrmann classification scores suggest a positive relationship between BMI and the degree of lumbar disc degeneration, which provides substantial evidence that obesity plays a role in the course of disc disease. Furthermore, our findings are consistent with the literature reviewed for this research, supporting the validity of our findings.

Although the primary aim of our research was to shed light on the connection between disc degeneration severity and BMI, we did not come across any surprising or contradictory data. It is imperative to recognize the possibility of confounding variables, such as lifestyle factors or comorbidities, that could have impacted our findings and demand a deeper investigation in subsequent studies.

Despite our study offering interesting insights, it is important to acknowledge numerous limitations. To begin with, the small sample size we used constrained the generalizability of our findings to larger groups. Additionally, using body mass index as an indirect indicator of fatness might not account for essential elements like body composition or the way body fat is distributed, which could affect the likelihood of disc degeneration. In our investigation, age was not further examined because of its confounding effects, despite being an important demographic factor in determining the risk of disc degeneration. Age is a confounding factor that can distort the connection between the dependent variable (disc degeneration severity) and the independent variable (BMI) because it correlates with both. We found that age had a weak relationship (especially at L4-L5) with the severity of disc degeneration in our data. However, considering age alongside BMI would require adjustments to account for its influence on both variables. We chose to emphasize the analysis of BMI as the key driver of disc degeneration risk due to the complexity of such modifications and the small sample size of our study. Larger sample numbers and more thorough datasets in future studies could allow for a more in-depth examination of the complex interactions between age, BMI, and disc degeneration severity, clarifying the subtle variations in these associations.

Both clinical practice and public health could be significantly impacted by our findings. Our work highlights how important it is to keep researching weight management techniques for controlling and preventing disc disease by showing a potential link between obesity and the severity of lumbar disc degeneration. When BMI screening procedures are incorporated into routine clinical evaluations, people who are more likely to develop disc degeneration may be identified earlier, allowing for more focused therapies and better patient outcomes.

Our research offers a perspective on the connection between lumbar disc degeneration severity and BMI in the context of the Mexican population. Through an examination of these variables, we provide a nuanced picture of the complex process of disc disease progression. In addition, we promote the focus on early detection and prevention, marking a paradigm change in the treatment of degenerative spine disorders and opening

the door for creative methods of patient care and public health campaigns.

Conclusion

In this study, data analysis demonstrated that lumbar degenerative disc disease was correlated with the ascending linear prediction concerning the increase in body mass index. The sample exhibited a prevalence of overweight patients, with an average BMI of 27.51 for males and 28.33 for females. These results are approximate to the latest updated census from the ENSANUT 2018 survey.[1]

There is statistical significance upon reviewing the data, enhancing the relevance of this finding. Paired statistical analyses using the Dunn test show statistical significance in each, with values $p < 0.05$. In a systematic review performed by Xu Xian, a strong correlation between obesity and overweight and a heightened susceptibility to lumbar diseases such as Lumbar Disc Disease, Lumbar Herniated Disc, and Localized Hypertrophic Neuropathy was found. Additionally, subgroup analyses provided compelling evidence that being overweight was strongly linked to the onset of lumbar disk disease when compared to factors like age and gender.[16] Similarly, in a study performed by Sheng et al. overweight or obese individuals compared to those with normal or lower weight, showed a heightened probability of developing lower back issues, with a logged odds for overweight patients of 0.218 and .395 for obese patients and intervertebral disc degeneration with logged odds of 0.441 and 0.528 for overweight patients and obese patients, respectively (IDD) The statistical analysis indicated that the connections between body weight status and the onset of spondylitis were not statistically significant.[17]

In our study, the median disc degeneration for the female population is 2.125 in individuals with a normal BMI. As individuals transition to the overweight category, the median increases to 3.541. The highest median, reaching 4.454, is observed among individuals with obesity. This pattern underscores a discernible trend: as BMI categories progress from normal to overweight and then to obesity within the population, there is a corresponding escalation in the median of disc degeneration. This alignment suggests that higher BMI levels are associated with elevated levels of lumbar disc degeneration.

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