MRI Study of Lumbar and Cervical Intervertebral Disc Degeneration – A cross sectional analysis.

C P Kirthika[1], P M Venkata Sai[3]

Tutor, Department of Anatomy,Sri Ramachandra Institute of Higher Education and Research, Porur, Chennai – 600116.

Corresponding author – **SenthilKumar S[2]**

Professor, Department of Anatomy,Sri Ramachandra Institute of Higher Education and Research, Porur, Chennai – 600116.

Professor, Department of Radiology and Imaging sciences,

Sri Ramachandra Institute of Higher Education and Research, Porur, Chennai – 600116.

Abstract:

Background

Low back pain (LBP) is a condition characterized by degenerative changes in the spine, including intervertebral discs and ligaments. This degeneration leads to increased impairment, reduced productivity, and increased healthcare costs. Risk factors for disc degeneration include genetic factors, mechanical stress, and injury. Imaging procedures like X-rays, CT scans, and MRIs are used to diagnose intervertebral disc diseases.

Methods

The study was conducted in the Department of Radiology and Imaging Sciences in Sri Ramachandra Hospital & Research Institute, SRIHER, Porur, Chennai – 600116. A total of 222 patients participated in the study (120 females and 102 males), age range (18-80) years. MRI images of the spine of the participants were used for the study.

Results

Totally 2442 IV (Intervertebral)discs were evaluated (lumbar – 1110 and cervical – 1332), out of which 1081 discs were involved in degeneration. In cervical region, totally 561 IV discs were involved in degeneration out of 1332 (42.1%). In lumbar region, totally 520 IV discs were involved in degeneration out of 1110 (46.8%). Disc bulge was the most common finding seen among the participants, both in cervical and lumbar regions. Pearson correlation revealed that there was a significant positive correlation between age and the degeneration, there was no significant correlation for gender and BMI. Older age significantly increases the risk of disc degeneration. Body mass index does not significantly predict IVDD(Intervertebral Disc Degeneration). There is no strong correlation between IVDD and pain.

Conclusion

The results highlight the necessity of thorough imaging and uniform diagnostic standards to improve therapy effectiveness and patient results.

Keywords: Low back pain, Intervertebral disc, degeneration, MRI spine, Neck pain, Lumbar spine.

Introduction

The structures of the spine, including intervertebral discs, ligaments, and osseous elements, undergo morphological changes that can be classified as degenerative(Kushchayev et al., n.d.). LBP is closely associated with degeneration of intervertebral disc, which is linked to changes in the complex structure of the annulus fibrosus, nucleus pulposus, and the surrounding spinal support structures. LBP imposes a considerable economic, social, and physical stress on the community. The impact on individuals' functional capability results in increased impairment, reduced productivity, and elevated healthcare costs(A. J. Rahyussalim et al., 2020). Risk factors associated with disc degeneration include genetic factors, mechanical stress and injury. A study done in 1995 on 115 pairs of male monozygotic twins found that genetic factors are the main causes of lumbar intervertebral disc degeneration (IVDD)(Battie et al., n.d.).Familial aggregation described 61% of IVDD scores in the upper lumbar spine and 34% of IVDD scores in the lower lumbar spine. This predominance was reinforced by additional twin studies, which estimated that genetic factors contribute to up to seventy-five percent of the vulnerability to lumbar IVDD(Livshits et al., 2011; Sambrook et al., n.d.). Possible genes involved in IVDD include VDR(Kawaguchi, Kanamori, et al., n.d.; Videman et al., n.d.),COL9A2(Annunen et al., 1999), ACAN(Kawaguchi, Osada, et al., n.d.),MMP3(Takahashi et al., 2001), COL1A1(Pluijm et al., 2004),IL-1(Solovieva et al., n.d.), IL-6 (Noponen-Hietala et al., n.d.), COL11A1(Mio et al., n.d.),MMP2 (Dong et al., 2007), IGF1R(Urano et al., n.d.), THBS2 (Hirose et al., n.d.),MMP9(Sun et al., 2009),SKT (Karasugi et al., 2009), GDF5(Williams et al., 2011). Problems with these genes could make the IV disc more sensitive to outside forces, which could lead to early degeneration. Additional research is required to elucidate the molecular mechanisms underlying each gene polymorphism. Research has demonstrated that physical activities account for only 2% to 7% of IVDD scores. Physical exercise was weakly linked to lumbar spondylosis in a study, but it was strongly linked to knee osteoarthritis(Muraki

et al., 2008). This suggests that IV discs are less susceptible to mechanical stress compared to knee joints (Oichi et al., 2020).According to a study that compared discography and control subjects, discography subjects exhibited an increased rate of disc degeneration (DD) during the 7-to-10-year follow-up period. In discography subjects, 35% showed progressing disc degeneration on MRI, compared to 14% of control subjects (Carragee et al., n.d.). It was also found that young people with a history of spinal fractures were more likely to have IVDD than healthy controls (57% vs. 8%), which suggests that trauma may be a cause of degeneration (Kerttula et al., n.d.).To diagnose precise abnormalities and sources of pain in patients with LBP, imaging procedures such as X-rays, CT scans, or MRIs are employed alongside physical examinations. MRI(Magnetic Resonance Imaging) is the most reliable and effective modality for diagnosing intervertebral disc diseases, owing to its superior image quality that reveals degeneration(A. Rahyussalim et al., n.d.).

AIM

The study's aim was to evaluate cervical and lumbar intervertebral disc degeneration's prevalence and distribution using MRI.

OBJECTIVES:

To observe the patterns of IV disc degeneration in people with low back pain(LBP) and neck pain(NP).

To assess the number of discs implicated.

To correlate the IVDD with age, gender, BMI and pain.

Materials and method

The study was conducted in the Department of Radiology and Imaging Sciences in Sri Ramachandra Hospital & Research Institute, SRIHER, Porur, Chennai – 600116 after obtaining

the approval of the Institutional ethical committee(IEC-NI/17/NOV/62/99). The consent from the participants was also obtained. A total of 222 patients participated in the study (120 females and 102 males), age range (18-80) years.1.5 Tesla GE SignaHDxt machine was used for the study. T1 and T2 weighted images of axial and sagittal projections were utilised for the study. MRI images of the spine of the above participants were used for the study. Images with anomalies obscuring the area of interest, participants with previous history of surgery were excluded.

RESULTS:

The study population included 222 participants (120 females and 102 males) (Figure1).The age range was 20 to 84 years (mean age = 47.31 ± 14.27) (Table 1). The demographic details of the participants are depicted in Table 1. Number of males and females in different age groups have been classified and shown in Table2. Totally 2442 IV discs were evaluated (lumbar – 1110 and cervical – 1332), out of which 1081 discs were involved in degeneration.

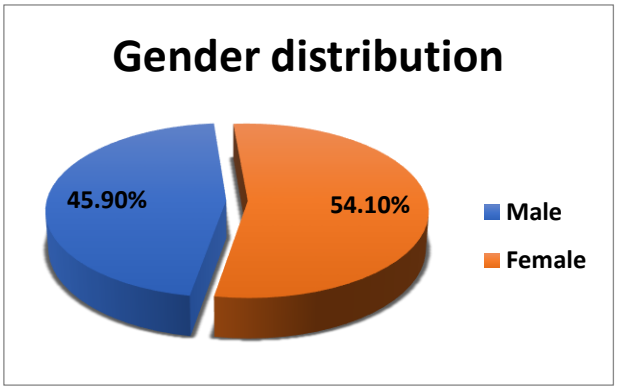

Figure 1

Variable	Min	Max	Mean	SD
Age (years)	20.00	80.00	47.34	14.27
Height (cm)	133.00	180.00	160.38	10.82
Weight (kg)	42.50	131.00	66.65	12.25
BMI	14.20	48.12	26.12	5.34

Table 1: Demographic details of the participants

Age Group	Male	Female	Total
20-40	38 (50%)	38 (50%)	76 (34%)
41-60	46 (42%)	63 (58%)	109 (49%)
61-84	18 (49%)	19 (51%)	37 (17%)
Total	**102**	**120**	**222**

Table 2: Shows no. of males & females in different age groups.

Age range (years)	Average of no. of degenerated discs
20-40	3.06
41-60	5.76
61-84	5.94

Table 2: Shows the average no. of degenerated discs in the different age groups.

In cervical region, totally 561(42.1%) IV discs were involved in degeneration out of 1332. In lumbar region, totally 520 (46.8%) IV discs were involved in degeneration out of 1110 . In the cervical region, (162) discs at C5–C6 level were profoundly affected by degeneration.

Secondly, (136) discs at C4–C5 level underwent degeneration. In the lumbar region, 172 discs at L4–L5 level were profoundly affected by degeneration. Secondly, 128 discs were affected at L3–L4 IV disc level, followed by L5–S1 (127). Disc bulge was the most common finding seen among the participants, both in cervical and lumbar regions. (Table 4) (Images 1,2,3)

Degenerative changes	Male	Female	Total
Disc Bulge	219	280	499
Protrusion	90	95	185
Dehydration/Desiccation	63	96	159
Osteophyte protrusion	24	21	45
Osteophyte	48	60	108
Disc bulge & Protrusion	13	16	29
Extrusion	7	1	8
Disc bulge & desiccation	7	11	18
Osteophyte & Bulge	5	3	8
Protrusion & desiccation	1	0	1
Desiccation & osteophyte complex	4	0	4
Disc bulge with osteophytes	3	4	7
Extrusion	0	1	1
Osteophyte & extrusion	1	0	1
Herniation	5	3	8

Table 3 Types of degenerative changes seen among the participants.

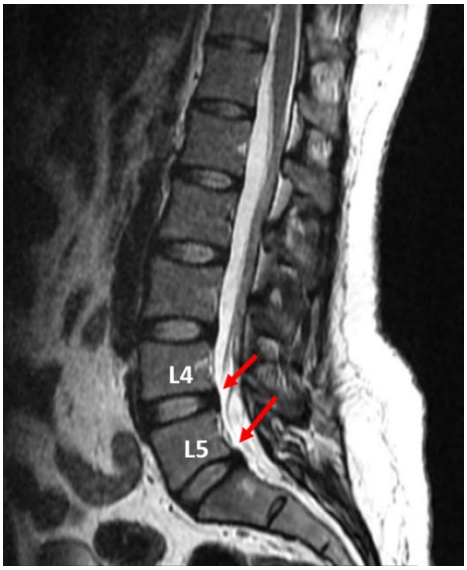

Image 1: Arrows show diffuse disc bulge at L4-L5 level and disc bulge and herniation at L5-S1 IV disc level

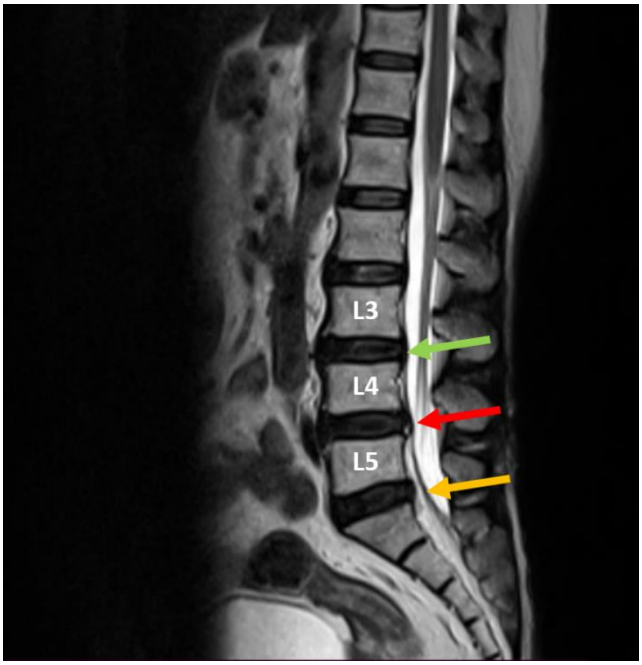

Image 2 :Green arrow shows annular bulge of L3-4 IV disc. Red arrow shows broad-based posterior protrusion with left paracentral herniation of L4-5 IV disc. Yellow arrow shows annular bulge with left paracentral extrusion of L5-S1 IV disc

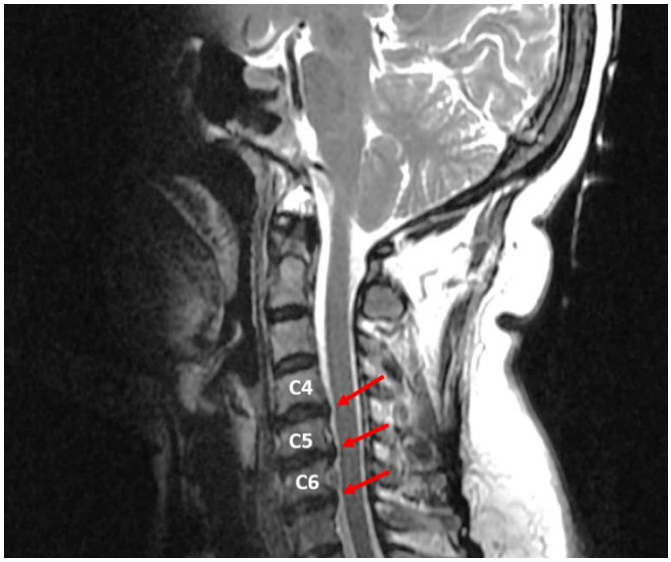

Image 3: Red arrows show mild disc bulges at C4 - C5, C5 - C6 and C6 - C7 IV disc levels.

In lumbar region, disc bulge was commonly observed in L4–L5 IV disc level in males and in L3–L4 IV disc level in females. In cervical region, disc bulge was commonly observed at C5-C6 and C6-C7 disc levels in males and C5-C6 level in females. Among the participants, 162 (73%) had LBP, 42 (18.9%) had NP, and 18 (8.1%) had both NP and LBP.(Table 5)

Region of Pain	No. of participants	Percentage
LBA	162	73.0%
NP	42	18.9%
LBA & NP	18	8.1%

Table 4: Denotes the region of pain among the participants.

The BMI distribution showed that 52.7% of the participants fell under the obese category.

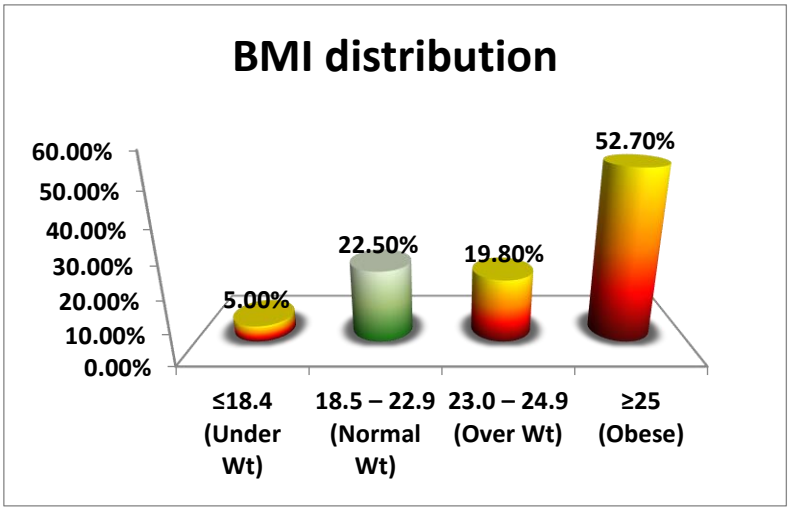

Figure 2: Shows the distribution of BMI among the participants.

IV disc degeneration was correlated with age, BMI, and gender. Pearson correlation revealed that there was a significant positive correlation between age and the degeneration(r = 0.524, p=0.000), there was no significant correlation for gender (r = 0.026, p = 0.701)and BMI (r = 0.087, p value =0.198). (Table 6)

		No of Disc
Age	Pearson Correlation	.524**
	Sig. (2-tailed)	.000
Gender	Pearson Correlation	.026
	Sig. (2-tailed)	.701
BMI	Pearson Correlation	.087
	Sig. (2-tailed)	.198

Table 5 : Pearson's correlation of DD with age, gender & BMI of the subjects.

Pain was classified into acute(<6weeks), subacute (6 weeks to 3 months) and chronic (>3 months)(Hüllemann et al., 2018)(Table 7)

Type of pain	No. of Participants
ACUTE	76 (34%)
CHRONIC	118 (53%)
SUBACUTE	28 (13%)

Table 6: Shows the no. of participants with acute, subacute and chronic pain.

This study analysed the impact of several predictors on the likelihood of IVDD using logistic regression (Table 8).

Model Fitting Information				
	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	980.395			
Final	839.333	141.062	44	.000

Likelihood Ratio Tests		
Effect	Model Fitting Criteria	Likelihood Ratio Tests

	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	876.288	36.955	11	.000
Age	940.064	100.731	11	.000
BMI	851.766	12.433	11	.332
Pain	850.256	10.923	11	.450
Gender	860.562	21.229	11	.031

Table 7 : Logistic regression

Our investigation into the predictors of IVDD sheds light on critical factors influencing spinal health. Older age significantly increases the risk of disc degeneration (p value = 0.000). Clinicians should consider age when assessing patients' spinal health and planning preventive strategies. While body mass index (BMI) is relevant for overall health, it does not significantly predict DD(p value = 0.332) . Focusing solely on BMI may not yield substantial insights into disc health. There is no strong correlation between DD and pain alone(p value = 0.450). Nonetheless, nuanced gender disparities are present (p value = 0.031). Customizing therapies according to gender-specific risk variables may improve patient care. To summarize, a comprehensive strategy that takes into account factors like gender, age, BMI, and pain will enable medical professionals to make wise choices and support spinal health.

DISCUSSION

Prevalence of MRI Findings and Degenerative Changes

The research articles reviewed revealed that the MRI findings of lumbar spine were prevalent in both groups with and without symptoms. Kasch et al. (2022) showed that 76.4% of their

population-based sample had at least one MRI finding, with degenerative alterations increasing with age (Kasch et al., 2022).The incidence of lumbar discs with lower signal intensity increased dramatically over a 30-year follow-up by Sääksjärvi et al. (2020), demonstrating that age is a major role in disc degeneration. According to their study, distribution of disc degeneration has shifted from predominantly occurring in the L4–L5 and L5–S1 discs to a more equitable distribution among the four lowest discs (Sääksjärvi et al., 2020). The prevalence of degeneration was highest in the L4/L5 disc, with 21.5% of the subjects exhibiting it, followed by the L3/L4 disc, which had a frequency of 12.3%(Anne et al., 2024).The findings of the present study corroborate the aforementioned results. The L4-L5 intervertebral discs exhibited the highest degree of impact, demonstrating the most significant prevalence of degenerative changes (Maryam et al., 2021; Suthar et al., 2015).

Disc degeneration levels most often seen in the study are L4-L5 (41.2%) and L5-S1 (24.8%)(Ravikanth, 2020; Singh et al., 2021).According to Salama AA et al, the L4/L5 level was the most impacted disc level in the study that analysed lumbar disc degeneration amongst construction workers. Most workers had grade 4 disc degeneration at this level, characterised by notable observations of decreased disc space height and disc bulging mostly around the L4/L5 level(Salama et al., 2017). But in contrast in the findings of a study revealed that L5/S1 level (339 discs) was the most impacted followed by L4/L5 (273 discs)(Berg et al., 2020). The findings of the study by sasi kuppuswamy et al also indicated that the L5-S1 disc is more prone to degeneration and herniation in the asymptomatic Indian participants examined(Kuppuswamy et al., 2017). Abdalkader M et al concluded that in cases of mild and moderate disc degeneration(DD), the L4-L5 and L5-S1 levels of the lumbar spine were most significantly impacted(Abdalkader et al., 2020).Suthar P et al found the total number of disc involvement to be 241, resulting in an average of 2.21-disc involvements per patient(Suthar et al., 2015). Among the 428 individuals, 255 (59.6%) had single level pathology, while 173

(41.4%) displayed signs of multilevel pathology in a research study by Berg AJ(Berg et al., 2020). The research on MRI Assessment of Lumbar Disc Degenerative Condition examined a total of 1,820 discs. This encompassed an average of 1.82 disc involvements per patient, with a notable emphasis on diverse degenerative alterations identified in these discs(Ravikanth, 2020).Moreover, Näther et al. (2022) emphasized the age-related distribution patterns of degeneration, noting that degeneration symptoms were present in 38.8% of younger individuals but escalated to 91.6% in older cohorts(Näther et al., 2022). This suggests that while degenerative changes are common, their clinical significance may vary, as Dragsbaek et al. (2020) found that different thresholds for defining degeneration influenced its association with LBP(Dragsbæk et al., 2020).Teraguchi et al. (2014) conducted a population-based study revealing that over 90% of individuals aged 50 and older exhibit signs of Degenerative disc disease (DDD), with specific intervertebral regions such as C5/6, T6/7, and L4/5 being most affected. This perfectly correlated with the present study. Their findings emphasize a consistent correlation between age, obesity, and the occurrence of DDD, while LBP was predominantly linked to lumbar degeneration(Teraguchi et al., 2014).Mustapha et al. (2014) focused on cervical spine MRI results in patients suffering from neck pain and radiculopathy, identifying cervical spondylosis as the leading diagnosis. They noted that a substantial proportion of these patients also presented with disc prolapse, particularly at the C4/C5 level(Mustapha Z et al., 2014). Whereas C4-C5 level was the second most affected IV disc in the present study. This underscores the necessity for comprehensive imaging to accurately diagnose cervical spine disorders, especially in elderly populations where such conditions are prevalent. Furthermore, Okada et al. (2011) explored the relationship between cervical degeneration and lumbar disc herniation. Their research indicated a higher frequency of cervical disc degeneration in patients with lumbar herniation compared to asymptomatic controls, suggesting that lumbar disc issues may reflect broader degenerative changes in the cervical region, particularly in individuals over

40 years old. The study's strong inter-observer reliability enhances the credibility of these findings(Okada et al., 2011).Lastly, Suzuki et al. (2018) investigated a large cohort of symptomatic patients and established a robust link between age and cervical disc degradation, particularly at mid-cervical levels. Their results indicate that understanding these degenerative patterns is crucial for surgical interventions like spinal fusion, as they may lead to complications such as neighbouring level degeneration post-operatively(Suzuki et al., 2018).

Gender Differences in Degenerative Disc Disease

Gender appears to influence the prevalence and severity of degenerative disc disease, as highlighted by multiple studies. Abdalkader et al. (2020) reported a 40% prevalence of degenerative changes among athletes, with a notable gender distribution indicating higher rates in males(Abdalkader et al., 2020). Conversely, Maryam et al. (2021) found that females exhibited a higher prevalence of various degenerative conditions, particularly at the L4–L5 level. This discrepancy suggests that while men may experience more severe forms of degeneration, women may be more susceptible to developing degenerative changes, potentially due to differences in physical activity levels and biomechanical factors(Maryam et al., 2021).Bento et al. (2020) and Parenteau et al. (2021) both emphasized the gender disparities in LBP prevalence, with women exhibiting a notably higher incidence(Bento et al., 2020; Parenteau et al., 123 C.E.). This aligns with Chen et al. (2022), who reported a global increase in LBP cases, particularly among older adults, and a consistent trend of higher prevalence in females. The findings underscore the need for gender-sensitive approaches in LBP management and prevention strategies(Chen et al., 2022). But there was no much significant correlation for the gender in the present study.

Impact of Diagnostic Criteria on Clinical Outcomes

The variability in diagnostic criteria for lumbar disc degeneration significantly impacts clinical outcomes related to LBP. Dragsbæk et al. (2020) emphasized that different definitions and thresholds for degeneration can alter associations with pain. More severe thresholds for disc signal loss were linked to LBP at specific ages, indicating that clinicians must carefully consider how they define and assess degeneration when diagnosing and treating patients. This highlights the need for standardized protocols to improve diagnostic accuracy and treatment efficacy(Dragsbæk et al., 2020).

Longitudinal Associations with Pain

Longitudinal studies provide valuable insights into how new MRI findings relate to chronic pain outcomes. Suri et al. (2014) identified that incident annular fissures were significantly associated with chronic LBP, suggesting that certain MRI findings can predict future pain experiences. This finding is critical for clinicians as it underscores the importance of monitoring specific degenerative changes over time to anticipate potential complications in patients presenting with LBP(Suri et al., 2014).

Lifestyle Factors and Recent Contexts

Recent studies have begun to explore how lifestyle factors influence LBP, particularly during significant societal changes such as the COVID-19 pandemic. Šagát et al. (2020) found that quarantine conditions led to increased reports of LBP due to prolonged sitting and decreased physical activity among adults, particularly affecting those with higher body mass indices (BMIs). The study's findings suggest that interventions aimed at promoting physical activity and ergonomic practices could be beneficial for individuals experiencing LBP. The impact of lifestyle factors during extraordinary circumstances, such as the COVID-19 pandemic, has also been documented (Šagát et al., 2020).

CONCLUSION

This study underscores the notable incidence and distribution of intervertebral disc degeneration in individuals experiencing low back pain and neck pain, as demonstrated by MRI data. The findings demonstrate that age is a significant determinant affecting the probability of degeneration, since older individuals have a greater prevalence of compromised discs. Although BMI and pain levels were evaluated, they did not exhibit a significant link with disc degeneration in this study, indicating that age should be addressed in clinical assessments. There is a need for customized strategies in the management of LBP and NP according to demographic variables. The results highlight the necessity of thorough imaging and uniform diagnostic standards to improve therapy effectiveness and patient results. A comprehensive understanding of the interaction between age, gender, and lifestyle factors is crucial to effectively manage spinal health and enhance the quality of life for persons with disc degeneration and related pain.

REFERENCES:

Abdalkader, M., Guermazi, A., Engebretsen, L., Roemer, F. W., Jarraya, M., Hayashi, D., Crema, M. D., & Mian, A. Z. (2020). MRI-detected spinal disc degenerative changes in athletes participating in the Rio de Janeiro 2016 Summer Olympics games. *BMC Musculoskeletal Disorders*, *21*(1), 1–8. https://doi.org/10.1186/s12891-020-3057-3

Anne, N. N., Eze, J. C., & Ogolodom, M. P. (2024). Magnetic resonance imaging assessment of the patterns and distributions of spinal disc degeneration in patients residing in Lagos State. *Salud, Ciencia y Tecnologia - Serie de Conferencias*, *3*, 4–11. https://doi.org/10.56294/sctconf2024692

Annunen, S., Paassilta, P., Lohiniva, J., Perälä, M., Pihlajamaa, T., Karppinen, J., Tervonen, O., Kröger, H., Lände, S., Vanharanta, H., Ryhänen, L., Göring, H. H. H., Ott, J., Prockop, D. J., & Ala-Kokko, L. (1999). An allele of COL9A2 associated with intervertebral disc disease. *Science*, *285*(5426), 409–412. https://doi.org/10.1126/SCIENCE.285.5426.409

Battie, M., Videman, T., Gibbons, L., Spine, L. F.-, & 1995, undefined. (n.d.). 1995 Volvo Award in clinical sciences. Determinants of lumbar disc degeneration. A study relating lifetime exposures and magnetic resonance imaging findings in. *Europepmc.OrgMC Battie, T Videman, LE Gibbons,*

LD Fisher, H Manninen, K GillSpine, 1995•europepmc.Org. Retrieved January 27, 2025, from https://europepmc.org/article/med/8747238

Bento, T. P. F., Genebra, C. V. dos S., Maciel, N. M., Cornelio, G. P., Simeão, S. F. A. P., & Vitta, A. de. (2020). Low back pain and some associated factors: is there any difference between genders? *Brazilian Journal of Physical Therapy*, *24*(1), 79–87. https://doi.org/10.1016/j.bjpt.2019.01.012

Berg, A. J., Ahmadje, U., Jayanna, H. H., Trégouët, P., Sanville, P., & Kapoor, V. (2020). The prevalence of lumbar disc degeneration in symptomatic younger patients: A study of MRI scans. *Journal of Clinical Orthopaedics and Trauma*, *11*(5), 932–936. https://doi.org/10.1016/j.jcot.2020.07.021

Carragee, E., Don, A., Hurwitz, E., Spine, J. C.-, & 2009, undefined. (n.d.). 2009 ISSLS prize winner: does discography cause accelerated progression of degeneration changes in the lumbar disc: a ten-year matched cohort study. *Journals.Lww.Com*. Retrieved January 27, 2025, from https://journals.lww.com/spinejournal/fulltext/2009/10010/Low_Pressure_Positive_Discography_in_Subjects.00015.aspx?casa_token=BXvG7301C2gAAAAA:sx9AdTia3ufc5bmojRCmkeg_I1gBTnXqQxlJIbJ0RRrjDa1yYj1UOy0VgHvjcTnnE3OYcoh6nL6hU4zCe0WWaZaZh_0

Chen, S., Chen, M., Wu, X., Lin, S., Tao, C., Cao, H., Shao, Z., & Xiao, G. (2022). Global, regional and national burden of low back pain 1990–2019: A systematic analysis of the Global Burden of Disease study 2019. *Journal of Orthopaedic Translation*, *32*, 49–58. https://doi.org/10.1016/J.JOT.2021.07.005

Dong, D. M., Yao, M., Liu, B., Sun, C. Y., Jiang, Y. Q., & Wang, Y. S. (2007). Association between the -1306C/T polymorphism of matrix metalloproteinase-2 gene and lumbar disc disease in Chinese young adults. *European Spine Journal*, *16*(11), 1958–1961. https://doi.org/10.1007/S00586-007-0454-3

Dragsbæk, L., Kjaer, P., Hancock, M., & Jensen, T. S. (2020). An exploratory study of different definitions and thresholds for lumbar disc degeneration assessed by MRI and their associations with low back pain using data from a cohort study of a general population. *BMC Musculoskeletal Disorders*, *21*(1), 1–11. https://doi.org/10.1186/s12891-020-03268-4

Hirose, Y., Chiba, K., Karasugi, T., … M. N.-T. A. J. of, & 2008, undefined. (n.d.). A functional polymorphism in THBS2 that affects alternative splicing and MMP binding is associated with lumbar-disc herniation. *Cell.ComY Hirose, K Chiba, T Karasugi, M Nakajima, Y Kawaguchi, Y Mikami, T Furuichi, F MioThe American Journal of Human Genetics, 2008•cell.Com*. Retrieved January 27, 2025, from https://www.cell.com/AJHG/fulltext/S0002-9297(08)00223-1

Hüllemann, P., Keller, T., Kabelitz, M., Gierthmühlen, J., Freynhagen, R., Tölle, T., Forstenpointner, J., & Baron, R. (2018). Clinical Manifestation of Acute, Subacute, and Chronic Low Back Pain in Different Age Groups: Low Back Pain in 35,446 Patients. *Pain Practice : The Official Journal of World Institute of Pain*, *18*(8), 1011–1023. https://doi.org/10.1111/PAPR.12704

Karasugi, T., Semba, K., Hirose, Y., Kelempisioti, A., Nakajima, M., Miyake, A., Furuichi, T., Kawaguchi, Y., Mikami, Y., Chiba, K., Kamata, M., Ozaki, K., Takahashi, A., Mä, P., Karppinen, J., Kimura, T., Kubo, T., Toyama, Y., Yamamura, K.-I., … Ikegawa, S. (2009). Association of the Tag SNPs in the Human SKT Gene (KIAA1217) With Lumbar Disc Herniation. *Wiley Online LibraryT Karasugi, K Semba, Y Hirose, A Kelempisioti, M Nakajima, A Miyake, T FuruichiJournal of Bone and Mineral Research, 2009•Wiley Online Library*, *24*(9), 1537–1543. https://doi.org/10.1359/JBMR.090314

Kasch, R., Truthmann, J., Hancock, M. J., Maher, C. G., Otto, M., Nell, C., Reichwein, N., Bülow, R., Chenot, J. F., Hofer, A., Wassilew, G., & Schmidt, C. O. (2022). Association of Lumbar MRI Findings with Current and Future Back Pain in a Population-based Cohort Study. *Spine*, *47*(3), 201–211. https://doi.org/10.1097/BRS.0000000000004198

Kawaguchi, Y., Kanamori, M., Ishihara, H., JBJS, K. O.-, & 2002, undefined. (n.d.). The association of lumbar disc disease with vitamin-D receptor gene polymorphism. *Journals.Lww.ComY Kawaguchi, M Kanamori, H Ishihara, K Ohmori, H Matsui, T KimuraJBJS, 2002•journals.Lww.Com*. Retrieved January 27, 2025, from https://journals.lww.com/jbjsjournal/fulltext/2002/11000/The_Association_of_Lumbar_Disc_Disease_with.18.aspx?__hstc=215929672.98fa600b1bb630f9cde2cb5f07430159.1535673600299.1535673600300.1535673600301.1&__hssc=215929672.1.1535673600302&__hsfp=2025384311

Kawaguchi, Y., Osada, R., Kanamori, M., Spine, H. I.-, & 1999, undefined. (n.d.). Association between an aggrecan gene polymorphism and lumbar disc degeneration. *Journals.Lww.ComY Kawaguchi, R Osada, M Kanamori, H Ishihara, K Ohmori, H Matsui, T KimuraSpine, 1999•journals.Lww.Com*. Retrieved January 27, 2025, from https://journals.lww.com/spinejournal/fulltext/1999/12010/Association_Between_an_Aggrecan_Gene_Polymorphism.6.aspx?casa_token=h7Z_-BmJSOQAAAAA:lBwNGeQN-znxFA__tITzvy25lb9KkQRxyvJa9_Fm4tt6_SWbrYcfleQMjDRmtiyTrmT4V2jTTeGN3_2YZujc90CpLUE&casa_token=UOeEkWnHHHMAAAAA:g1h5jzOEP3rv2HAZEvjZNjrP--fb-xEacI9_zhFh8NbaVEyMukEbXMYoialsYWCXyNd-k0t09q9z8_lcbYuJFoNdeTs

Kerttula, L., Serlo, W., Tervonen, O., Spine, E. P.-, & 2000, undefined. (n.d.). Post-traumatic findings of the spine after earlier vertebral fracture in young patients: clinical and MRI study. *Journals.Lww.ComLI Kerttula, WS Serlo, OA Tervonen, EL Pääkkö, HV VanharantaSpine, 2000•journals.Lww.Com*. Retrieved January 27, 2025, from https://journals.lww.com/spinejournal/fulltext/2000/05010/post_traumatic_findings_of_the_spine_after_earlier.11.aspx?casa_token=QxUlgOGVeZ8AAAAA:kvgsbNOSr_zOdSalAxZ7cw4mcS7EHKWHWqwdmTK9E1Pmsqrm8YkTzbPGUQ6t_7kmZQOhXQ-h3a497zfjE03_q1DLBRs

Kuppuswamy, Dr. S., George, Dr. J. C., & Chemmanam, Dr. M. (2017). Prevalence of lumbar disc herniation and disc degeneration in asymptomatic Indian subjects: An MRI based study. *International Journal of Orthopaedics Sciences*, *3*(4e), 357–360. https://doi.org/10.22271/ortho.2017.v3.i4e.50

Kushchayev, S., Glushko, T., Jarraya, M., imaging, K. S.-… into, & 2018, undefined. (n.d.). ABCs of the degenerative spine. *SpringerSV Kushchayev, T Glushko, M Jarraya, KH Schuleri, MC Preul, ML Brooks, OM TeytelboymInsights into Imaging, 2018•Springer*. Retrieved December 6, 2024, from https://link.springer.com/article/10.1007/s13244-017-0584-z

Livshits, G., Popham, M., Malkin, I., … P. S.-A. of the, & 2011, undefined. (2011). Lumbar disc degeneration and genetic factors are the main risk factors for low back pain in women: the UK Twin Spine Study. *Ard.Bmj.ComG Livshits, M Popham, I Malkin, PN Sambrook, AJ MacGregor, T Spector, FMK WilliamsAnnals of the Rheumatic Diseases, 2011•ard.Bmj.Com*, *70*, 1740–1745. https://doi.org/10.1136/ard.2010.137836

Maryam, S., Zakir, M., Yousaf Gilani, S., Bashir, S., Bashir MID, S., Maryam MBBS, S., Zakir MID, M., Phil, M., Yousaf Farooq, S. M., Salam, A., Shafqat, S., & Fatima, J. (2021). Association Between

Magnetic Resonance Imaging and Clinical Findings of Lumbar Degenerative Disc Disease Correlation Between Magnetic Resonance Imaging and Clinical Diagnostic Findings of Lumbar Degenerative Disc Disease Association Between Magnetic Reson. *Ophthalmology Update*, *19*(3). https://www.researchgate.net/publication/352993192

Mio, F., Chiba, K., Hirose, Y., … Y. K.-T. A. J. of, & 2007, undefined. (n.d.). A functional polymorphism in COL11A1, which encodes the α1 chain of type XI collagen, is associated with susceptibility to lumbar disc herniation. *Cell.ComF Mio, K Chiba, Y Hirose, Y Kawaguchi, Y Mikami, T Oya, M Mori, M Kamata, M MatsumotoThe American Journal of Human Genetics, 2007•cell.Com*. Retrieved January 27, 2025, from https://www.cell.com/ajhg/fulltext/S0002-9297(07)63774-4

Muraki, S., Oka, H., Akune, T., Mabuchi, A., En-Yo, Y., Yoshida, M., Saika, A., Suzuki, T., Yoshida, H., Ishibashi, H., Yamamoto, S., Nakamura, K., Kawaguchi, H., & Yoshimura, N. (2008). Prevalence of radiographic lumbar spondylosis and its association with low back pain in elderly subjects of population-based cohorts: the ROAD study. *Ard.Bmj.ComS Muraki, H Oka, T Akune, A Mabuchi, Y En-Yo, M Yoshida, A Saika, T Suzuki, H YoshidaAnnals of the Rheumatic Diseases, 2009•ard.Bmj.Com*. https://doi.org/10.1136/ard.2007.087296

Mustapha Z, Okedayo M, Ibrahim K, Abba Ali A, Ahmadu MS, Abubakar A, & Yusuf M. (2014). Cervical spine MRI findings in patients presenting with neck pain and radiculopathy. *International Research Journal of Basic and Clinical Studies*, *2*(2), 20–26.

Näther, P., Kersten, J. F., Kaden, I., Irga, K., & Nienhaus, A. (2022). Distribution Patterns of Degeneration of the Lumbar Spine in a Cohort of 200 Patients with an Indication for Lumbar MRI. *International Journal of Environmental Research and Public Health*, *19*(6). https://doi.org/10.3390/ijerph19063721

Noponen-Hietala, N., Virtanen, I., Pain, R. K.-, & 2005, undefined. (n.d.). Genetic variations in IL6 associate with intervertebral disc disease characterized by sciatica. *Elsevier*. Retrieved January 27, 2025, from https://www.sciencedirect.com/science/article/pii/S0304395904005858

Oichi, T., Taniguchi, Y., Oshima, Y., Tanaka, S., & Saito, T. (2020). Pathomechanism of intervertebral disc degeneration. *JOR Spine*, *3*(1), 1–9. https://doi.org/10.1002/jsp2.1076

Okada, E., Matsumoto, M., Fujiwara, H., & Toyama, Y. (2011). Disc degeneration of cervical spine on MRI in patients with lumbar disc herniation: Comparison study with asymptomatic volunteers. *European Spine Journal*, *20*(4), 585–591. https://doi.org/10.1007/s00586-010-1644-y

Parenteau, C. S., Lau, E. C., Campbell, I. C., & Courtney, A. (123 C.E.). Prevalence of spine degeneration diagnosis by type, age, gender, and obesity using Medicare data. *Scientific Reports |*, *11*, 5389. https://doi.org/10.1038/s41598-021-84724-6

Pluijm, S. M. F., Van Essen, H. W., Bravenboer, N., Uitterlinden, A. G., Smit, J. H., & Pols, A. P. (2004). Collagen type I α1 Sp1 polymorphism, osteoporosis, and intervertebral disc degeneration in older men and women. *Ard.Bmj.ComSMF Pluijm, HW Van Essen, N Bravenboer, AG Uitterlinden, JH Smit, HAP Pols, P LipsAnnals of the Rheumatic Diseases, 2004•ard.Bmj.Com*, *63*, 71–77. https://doi.org/10.1136/ard.2002.002287

Rahyussalim, A. J., Zufar, M. L. L., & Kurniawati, T. (2020). Significance of the association between disc degeneration changes on imaging and low back pain: A review article. *Asian Spine Journal*, *14*. https://doi.org/10.31616/ASJ.2019.0046

Rahyussalim, A., journal, M. Z.-A. spine, & 2019, undefined. (n.d.). Significance of the association between disc degeneration changes on imaging and low back pain: a review article. *Pmc.Ncbi.Nlm.Nih.GovAJ Rahyussalim, MLL Zufar, T KurniawatiAsian Spine Journal, 2019•pmc.Ncbi.Nlm.Nih.Gov*. Retrieved December 6, 2024, from https://pmc.ncbi.nlm.nih.gov/articles/PMC7113468/

Ravikanth, R. (2020). Magnetic Resonance Evaluation of Lumbar Disc Degenerative Disease as an Implication of Low Back Pain: A Prospective Analysis. *Neurology India*, *68*(6), 1378–1384. https://doi.org/10.4103/0028-3886.304091

Sääksjärvi, S., Kerttula, L., Luoma, K., Paajanen, H., & Waris, E. (2020). Disc Degeneration of Young Low Back Pain Patients: A Prospective 30-year Follow-up MRI Study. *Spine*, *45*(19), 1341–1347. https://doi.org/10.1097/BRS.0000000000003548

Šagát, P., Bartík, P., González, P. P., Tohănean, D. I., & Knjaz, D. (2020). Impact of COVID-19Quarantine on Low Back Pain Intensity, Prevalence, and Associated Risk Factors among Adult Citizens Residing in Riyadh (Saudi Arabia): A Cross-Sectional Study. *International Journal of Environmental Research and Public Health 2020, Vol. 17, Page 7302*, *17*(19), 7302. https://doi.org/10.3390/IJERPH17197302

Salama, A. A., Alarabawy, R. A., Dawoud, M. M., Zayed, H. A., Soliman, A., & El-Tantawy, A. (2017). Functional disability of occupational-related lumbar disc degeneration: Evaluation by magnetic resonance imaging with surgical correlation. *Egyptian Journal of Radiology and Nuclear Medicine*, *48*(1), 189–199. https://doi.org/10.1016/j.ejrnm.2016.11.010

Sambrook, P., … A. M.-A. & R., & 1999, undefined. (n.d.). Genetic influences on cervical and lumbar disc degeneration: a magnetic resonance imaging study in twins. *Wiley Online LibraryPN Sambrook, AJ MacGregor, TD SpectorArthritis & Rheumatism: Official Journal of the American College, 1999•Wiley Online Library*. Retrieved January 27, 2025, from https://onlinelibrary.wiley.com/doi/abs/10.1002/1529-0131(199902)42:2%3C366::AID-ANR20%3E3.0.CO;2-6?casa_token=D5nuKPBcxDsAAAAA:v-cTtzdsC9eTxRJrIu7fLGC5pMnkkDUJa1NUJzvF0ExXvYtaghUc5vXtuIJI_6LRwgnIW6FGpJ6cZmat

Singh, R., Kumar, P., Wadhwani, J., Yadav, R. K., Khanna, M., & Kaur, S. (2021). A comparative study to evaluate disc degeneration on magnetic resonance imaging in patients with chronic low back pain and asymptomatic individuals. *Journal of Orthopaedics, Trauma and Rehabilitation*, *28*, 1–7. https://doi.org/10.1177/22104917211039522

Solovieva, S., Kouhia, S., Leino-Arjas, P., … L. A.-K.-, & 2004, undefined. (n.d.). Interleukin 1 polymorphisms and intervertebral disc degeneration. *Journals.Lww.Com*. Retrieved January 27, 2025, from https://journals.lww.com/epidem/fulltext/2004/09000/Low_Back_Pain_in_Relation_to_Lumbar_Disc.00021.aspx

Sun, Z. M., Miao, L., Zhang, Y. G., & Ming, L. (2009). Association between the -1562 C/T polymorphism of matrix metalloproteinase-9 gene and lumbar disc disease in the young adult population in North China. *Connective Tissue Research*, *50*(3), 181–185. https://doi.org/10.1080/03008200802585630

Suri, P., Boyko, E. J., Goldberg, J., Forsberg, C. W., & Jarvik, J. G. (2014). Longitudinal associations between incident lumbar spine MRI findings and chronic low back pain or radicular symptoms:

Retrospective analysis of data from the longitudinal assessment of imaging and disability of the back (LAIDBACK). *BMC Musculoskeletal Disorders*, *15*(1), 1–10. https://doi.org/10.1186/1471-2474-15-152/TABLES/3

Suthar, P., Patel, R., Mehta, C., & Patel, N. (2015). MRI evaluation of lumbar disc degenerative disease. *Journal of Clinical and Diagnostic Research*, *9*(4), TC04–TC09. https://doi.org/10.7860/JCDR/2015/11927.5761

Suzuki, A., Daubs, M. D., Hayashi, T., Ruangchainikom, M., Xiong, C., Phan, K., Scott, T. P., & Wang, J. C. (2018). Patterns of Cervical Disc Degeneration: Analysis of Magnetic Resonance Imaging of Over 1000 Symptomatic Subjects. *Global Spine Journal*, *8*(3), 254–259. https://doi.org/10.1177/2192568217719436/ASSET/IMAGES/LARGE/10.1177_2192568217719436-FIG4.JPEG

Takahashi, M., Haro, H., Wakabayashi, Y., Kawa-uchi, T., Komori, H., & Shinomiya, K. (2001). The association of degeneration of the intervertebral disc with 5a/6a polymorphism in the promoter of the human matrix metalloproteinase-3 gene. *The Journal of Bone and Joint Surgery. British Volume*, *83-B*(4), 491–495. https://doi.org/10.1302/0301-620X.83B4.0830491

Teraguchi, M., Yoshimura, N., Hashizume, H., Muraki, S., Yamada, H., Minamide, A., Oka, H., Ishimoto, Y., Nagata, K., Kagotani, R., Takiguchi, N., Akune, T., Kawaguchi, H., Nakamura, K., & Yoshida, M. (2014). Prevalence and distribution of intervertebral disc degeneration over the entire spine in a population-based cohort: the Wakayama Spine Study. *Osteoarthritis and Cartilage*, *22*(1), 104–110. https://doi.org/10.1016/J.JOCA.2013.10.019

Urano, T., Narusawa, K., Shiraki, M., Usui, T., Spine, N. S.-, & 2008, undefined. (n.d.). Association of a single nucleotide polymorphism in the insulin-like growth factor-1 receptor gene with spinal disc degeneration in postmenopausal Japanese women. *Journals.Lww.ComT Urano, K Narusawa, M Shiraki, T Usui, N Sasaki, T Hosoi, Y Ouchi, T Nakamura, S InoueSpine, 2008•journals.Lww.Com*. Retrieved January 27, 2025, from https://journals.lww.com/spinejournal/FullText/2008/05150/Association_of_a_Single_Nucleotide_Polymorphism_in.16.aspx?casa_token=WLg5jD9kDEwAAAAA:oXnUjOj98Wgzh1yCfLo1fTUoee_C31We-SadBiGh5UGDifu6M3VKVdNiVAn5diIqHv6Wl8gnCmiN_dAQiCovkVzvD7k&casa_token=TRMXj_2NPGwAAAAA:FCdHXsSkv8Lqpxzr1OoQta2jwHszZhQMrSkx7z3iM2k5Ssdot9feEsD0kSIJHz0yqAKXhCosdInryrjs6iOSiZJzVnc

Videman, T., Leppävuori, J., Kaprio, J., Spine, M. B.-, & 1998, undefined. (n.d.). Intragenic polymorphisms of the vitamin D receptor gene associated with intervertebral disc degeneration. *Europepmc.OrgT Videman, J Leppävuori, J Kaprio, MC Battie, LE Gibbons, L Peltonen, M KoskenvuoSpine, 1998•europepmc.Org*. Retrieved January 27, 2025, from https://europepmc.org/article/med/9854746

Williams, F. M. K., Popham, M., Hart, D. J., De Schepper, E., Bierma-Zeinstra, S., Hofman, A., Uitterlinden, A. G., Arden, N. K., Cooper, C., Spector, T. D., Valdes, A. M., & Van Meurs, J. (2011). GDF5 single-nucleotide polymorphism rs143383 is associated with lumbar disc degeneration in Northern European women. *Arthritis and Rheumatism*, *63*(3), 708–712. https://doi.org/10.1002/ART.30169