

Association Between Lumbar Disc Degeneration and Lumbar Multifidus Muscle Fatty Atrophy in Patients with Chronic Low Back Pain: A Prospective Observational Study

¹Dr. Allu Rajesh, ²Dr. K. Hemalatha, ³Dr. C. Rashad, ⁴Dr. K. Anil Kumar, ⁵Dr. Ch. Madhavi

^{1,2,3}Junior Resident, ⁴Associate Professor, ⁵Professor

Department of Radiodiagnosis,

Maharajah's Institute of Medical Sciences (MIMS), Vizianagaram, Andhra Pradesh, India.

Abstract: Aim: To determine the association between lumbar disc degeneration and lumbar multifidus muscle fatty atrophy in patients with chronic low back pain using Magnetic Resonance Imaging (MRI).

Methods: This prospective observational study was conducted from April 2023 to April 2024 in the Department of Radiodiagnosis at the esteemed Maharajah's Institute of Medical Sciences (MIMS) in Vizianagaram, Andhra Pradesh, India, with a sample size of 125 who met the inclusion and exclusion criteria. The subjects underwent MRI LS (lumbosacral)-spine on 1.5 Tesla Philips Ingenia machine. The grading of intervertebral disc degeneration at L4-L5 and L5-S1 disc levels was done according to Pfirrmann classification on T2W imaging sequence in the sagittal plane. Using axial T1W imaging, the total muscle cross-sectional area (TMCSA) of the LMM, the pure fat cross-sectional area (PFCSA), and percentage of PFCSA to TMCSA at L4-L5 and L5-S1 disc levels were obtained. Chi-square test was applied to find association between varying grades of disc degeneration and severity of fat infiltration at L4-L5 and L5-S1 regions.

Results: The majority of the subjects had Grade III disc degeneration at both L4-L5 and L5-S1 intervertebral disc levels. A significant association was found between the grade of lumbar disc degeneration and degree of lumbar multifidus muscle fatty atrophy in middle-aged patients with chronic low back pain; the obtained p-value at L4-L5 and L5-S1 was <0.001.

Conclusion: The results revealed a significant relation between the severity of fat infiltration in the LMM and varying grades of disc degeneration at the L4/L5 and L5/S1 regions. The data obtained from the study underscores the importance of assessing both LMM fatty atrophy and lumbar disc degeneration in patients with chronic LBP.

Index Terms: Lumbar multifidus muscle fatty atrophy, Disc degeneration, Low back pain

I. INTRODUCTION

Low back pain (LBP) is a major public health issue worldwide. It is estimated that 619 million people live with LBP, making it the leading cause of disability globally¹. LBP affects individuals of any age, including children and adolescents. However, the peak incidence occurs around 50–55 years of age. Women tend to experience LBP more frequently than men². Chronic LBP is defined as backache lasting longer than 3 months³. Rates increase with age, starting in the thirties. LBP often presents without a clear cause but can be linked to lumbar disc herniation, most commonly occurring in the lower back⁴. Risk factors include a sedentary lifestyle, decreased physical activity, and overweight. These factors can lead to weak and atrophied paraspinal muscles, particularly the lumbar multifidus muscle (LMM). LMM dysfunction or injury can cause prolonged neurological inhibition, further contributing to chronic LBP. There are two main mechanisms for muscle atrophy in the paraspinal muscles: disuse and denervation. Disuse is less likely as atrophy is localized, while denervation is more common in disc herniation and nerve compression⁵. LMM fatty atrophy is strongly associated with LBP⁶. Magnetic resonance imaging (MRI) can detect this fatty atrophy, which appears in high-intensity areas within the muscle⁶. This study aimed to investigate the association between lumbar disc degeneration and LMM fatty atrophy in patients suffering from chronic low back pain (LBP).

II. METHODS

This prospective observational study was conducted from April 2023 to April 2024 in the Department of Radiodiagnosis at the esteemed Maharajah’s Institute of Medical Sciences (MIMS) in Vizianagaram, Andhra Pradesh, India.

Participants

The study included 125 patients. All participants provided written informed consent before enrolment. Patients were selected based on the following criteria:

- Age: 21 to 50 years old
- Medical history: Chronic low back pain for more than three months

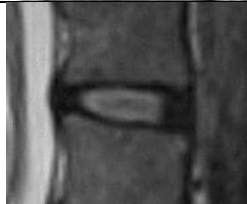
Exclusion Criteria

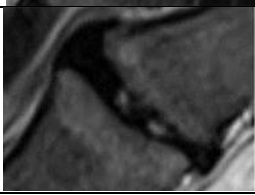
Patients meeting any of the following criteria were excluded from the study.

- Age above 50 years
- Spinal fractures
- Spinal cord injuries
- Spinal infections
- Spinal tumors
- Previous lumbosacral surgery
- Contraindications for MRI scans

Procedure

Image acquisition was done on a 1.5 Tesla Philips Ingenia machine. The DICOM files of MRI examinations of study subjects were viewed on Osirix version 9.5. These slices were acquired at L4-L5 & L5-S1 levels to focus on the lumbar multifidus muscle (LMM). T1-weighted images were preferred for evaluating muscle fat content. T2-weighted FSE MRI sequences were used to assess the lumbar intervertebral discs. Sagittal planes were used to determine the grade of lumbar intervertebral disc degeneration according to the Pfirrmann classification.

Pfirrmann grading system ⁷ .			
Grade	Height of the IVD	Annulus and Nucleus	Reference Image
I.	Normal	High T2 signal with a homogeneous nucleus and clear distinction of annulus & nucleus	
II.	Normal	High T2 signal nucleus with central low T2 signal horizontal line and clear distinction of annulus & nucleus	
III.	Normal /slightly decreased	Low T2 signal with an inhomogeneous nucleus and unclear distinction of annulus & nucleus	

IV.	Moderately decreases	Very low to moderate T2 signal inhomogeneous nucleus and lost distinction of nucleus & annulus	
V.	Collapsed	Very low T2 signal inhomogeneous nucleus and lost distinction of nucleus & annulus	

To evaluate LMM, axial T1-weighted slices were taken at levels at the L4/L5 and L5/S1 intervertebral discs to detect the cross-sectional areas. Total muscle cross-sectional area (TMSCA) of LMM & pure fat cross-sectional area (PFCSA) were calculated by segmenting the muscle area and T1 hyperintense fat areas on the muscle using segmentation cross-sectional area module in 3D slicer segmentation free software by uploading the DICOM files in the software. After estimating cross-sectional areas, the percentage of PFCSA to the TMCSA was calculated.

Four-grade fat infiltration classification method for lumbar paraspinal fat infiltration⁸

- Grade 1: Normal muscle with < 10% of fatty infiltration [Fig-3].
- Grade 2: Mild muscle degeneration, 10 to 30% fatty infiltration [Fig-4].
- Grade 3: Moderate muscle degeneration, 30 to 50% fat infiltration [Fig-5].
- Grade 4: Severe muscle degeneration, > 50% of fatty infiltration [Fig-6].

III. STATISTICAL ANALYSIS

Statistical analyses were done using IBM SPSS Statistics software version 29, released in September 2022. The chi-square test was used to determine the association between the severity of fat infiltration and varying grades of disc degeneration at L4-L5 and L5-S1 regions. The level of significance was set at p-value<0.05.

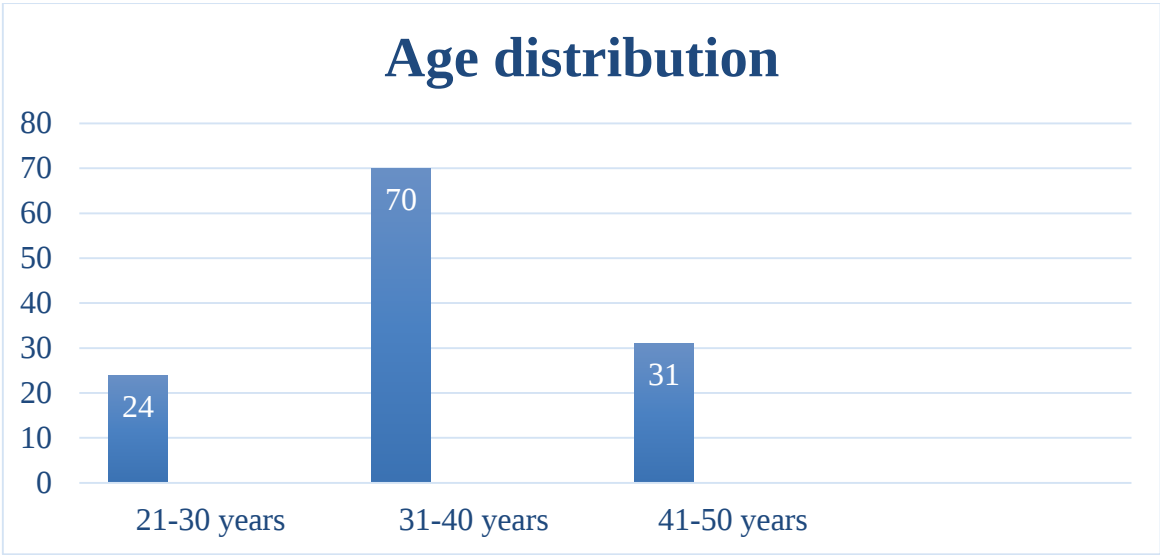
IV. RESULTS

A total of 125 subjects were included in the study, with ages ranging from 21-50 years, there was slight female preponderance with 51.2%(n=64) and males constituting 48.8%(n=61(Table:2).56%(n=70) of the subjects were in the age group of 31-40 years.(Table:1)

Variable	Categories	n	%
Age (years)	21-30	24	19.2%
	31-40	70	56 %
	41-50	31	24.8%

Table 1: Age distribution among study patients (N=125).

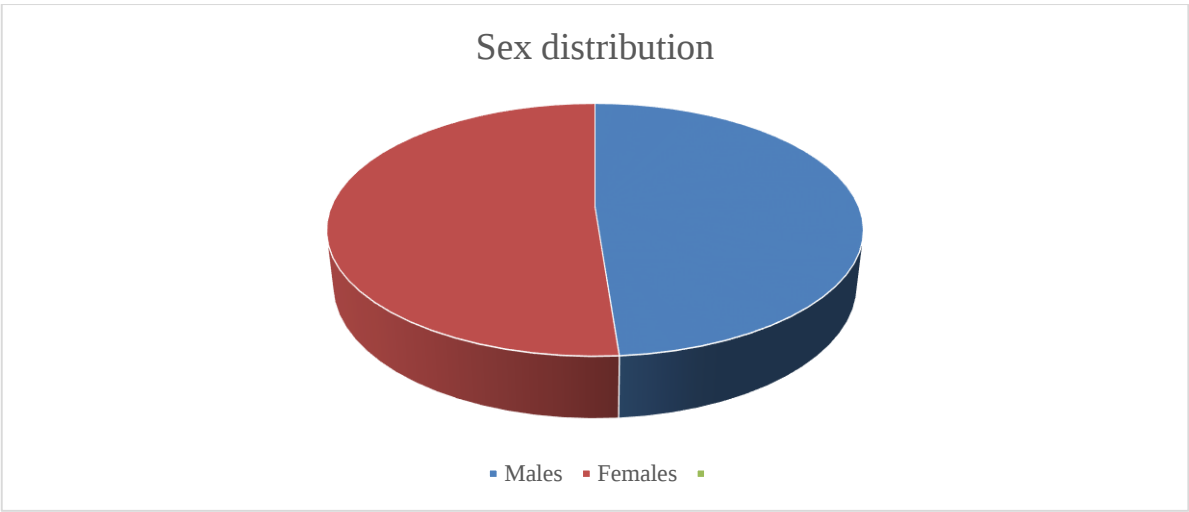
Figure 1: Showing Age distribution.



Variable	Categories	n	%
Gender	Males	61	48.8
	Females	64	51.2

Table 2: Age distribution among study patients (N=125).

Figure 2: Showing Gender distribution.



Most subjects had Grade III lumbar disc degeneration at L4-L5(n=48) & L5-S1(n=51)levels. In this study, there was no relation between gender and the degree of lumbar disc degeneration (Table: 4), whereas a significant relation was found with fatty muscle infiltration with p-value of <0.0002 at L4-L5 and 0.0042 at L5-S1 intervertebral disc space levels (Table: 6). With advancement of age, there was a notable escalation in the severity of fatty infiltration within LMM, as depicted in Table: 5. Furthermore, the correlation between the grade of lumbar disc degeneration and the severity of fatty infiltration in the lumbar multifidus muscles was statistically significant at the L4/L5 and L5/S1 levels.

Region	Grades	21-30 years		31-40 years		41-50 years		χ ² value	p- Value
		n	%	N	%	n	%		
	Grade 1	2	8.3%	4	5.7%	2	6.4%	20.94	0.007
	Grade 2	13	54.1%	20	28.5%	6	19.3%		
	Grade 3	7	29.1%	28	40%	13	41.9%		

L4-L5	Grade 4	2	8.3%	18	25.7%	7	22.5%		
	Grade 5	0	0.0%	0	0.0%	3	9.6%		
L5-S1	Grade 1	2	8.3%	4	5.7%	1	3.22%	16.48	0.036
	Grade 2	9	37.5%	13	18.5%	6	19.35%		
	Grade 3	10	41.6%	32	45.7%	9	29.03%		
	Grade 4	3	12.2%	21	30%	13	41.93%		
	Grade 5	0	0.0%	0	0.0%	2	6.45%		
Table 3: Age Comparison of grades of Disc Degeneration at L4-L5 and L5-S1 levels based on the age of the patients.									

Region	Grades	Males		Females		χ ² value	p- Value
		N	%	n	%		
L4-L5	Grade 1	3	4.9%	5	7.8%	1.77	0.78
	Grade 2	22	36.0%	17	26.5%		
	Grade 3	22	36.0%	26	40.6%		
	Grade 4	13	21.3%	14	21.8%		
	Grade 5	1	1.6%	2	3.1%		
L5-S1	Grade 1	4	6.5%	3	4.6%	0.0	0.1
	Grade 2	13	21.3%	15	23.4%		
	Grade 3	26	42.6%	25	39.06%		
	Grade 4	18	29.5%	19	29.6%		
	Grade 5	0	00%	02	3.12%		
Table 4: Comparison of grades of Disc Degeneration at L4-L5 and L5-S1 levels based on the gender of the patients.							

Regions	Fat infiltration	21-30 years	31-40 years	41-50 years	χ^2 Value	p-value
		n	N	n		
L4-L5	Normal (57)	17	28	12	21.8605	0.0013
	Mild (51)	7	27	17		
	Moderate (13)	0	3	10		
	Severe (4)	0	1	3		
L5-S1	Normal (29)	7	17	5	29.3956	0.0092
	Mild (72)	15	36	21		
	Moderate (19)	2	11	6		
	Severe (5)	0	2	3		
Table 5: Association between severity of fat Infiltration based on the age at L4-L5 and L5-S1 region.						

Regions	Fat infiltration	Males	Females	χ^2 Value	p-value
		N	n		
L4-L5	Normal	40	17	19.6559	0.0002
	Mild	17	34		
	Moderate	3	10		
	Severe	1	3		
L5-S1	Normal	20	9	13.20	0.0042
	Mild	36	36		
	Moderate	3	16		
	Severe	2	3		

Table 6: Association between severity of fat Infiltration based on gender at L4-L5 and L5-S1 region.

Regions	Fat infiltration	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	χ^2 Value	p-value
		N	N	n	n	N		
L4-L5	Normal	5	24	22	6	0	69.82	<0.001
	Mild	3	15	23	10	0		
	Moderate	0	0	2	10	1		
	Severe	0	0	1	1	2		
L5-S1	Normal (29)	5	10	10	4	0	68.72	<0.001
	Mild (72)	2	17	31	22	0		
	Moderate (19)	0	1	9	9	0		
	Severe (5)	0	0	1	2	2		

Table 7: Association between severity of fat Infiltration at varying grades of Disc degeneration at L4-L5 and L5-S1 regions.

Axial T1W images of MRI LS spine showing different grades of LMM fatty muscle atrophy

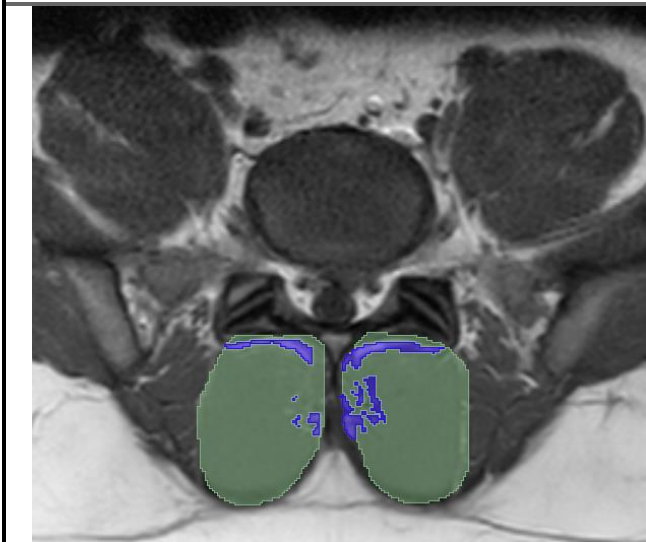


Fig 3: Shows Grade 1 LMM fatty atrophy, with 8 % fat infiltration

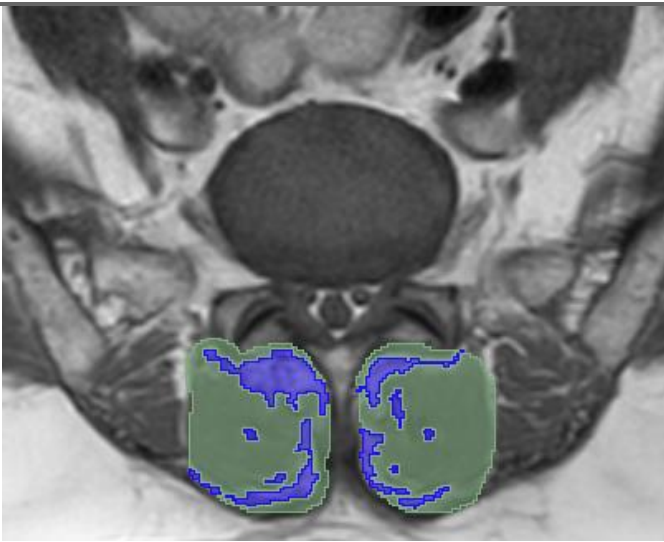


Fig 4: Shows Grade 2 LMM fatty atrophy, with 22 % fat infiltration

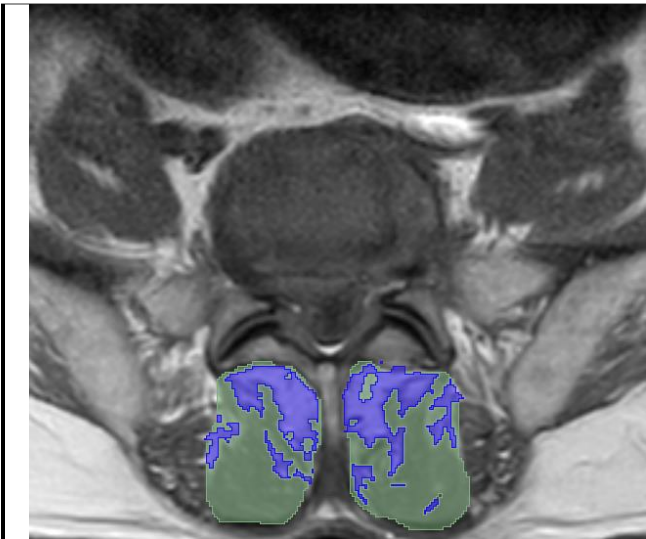


Fig 5: Shows Grade 3 LMM fatty atrophy, with 34 % fat infiltration

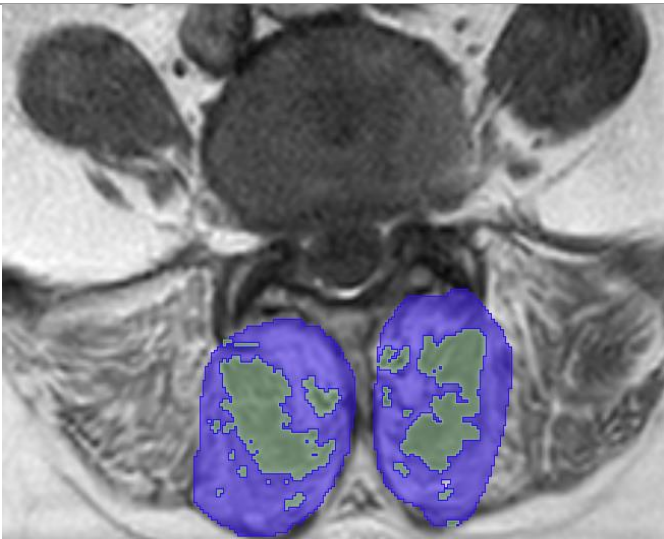


Fig 6: Shows Grade 4 LMM fatty atrophy, with 67 % fat infiltration

V. DISCUSSION

The transversospinales muscle group lies deep in the Erector Spinae, consisting of semispinalis, multifidus, and rotatores. The multifidus muscle extends from cervical to sacral levels, lying lateral to spinous processes and covering laminae of the underlying vertebrae from cervical to upper lumbar levels, then expanding to encompass the sacrum at lumbosacral levels⁹. Multifidus muscle atrophy is seen in individuals with spine pathology¹⁰. This prospective observational study on 125 subjects aimed to find an association between the atrophy of the lumbar multifidus muscle and the degree of disc degeneration at L4/5 and L5/S1 intervertebral disc spaces to find an association with low backache.

Out of 125 subjects, the majority(n=70) were in the age group of 31-40, and our study is concordant with the study by Sanjay SC et al ¹¹. There was a slight female preponderance, with 51.2 % (n= 64) concordant with the study by Faur C et al ¹². Grade III lumbar disc degeneration at both L4-L5 and L5-S1 intervertebral disc levels was noted in most subjects, and our study is concordant with Sanjay SC et al¹¹. No relation was found in this study between gender and the degree of lumbar disc degeneration, making this study concordant with the study by Sanjay SC et al¹¹.

The results of this study showed a noticeable increase in fatty infiltration within the lumbar multifidus muscles as people age. The data presented clearly illustrates this trend. The study also found a significant relationship between gender and fatty infiltration of the lumbar multifidus muscle, with females being more susceptible to fatty atrophy of the LMM. This study is concordant with the study by Kjaer P et al.,¹³ which reported a higher risk to females and a higher incidence in adults than adolescents.

The correlation between grade of lumbar disc degeneration and severity of fatty infiltration in LMM was statistically significant at both the L4-L5 & L5-S1 levels in this study, compared to the study by Özcan-Ekşi et al ¹⁴, which also showed that patients with severe intervertebral disc degeneration had increased fatty infiltration in the multifidus and erector spinae muscles. The study by Özcan-Ekşi et al. ¹⁴ also showed that women had greater lumbar intervertebral disc degeneration scores at L4-L5 and L5-S1 and had more fatty infiltration in multifidus and erector spinae muscles at L4-L5 and L5-S1.

VI. CONCLUSION

This study revealed a significant association between the severity of fat infiltration in the LMM and varying grades of disc degeneration at the L4-L5 and L5-S1 regions. The data obtained from the study underscores the importance of assessing both LMM fatty atrophy and lumbar disc degeneration in patients with chronic LBP, which could potentially aid in developing more targeted treatment strategies for this prevalent and debilitating condition. Further research in this area could potentially lead to improved diagnostic and therapeutic interventions for individuals suffering from chronic low back pain.

ABBREVIATIONS

LBP-Low back pain
 LMM-Lumbar multifidous muscle,
 MRI- Magnetic resonance imaging
 TMSCA Total muscle cross-sectional area
 PFCSA- Pure fat cross-sectional area
 DICOM- Digital Imaging and Communications in Medicine
 FSE-Fast spin echo

ACKNOWLEDGMENTS

We extend our gratitude to all the individuals involved in the acquisition and interpretation of data of subjects.

FUNDING

The authors declare that this work did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sector.

AVAILABILITY OF DATA AND MATERIALS

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

REFERENCES

- [1] GBD 2021 Low Back Pain Collaborators. Global, regional, and national burden of low back pain, 1990–2020, its attributable risk factors, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. *Lancet Rheumatol* 2023; 5: e316–29.
- [2] Wáng YX, Wáng JQ, Káplár Z. Increased low back pain prevalence in females than in males after menopause age: evidences based on synthetic literature review. *Quantitative imaging in medicine and surgery*. 2016 Apr;6(2):199.
- [3] Treede RD, Rief W, Barke A. A classification of chronic pain for ICD-11. *PAIN* 2015;156:1003–7.
- [4] Aure O, Nilsen J, Vasseljen O. Manual therapy and exercise therapy in patient with chronic low back pain: A randomized, controlled trial with 1-year follow up. *Spine*. 2003;28(6):525–32.
- [5] Woodham M, Woodham A, Skeate JG, Freeman M. Long-term lumbar multifidus muscle atrophy changes documented with magnetic resonance imaging: A case series. *J Radiol Case Rep* 2014;8:27–34.
- [6] Woodham M, Woodham A, Skeate JG, Freeman M. Long-term lumbar multifidus muscle atrophy changes documented with magnetic resonance imaging: A case series. *J Radiol Case Rep* 2014;8:27–34.
- [7] Pfirrmann CW, Metzdorf A, Zanetti M, Hodler J, Boos N. Magnetic resonance classification of lumbar intervertebral disc degeneration. *Spine (Phila Pa 1976)*. 2001 Sep 1;26(17):1873–8. doi: 10.1097/00007632-200109010-00011. PMID: 11568697.
- [8] Yazici A, Yerlikaya T, Oniz A. An evaluation of the efficacy of a four-grade fat infiltration classification method, presented for the first time in literature. *BMC Musculoskeletal Disorders*. 2022 Mar 8;23(1):226.
- [9] Toumanidou T. Spinal muscles. In *Biomechanics of the Spine* 2018 Jan 1 (pp. 141–166). Academic Press.
- [10] Shahidi B, Hubbard JC, Gibbons MC, Ruoss S, Zlomislic V, Allen RT, Garfin SR, Ward SR. Lumbar multifidus muscle degenerates in individuals with chronic degenerative lumbar spine pathology. *Journal of Orthopaedic Research*. 2017 Dec;35(12):2700–6.
- [11] Sanjay SC, Sanjith VR, Harsha Vardhan VS. Lumbar Multifidus Muscle Fatty Atrophy and Lumbar Disc Degeneration: Are they Associated in Middle-Aged Patients with Low Backache?.
- [12] Faur C, Patrascu JM, Haragus H, Anglitoiu B. Correlation between multifidus fatty atrophy and lumbar disc degeneration in low back pain. *BMC musculoskeletal disorders*. 2019 Dec;20:1–6.
- [13] Kjaer P, Bendix T, Sorensen JS, Korsholm L, Leboeuf-Yde C. Are MRI-defined fat infiltrations in the multifidus muscles associated with low back pain? *BMC Med*. 2007;5:2. PMID: 17254322
- [14] Özcan-Ekşi, E.E., Ekşi, M.Ş. and Akçal, M.A., 2019. Severe lumbar intervertebral disc degeneration is associated with modic changes and fatty infiltration in the paraspinal muscles at all lumbar levels, except for L1-L2: a cross-sectional analysis of 50 symptomatic women and 50 age-matched symptomatic men. *World neurosurgery*, 122, pp.e1069–e1077.