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Original Research Article

Examination of the Effect of Lumbar Disc Hernia on Atrophy of Paravertebral Muscles

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ABSTRACT

Aim: Present study aimed to evaluate the effect of the presence of lumbar disc herniation on the atrophy of the paravertebral muscles in patients who were admitted to the hospital with the complaint of lumbalgia.

Material and Methods: Following the approval of Aydýn Adnan Menderes University clinical studies ethics committee, MRI images of adult patients who applied to our hospital with the complaint of lumbalgia between December 1, 2020 and June 1, 2021 began to be examined. Patients with structural deformities, lumbar region neoplasms, infectious diseases, vertebral fractures and lumbar region surgery were not included in the study. As a result of the examinations, 443 patients with low back pain and lumbar disc herniation formed the case group. The control group consisted of 135 patients with low back pain but without lumbar disc herniation. The patients were evaluated in terms of gender, age, number of lumbar disc herniations, lumbar disc herniation level, lumbar disc herniation degree, surface measurements of paravertebral muscles and atrophy of paravertebral muscles.

Results and Conclusion: As a result of our study, statistical significance was found between atrophy of m.multifidus lumborum and m.quadratus lumborum muscles and LDH. In addition, the relationship of age and gender factors with LDH, lumbar disc degeneration and atrophy of paravertebral muscles were examined.

KEYWORDS: Lumbar disc herniation, paravertebral muscles, Pfirrmann classification, Goutallier classification

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INTRODUCTION

Seventy to eighty percent of adults will at some point in their life experience low back pain, also known as lumbalgia [1,2].

Lumbalgia reduces people's quality of life and causes loss of workforce and productivity. It becomes an expensive health issue if it becomes chronic [3].

reveals a broad range of conditions, from hereditary illnesses to occupational diseases. Lumbar disc herniation (LDH), which is a mechanical cause, is one of the frequently encountered causes in the etiology of lumbalgia [2,4]. Nowadays, the relationship between lumbalgia and paravertebral muscles is frequently examined [5–9]. Previous studies have also shown that chronic lumbalgia causes atrophy and fatty degeneration in the paravertebral muscles [5,8,10].

In our study, we aimed to examine the atrophy of paravertebral muscles in adult patient groups in which LDH accompanies lumbalgia (case group) and in which LDH does not accompany lumbalgia (control group). Our goal was to reveal the significance of LDH as a risk factor for paravertebral muscular atrophy, given its role in the etiology of lumbalgia. While examining atrophy of paravertebral muscles, we simultaneously evaluated both cross-sectional surface area and fatty degenerations in the same cross-sectional surface area. Thus, we were able to evaluate both cardinal signs of muscle atrophy together.Furthermore, we documented the degree of discus intervertebralis degeneration in each patient and the correlation between discus intervertebralis degeneration and paravertebral muscle atrophy.

MATERIALS AND METHODS

Determination of Case and Control Groups: The study was approved by Aydýn Adnan Menderes University's non-invasive clinical research ethics committee before it was initiated (Protocol No: 2021/117). MRI images of patients who applied to Aydýn Adnan Menderes University Application and Research Hospital with complaints of lumbalgia between December 1, 2020 and June 1, 2021 and whose lumbar MRI examination was deemed appropriate by the clinicians began to be examined. The total number of participants that could be included in our study was 1266. The following criteria were applied to the sample pool: individuals under the age of eighteen, those with structural deformities (scoliosis and rotoscoliosis of more than ten degrees), infectious diseases (spondylosis, spondylolisthesis, and spondylodiscitis) in the lumbar region, those with a history of lumbar surgery, those with a lumbar neoplasm, those with a fracture along the vertebra lumbales, and those with multiple myeloma, vertebral fusion defect, and Paget disease were excluded from the sample pool. Lastly, individuals for whom the required measurements were not possible due to MRI scans not being acceptable for measuring the paravertebral muscles or the discus interverebralis were eliminated from the study, leaving 578 patients eligible for examination. The case group consisted of 290 female and 153 male patients with LDH paired with lumbalgia (LDH diagnosis was already reported by faculty radiologists), while the control group consisted of 80 female and 55 male patients with lumbalgia without LDH.

Imaging Method: Philips Achieva 1.5 Tesla MRI scanner was used to acquire images of the control and case groups.The patients were positioned supine when the images were captured.Both axial T_2 images and sagittal T_1 and T_2 images were 4 mm thick in the sequences that were obtained.

Analysis of Data: Magnetic resonance images of the case and control group patients included in the study were examined with the Sectra Workstation IDS7 (Version 23.2.2.5087) program, which our institution currently uses. DICOM (Digital Imaging and Communications in Medicine) and PACS (Picture Archiving and Communication System) formats were used in this program to store magnetic resonance pictures.

The genders of the patients in the control and case groups were noted. Furthermore, based on the most recent data [11-13], the patients were analyzed in three age groups: those who were over fifty, those who were between thirty and fifty, and those who were between eighteen and thirty.

To detect the presence of LDH, T2-weighted sagittal and axial images were examined at each discus intervertebralis level between L_I-S_I levels. The case group with one or more instances of LDH was studied for LDH level. Three groups of LDH levels were assessed: L_I-L_{II} and L_{II}-L_{III} levels; L_{III}-L_{IV}, L_{IV}-L_V, and L_V-S_I levels; and both L_I-L_{III} and L_{III}-S_I levels.

LDH degenerations that were found were categorized using the Pfirrmann method (14-16).

The Pfirrmann method classifies intervertebral disc degeneration by using MRI T_2 spin-echo weighted images. Evaluation criteria include

Table 1: Algorithm of Pfirrmann Classification [14].

Degree	Structure	Distinction of Nucleus and Annulus	Signal Intensity	Height of Intervertebral Disc
I	Homogeneous. bright white	Clear	Hyperintense. isointense to cerebrospinal fluid	Normal
II	Inhomogeneous with or without horizontal bands	Clear	Hyperintense. isointense to cerebrospinal fluid	Normal
III	Inhomogeneous. grey	Unclear	Intermediate	Normal to slightly decreased
IV	Inhomogeneous. grey to black	Lost	Intermediate to hypointense	Normal to moderately decreased
V	Inhomogeneous. black	Lost	Hypointense	Collapsed disc space

Fig. 1: Measurement of Paravertebral Muscles Surface Area.

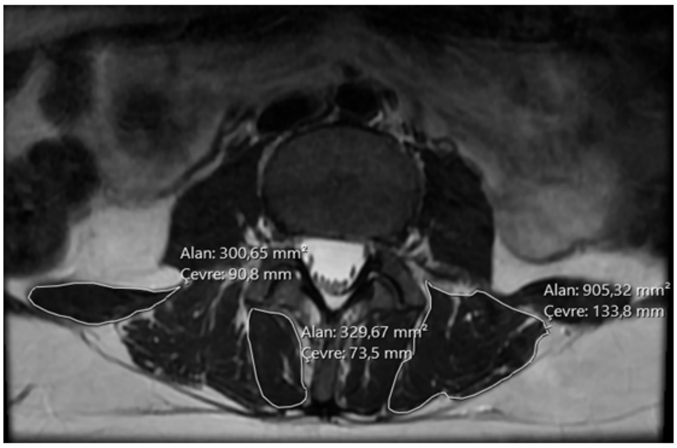

Table 2: Algorithm of Goutallier Classification (19-21).

	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Goutallier Classification	Completely normal muscle tissue. no fatty streaks.	Muscle tissue contains some fatty streaks.	Fat infiltration is observed. but muscle tissue predominates.	Fat and muscle tissue are in equal amounts.	Fat tissue is more than muscle tissue.

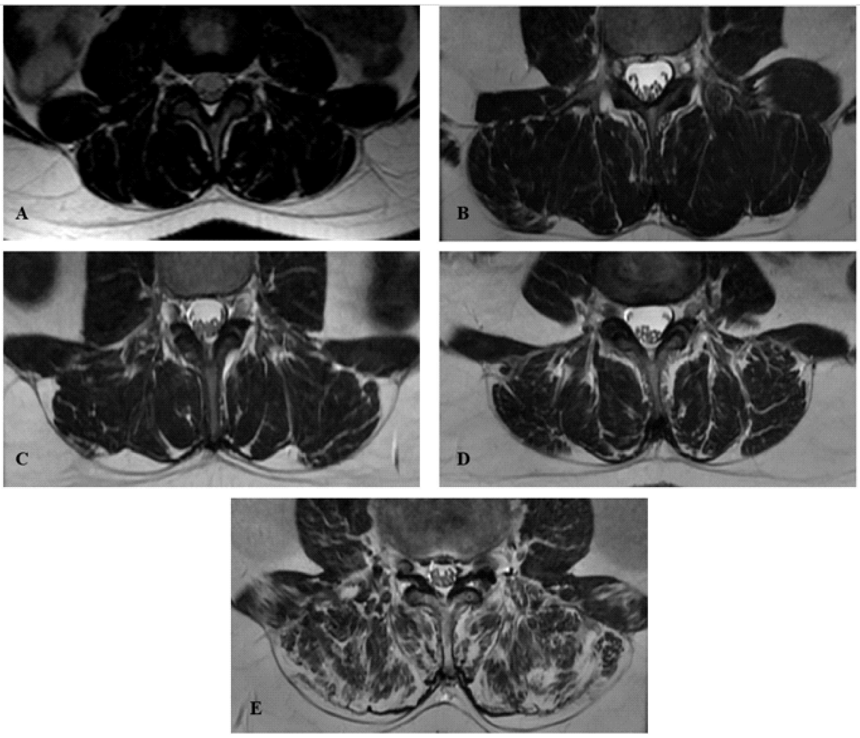

Fig. 2: Goutallier Classification: Image A represents stage 0; Image B represents stage 1; Image C represents stage 2; Image D represents stage 3; and Image E represents stage 4.

discus intervertebralis homogeneity, height, and brightness of signal generated by discus intervertebralis in MRI image. Additionally, it examines at whether or not discus intervertebralis can distinguish between annulus fibrosus and nucleus pulposus.The algorithm of classification is as follows (Table 1).

Another procedure performed was to measure the surface areas of the paravertebral muscles (m. multifidus, m. erector spina and m. quadratus lumborum) from the L_{III}-$_{IV}$ discus intervertebralis level in mm^2 separately, right and left, with the area measurement command in the Sectra Workstation IDS7 program. During the measurement, adipose tissue located at the periphery of the paravertebral muscles was not included in the measurement (Fig. 1). The reason why the L_{III}-$_{IV}$ level was chosen was that this is the level where the surface areas of the paravertebral muscles are measured at their largest [17,18].

Finally, fatty degenerative changes of the muscles, whose surface areas were also measured, were graded. For this purpose, the Goutallier method, which was initially used to classify fatty degenerative changes of the shoulder rotator cuff muscles but is now also used for paravertebral muscles in magnetic resonance T2 sequences (Table 2). Sample images of this classification are shared below (Fig. 2).

Statistical Analysis: SPSS, or the statistical package for the social sciences, version 26.0 was used for data analysis. Kolmogorov Smirnov and Shapiro-Wilk tests were used to evaluate whether the data showed normal distribution. Levene test was used to examine homogeneity of variances. In the research's descriptive statistics, the mean and standard deviation were calculated for data that comply with a normal distribution; for data that did not, the median, lowest and maximum value were measured. The Chi-Square test was used in the study to show whether there was a difference between categorical variables. Continuous variables with non-parametric distributions in independent groups were compared using the Mann Whitney U test or the Kruskal Wallis test. Post hoc analyzes for variables using Kruskal Wallis tests were evaluated with the Games-Howell test. Correlation of non-parametric variables was measured by Lambda test.

RESULTS

The control group consisted of 80 female and 55 male patients who met the study's inclusion criteria and had lumbalgia without LDH. The remaining 290 women and 153 men in whom LDH accompanied lumbalgia represented the case group. There was no statistically significant difference between the control and case groups based on gender ($p = 0.189$).

When the relationship between gender and the number of herniations was investigated, single-level lumbar disc herniation was found in 61 women and 42 men; lumbar disc herniation at multiple-level was found in 229 women and 111 men. No statistical significance was found between herniations at single or multiple levels and the gender factor ($p = 0.136$).

In the case group, only three female patients and one male patient had a single LDH at the L_I-L_{III} level. In 159 women and 104 men, a single LDH was observed between L_{III}-S_I levels. In 128 women and 48 men, multiple LDHs were observed at the LI-LIII and LIII-SI levels (Table 3). The incidence of herniation at the L_{III}-S_I level in both genders in the case group was found to be statistically significant ($p = 0.029$).

The age of the participants, unlike the gender factor, was found to be a statistically significant parameter in grouping the patients. The case group was primarily made up of individuals over 30, whereas the control group was primarily made up of individuals between the ages of 18 and 30 ($p<0,001$) (Table 4).

Additionally, as the age of the participants increased, the number of herniations observed in the lumbar region also increased. Only 15 of the participants between the ages of 18 and 30 had herniation at one level; 61 participants between the ages of 30 and 50 had single-level herniation. In participants older than 50 years of age, the number of herniations at a single

Table 3: Relationship Between Gender and Herniation Level.

			Herniation Level				Total
			None	L_I-L_{III}	L_{III}-S_I	L_I-L_{III} & L_{III}-S_I	
Gender	Female	Number	80	3	159	128	370
		Percentage (%)	21.6	0.8	43	34.6	
	Male	Number	55	1	104	48	208
		Percentage (%)	26.4	0.5	50	23.1	
Total		Number	135	4	263	176	578
		Percentage (%)	23.4	0.7	45.5	30.4	

Table 4: Distribution of Case and Control Groups by Age Groups.

			Group		Total	Chi-Square Test
			Control	Case		
Groups by Age	18 to 30 years	Number	52	21	73	p < 0.001
		Percentage (%)	71	29		
	30 to 50 years	Number	72	193	265	
		Percentage (%)	27	73		
	over 50 years	Number	11	229	240	
		Percentage (%)	5	95		
Total		Number	135	443	578	
		Percentage (%)	23	77		

Table 5: Relationship between Number of Herniations and Age.

			Number of Herniations			Total
			None	Single	Multiple	
Groups by Age	18 to 30 years	Number	52	15	6	73
		Percentage (%)	71.2	20.5	8.2	
	30 to 50 years	Number	71	61	133	265
		Percentage (%)	26.8	23	50.2	
	over 50 years	Number	12	27	201	240
		Percentage (%)	5	11.3	83.8	
Total		Number	135	103	340	578
		Percentage (%)	23.4	17.8	58.8	

Table 6: Distribution of Control and Case Groups According to Pfirrmann Classification.

			Pfirrmann Classification					Total
			I	II	III	IV	V	
Groups	Control	Number	50	73	11	1	0	135
		Percentage (%)	37	54.1	8.1	0.7	0	
	Case	Number	0	19	143	207	74	443
		Percentage (%)	0	4.3	32.3	46.7	16.7	
Total		Number	50	92	154	208	74	578
		Percentage (%)	8.7	15.9	26.6	36	12.8	

Table 7: Relationship between Pfirrmann Classification and Age.

			Pfirrmann Classification					Total
			I	II	III	IV	V	
Age	18 to 30 years	Number	31	21	12	9	0	73
		Percentage (%)	42.5	28.8	16.4	12.3	0	
	30 to 50 years	Number	19	62	94	74	16	265
		Percentage (%)	7.2	23.4	35.5	27.9	6	
	over 50 years	Number	0	9	48	125	58	240
		Percentage (%)	0	3.8	20	52.1	24.2	
Total		Number	50	92	154	208	74	578
		Percentage (%)	8.7	15.9	26.6	36	12.8	

Table 8: Examination of Control and Case Groups According to Goutellier Classification.

			Goutellier Classification					Total
			0	1	2	3	4	
Groups	Control	Number	31	62	37	4	1	135
		Percentage (%)	23	45.9	27.4	3	0.7	
	Case	Number	0	19	122	155	147	443
		Percentage (%)	0	4.3	27.5	35	33.2	
Total		Number	31	81	159	159	148	578
		Percentage (%)	5.4	14	27.5	27.5	25.6	

Table 9: Goutallier Classification and Relationship Between Age Groups.

			Goutallier Classification					Total
			0	1	2	3	4	
Age	18 to 30 years	Number	18	29	24	2	0	73
		Percentage (%)	24.7	39.7	32.9	2.7	0	
	30 to 50 years	Number	12	49	104	78	22	265
		Percentage (%)	4.5	18.5	39.2	29.4	8.3	
	over 50 years	Number	1	3	31	79	126	240
		Percentage (%)	0.4	1.3	12.9	32.9	52.5	
Total		Number	31	81	159	159	148	578
		Percentage (%)	5.4	14	27.5	27.5	25.6	

Table 10: Fatty Degenerations and Gender Relationship.

			Goutallier Classification					Total
			0	1	2	3	4	
Gender	Female	Number	18	42	93	110	107	370
		Percentage (%)	4.9	11.4	25.1	29.7	28.9	
	Male	Number	13	39	66	49	41	208
		Percentage (%)	6.3	18.8	31.7	23.6	19.7	
Total		Number	31	81	159	159	148	578
		Percentage (%)	5.4	14	27.5	27.5	25.6	

Table 11: Effect of Gender on the Surface Area of Paravertebral Muscles (mm^2).

Gender		Right m. multifidus lumborum	Left m. multifidus lumborum	Right m. erector spinae	Left m. erector spinae	Right m. quadratus lumborum	Left m. quadratus lumborum
Female	Median	380.7	360.44	1338.45	1377.55	309.56	338.17
	Standard deviation	102.06	107.9	313.46	305.02	113.21	125.1
Male	Median	486.76	469.65	1748.27	1769.4	511.3	566.97
	Standard deviation	127.75	178.75	428.26	421.3	182.45	175.73
All participants	Median	415.66	389.12	1495.64	1515.8	358.01	402.95
	Standard deviation	122.6	146.94	409.68	402.1	171.52	178.73

level decreased to 27 because herniations at more than one level were predominant in this age group. Herniation at multiple levels was observed in 6 participants under the age of 30, while it was observed in 133 participants between the ages of 30 and 50. This number increased to 201 among participants over the age of 50.This was statistically significant (p<0.001) (Table 5).

When the degeneration of the disc intervertebralis of the control and case groups is compared, as expected, Pfirrmann I and II degree discs were found in 91.1% at control group. Pfirrmann III and IV degree interverte-bral discs, where the distinction between an-nulus fibrosus and nucleus pulposus could not be clearly made or was not possible, and the discs intervertebralis lost their signal intensity, were found in 79% of the case group. Both cases were found to be statistically significant (p <0.001) (Table 6).

The age factor had a statistically significant effect on the number of lumbar region herniations or the presence of lumbar region herniations; this effect was also consistent with the Pfirrmann classification, and discus intervertebralis degenerations, whose degree increases with age, could be reported (p <0.001). While Pfirrmann I and II degree degenerations were predominantly observed in participants between the ages of 18 and 30 (71.3%); Grade III and IV degenerations (63.4% and 72.1%, respectively) were frequently encountered in participants aged 30 to 50 years and older than 50 years. While no collapsed lumbar disc was observed in participants between the ages of 18 and 30; Pfirrmann I degree degeneration, which represents the healthy lumbar disc, was not observed in participants older than 50 years (Table 7).

The gender factor was shown to have no statistically significant impact on the lumbar region's intervertebral disc degeneration (p = 0.22).

When the control and case groups were examined with the Goutallier classification, which evaluate the fatty degeneration of paravertebral muscles, Goutallier stages 0 and 1, where there was no fat or some fatty lines were seen, were detected as 23% and 45.9% in the control group, respectively. In the case group, stages 3 and 4, in which muscle and fat volumes were equal or fat volume was more than muscle volume, were encountered in 35% and 33.2%, respectively. These situations were found to be statistically significant (p<0,001). Additionally, only one patient in the control group had stage 4 fat infiltration; no patient fitting stage 0 was found in the case group (Table 8).

As expected, the degree of fatty degeneration of muscles increased with aging. 64.4% of participants under 30 years of age had stage 0 or 1 degeneration. Among participants aged 30 to 50 years, the proportion of patients withstage 2 or 3 degeneration was 68.6%. In patients over 50 years of age, stages 3 and 4 were predominantly encountered and this rate was 85.4%. The increase in the degree of degeneration between age groups was found to be statistically significant (p<0.001) (Table 9).

Considering the gender of the participants, 3rd and 4th degree fatty degenerations (58.6%) were noted in women; for male participants, 0.,1. and 2nd degree fatty degenerations were encountered more frequently (50.5%). This was found to be statistically significant (p=0.007) (Table 10).

The surface areas of the quadratus lumborum, erector spinae, and multifidus lumborum muscles were measured separately in square millimeters, right and left, at the L_{III}-L_{IV} discus intervertebralis level. Median value of the right side multifidus lumborum muscles of the participants in the control group was 438,4 ± 10,28 mm^2, this value was found to be 400,14 ± 5,82 mm^2 in the case group. The difference in area measurements of the right-sided multifidus lumborum muscle between the control and case groups was found to be statistically significant (p = 0.004).

The median surface area measurements of the left side multifidus lumborum muscle of the participants in the control and case groups were found to be 443,6 ± 10,13 mm^2 and 374,2±7,29 mm^2, respectively. Similar to the right side, surface area measurements of these control and case groups revealed statistically significant results (p=0.002).

Considering the right side quadratus lumborum muscle, the median value of the surface area of this muscle for the control group was 360,3 ± 16,26 mm^2 and for the case group, it was 357,13 ± 7,82 mm^2. These values revealed statistical significance (p = 0.04).

Unlike musculus quadratus lumborum and musculus multifidus lumborum, median values of musculus erector spinae did not show statistical significance between the control and case groups on the right and left sides. The p values of the tests were calculated as 0.733 and 0.341, respectively. The median values for the right musculus erector spinae were found to be 1482,6 ± 37,04 mm^2 in the control group and 1499 ± 19,16 mm^2 in the case group. The median values of the left side musculus erector spinae were measured as 1514,8 ± 34,83 mm^2 in the control group and 1516,8 ± 19,05 mm^2 in the case group.

When the effect of gender on the surface areas of the paravertebral muscles examined in the study was evaluated, as expected, the surface areas of the paravertebral muscles of male participants at the L_{III}-L_{IV} discus intervertebralis level were found to be larger than the surface areas of the muscles of female participants and showed statistical significance ($p < 0.001$) (Table 11).

When the effect of the age factor on paravertebral muscle surface areas was examined, the areas of the multifidus lumborum, erector spinae and quadratus lumborum muscles, measured separately in square millimeters for right and left, revealed statistical significance ($p < 0.001$). To ascertain which age groups had statistical significance, post hoc analyses were also used (Table 12).

When the table above is examined, the surface areas of the participants aged 18 to 30 and the participants aged 30 to 50 at the L_{III}-L_{IV} discus intervertebralis level of the right multifidus lumborum muscle are statistically larger than those of participants older than 50 years of age ($p = 0.02$ and $p < 0.001$, respectively). There was no statistical significance between the muscle surface area measurements of participants under the age of 30 and the muscle surface area measurements of participants between the ages of 30 and 50.

In the left multifidus lumborum muscle, the surface area measurements at the L_{III}-L_{IV} discus intervertebralis level of participants over 50 years of age are statistically smaller than the muscle surface areas of participants between 18 and 30 years of age and between 30 and 50 years of age ($p = 0.039$ and $p < 0.001$, respectively). There was no statistical significance between the muscle surface area measurements of participants under the age of 30 and the muscle surface area measurements of participants between the ages of 30 and 50.

When the right erector spinae muscle was examined in a similar manner, the largest surface areas were found in participants between the ages of 30 and 50. Surface area measurements of participants in this group were statistically greater than both participants aged 18 to 30 and participants older than 50 years ($p < 0.001$ and $p = 0.02$, respectively).

Left erector spinae muscle measurements also match the right erector spinae muscle results. The muscle surface areas of participants between the ages of 30 and 50 are statistically larger than both the participants between the ages of 18 and 30 and the participants over the age of 50 ($p < 0.001$ and $p = 0.003$, respectively).

In the right quadratus lumborum muscle, only the muscle surface areas of participants aged between 30 and 50 were statistically larger than those of participants older than 50 years ($p < 0.001$).

In the left quadratus lumborum muscle, the muscle surface area measurements of both the participants between the ages of 18 and 30 and the participants between the ages of 30 and 50 were statistically greater than the muscle surface area measurements of the participants over the age of 50 ($p = 0.041$ and $p < 0.001$, respectively).

The average surface area measurements of the paravertebral muscles at the L_{III}-L_{IV} discus intervertebralis level according to age groups are shown in the table below (Table 13).

Another aim of our study was to examine the effect of the number of herniations on fatty degeneration in paravertebral muscles. When the data were examined, we found mostly Goutallier stage 0 and 1 degenerations in the control group (67.1%). If the patients in the case group had a single herniation, we frequently encountered Goutallier stages 2 and 3 (73.5%). Finally, as expected, Goutallier stages 3 and 4 were frequently observed in participants with multiple herniations (75.3%). Statistical significance and a moderate relationship were detected between the number of herniations and degeneration of paravertebral muscles (Lambda test v = 037; $p < 0.001$) (Table 14).

Table 12: Effect of Age on the Surface Area of Paravertebral Muscles.

Muscles			Mean Difference	p
Right m. multifidus lumborum	18 to 30 years	30 to 50 years	-11.64	0.788
		over 50 years	48.88	0.02
	30 to 50 years	18 to 30 years	11.64	0.788
		over 50 years	60.52	0
	over 50 years	18 to 30 years	-48.88	0.02
		30 to 50 years	-60.52	0
Left m. multifidus lumborum	18 to 30 years	30 to 50 years	-14.24	0.755
		over 50 years	47.3	0.039
	30 to 50 years	18 to 30 years	14.24	0.755
		over 50 years	61.54	0
	over 50 years	18 to 30 years	-47.3	0.039
		30 to 50 years	-61.54	0
Right m. erector spinae	18 to 30 years	30 to 50 years	-205.74	0
		over 50 years	-108.09	0.066
	30 to 50 years	18 to 30 years	205.74	0
		over 50 years	97.65	0.02
	over 50 years	18 to 30 years	108.09	0.066
		30 to 50 years	-97.65	0.02
Left m. erector spinae	18 to 30 years	30 to 50 years	-190.57	0
		over 50 years	-74.11	0.263
	30 to 50 years	18 to 30 years	190.57	0
		over 50 years	116.46	0.003
	over 50 years	18 to 30 years	74.11	0.263
		30 to 50 years	-116.46	0.003
Right m.quadratus lumborum	18 to 30 years	30 to 50 years	-35.03	0.349
		over 50 years	47.64	0.135
	30 to 50 years	18 to 30 years	35.03	0.349
		over 50 years	82.66	0
	over 50 years	18 to 30 years	-47.64	0.135
		30 to 50 years	-82.66	0
Left m. quadratus lumborum	18 to 30 years	30 to 50 years	-30.66	0.474
		over 50 years	62.33	0.041
	30 to 50 years	18 to 30 years	30.66	0.474
		over 50 years	92.99	0
	over 50 years	18 to 30 years	-62.33	0.041
		30 to 50 years	-92.99	0

Table 13: Surface Area Measurements of Paravertebral Muscles According to Age Groups (mm^2).

Age		Right m. multifidus lumborum	Left m. multifidus lumborum	Right m. erector spinae	Left m. erector spinae	Right m. quadratus lumborum	Left m. quadratus lumborum
18 to 30 years	Standard deviation	138.28	147.85	353.12	350.55	194.11	200.96
	Median	426.28	392.4	1332.2	1345.6	330.9	398.8
30 to 50 years	Standard deviation	115.03	159.93	442.28	435.7	176.3	189.2
	Median	438.4	426.6	1524.6	1556.6	388.3	438.3
over 50 years	Standard deviation	117.9	123.43	373.83	362.77	147.43	144.24
	Median	380.25	364.69	1501.3	1513.51	324.94	368.2
All participants	Standard deviation	122.6	146.94	409.68	402.1	171.52	178.73
	Median	415.66	389.12	1495.64	1515.8	358.01	402.95

Table 14: Relationship Between Number of Herniations and Fatty Degeneration of Paravertebral Muscles.

			Goutallier Classification					Total
			0	1	2	3	4	
Number of herniation	None	Number	31	63	38	7	1	140
		Percentage (%)	221	45	27.1	5	0.7	
	Single	Number	0	12	43	29	14	98
		Percentage (%)	0	12.2	43.9	29.6	14.3	
	Multiple	Number	0	6	78	123	133	340
		Percentage (%)	0	1.8	22.9	36.2	39.1	
Total		Number	31	81	159	159	148	578
		Percentage (%)	5.4	14	27.5	27.5	25.6	

Table 15: Effect of Discus Intervertebralis Degeneration on Fatty Degeneration of Paravertebral Muscles.

			Goutallier Classification					Total
			0	1	2	3	4	
Pfirrmann Classification	I	Number	19	25	6	0	0	50
		Percentage(%)	38	50	12	0	0	
	II	Number	12	42	34	2	2	92
		Percentage(%)	13	45.7	37	2.2	2.2	
	III	Number	0	10	78	55	11	154
		Percentage(%)	0	6.5	50.6	35.7	7.1	
	IV	Number	0	4	39	83	82	208
		Percentage(%)	0	1.9	18.8	39.9	39.4	
	V	Number	0	0	2	19	53	74
		Percentage(%)	0	0	2.7	25.7	71.6	
Total		Number	31	81	159	159	148	578
		Percentage(%)	5.4	14	27.5	27.5	25.6	

Another question we sought to answer in our study was whether discus intervertebralis degenerations had an effect on fatty degeneration of paravertebral muscles. When we examined the data we had, 88% of the participants with low discus intervertebralis degeneration (Pfirrmann I and II degree) were also found to have low fatty degeneration (Goutallier stage 0 and I) in the paravertebral muscles. Following similar logic, Goutallier grade 2 and 3 fatty degenerations were observed in 86.3% of the participants with Pfirrmann III degree discus intervertebralis degenerations. Goutallier stage 3 and 4 fatty degenerations were observed in 79.3% of participants with Pfirrmann IV degree disc intervertebralis degenerations. Goutallier stage 3 and 4 fatty degenerations were observed in 97.3% of participants with Pfirrmann V degree discus intervertebralis degenerations. A statistically significant and moderate relationship was detected between the degrees of degeneration of the discus intervertebralis and the fatty degeneration of the paravertebral muscles (Lambda test v = 0.259; p <0.001) (Table 15).

DISCUSSION

Several factors come to light when the etiology of lumbalgia is investigated. Gender is a factor that is frequently brought up, but no consensus has been reached on it. According to the Institute for Quality and Efficiency in Healthcare (IQWiG), headquartered in Germany, LDH is almost twice as common in men as in women (22). In our country (Turkey) Prof. Dr. Ýsmet Çetinyalçýn [23] and Prof. Dr. A. Fahir Özer [24] stated in his books that LDH is more common in the male population. Recent studies have also shown that LDH is more common in the female population. For example, in a study conducted by Benlidayý et al., the relationship between columna vertebralis morphology and LDH was investigated, and 151 of 224 patients who had an MRI request with complaints of lumbalgia in a six-month period were diagnosed with LDH [25]. Of these 151 patients, 60 were identified as male and 91 as female. Similarly, in another six-month study conducted by Yýlmaz et al. investigating the quality of life of patients diagnosed with LDH, 132 participants diagnosed with LDH were included in the study, and 65.2% of these patients were women [26].

In another study conducted by Öztürk et al., the degree of degeneration of LDH and paravertebral muscles was examined in a six-month period, and 392 people who requested MRI due to complaints of lumbalgia were included in the study [27].

100 female and 105 male participants were diagnosed with LDH, but it was stated that there was no statistical significance between the diagnosis of LDH and the relationship between gender. Another recent study arguing that there is no statistically significant relationship between gender and LDH was published by Çelebi et al. [28].

In this study, 40 people with LDH hernia were matched with 40 volunteer patients without LDH hernia and the ischiadicus nerve was examined with ultrasound. In this study, no statistical significance was found between gender and LDH. In our study, 443 of 598 patients who underwent lumbar MRI with complaints of lumbalgia were diagnosed with LDH. Of the participants diagnosed with LDH, 290 were female and 153 were male. However, no statistical significance was found between LDH and gender.

When the relationship between gender and discus intervertebralis degeneration was investigated in the literature, Faur et al. reported in their study that in a group of 35 patients, the average Pfirrmann score was 3.4 in male patients and 2.8 in female patients [29]. The statistical significance of the study results was not stated. 653 patients participated in a study by Oh et al. that examined the cervical and lumbar disc herniations of the subjects [30]. The age distribution of the participants was categorized by decades. The only finding with statistical significance was the findings of increased Pfirrmann scores in male patients at the L_{IV}-L_{V} disc intervertebralis level in the fifth decade. Hong et al. conducted a study wherein only collapsed disc herniation (Pfirrmann V) was considered [31]. When the results of 369 participants were evaluated, no statistical significance was found between genders. We, also, found no statistically significant relationship gender factor and discus intervertebralis degeneration in our study.

Although a common decision has not yet been reached in the literature regarding the gender factor and the presence of LDH, this uncertainty is not seen in the gender factor and fatty degeneration of paravertebral muscles. Almost all of the current studies published to the best of our knowledge have found that the fat in the paravertebral muscles is higher in the female gender than in the male gender. For example, in the previously mentioned study conducted by Öztürk et al., the degree of fatness of the multifidus lumborum and erector spinae muscles in both the lumbalgia groups with and without LDH was evaluated with the Goutallier classification, and statistically significant more fat was observed in the female gender [27].

Another study with a similar studying principle was conducted by Ekin and colleagues [32]. This study evaluated atrophy in the multifidus lumborum muscle using MRI images of 2028 patients. Researchers examined fatty degeneration in the multifidus lumborum muscle in three levels: below 10%, between 10% and 50%, and more than 50%, and found it to be statistically high in the female population. In another study by Faur et al., fatty degeneration in the multifidus lumborum muscle was examined in four stages. In this study, fatty degenerations were considered normal if they were less than 10%, mild if they were between 10 and 30%, moderate if they were between 30 and 50%, and severe if they were more than 50%. The average fatty degeneration rate for female patients was reported to be 25.62±9.89%, whereas the average for male patients was 23.47±16.14%.

Fatty degeneration in the female patient group was found to be statistically higher than in the male patient group [29]. In their retrospective study with 230 participants, Koji Tamai and colleagues observed Goutallier stage 0 in the paravertebral muscles at the L_{IV}-L_{V} discus intervertebralis level in men, while Goutallier stage 2 and 3 were observed in female participants. This situation was found to be statistically significant [33]. In our study, we recorded findings parallel to the studies mentioned above. While Goutallier stages 3 and 4 were observed in 58.6% of the female patients participating in our study, Goutallier stages 0.1 and 2 were observed in 50.5% of our male participants. This situation was statistically significant.

Examining whether there are gender differences in the surface areas of the paravertebral muscles at the L_{III-IV} discus interverte bralis level was one of our study's secondary objectives. In our study, the surface area of the left side multifidus lumborum muscle was found to be 360,44 ± 107,9 mm^2 in women and 469,65 ± 178,75 mm^2 in men. The surface area of the right side multifidus lumborum muscle was determined as 380,70 ± 102,06 mm^2 in women and 486,76 ± 127,75 mm^2 in men. The surface area of the right side erector spinae muscle was found to be 1338,45 ± 313,46 mm^2

in women and 1748,27 ± 428,26 mm^2 in men. The surface areas of the left side erector spinae muscle were determined as 1377,55 ± 305,02 mm^2 in women and 1769,40 ± 421,30 mm^2 in men. The surface area of the right side quadratus lumborum muscle was measured as 309,56 ± 113,21 mm^2 in women and 511,30 ± 182,45 mm^2 in men. The surface area of the left side quadratus lumborum muscle was measured as 338,17 ± 125,10 mm^2 in women and 566,97 ± 175,73 mm^2 in men. All these measurements showed statistical significance between male and female genders, and it was concluded that the surface areas of the paravertebral muscles of male participants were larger. A review of the literature revealed that the study by Cankurtaran et al. [34] contained 164 patients.In this study, the multifidus lumborum and erector spinae lumborum muscles were measured as a whole.In the surface area measurement performed at the L_{III}-L_{IV} discus intervertebralis level, the total surface area of the above-mentioned muscles was determined as 8,56 ± 2,34 cm^2 in female patients and 10,73 ± 3,02 cm^2 in men. It has been reported that muscle surface areas show statistically significant differences between genders. In another study conducted by Mannion et al., 55 patients were included in the study (35). Surface area measurements performed at the L_{III}-L_{IV} discus intervertebralis level of the patients were found to be 18,8 ± 3,0 cm^2 in women and 25,1 ± 3,4 cm^2 in men for the erector spinae muscles. For the quadratus lumborum muscle at the same disc level, these values were determined as 4,5 ± 1,1 cm^2 in women and 7,6 ± 1,4 cm^2 in men. Once more, this study revealed a statistically significant difference in surface area between the male and female genders. Overall, there is consistency between the data from our research and the literature. We believe that the slight variations in the paravertebral muscle surface areas originate from the various participant pools.

One of the more frequently investigated topics is the correlation between the incidence of lumbar disc herniations and age. The general belief is that lumbar disc herniations will increase with aging. One of the most comprehensive studies supporting this opinion was conducted by Kim et al., over a 7-year period and with 100,000 participants [12]. The ages of the participants are stated as between 20 and 69 years old. The research groups created are based on ten-year age ranges. As a result of this research, lumbar disc herniations are observed to increase with age in both genders from the second decade to the seventh decade, and this was found to be statistically significant. Occasionally, studies claiming that age and the incidence of lumbar disc herniation are not related have also appeared in the literature. One of such studies is the study conducted by Zhang et al., in which 2010 patients with lumbar disc herniation were considered as the case group and 2070 participants without lumbar disc herniation were considered as the control group [13]. Participants were divided into three groups: people aged 18 to 30, people aged 30 to 55, and people over 55. As a result of this study, age was not seen as a risk factor for lumbar disc herniation. Additionally, the notable study by Ma et al. was also included in the literature [36]. In this study, 601 patients over the age of 65 diagnosed with lumbar disc herniation were included in the study and it was examined whether new lumbar disc herniations would occur in later ages. No statistical significance was found between the observation of new disc herniations with increasing age, and they suggested that age was not a risk factor for lumbar disc herniations in elderly patients.

Our research provided results that align with the literature. While lumbar disc herniation was not found in 71% of persons under 30, it was in 73% of participants between 30 and 50 years old. We observed a 95% rate of lumbar disc herniation in our participants over 50 years of age. Aging was found to be a statistically significant risk factor for lumbar disc herniation in our study.

With aging, changes begin to be observed in the intervertebral disc. Especially decrease in annulus fibrosus density is striking [37].

In addition, proteoglycan synthesis decreases with aging. This decrease is most notable in the nucleus pulposus [38].

Researchers investigating the degeneration of the intervertebral discs with aging also obtained results parallel to the changes mentioned above. In a study conducted by Singh et al., 50 patients with lumbalgia complaints (26 of whom had LDH) and 25 patients without lumbalgia complaints were included in the study [39]. They detected the increasing degeneration with age in all discus intervertebralis in the lumbar region using the Pfirrmann classification. Statistically, they revealed a strong correlation between aging and disc degeneration at all levels except the L_V-S_I discus intervertebralis level. Disc degeneration with aging was evaluated as well in the Oh et al. study, which we previously discussed when evaluating gender and disc degeneration. The Pfirrmann classification was applied in this study [30]. Pfirrmann IV degree degeneration was most commonly found in the sixth decade of this study, whereas Pfirrmann III degree degeneration was found most frequently in the second through fifth decades. Additionally, the increase in degeneration in the discus intervertebralis with aging was determined to be statistically significant. In our study, we observed Pfirrmann I and II degree degenerations in 71.3% of participants between the ages of 18 and 30. In participants 30 to 50 years old and older than 50 years old, we frequently observed Pfirrmann III and IV degree degeneration (respectively %63,4 and %72,1). Furthermore, Pfirrmann degree V degenerations were discovered in 6% of participants between the ages of 30 and 50, but in participants over 50, the rate increased to 24.2%. Statistically significant results were obtained between aging and disc degeneration of the participants.

In order to talk about atrophy in any muscle group, the presence of two cardinal findings is required. The first of these is the decrease in muscle surface area, and the other is the presence of fatty degenerations in the muscle [7,40]. In our study, while examining muscle atrophy with aging, we examined both the surface area of the paravertebral muscles and the degree of fat in these muscles. When the surface areas of the right side multifidus lumborum muscle at the L_{III}-L_{IV} discus intervertebralis level were examined, the measured surface areas of both the participants between the ages of 18 and 30 and the participants between the ages of 30 and 50 were found to be statistically larger than the participants over the age of 50. A similar situation was also valid for the left side multifidus lumborum muscle. When the literature was examined, 240 participants were included in a 6-month retrospective study conducted by Özelçi et al. [17]. Similar to our study, multifidus lumborum muscle atrophy was found to be statistically significant in participants over the age of 51. In our study, the right and left side erector spinae muscle surface areas of participants aged between 30 and 50 were found to be statistically significantly larger than the erector spinae muscle surface areas of participants older than 50 years of age. In a study conducted by Takayama et al., multifidus lumborum and erector spinae muscles were measured together and 160 participants were divided into groups according to their ages [41].

In this study, the surface areas of the multifidus lumborum and erector spinae muscles in participants older than 60 years were found to be statistically smaller at all lumbar levels compared to younger age groups. The quadratus lumborum muscle surface area was found to be statistically larger in participants aged between 30 and 50 compared to participants aged over 50 within our research. To the best of our knowledge, there is no study in the literature that can be compared with our study on the surface area of the quadratus lumborum muscle and its change with aging.

The second cardinal finding we examined when examining paravertebral muscle atrophy with aging was fatty degenerations. In a study conducted by Ekin et al., fat in the multifidus lumborum muscle of the participants was examined in three degrees [32].

If the fat level is below 10%, it is considered stage 0, if it is between 10% and 50%, it is considered stage 1, and if it is more than 50%, it is considered stage 2. In this study, stage 1 and 2 muscle fat was found to be statistically higher in participants after the age of 40 in both genders. In another study conducted by Peng et al., fatty degenerations of the erector spinae and multifidus lumborum muscles were evaluated together in 516 patients [42]. The data obtained were interpreted as indicating that fat in the paravertebral muscles would increase with aging and were found to be statistically significant. Our study revealed results that support available data as well. 64.4% of patients under 30 years of age had stage 0 or 1 degeneration. In patients aged 30 to 50 years, the proportion of patients with stage 2 or 3 degeneration was 68.6%. In patients over 50 years of age, stages 3 and 4 were predominantly encountered and this rate was 85.4%. The data obtained was found to be statistically significant.

The main goal of our study was to examine the effect of LDH on atrophy of paravertebral muscles. For this purpose, lumbalgia patients not accompanied by LDH were considered as the control group, while lumbalgia patients accompanied by LDH were considered as the case group. When the discus intervertebralis degenerations of the control and case groups were evaluated, as previously explained, the average age of the case group was statistically older than the control group. Additionally, research has shown that aging increases disc degeneration. For these reasons, as expected, Pfirrmann I and II degree discs were found in 91.1% of the control group. A similar situation resulted in a 79% incidence of Pfirrmann III and IV degree discs in the case group. The difference in disc degeneration between the control and case groups was found to be statistically significant.

While evaluating fatty degenerations in the paravertebral muscles, when the control and case groups were examined using the Goutallier classification in our study, Goutallier stages 0 and 1 were more common in the control group (23% and 45.9%, respectively). In the case group, stages 3 and 4 were more common (35% and 33.2%, respectively). The difference between fatty degenerations in the control and case groups was found to be statistically significant. As mentioned before, this situation can be explained by the fact that older participants are more likely to be in the case group and the correlation between aging and fatty degenerations. In the previously mentioned study conducted by Ekin et al., fatty degenerations of the multifidus lumborum muscle at both the L_{IV}-L_{V} discus intervertebralis level and the L_{V}-S_{I} discus intervertebralis level were found to be statistically higher in lumbalgia patients accompanied by LDH than in lumbalgia patients without LDH [32]. In another study conducted by Liu et al., MRI images of 132 patients diagnosed with LDH and 132 healthy participants were examined (43). In this study, fatty degenerations in the multifidus lumborum muscle were examined and found that fatty degenerations were higher in the case group with LDH than in the control group without LDH. The results of our study are compatible with the literature on this subject.

Another cardinal sign of muscle atrophy is a decrease in muscle surface area or loss of muscle volume. In a study conducted by Yaltýrýk et al., 110 participants were divided into two groups, similar to our study, as patients with lumbalgia accompanied by LDH and patients with lumbalgia without LDH [44]. The surface area differences of the multifidus lumborum and erector spinae lumborum muscles between the control and case groups were found to be statistically significant. The surface areas of both muscles mentioned were measured higher in the control group. Another muscle whose surface area was measured in this study was the psoas major muscle, which did not show statistical significance. In another study conducted by Özelçi et al., a total of 240 participants were included in the study. The determination of control and case groups is compatible with the basis of our study [17].

In this study, the surface areas of the multifidus lumborum, psoas major and erector spinae muscles were measured. Only in participants over the age of 51, multifidus lumborum muscle surface area measurement revealed statistical significance between the control and case groups. In our study, although the surface areas of the multifidus lumborum and quadratus lumborum muscles showed significant statistical differences between the control and case groups, the erector spinae muscle was not found to be statistically significant between the case and control groups. Although all three studies mentioned were conducted within the borders of Turkey, the reason why they did not produce completely overlapping results may be due to the quantitative inadequacy and qualitative differences of the patient populations. Similar studies need to be repeated with larger populations.

The last parameter we examined in our study was whether there was a correlation between fatty degenerations of the paravertebral muscles and degenerations of the discus intervertebralis. When we examined the data we had, 88% of the participants with low discus intervertebralis degeneration (Pfirrmann I. and II. degree) were also found to have low fatty degeneration (Goutallier stage 0 and 1) in the paravertebral muscles. Following a similar logic, Goutallier stage 2 and 3 fatty deposits were found in 86.3% of the participants with Pfirrmann III degree disc intervertebralis degeneration. Goutallier stages 3 and 4 fatty degenerations were found in 79.3% of the participants with Pfirrmann IV degree discus intervertebralis degenerations, and finally, Goutallier stages 3 and 4 fatty degenerations were found in 97.3% of those with Pfirrmann V degree discus intervertebralis degenerations. Statistical significance and moderate correlation were detected between the degrees of degeneration of the discus intervertebralis and the fatty degeneration of the paravertebral muscles. In a similar study conducted by Sualp et al. with 50 participants, a strongly significant correlation was detected when the Pfirrmann score averages were compared with the stages of fatty degeneration in the paraspinal muscles [45]. Studies on the correlation of Pfirrmann and Goutallier classifications will strengthen risk calculations in the monitoring and treatment of LDH and fatty degeneration of paravertebral muscles.

CONCLUSION AND RECOMMENDATIONS

The incidence of lumbargia and LDH, which is one of the causes of lumbargia, is increasing day by day. Lumbalgia and LDH cause atrophy in paravertebral muscles and reduce the quality of life of patients. In addition, LDH is one of the important socio-economic disorders of our time because it causes workforce losses.

In our study, we aimed to reveal how much LDH, which is one of the etiologies of lumbalgia, aggravates the atrophy in the paravertebral muscles, which is one of the results of lumbalgia. In light of our study results, the paravertebral muscle surface areas of our case group were statistically smaller than the control group. The degree of fatty degeneration of the paravertebral muscles in the case group was statistically higher than the control group. Thus, we have demonstrated that the presence of LDH in patients with lumbalgia affects the two cardinal signs of atrophy in a way that is unfavorable to the patients.

A factor limiting our study was that our control group also had lumbalgia complaints. This actually made our control group a group of patients. Since we thought that we could not find healthy volunteers equivalent to our case group of 443 people, our control group was composed of lumbalgia patients without LDH. It would be beneficial for the literature to compare MRI images of large volunteers, healthy masses, with our findings in the future.

While examining atrophy of paravertebral muscles, we simultaneously evaluated both cross-sectional surface area and fatty degenerations in the same cross-sectional surface area. Thus, we evaluated the two cardinal findings of muscle atrophy together. However, when the literature is examined, there is no standard discus intervertebralis level for atrophy measurement or a classification for muscle fatty degeneration. Finding certain standards in future studies will make it easier to evaluate control and case groups in studies on LDH and paravertebral muscle atrophy.

While investigating whether gender factor is a risk factor for disc degeneration and LDH, statistically insignificant results were obtained. In order to examine these data in more detail, we believe that including participants' lumbalgia pain scales and lifestyle information in the study or comparing patients with similar factors will make more accurate contributions to the literature.

In addition, by recording the degeneration degrees of the intervertebral discs of each patient, we were able to reveal the relationship between discus intervertebralis degeneration and atrophy of the paravertebral muscles. If our results are supported by larger studies, clinicians can estimate the amount of fat in the paravertebral muscles by looking at the age and disc degeneration of their patients and plan treatment methods to prevent this condition.

COMPETING INTERESTS

The authors declare that they have no conflict of interest.

Author Contributions

All authors contributed equally to this work. This includes the collection, analysis, and interpretation of data, as well as drafting, revising, and approving the manuscript for submission. Each author agrees to be accountable for all aspects of the work, ensuring its accuracy and integrity.

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