

Change in the dimensions of the lumbar area muscles after surgery: MRI analysis

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ABSTRACT

OBJECTIVE: This study aims to assess the change in the dimensions of the lumbar muscles in patients with chronic lower back pain using Magnetic Resonance Imaging (MRI) and to determine pre/post effects of surgery.

METHODS: We enrolled 28 individuals (13F/15M; age: 45.39±11.56 years) whose L2–S1 muscle measurements were obtained using MRI, before and at follow-up 6–12 months after surgery. The control group comprising 37 individuals (18F/19M; age: 34.41±10.72 years) who had no lumbar pathology but for whom retrospective archive images were available. In the axial MRI analysis, the cross-sections of m.multifidus, mm.erector spinae and m.psoas major on both sides were measured with the ‘closed polygon’ technique.

RESULTS: The L2–3 and L4–5 levels of the m.multifidus on the right side, the L2–3, L4–5 and L5–S1 levels of the m.multifidus and the L5–S1 levels of the mm. erector spinae on the left side cross-sectional areas were significantly lower than the control group ($p<0.05$). The right-side m.multifidus and the left-side mm.erector spinae sectional areas were significantly lower than the pre-surgery values at the L5–S1 levels ($p<0.05$).

CONCLUSION: This study demonstrated that chronic lower back pain causes atrophy in the lumbar muscles and established the existence and continuity of atrophy after surgery.

Keywords: Lumbar surgery; MRI; muscle atrophy.

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Chronic lower back pain is a critical health-related problem, with over 70% lifetime prevalence reported in industrialised countries [1]. While 80% of patients with acute lower back pain recover within six weeks, the pain lasts for more than three months in approximately 7%–10% of patients, thereby adversely affecting work performance and the economy [2]. Besides the loss in muscle power associated with long-term inactivation and inadequacies in voluntary neural activation, atrophy of type two muscle fibres and changes in connective tis-

ues are observed in patients with lower back pain. These changes could be attributed to the non-use and reflex inhibition that result in strength loss in muscles and muscle groups [3].

Notwithstanding the primary pathology, other components of the spinal motion segment are also affected in patients with chronic lower back pain [4]. Reportedly, leading changes are in the dimensions and symmetry of the paraspinal muscles, which play a vital role in facilitating movements and the formation of posture [5]. Some stud-



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ies have reported atrophy in these muscles after lumbar area operations that negatively affect the life quality of the patients and decreases post-operative satisfaction [6, 7].

Regarding post-operative atrophy, some studies suggest that it is a result of iatrogenic denervation or ischaemic or thermal damage [8–10]. Moreover, this condition has been proven to increase morbidity besides pain and instability [11]. Some other studies have considered the affection of the posterior branches of spinal nerves to be the reason for atrophy, and it is reported that the damage does not remain intersegmental only but causes a potential risk regarding innervation [11, 12].

This study aims to investigate the changes in the dimensions of lumbar area muscles (m. psoas major, m. multifidus and mm. erector spinae) in patients with chronic lower back pain through magnetic resonance imaging (MRI) and to compare these results with measurements taken for healthy individuals, to elucidate the relationship between the dimensions of these muscles before and after surgery. In addition, another aim was to determine the changes in patients' daily life activities (DLA), capacity loss and satisfaction levels after surgery.

MATERIALS AND METHODS

Patients

This study was conducted by members of the Mustafa Kemal University, Department of Anatomy, Physiotherapy and Rehabilitation College and the Department of Neurosurgery and Radiology, with the approval of the Clinical Research Ethics Committee (no: 4298783/05023). We obtained written, informed consent from all participants in this study.

The study group comprised 28 individuals (13 females and 15 males) who underwent a lumbar microdiscectomy in patients with lumbar disc herniation. We obtained the morphometric measurements of the lumbar area muscles at the L2–S1 level through the routine MRI performed for normal follow-up before surgery and at 6–12 months after surgery [13]. The control group comprised 37 individuals (18 females and 19 males) for whom retrospective archive images were available. These individuals had attended our hospital for a consultation about lower back pain complaints but did not present any pathology in the radiological analyses.

We examined the members of the study group, obtained their demographic information and performed clinical examinations. Then, the effects of lower back

complaints on their daily lives and pain levels before and after surgery were queried using the Modified Functional Ability Evaluation Form [2]. In addition, their satisfaction concerning their surgeries was evaluated with the Prolo Satisfaction Scale. This scale was comprised of two sub-groups: the economic part reflects each patient's work capacity, and the functional part reflects the impact on each patient's daily activities [14, 15]. In addition, we asked participants whether they had physiotherapy and rehabilitation before and after surgery. From patients who had physiotherapy and rehabilitation, data about the treatment method (home-based programme/PR unit) and duration were also included in the evaluation.

Surgical Procedure

Under the general anaesthesia, the patients were placed in the prone position and after identifying the correct level with a C-arm scopy, a midline small skin incision was made. The dorsolumbar fascia was incised with a scalpel. The paraspinal muscles were exposed and dissected subperiosteally from the spinous processes and lamina using a periosteal elevator pressed against the edge of the spinous process on the ipsilateral side. The lateral border of the dissection is the medial facet joint. A hemilaminectomy retractor was placed. Under a surgical microscope, a laminotomy, flavectomy, microdiscectomy and foramino-tomy were performed on the herniated disc level.

MRI Protocol and Measurements

In this study, MRI was performed on all participants with the 1.5 Tesla MR Device (Philips Achieva, Best, the Netherlands), using the 'Spain 15' coil. In addition, the sagittal and axial T2A turbo-spin echo (TSE) sequences were evaluated retrospectively. The sagittal T2A TSE sequence protocol was as follows: TR/TE, 3000/120; TSE, 3; matrix: 252x320; field of view (FOV), 250 and section thickness, 4 mm. The axial T2A TSE sequence protocol was as follows: TR/TE, 4000/120; TSE, 3; matrix: 252x147; FOV, 200 and section thickness, 4 mm.

We assessed the lumbar MRI measurements of the patients with the DICOM viewer programme (OsiriX, Pixmeo Labs, Geneva, Switzerland). In the axial lumbar MRI analysis, the cross-sections of m. multifidus, mm. erector spinae and m. psoas major on both sides of the L2–3, L3–4, L4–5 and L5–S1 intervertebral disc distance levels were evaluated using the existing software (Fig. 1–3). All measurements were made from the section passing through the midpoint of the intervertebral

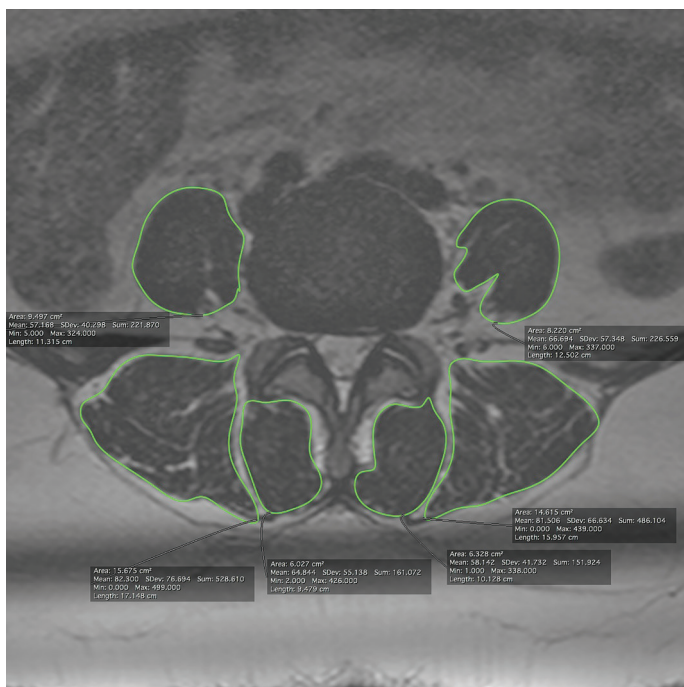


FIGURE 1. Through the axial T2A TSE images, which pass through different levels in the control group, the morphometric analysis of mm. erector spinae (A), m. multifidus (B) and m. psoas major (C).

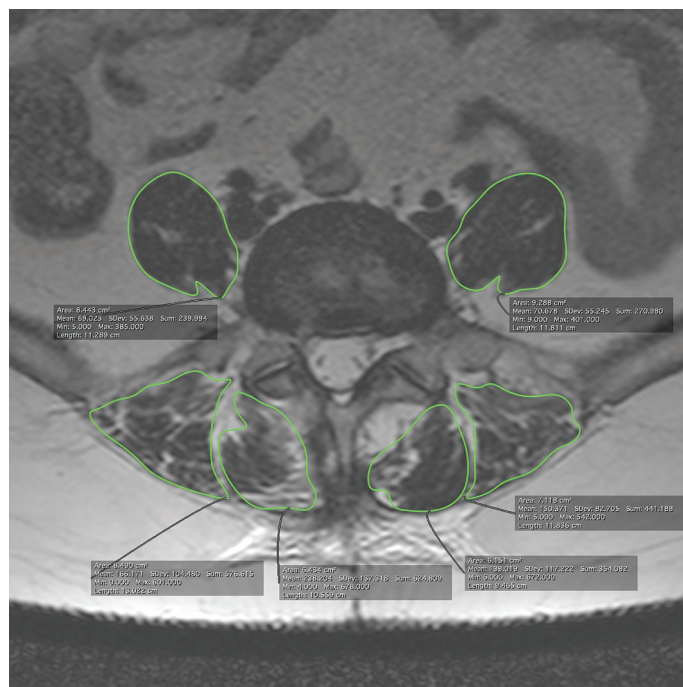


FIGURE 3. Through the axial T2A TSE images, which pass through different levels in the study group in the post-operative period, the morphometric analysis of mm. erector spinae (A), m. multifidus (B) and m. psoas major (C).

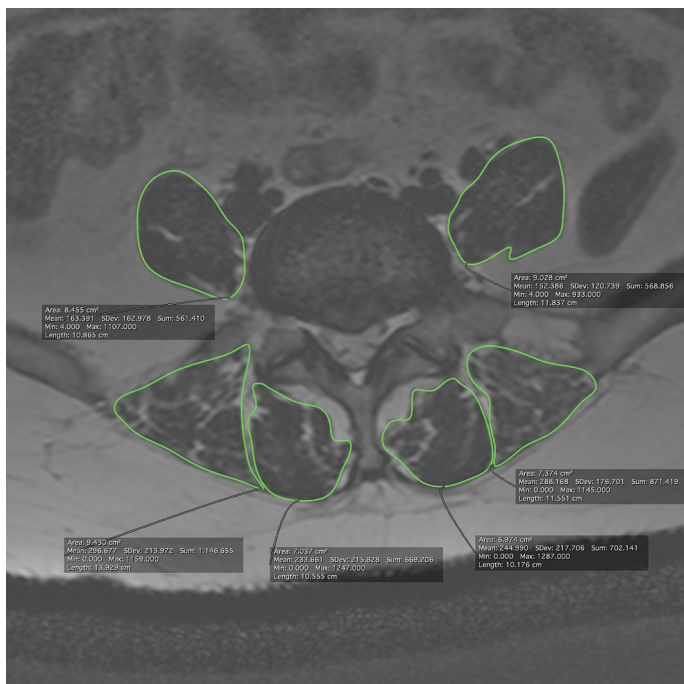


FIGURE 2. Through the axial T2A TSE images, which pass through different levels in the study group in the pre-operative period, the morphometric analysis of mm. erector spinae (A), m. multifidus (B) and m. psoas major (C).

TABLE 1. Distribution of the demographic characteristics according to group

	Study %	Control %
Gender		
Female	46.4	48.6
Male	53.6	51.4
Total	100.0	100.0
Has had PR?		
Yes	28.6	–
No	71.4	–
Total	100.0	
Treatment manner		
Home programme	75.0	–
PR unit	25.0	–
Total	100.0	
Age, Mean±SD (Min.–Max.)	45.39±11.558 (24–70)	34.41±10.717 (19–57)

PR: Physiotherapy and rehabilitation; SD: Standard deviation.

disc level. The measurements of the cross-sectional area were measured by manually constructing polygon points around the outer margins of the individual muscles [16].

Statistical Analysis

G*Power package software program (G*Power, Version 3.1.9.4, Franz Faul, Universität Kiel, Germany) was used to calculate the required sample size for this study. According to the multifidus muscle's area measurements (cm^2) in sections that traversed the level of the L4 upper endplate, it was calculated that a sample consisting of 46 subjects (23 per group) was needed to obtain 80% power with $d=0.74$ effect size, $\alpha=0.05$ type I error, and $\beta=0.20$ type II error. Due to an expected dropout rate of 20%, we planned to recruit at least 56 patients (28 per group) for this study [17].

The data were analysed using the IBM SPSS Statistics 22 programme. We used frequency distributions for categorical variables and descriptive statistics for numerical variables (mean \pm standard deviation [SD]). Since the normalcy assumption was supported by the preceding test, we proceeded to analyse the data with parametrical tests. In addition, we assessed the difference between the two dependent groups (comparison of lumbar area muscle dimensions before and after surgery) with the Dependent Sampling T-Test and the two independent groups (comparison of lumbar area muscle dimensions before surgery with those for the control group) with the Independent Sampling T-Test, respectively. Furthermore, we used the Pearson Correlation Coefficient to determine the degree of correlation between the functional ability of daily life activities and satisfaction concerning their surgeries.

RESULTS

In the study group, 46.4% of 28 individuals were females (median age: 45.39 ± 11.56 years) and 53.6% were males. In contrast, in the control group, 48.6% of participants were females and 51.4% were males (median age: 34.41 ± 10.72 years; Table 1).

Of note, a majority of participants who had surgery were housewives. In addition, 28.6% of participants had physiotherapy; of these, only two participants were treated at the PR unit and the remaining participants were followed-up through a home-based programme (Table 1).

Regarding measurements taken before surgery through MRI, a comparison between the study and

control groups' lumbar area muscle dimensions revealed significant differences between the two groups ($p < 0.05$). In the study group and on the right side, the segment areas of m. multifidus at the L2–3 ($p=0.017$) and L4–5 ($p=0.042$) levels were significantly lower than those of the control group. On the left side, the segment areas of m. multifidus at the L2–3 ($p=0.034$), L4–5 ($p=0.14$) and L5–S1 ($p=0.027$) levels and the segment areas of mm. erector spinae at the L5–S1 ($p=0.038$) levels were significantly lower than those of the control group (Table 2).

A comparison of the measurements of the lumbar area muscle dimensions before and after surgery revealed significant differences between the two groups ($p < 0.05$). It was determined that the right-side m. multifidus ($p=0.038$) and the left-side mm. erector spinae ($p=0.031$) segment areas after surgery were significantly smaller at the L5–S1 levels compared to those before surgery (Table 3).

The Modified Oswestry score after surgery displayed a positive decline ($p=0.000$; Table 4). Furthermore, we observed a negative medium-level significant and direct correlation between the Modified Oswestry total score and Prolo Satisfaction economic ($r=-0.479$; $p=0.010$) and functional ($r=-0.569$; $p=0.002$) scores of the individuals after surgery (Table 5).

DISCUSSION

Although several trunk muscles play a role in the control and stability of the spine, the paraspinal muscles are critical in the segmental stabilisation of the spine. Of the lumbar area pathologies and at all of their phases, whether acute or chronic, the structural and functional changes of the paraspinal muscles of this area are always significant [5]. Studies have demonstrated atrophy in the lumbar area muscles and the increase of fat tissues in patients with lumbar area pathologies [18–21].

In this study, the segment areas of m. multifidus, m. psoas major and mm. erector spinae in individuals who underwent lumbar microdiscectomy surgery throughout the L2–S1 levels were measured. A comparison of the muscles' lengths of the surgery group and the control group revealed that the average segment area of individuals who had surgery was significantly lower than that of the control group ($p < 0.05$). On the right side, m. multifidus at the L2–3 ($p < 0.0179$) and L4–5 ($p < 0.042$) levels and, on the left side, m. multifidus at the L2–3

TABLE 2. Comparison of the lumbar area muscle dimensions before surgery with those for the control group

Before surgery	Study (N=28)		Control (N=37)		t	p
	Mean	SD	Mean	SD		
Right						
L2–L3						
M. multifidus	3001.86	782.949	3641.73	1193.972	-2.461	0.017*
Mm. erector spinae	17,674.54	4950.963	16,240.41	4470.274	1.223	0.226
M. psoas major	6352.79	3265.802	6109.11	3126.971	0.305	0.761
L3–L4						
M. multifidus	4914.89	1443.369	5310.14	1342.866	-1.138	0.260
Mm. erector spinae	16,042.25	4748.016	15,338.57	4633.995	0.600	0.551
M. psoas major	9976.04	4081.503	9256.54	3879.356	0.724	0.472
L4–L5						
M. multifidus	6445.14	1830.549	7266.49	1359.678	-2.077	0.042*
Mm. erector spinae	11,588.54	2697.908	12,426.14	3410.18	-1.070	0.289
M. psoas major	11,921.07	4860.716	11,958.11	4404.672	-0.032	0.974
L5–S1						
M. multifidus	7274.43	2826.568	8325.95	1545.567	-1.918	0.060
Mm. erector spinae	5364.89	2232.086	6604.76	3854.717	-1.518	0.134
M. psoas major	9666.07	3984.139	10,867.19	4862.893	-1.064	0.291
Left						
L2–L3						
M. multifidus	3123.18	1124.038	4342.81	2801.054	-2.172	0.034*
Mm. erector spinae	17,968.93	4867.261	15,925.35	5429.253	1.570	0.121
M. psoas major	6229.71	3159.936	6197.19	3271.376	0.040	0.968
L3–L4						
M. multifidus	5002.25	1514.353	5843.59	2912.448	-1.391	0.169
Mm. erector spinae	15,986.64	39,72.149	14,958.27	4906.366	0.906	0.368
M. psoas major	9508.36	4085.307	9502.7	3883.043	0.006	0.995
L4–L5						
M. multifidus	6310.36	1530.957	7619.78	2378.428	-2.540	0.014*
Mm. erector spinae	11,080.64	3256.125	11,811.46	3590.711	-0.845	0.401
M. psoas major	11,640.00	4709.539	11,801.97	4357.381	-0.143	0.886
L5–S1						
M. multifidus	6723.82	2378.736	8213.38	2804.441	-2.261	0.027*
Mm. erector spinae	4878.32	2487.575	6450.73	3275.489	-2.118	0.038*
M. psoas major	9475.36	4264.56	10,586.86	4429.952	-1.018	0.313

SD: Standard deviation; Independent Sample T-Test; *: $p < 0.05$; L: Lumbar; S: Sacral (measurements are of the mm² type).

($p=0.034$), L4–5 ($p=0.014$) and L5–S1 ($p < 0.027$) levels and mm. erector spinae at the L5–S1 ($p=0.034$) levels were found to be atrophic.

Lumbar surgeries aim to decompress neurological structures and achieve the integrity of the spine. Although differences are observed for surgical techniques,

the manipulation of the paraspinal muscles is inevitable, which makes these muscles prone to the atrophy after surgery. Some studies have underlined that muscle damage after surgery is significantly related to long-term muscle atrophy and fat infiltration [11, 22]. This study demonstrated that the atrophy of the lumbar area mus-

TABLE 3. Analysis of the difference between lumbar area muscle dimensions before and after surgery

	Pre-op		Post-op		t	p
	Mean	SD	Mean	SD		
Right						
L2–L3						
M. multifidus	3001.86	782.949	3181.21	1047.862	-1.465	0.154
Mm. erector spinae	17,674.54	4950.963	17,524.21	4714.589	0.450	0.657
M. psoas major	6352.79	3265.802	6342.07	3389.533	0.058	0.954
L3–L4						
M. multifidus	4914.89	1443.369	5027.54	1692.319	-0.901	0.376
Mm. erector spinae	16,042.25	4748.016	15,436.68	3857.168	1.724	0.096
M. psoas major	9976.04	4081.503	9938.50	4212.883	0.137	0.892
L4–L5						
M. multifidus	6445.14	1830.549	6261.25	1984.599	0.733	0.470
Mm. erector spinae	11,588.54	2697.908	10,452.00	3539.258	1.948	0.062
M. psoas major	11,921.07	4860.716	11,952.79	4654.499	-0.094	0.926
L5–S1						
M. multifidus	7274.43	2826.568	6584.43	2278.646	2.186	0.038*
Mm. erector spinae	5364.89	2232.086	4979.54	2858.615	1.101	0.281
M. psoas major	9666.07	3984.139	9736.07	3186.25	-0.191	0.850
LEFT						
L2–L3						
M. multifidus	3123.18	1124.038	3302.50	1129.02	-1.560	0.130
Mm. erector spinae	17,968.93	4867.261	17,934.14	4672.997	0.100	0.921
M. psoas major	6229.71	3159.936	6222.00	3352.982	0.039	0.969
L3–L4						
M. multifidus	5002.25	1514.353	4960.96	1826.822	0.253	0.802
Mm. erector spinae	15,986.64	3972.149	15,548.61	3606.883	1.251	0.222
M. psoas major	9508.36	4085.307	9669.57	4329.1	-0.677	0.504
L4–L5						
M. multifidus	6310.36	1530.957	6224.32	1836.204	0.413	0.683
Mm. erector spinae	11,080.64	3256.125	10,498.68	3046.011	1.257	0.219
M. psoas major	11,640	4709.539	11,456.57	4551.296	0.993	0.330
L5–S1						
M. multifidus	6723.82	2378.736	6678.64	2061.88	0.188	0.853
Mm. erector spinae	4878.32	2487.575	4256.79	2579.071	2.275	0.031*
M. psoas major	9475.36	4264.56	9958.43	4434.805	-1.295	0.206

SD: Standard deviation; Dependent Sample T-Test; *: $p < 0.05$; L: Lumbar; S: Sacral (measurements are of the mm² type).

cles in the post-operative period gradually increased. In addition, a comparison of MRI images before and after surgery revealed that m. multifidus ($p=0.038$) on the right side and mm. erector spinae ($p<0.031$) on the left side were significantly atrophied at the L5–S1 levels after surgery.

Suwa et al. [21] reported that an average of 30-min muscle retraction was experienced by 42 patients who underwent a one-level interlaminar laminectomy procedure. On the 10th and 12th pre-op and post-op months, the researchers evaluated the thickness of the paraspinous muscles with the anteroposterior 'CT slice parallel'

TABLE 4. Analysis of the relationship between the Modified Oswestry Scale scores before and after surgery

	N	Pre-op		Post-op		t	p
		Mean	SD	Mean	SD		
Modified Oswestry Scale Total Score	28	54.50	7.244	21.46	7.105	21.345	0.000*

SD: Standard deviation; Dependent Sample T-Test; *: $p < 0.001$.

TABLE 5. Analysis of the relationship between the Prolo Satisfaction Scale scores and Modified Oswestry Scale after surgery

	N	r	p
Oswestry Total Score* Economic Prolo Score	28	-0.479	0.010*
Oswestry Total Score* Functional Prolo Score	28	-0.569	0.002**

Pearson Correlation; *: $p < 0.05$; **: $p < 0.01$.

method and reported atrophy at the end of 12 months [23]. Gejo et al. [24] reported that post-op trunk muscle strength was related to muscle retraction time and operation time.

Hartwig et al. [25] reported an increase in the atrophy of and the fat amount in the volume of the paravertebral muscles, through three-dimensional analysis of the lumbar paravertebral muscle measurements obtained in the 1st and 12th post-op months for 20 patients who had undergone a single level (L4–5) fusion. In another study in which three different decompressive surgery techniques were compared, the atrophy amount of the more invasive method was statistically higher than that of the other methods, and the average C-reactive protein and haemoglobin amounts varied as well [6]. For laterality, the literature has shown that there is no significant difference in right or left side [26, 27]. In this study, there were no statistically differences between sides, but different muscle atrophies were observed on the several vertebral level. Considering that the surgical method is the same in all cases for the right and left side, these differences can be explained as: negative postural changes with muscle strength weakness in the preoperative period, time period between disease and surgery, and presence of inactivity in daily life. We believe that these parameters should be evaluated clearly in future studies. However, we should note that these studies provided no information regarding whether exercise, a leading factor that might

prevent muscle atrophy, was performed before the surgeries and during the recovery periods. Hence, the lack of information about physiotherapy protocol modalities and durations is a disadvantage of these studies.

In this study, only 28.6% (N=8) of the participants had PR after surgery. While only two of these participants were followed-up in the PR unit, the remaining participants were followed-up with a home-based programme. All of these participants denied performing any exercise at home. In addition, it was observed that individuals limited even their simple DLA and household chores to avoid the pain that they had before surgery and to not risk requiring another operation. Hence, inactivity also plays a role in the formation of atrophy. However, it is underlined in the literature that exercise positively affects the lumbar area muscles [19]. Furthermore, Gildea et al. [28] reported a positive development in the lumbar muscles sectional area after individuals started exercising again after surgery.

The assessment of the loss of function ability to perform daily activities and the life quality of participants with the Modified Oswestry Scale determined that the pain experienced by individuals was significantly lower, and there was a significant increase in their functionality during daily life after surgery. Besides this positive development, it was also observed that individuals' economic and functional satisfaction increased [14]. Consistent with the literature, we observed a negative medium-level

significant and direct correlation between the Modified Oswestry total score and Prolo Satisfaction economic and functional scores of the individuals after surgery (Table 5).

This study has several limitations. This study had a limited sample size and muscle quality and fatty degeneration could not be evaluated. The measurement technique we used only gave a gross measurement of muscle CSA and we did not measure the total volume of each muscle. Volume outcomes will be important to show atrophy clearly.

In conclusion, this study demonstrates that chronic lower back pain hinders the daily life of people experiencing this pain and causes atrophy in the lumbar area muscles of these individuals. In addition, this study established the existence and continuity of atrophy in people who had undergone lumbar area surgery, whereas clinical findings are getting better. Thus, further studies investigating etiological factors and effective factors during surgery (surgery duration, the surgery type and muscle retraction) are warranted to investigate how to prevent or minimise atrophy for patients undergoing this form of surgery. Overall, it is suggested that the effects of inactivity on atrophy should not be ignored, and the efficiency of different exercise programmes to be suggested to individuals in the post-op period should be studied.

Informed Consent: We obtained written, informed consent from all participants in this study.

Ethics Committee Approval: This study was conducted by members of the Mustafa Kemal University Department of Anatomy, Physiotherapy and Rehabilitation College and the Department of Neurosurgery and Radiology, with the approval of the Clinical Research Ethics Committee (date: 22.10.2015, number: 06).

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