







The relationship between muscle size, obesity, body fat ratio, pain and disability in individuals with and without nonspecific low back pain

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Abstract

Patients with nonspecific low back pain (NSLBP) may face motor control problems and health disability barriers during various tasks. However, studies investigating the extent of these disadvantages, and possible associated factors are quite limited in patients with NSLBP. To compare motor control performances and physical assessment domains between patients with NSLBP and asymptomatic controls. Twenty-seven patients with NSBLP and 27 age- and sex-matched asymptomatic controls participated in this cross-sectional study. Ultrasonographic imaging was used to determine abdominal and multifidus muscles thicknesses and adipose tissue rate. Visual analog scale was used to assess LBP severity. Body mass index (BMI) and Oswestry Disability Index (ODI) scores of the participants were physical assessment domains of LBP. BMI values were greater in the NSLBP group compared to the asymptomatic participants. ANCOVA revealed a significant interaction effect regarding external abdominal oblique and multifidus lumborum muscles thickness, and abdominal adipose tissue ($p = 0.015$; $p = 0.001$; $p = 0.006$), respectively in terms of two groups. The thicknesses of these muscles were lesser in the NSLBP group compared with the control group. Similarly, abdominal adipose tissue was higher in the NSLBP group. The stepwise multiple regression analysis demonstrated that the Oswestry Disability Index and abdominal adipose tissue rate were significant and independent factors of the low back pain severity with 73.5% of the variance. The study results indicate that increased disability and fat infiltration are possible determinants influencing pain severity, although further research is required. Examining musculo-skeletal properties of lumbar region could provide information about the limitation in patients with NSBLP.

KEYWORDS

abdominal muscles, adipose tissue, back pain, diagnostic imaging, paraspinal muscles

1 | INTRODUCTION

Low back pain (LBP) is one of the most common musculoskeletal disorders leading to inactivity, postural disorders, and muscle problems

and can result in disability, reduced quality of life, and workforce loss (Creze et al., 2017). While LBP can occur in almost every age group, it is very rare in the preschool age group, whereas the incidence reaches 36% in adults (Cayea et al., 2006). About 85%–95% of LBP cases have

no identifiable cause and are therefore referred to as nonspecific LBP (NSLBP) (Huang et al., 2020).

Many factors have been reported to play a role in the etiology of NSLBP including occupational factors (e.g., lifting heavy weights, exposure to vibration), personal factors (e.g., depression, job dissatisfaction, and obesity), and behavioral risk factors (e.g., sedentary lifestyle, smoking, and alcohol) (Balague et al., 2012; Bernstein et al., 2017; Malla et al., 2018). In addition, recent studies associate low back pain with physical factors such as lumbar spinal stiffness, muscle shortness, and decreased endurance and muscle strength (Sánchez Romero et al., 2021). These findings necessitate focusing on core stabilizing muscles that provide lumbar stabilization and mobility.

In this study, we aimed to compare the size of abdominal and multifidus lumborum muscles, obesity, and abdominal fat ratio in NSLBP and asymptomatic volunteers, and to analyze the relationship between these parameters and disability and pain in individuals with NSLBP.

2 | MATERIALS AND METHODS

2.1 | Participants and study groups

Individuals with NSLBP who applied to Kırşehir Ahi Evran University Training and Research Hospital Physical Therapy and Rehabilitation Polyclinic between February 2020 and February 2021 and healthy individuals with similar demographic characteristics were included in the cross-sectional study. The purpose and scope of the study were explained to all individuals in detail, and necessary permissions were obtained before the study. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Inclusion and exclusion criteria for the case group were listed below.

Inclusion criteria:

- To be diagnosed with NSLBP by a specialist in Kırşehir Ahi Evran University Training and Research Hospital, Physical Therapy and Rehabilitation Unit.
- Being cooperative.
- Being in the age range of 18–65 years.
- Volunteering to participate in the study.

Exclusion criteria:

- Untreated hypertension and heart disease.
- Untreated neurological and/or mental illness.
- History of trauma in the last 6 months.
- Sacroiliac joint pathologies.
- Spinal fracture or dislocation.
- Having spondylolisthesis or spondylosis.
- Sensitivity to gel diagnosed by a medical doctor.

- Serious musculoskeletal problems or other pathologies that negatively affect balance.
- Severe mental deficits.
- Previous surgery in lower limb(s).

Inclusion criteria for control group:

- No pain in low back during the past 3 months.
- Being in the age range of 18–65 years.
- Being cooperative.
- Volunteering to participate in the study.

2.2 | Obesity assessment

The Body Mass Index (BMI) was calculated for each participant.

$$\text{BMI} = \text{Weight/Height} \times \text{Height (kg/m}^2\text{)}$$

2.3 | Pain assessment

The Visual Analogue Scale (VAS) was used to assess the severity of pain. The participants were asked to mark the intensity of their pain at rest and during activity on a 10 cm line with two ends marked as 0 = No pain and 10 = extreme pain. The distance of the marked point to the zero point was recorded for each participant.

2.4 | Disability assessment

The Oswestry Disability Index (ODI) was used to quantify the participants' disability and loss of function in relation with their low back pain. The Turkish validity and reliability of the questionnaire was demonstrated in 2004 (Koç, 2017). This self-completed questionnaire consists of 10 topic categories including the severity of pain, self-care, lifting-carrying, walking, sitting, standing, sleeping, sexual life, the ability to travel, and social life. Each category is followed by six statements (scored from "0 = least disability" to "5 = most severe disability") and the patient checks the statement that most closely describes their situation related to the topic. Item scores are summed and multiplied by two. Total scores range from a minimum of 0 to a maximum of 100. Higher scores indicate higher levels of disability.

2.5 | Ultrasonographic measurements

Ultrasonographic (US) measurements were performed using a Toshiba Aplio 500, Toshiba Medical Corporation, Nasu, Japan brand ultrasound device in the Radiology department of Kırşehir Ahi Evran University, Training and Research Hospital. Two images of each structure were taken at rest and measurements were performed by the radiologist (DY) and the anatomist (UI) for each structure. Mean of the two

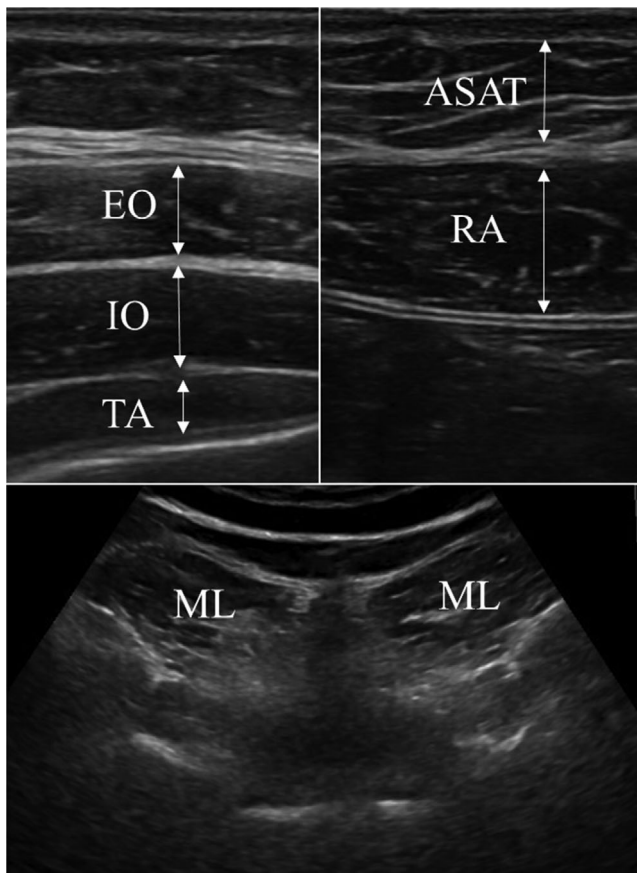


FIGURE 1 Measurements of anatomical structures. Abdominal and multifidus lumborum muscles at rest and adipose tissue. ASAT, Abdominal subcutaneous adipose tissue thickness; EO, External abdominal oblique muscle; IO, Internal abdominal oblique muscle; RA, Rectus abdominis muscle; TA, Transversus abdominis muscle; ML, Multifidus lumborum muscle

measurements was used in the statistical analyses. The images of the anatomical structures at rest were shown in Figure 1.

To evaluate the multifidus lumborum muscle (ML), the participant was asked to lie down in prone, with their arms comfortably extended by the sides of the body. To reduce the lumbar lordosis, the abdomen was supported with a pillow. The L4-5 segment was determined by palpating the spinous process before the measurement was performed (Hides et al., 2008).

For the evaluation of external abdominal oblique muscle (EO), internal abdominal oblique muscle (IO) and transversus abdominis muscle (TA), the participant was lying in supine with a pillow underneath the head. Muscle thickness was measured by placing the US probe—in a slightly oblique position—over the anterior axillary line, in the middle of the 12th rib and iliac crest (Ferreira et al., 2004).

The thickness of the rectus abdominis muscle (RA) was measured by placing the probe 2–3 cm above the umbilicus and 2–3 cm away from the midline while the patient was in the supine position (Tahan et al., 2016).

Ultrasonographic measurement of abdominal subcutaneous adipose tissue thickness (ASAT) was performed at the same point where the RA thickness was measured (Tahan et al., 2016).

2.6 | Statistical analysis

The Statistical Package for the Social Sciences 22.0 program for Windows was used for the statistical analyses. The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk's test) to check normality. We used descriptive statistics and reported counts and proportions for categorical data and measures of distribution for continuous data. An independent t test was performed to compare the means of continuous variables. To evaluate the changes in the muscle thicknesses, a 2*2 (group*side) repeated measures ANCOVA was performed with group as a between-groups factor and side as a within-subjects factor, and with demographical measures set as the covariates. Effect sizes were determined as partial eta squared (η^2_p). Also, the stepwise multiple linear regression analysis was used to determine the variables that had the greatest influence on pain severity in participants with NSLBP. Significantly correlated variables with pain severity were included in the regression model. In addition, the regression equation formula of the study was also calculated. Cook's Distance and Centered Leverage Value were used to identify and treat outliers.

3 | RESULTS

Fifty four participants with ($n = 27$) and without NSLBP ($n = 27$) were included in the study. Descriptive characteristics of the participants are presented in Table 1. There was no significant difference between the two groups in terms of baseline characteristics except for BMI ($p > 0.05$). BMI values were greater in the NSLBP group compared to the asymptomatic participants ($p = 0.03$).

ANCOVA revealed a significant group*side interaction effect regarding external abdominal oblique muscle thickness, multifidus lumborum muscle thickness, and abdominal adipose tissue ($[p = 0.015$; $\eta^2_p = 0.541$]; $[p = 0.001$; $\eta^2_p = 0.875$]; $[p = 0.006$; $\eta^2_p = 0.685$], respectively) between the two groups. These muscles were less thick in the NSLBP group compared to the control group. Similarly, abdominal adipose tissue was thicker in the NSLBP group (Table 2).

The stepwise multiple regression analysis demonstrated that the ODI and ASAT were the significant and independent factors of the low back pain severity explaining 73.5% of the variance (Table 3).

The regression equation formula of the dependent variable (pain severity of the participants with NSLBP) was calculated using explanatory variables and coefficients (Table 3).

The regression equation formula for pain severity:

$$\text{Pain severity} = 0.893 + (0.059 * \text{ODI Score}) + (0.193 * \text{ASAT})$$

4 | DISCUSSION

The present study investigated the effects of the ML and abdominal muscle thicknesses, obesity, and abdominal fat ratio on disability and pain in individuals with NSLBP. Our data showed that ODI and ASAT were independent factors of low back pain severity. Compared to

asymptomatic individuals, the EO and ML muscle thickness was lower and BMI and ASAT were higher in individuals with NSLBP.

Imaging techniques can show some of the morphological changes caused by muscle weakness and adipose tissue in individuals with LBP (Valentin et al., 2015). To determine the thickness of the muscles and adipose tissue, we used real-time US imaging as a safe, noninvasive, and nonionizing technique that is commonly used in the diagnosis and evaluation of pathologies and in therapeutic applications. It is also considered a valid and reliable tool for the assessment of cross-sectional area and dimension of muscles (Morales et al., 2018). A

recent reliability study reported that US imaging is highly reliable in assessing muscle morphology and function, both qualitatively and quantitatively, in patients with NCLBP and healthy participants (Sánchez Romero et al., 2021). Also, the magnetic resonance elastography technique, that gives information about the stiffness of the muscle is widely used in patients with NSLBP (Creze et al., 2018).

Low back pain is associated with many factors such as lumbar muscle stiffness, shortness, muscle weakness, and endurance (Karimi et al., 2008). The TA, IO, EO, and RA muscles in the anterior-lateral wall of the abdomen and the ML muscle in posterior part play a major role in the stability of the lumbar spine (Hodges et al., 2004). Correct muscle patterns and an effective neuromuscular control are required, especially to ensure a balanced load distribution and posture control (Muthukrishnan et al., 2010). Accordingly, factors such as insufficiency and weakness in the motor control of the core muscles that provide lumbar stabilization and regulate mobility are among the pathophysiological causes of LBP (Ambegaonkar et al., 2014). In their study comparing individuals with LBP and healthy individuals, Bae et al., reported that core muscles in individuals with LBP were smaller in dimension, had less increase of thickness during contraction, and had a different pattern of muscle fiber distribution compared to the healthy individuals (Bae et al., 2018). In addition, it is known that individuals with LBP have less type 1 fibers in the multifidus muscle compared to healthy

TABLE 1 Descriptive statistics of the participants

Variable	Participants with NSLBP	Asymptomatic participants	<i>p</i>
Age	35.70 ± 9.28	34.00 ± 8.95	.49
BMI	26.55 ± 3.19	24.96 ± 1.99	.003*
Symptom duration (months)	12.29 ± 7.71	-	-
Female/male	17/10	16/11	.063

Abbreviations: BMI, Body mass index, Independent samples *t*-test or χ^2 test.

TABLE 2 Comparison of muscle thicknesses and adipose tissue between two groups

Measurement parameters	Participants with NSLBP (<i>n</i> = 27)			Asymptomatic participants (<i>n</i> = 27)			2 × 2 ANCOVA	
	Right	Left	<i>p</i> ¹	Right	Left	<i>p</i> ¹	Side	Group*side
EO	5.99 ± 0.71	5.90 ± 0.74	0.64	6.29 ± 0.80	6.27 ± 0.86	0.92	0.044 (0.286)*	0.015 (0.541)*
IO	7.17 ± 1.00	6.97 ± 0.84	0.43	7.60 ± 0.91	7.54 ± 0.99	0.81	0.099 (0.102)	0.059 (0.261)
TA	4.91 ± 0.62	4.75 ± 0.80	0.40	5.23 ± 0.83	5.24 ± 0.80	0.94	0.075 (0.158)	0.090 (0.121)
RA	8.31 ± 1.52	8.32 ± 1.70	0.97	8.98 ± 1.35	8.87 ± 1.34	0.75	0.017 (0.504)	0.074 (0.163)
ML	5.98 ± 1.04	6.05 ± 1.15	0.81	7.16 ± 1.66	7.22 ± 1.74	0.89	0.024 (0.435)*	0.001 (0.875)*
ASAT	7.87 ± 2.23	7.77 ± 2.74	0.88	5.22 ± 2.11	5.27 ± 2.22	0.94	0.001 (0.873)*	0.006 (0.685)*

Abbreviations: ASAT, abdominal subcutaneous adipose tissue thickness; EO, external abdominal oblique muscle; IO, internal abdominal oblique muscle; ML, multifidus lumborum muscle; NSLBP, nonspecific low back pain; RA, rectus abdominis muscle; TA, transversus abdominis muscle; *p*¹, independent samples *t*-test results for within-group side comparisons; Figures in parentheses are effect sizes partial eta squared (η^2_p).

Coefficients ^a		Unstandardized coefficients		Standardized coefficients		<i>t</i>	<i>p</i>
Model		<i>B</i>	<i>SE</i>	Beta			
1	(Constant)	1.523	0.565			2.693	0.012
	ODI	0.078	0.012	0.803		6.739	<0.001
2	(Constant)	0.893	0.545			1.638	0.011
	ODI	0.059	0.012	0.610		4.880	<0.001
	ASAT	0.193	0.068	0.357		2.856	0.009

Note: ASAT, Abdominal subcutaneous adipose tissue thickness; ODI, Oswestry Disability Index score, $R = 0.857$, $R^2 = 0.735$, adjusted $R^2 = 0.713$, $p < 0.001$. The regression equation formula for pain severity is: Pain severity = 0.893 + (0.059* ODI) + (0.193* ASAT).

^aDependent Variable: Visual Analog Scale (pain).

TABLE 3 Stepwise multiple linear regression model of pain in participants with NSLBP

individuals, which leads to a decrease in muscle endurance in this population (Vanti et al., 2016). In the present study, the dimensions of the abdominal and ML muscles were measured using US in resting position. Lower values were observed in the LPB group compared to the asymptomatic group. However, low values of the EO and ML thicknesses were statistically significant. During axial rotation, the contralateral EO and ipsilateral IO are activated, whereas the ipsilateral EO and the contralateral IO act as antagonists. Such co-contractions play an important role in stabilizing the spine during exertion (Thelen et al., 1995). Muscular instability or weakness is an important risk factor for lumbar spine injury and LBP. The function of the ML is to balance the unwanted flexion moment created by the abdominal oblique muscles while rotating the trunk (Macintosh et al., 1993). Also, the architectural design of ML shows that it is designed as a stabilizer to produce large forces in the lumbar region (Ward et al., 2009). This situation supports the emergence of symptoms, such as low back pain in the weakness of ML. Studies have reported hyperactivation of the EO in individuals with back pain (França et al., 2010). This may be a compensatory adaptation that replaces weak muscles to reduce low back pain (Edgerton et al., 1996). The low EO thickness values in our participants may explain their low back pain complaints. Moreover, BMI and ASAT were higher in the NSLBP group. Avoiding painful movements leads to higher levels of inactivity in individuals with NSLBP and may ultimately result in muscle atrophy and an increase in BMI and ASAT. These changes can lead to increased mechanical load and decreased spinal motor control. This can cause higher degrees of tissue stiffness, leading to lumbar instability and chronic pain.

It is controversial whether physical inactivity and deconditioning cause low back pain or if patients with low back pain reduce their physical activity level leading to physical deconditioning (Verbunt et al., 2010). Spinal stability is provided by passive, active, and neural control systems. Dysfunction in any of these systems can cause lumbar spine instability (Panjabi, 1992). A sedentary lifestyle can cause atrophy in the lumbar stabilizing muscles, as in many other muscles. In addition, the increase in BMI and ASAT because of a sedentary lifestyle increases compressive loads on the spine. These changes negatively alter the stability and mechanical balance of the spine and cause low back pain in the absence of any specific underlying cause such as infection, tumor, osteoporosis, fracture, structural deformity, inflammatory disorder, or radicular pressure. In a population-based study on adults, Teichtahl et al. reported that physical inactivity was associated with a narrow intervertebral disc and high multifidus fat content and inactivity was associated with high-intensity low back pain and disability (Teichtahl et al., 2015).

Another mechanism is that physical deconditioning develops secondary to the pain-induced physical inactivity in patients with NSLBP. In this population, pain may cause a decrease in proprioception (i.e., the sense of joint position) (Ruhe et al., 2011). Decreased proprioceptive sensory input may increase the pressure load on the spine due to inadequate motor control, leading to more injury and pain (Della Volpe et al., 2006). This may deteriorate spinal stability by atrophying the core stabilizing muscles of the trunk (Hodges et al., 1997). It can lead to neuromuscular and psychological issues such as pain, decrease in muscle strength, decrease in core endurance, and

balance problems, as well as a decrease in physical functions and physical activity level. Physical activity performance is limited in individuals with chronic pain, leading to a more sedentary lifestyle and reduction in their physical fitness levels in the following periods (Astfalck et al., 2010). Panjabi suggested that kinesiophobia in NSLBP patients may result from their insecurity in motor control and their use of spine-stiffening strategies to increase spinal stability, leading to excessive tissue stretching and pain (Panjabi, 2006). A subsequent study revealed that kinesiophobia was positively associated with trunk stiffness in patients with low back pain (Karayannis et al., 2013). In addition to all these, inactivity can bring about an increase in BMI and ASAT and consequently predispose the patient to the risk of increased mechanical compression, pain, and degenerative changes in later stages. Our data show that ODI is an important and independent factor of low back pain severity in NSLBP. These findings support the pain-related mechanism of disability development.

Brooks et al. reported a significant relationship between abdominal adiposity and chronic LBP (Brooks et al., 2016). Our results showed that BMI and ASAT were higher in individuals with NSLBP, and ASAT was an important and independent determinant of low back pain severity. These data may confirm a possible physiological or biomechanical relationship between obesity and NSLBP. Increasing BMI and ASAT may increase the mechanical load on the lumbar spine and disturb the load distribution balance. This may increase the severity of perceived pain in individuals with NSLBP and decrease their quality of life.

The limitation of the present study is the small sample size, and different number of men and women. Another limitation is unspecified lordosis angles, which are closely related to anatomical structures. It is recommended to investigate the sex difference in muscle change and considering the relationship between lordosis and NSLBP.

5 | CONCLUSION

In conclusion, individuals with NSLBP had smaller muscle size and higher BMI and ASAT. In addition, ODI and ASAT were predictors of low back pain severity in individuals with NSLBP. However, this study cannot determine whether physical inactivity and deconditioning cause low back pain, or individuals with NSLBP reduce their physical activity due to pain leading to physical deconditioning. Large-scale longitudinal studies may help clarify such issues and elucidate the etiology of NSLBP. To increase lumbar spine stability, it is important to include treatment options such as endurance aerobic training and stabilization exercises in the rehabilitation programs of individuals with NSLBP. We believe that therapeutic lifestyle changes for increased BMI and ASAT can have a positive effect on the prognosis of pain in this population. Furthermore, examining anatomical structures such as musculoskeletal properties of the lumbar region could provide information about the limits of stability in patients with NSLBP.

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