RESEARCH ARTICLE

Ali Cihan Dagli [1]
Serkan Oner [2]
Zulal Oner [3]
Beyza Yazgan Dagli[4]

[1] Department of Anatomy, Graduate Education Institute, Karabuk University, Karabuk, Türkiye
[2] Department of Radiology, Faculty of Medicine, Izmir Bakircay University, Türkiye
[3] Department of Anatomy, Faculty of Medicine, Izmir Bakircay University, Izmir, Türkiye
[4] Department of Physiotherapy and Rehabilitation, Gazi University, Ankara, Türkiye

Corresponding Author:
Ali Cihan Dagli
mail: fzt.alicihandagli@gmail.com

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konuralptipdergi@duzce.edu.tr
konuralptipdergisi@gmail.com
www.konuralptipdergi.duzce.edu.tr

An MRI Analysis of the Lumbar Lordosis Angle and Lumbar Muscle Thicknesses in Patients with Non-Specific Low Back Pain

ABSTRACT

Objective: This study aimed to examine the relationship of lumbar lordosis angle and lumbar muscle thickness with non-specific low back pain (LBP) through magnetic resonance imaging (MRI) images.

Methods: The study included 96 individuals (43 men/53 women) aged between 18-65 with non-specific LBP that is not explained by disc pathology based on MRI, who applied to affiliated Training and Research Hospital with the complaint of LBP between March-June 2019. Sociodemographic information was recorded using an LBP assessment form. The Oswestry LBP Disability Questionnaire was used for LBP disability. The thicknesses of muscle (m.) psoas major, m. multifidus, m. quadratus lumborum and m. erector spinae were measured corresponding to the L3-L4 vertebral level by using Radiant DICOM viewer program. The Cobb Angle method was used for lumbar lordosis angle determination. Measurements were made in three repetitions using the Radiant DICOM viewer program.

Results: The results showed that an inverse relationship was found between the Oswestry Disability Index (ODI) and m. psoas major thickness ($p<0.05$). Given the comparison of right-left side muscle thicknesses, left side muscles were thicker ($p<0.05$). There were no significant differences observed between males and females in terms of lumbar lordosis angle (LLA). However, in terms of muscle thickness, males exhibited higher values, except for the transverse measurements of the right quadratus lumborum and left erector spinae muscles, which showed no significant differences ($p < 0.05$). Furthermore, a positive correlation was found between LLA and the transverse thickness of the left psoas major muscle ($p = 0.034$) and the anterior-posterior thickness of the bilateral erector spinae muscles ($p < 0.001$).

Conclusions: In regard to inverse relationship between m. psoas major thickness and ODI, m. psoas major should be taken into consideration to alleviate the disability caused by LBP. Additionally, the difference on both sides is likely one of the causes of muscle imbalance, and this might be one of the reasons for LBP, thereby causing disability in daily tasks due to LBP.

Keywords: Low Back Pain, Muscle Thickness, Spinal Curvatures, Lordosis Angle, Magnetic Resonance Imaging, Cobb Angle.

Non-Spesifik Bel Ağrılı Hastalarda Lumbal Lordoz Açısı ve Lumbal Kas Kalınlıklarının MRG Analizi

ÖZET

Amaç: Bu çalışmada lomber lordoz açısı ve lomber kas kalınlığı ile non-spesifik bel ağrısı arasındaki ilişkinin manyetik rezonans görüntüleme (MRG) görüntüleri aracılığıyla incelenmesi amaçlanmıştır.

Gereç ve Yöntem: Çalışmaya bel ağrısı şikayetiyle ilgili Eğitim ve Araştırma Hastanesine başvuran, MRG ile disk patolojisi ile açıklanamayan non-spesifik bel ağrısı olan, 18-65 yaş aralığındaki, 96 birey (43 erkek/53 kadın) dahil edildi. Sosyodemografik bilgiler bel ağrısı değerlendirme formu kullanılarak kaydedildi. Bel ağrısı engellilik düzeyi, Oswestry Bel Ağrısı Engellilik Anketi (ODI) ile değerlendirildi. L3-L4 vertebra seviyesine karşılık gelen musculus (m.) psoas major, m. multifidus, m. quadratus lumborum ve m. erector spinae'nın kalınlıkları ölçüldü. Lomber lordoz açısının belirlenmesinde Cobb açı ölçme yöntemi kullanıldı. Tüm ölçümler Radiant DICOM görüntüleme programı kullanılarak üç tekrarlı olarak yapıldı.

Bulgular: Elde edilen sonuçlar, ODI ile m. psoas major kalınlığı arasında ters bir ilişki bulunduğunu gösterdi ($p<0.05$). Sağ-sol taraf kas kalınlıkları karşılaştırıldığında, sol taraf kasların daha kalın olduğu görüldü ($p<0.05$). Lumbal lordoz açısı (LLA) bakımından cinsiyetler arasında istatistiksel bir fark bulunmazken, sağ m. quadratus lumborum ve sol m. erector spinae transvers ölçümleri dışında erkeklerde kas kalınlıkları daha yüksekti ($p<0.05$). Ayrıca, LLA, sol taraf m. psoas major transvers kalınlığı ($p =0.034$) ve bilateral anterior-posterior m. erector spinae kalınlığı ($p <0.0001$) ile pozitif yönlü ilişkiliydi.

Sonuç: Çalışma sonucunda ortaya çıkan m. psoas major kalınlığı ve ODI arasındaki ters ilişki, bel ağrısından kaynaklanan engelliliği azaltmada bu kasın da göz önünde bulundurulması gerektiğini göstermiştir. Ayrıca, her iki taraf kas kalınlıkları arasındaki fark, kas imbalansına neden olmuş olabilir, bu durum bel ağrısına yol açmış ve dolayısıyla günlük hayatta karşılaşılan engelliliğe neden olmuş olabilir.

Anahtar Kelimeler: Bel Ağrısı, Kas Kalınlığı, Omurga Eğrilikleri, Lordoz Açısı, Manyetik Rezonans Görüntüleme, Cobb Açısı

INTRODUCTION

Low back pain (LBP) is not only a widespread symptom, but it is also a significant public health problem that affects all civilizations and leads to lost productivity and economic losses due to functional restrictions (1–3). Moreover, LBP may also be highly prevalent due to the fact that it can affect adults of any age range (1,2). The worldwide point prevalence of LBP was shown to be 9.4% in a study by Damian Hoy et al. (2014). The results of Vos et al.'s study displayed that LBP point prevalence was found to be 7.3%, corresponding to 540 million people in the general population (4). Despite being widespread and having a high prevalence, the pathology that causes LBP in 85% of the patients cannot be determined clearly (5).

LBP can be caused by aberrant adaptations in the biomechanics of the lumbar region. The mechanical alterations in this region are able to change the traction angles of the muscles and thus affect the spine alignment; thereby, the altered body pattern might indirectly cause symptoms (6). Curvatures, one of the most important features of the spine biomechanics, provide optimal energy expenditure and movement capacity (7,8). Changes in curvatures such as loss or increase of lumbar lordosis might have an effect on muscle functions, range of motion and mobility by altering the biomechanical structure (7,8). Regarding muscular components of the region, the stabilization role of m. erector spinae and m. multifidus plays a significant role in the protection of the LLA, and maintaining normal movement capacity and stabilization with the help of these muscles may reduce the risk of LBP (9,10). In addition to these muscles, the m. psoas major and m. quadratus lumborum act synergistically with the deep back muscles in the body to gain upright posture (10).

Various studies on LBP have been conducted as to whether changing lumbar muscle thickness (LMT) and LLA cause LBP. Studies on LBP in the literature generally focused on the erector spinae and multifidus, and when comparing the thickness of the muscles, the results were mostly given by taking the average of both sides without comparison between the left and right sides (11–14). Additionally, there is a lack of studies examining the relationship between LLA and muscle thickness (15–17).

Looking at studies investigating the relationship between LBP and LLA, an association was found between LLA and LBP in a meta-analysis (8), while another study found no relationship between these two variables (18). A similar picture is seen in studies examining the correlation between LBP and LMT. Wallwork et al. (19) emphasised that alteration on LMT would be related to LBP, while Masaki et al. (20) came to the opposite conclusion. As is seen, the results of studies that investigated the relationship between LMT or LLA on LBP in the literature have discrepancies and have not reached a consensus.

The aim of this study was to determine the relationship of LLA and LMT with non-specific LBP through MRI images and to introduce a new perspective in addition to existing studies.

MATERIAL AND METHODS

Participants: This cross-sectional study included 43 males and 53 females with non-specific LBP, who applied to the Radiology Department of the authors' affiliated hospital between April-June 2019. The necessary permission for the study was obtained from the Non-Invasive Clinical Research Ethics Committee of the Rectorate of the authors' affiliated institutions. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The individuals who met the inclusion criteria were informed and the consent was obtained about the study.

During the data collection process of the study, patients who applied to the Radiology Department of the University Hospital with the complaint of LBP were asked to participate in the study. The participants of the current study were selected based on the purposive sampling method. A total number of 180 individuals was taken in the study for two weeks data collections term. According to our inclusion and exclusion criteria, 96 individuals were eligible to participate in the study. Prior to the data analysis, the following participant selection criteria were applied.

The inclusion criteria were determined as being aged between 18-65 years old, having non-specific LBP that is not explained by disc pathology, and volunteering to participate. To ensure participants had non-specific LBP, an experienced radiologist investigated the MRI of patients to omit participants who had pathological signs that would cause symptomatic low back pain. In addition, in the given LBP assessment form, participants were asked whether they had any other pathology, symptoms, or radiating pain. Individuals were excluded if there was the presence of any bone, muscular, or disc pathology causing LBP in the lumbar region (as seen on an MRI by an experienced radiologist), if they had any misalignments, such as scoliosis, by observing MRIs on the front view, or if they had undergone any previous operation on the lumbar region. Sociodemographic data, physical condition information, surgical status related to the lumbar region, trauma history, and pain duration of the individuals were questioned using the LBP assessment form prepared by us. The individual's height and weight were recorded in metres (m) and kilograms (kg). With these data obtained, body mass index (BMI) was calculated by dividing the individual's weight by the square of his height.

Outcome Measures

Low Back Pain Questionnaire: The Turkish version of Oswestry LBP Disability Questionnaire v2.0 was used to evaluate LBP disability (21). In this survey, there are 10 parameter titles: pain intensity, personal care, lifting, walking, sitting, standing, sleep, sexual life, social life, and travel. Numbers from 0 to 5 next to each answer qualify the score of that answer. For the questions given different answers for the same question, the option with the highest score among the given answers was chosen to reckon. ODI score as a percentage was obtained from the results.

MRI Analysis: Participants were taken into an MRI device in the supine position, and the MRI procedure was implemented with 1.5 T systems (GE Medical Systems, USA; Siemens Healthcare, Erlangen, Germany). All MRI measurements were made by an expert radiologist. MRI of the individuals was taken from the archives of the Radiology Department of the hospital. LMT and LLA measurements were evaluated on the Digital Imaging and Communications in Medicine (DICOM) imaging and processing program (Radiant DICOM Viewer 4.6.9) in three repetitions. The arithmetic averages of the values were recorded.

The COBB angle method was used to evaluate the LLA in the sagittal plane. It was determined by looking at the angle between the vertebrae forming the LLA (superior L1 endplate and inferior L5 endplate). A line was drawn parallel to the upper edge of the L1 vertebral body, which is the top vertebra involved in the curvature. Next, a line was drawn parallel to inferior L5 endplate, the last vertebra of the lumbar curve. The angle between the two linear lines drawn was measured (Fig. 1). Each measurement was repeated three times by an experienced radiologist and averages of those were recorded as degree values.

Figure 1. LLA Measurement According to COBB Angle Method (The degree between L1 and L5)

The thickness of the m. psoas major, m. multifidus, m. quadratus lumborum and m. erector spinae muscles were measured on the horizontal plane corresponding to the L3-L4 level in the sagittal plane (Fig. 2a). Since m. multifidus and m. erector spinae muscles could not be clearly distinguished from each other on the MRI, they were considered as a whole and recorded as m. erector spinae. Bilaterally, the thickest parts of the muscles were measured anterior-posterior and transverse and recorded in millimetres (mm) (Fig. 2b).

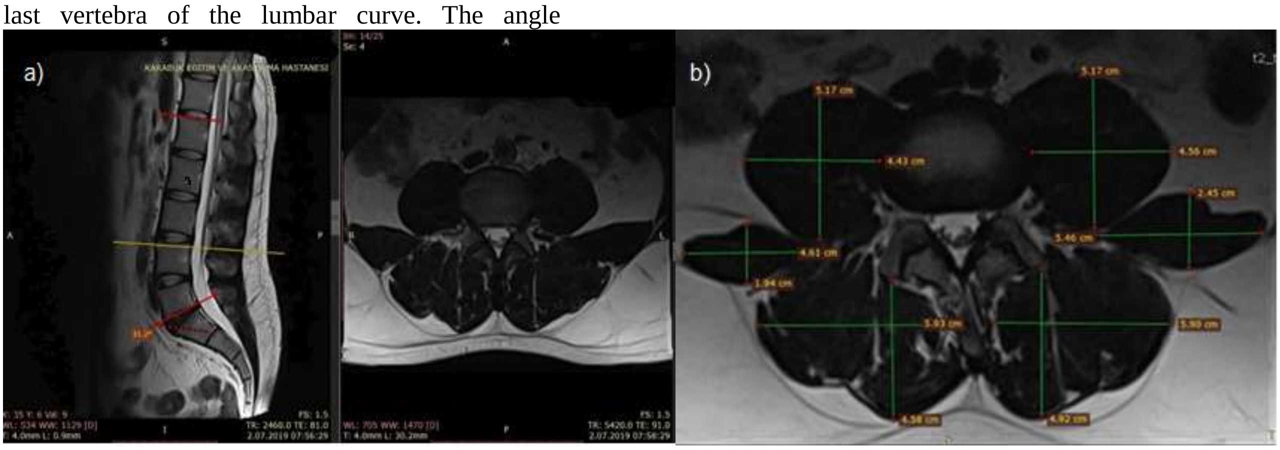

Figure 2. Muscle Thickness Measurement with MRI Imaging: a) T2W determination of L3-L4 level in sagittal and axial planes, b) Bilateral muscle thickness measurements

Statistical Analysis: The data were analysed with SPSS 24.0 (SPSS 24 for Windows, Armonk, NY: IBM Corp) package program. Descriptive values were expressed as mean, standard deviation (SD), number and percentage frequencies depending on the variable type. The compatibility of numerical properties to normal distribution was examined using the Shapiro Wilk test. Mann Whitney U test was performed in comparison of ODI, age, the anterior-posterior thickness of bilateral m. quadratus lumborum and right-side m. psoas major, and transverse thickness of left-side m. erector spinae. BMI, LLA, anterior-posterior thickness of bilateral m. erector spinae and left-side m. psoas major, the transverse thickness of bilateral m. quadratus lumborum, m. psoas major and right-side m. erector spinae differences were analysed with independent samples t test. The relationships between continuous variables were analysed using the Spearman correlation coefficient, and differences between categorical variables were analysed using the Pearson chi-square analysis. The correlation was classified as strong (r≥0.70), moderate (r≥0.40 or r<0.70) or weak (r<0.40), adopting a 95% confidence interval (22). A post-hoc power analysis was performed using an alpha value of 0.005. P<0.05 was accepted as the statistical significance level.

RESULTS

The participants' characteristics are illustrated in Table 1, while information of muscle thickness is shown in Table 2. Age, BMI, and LLA values were similar; therefore, participants displayed a homogeneous distribution regarding these parameters. The ODI score of females was determined to be higher than that of males in relation to gender (p <0.05).

Table 1. Characteristics of Patients

	Females (n=53)	Males (n=43)		Total (n=96)
	mean± SD	mean ± SD	p^{β}	mean ± SD
Age (year)	37.62 ± 10.62	38.72 ± 12.91	0.704	38.11 ± 11.65
BMI (kg/m^2)	26.69 ± 5.36	26.48 ± 3.72	0.826	26.59 ± 4.68
ODI (%)	35.94 ± 16.79	25.44 ± 16.12	0.003*	31.24 ± 17.22
LLA (º)	34.52º ± 11.33º	32.94º ± 12.15º	0.512	33.83º± 11.67º

*p<0.05, Values express as Mean ± Standard Deviation, BMI: Body Mass Index, ODI: Oswestry Disability Index, LLA: Lumbar Lordosis Angle, β: Mann Whitney U test and Independent sample t-test

The differences between the right and left side muscle thickness of the anterior-posterior m. quadratus lumborum and m. psoas major were statistically significant (p <0.05). It was determined that the difference between right and left transverse thicknesses was significant (p <0.05) (Table 2). As to LMT between gender, a significant difference was identified as higher in males except for right m. quadratus lumborum and left m. erector spinae transverse measurements (p <0.05) (Table 3).

Table 2. The Comparison of Individuals' Muscle Thicknesses According to Left and Right Sides

	Individuals (n=96) mean ± SD					
	Anterior-Posterior			Transverse		
	Right	Left	p^{β}	Right	Left	p^{β}
M. quadratus lumborum	20.53 ± 6.72	21.40 ± 6.08	0.014*	48.34 ± 7.59	50.81 ± 7.72	<0.001*
M. erector spinae	56.33 ± 6.75	56.69 ± 6.92	0.062	65.56 ± 6.78	66.69 ± 6.46	0.009*
M. psoas major	41.58 ± 6.42	42.34 ± 6.07	0.048*	33.71 ± 6.65	32.54 ± 6.58	0.009*

*p<0.05, Values express as Mean ± Standard Deviation, β: Independent sample t-test

Table 3. The Comparison of Muscle Thickness According to Genders

			Females (n=53)	Males (n=43)	
			mean ± SD	mean ± SD	P^{β}
TRANSVERSE	Right	M. quadratus lumborum	47.02 ± 7.39	49.96 ± 7.61	0.59
		M. erector spinae	63.05 ± 6.24	68.65 ± 6.17	<0.001*
		M. psoas major	30.20 ± 5.94	38.04 ± 4.64	<0.001*
	Left	M. quadratus lumborum	47.82 ± 7.37	54.49 ± 6.51	<0.001*
		M. erector spinae	65.40 ± 6.10	68.28 ± 6.60	0.05
		M. psoas major	29.09 ± 5.42	36.80 ± 5.15	<0.001*
ANTERIOR POSTERIOR	Right	M. quadratus lumborum	16.33 ± 4.35	25.70 ± 5.40	<0.001*
		M. erector spinae	52.62 ± 5.76	60.89 ± 4.81	<0.001*
		M. psoas major	37.27 ± 3.76	46.91 ± 4.82	<0.001*
	Left	M. quadratus lumborum	17.74 ± 3.88	25.90 ± 5.23	<0.001*
		M. erector spinae	52.71 ± 5.58	61.61 ± 5.01	<0.001*
		M. psoas major	38.39 ± 3.74	47.20 ± 4.70	<0.001*

*p<0.05, Values express as Mean ± Standard Deviation, β: Mann Whitney U test and Independent sample t-test

While there was no relationship between the ODI and age, BMI, or LLA, an inverse relationship was observed between the ODI and both sides anterior-posterior and the left side transverse m. psoas major thickness (Table 4). A relationship was found between LLA and BMI (p <0.05). Regarding the relation between LLA and muscle thickness, a relationship was determined between bilateral m. erector spinae anterior-posterior and left-sided m. psoas major transverse thicknesses (p <0.05) (Table 4).

Table 4 The Relationship between LLA, ODI and LMT

			Individuals (n=96)			
			LLA		ODI	
			r	**p**	**r**	**p**
ANTERIOR POSTERIOR	**Right**	M. quadratus lumborum	0.145	0.160	-0.164	0.110
		M. erector spinae	0.391	<0.001*	-0.093	0.366
		M. psoas major	-0.129	0.210	-0.251	0.014*
	Left	M. quadratus lumborum	0.131	0.204	-0.151	0.142
		M. erector spinae	0.381	<0.001*	-0.104	0.315
		M. psoas major	-0.110	0.286	-0.222	0.030*
TRANSVERSE	**Right**	M. quadratus lumborum	0.010	0.923	-0.126	0.221
		M. erector spinae	-0.107	0.297	-0.049	0.638
		M. psoas major	0.133	0.195	-0.153	0.136
	Left	M. quadratus lumborum	0.081	0.434	-0.148	0.150
		M. erector spinae	-0.111	0.283	-0.034	0.741
		M. psoas major	0.217	0.034*	-0.285	0.005*

*p<0.05, r: Pearson correlation coefficient, ODI: Oswestry Disability Index, LLA: Lumbar Lordosis Angle

A post hoc power analysis for the difference between muscle thickness (left and right sides) demonstrated 87% of power with 96 side matched pairs, with an effect size of d = 0.32 (α = 0.05).

DISCUSSION

In the present study, the relationship of LLA and LMT with LBP was investigated through the analysis of parameters related to muscles and spinal alignment on MRI. The results of the current study emphasise that as m. psoas major thickness increased, disability score decreased in individuals with LBP. In addition, this study also revealed imbalanced muscle pairs in individuals with LBP and corroborated that females were disabled more than males due to LBP.

Individuals with LBP have overactive muscles during physical activity as their muscles attempt to protect the spine while the body moves. It is presumed that misalignment of lumbar muscles and decreased LMT are associated with LBP (16). A systematic review by ShahAli et al. (23) questioned the relationship between muscle thickness and muscle activity. They reviewed 14 studies that assessed the correlation of muscle thickness and muscle activity with ultrasonography and electromyography on LBP and healthy control individuals. They resulted in a strong correlation between muscle thickness and muscle activation out of five studies. In a study comparing cross-sectional area of lumbar muscles by Singh et al. (13), m. psoas major was atrophic at the level of L3-L4 vertebra, whilst they found no statistically significant result in the cross-sectional area of the m. psoas major. In the other study using MRI to determine the size of lumbar muscles; m. psoas major, m. erector spinae, and m. multifidus were smaller in LBP patients (24). Similarly, the current study revealed an inverse correlation between ODI and both sides of the m. psoas major anterior-posterior and left side m. psoas major transverse thicknesses. It seems that the thickness of m. psoas major, and indirectly the activation of this muscle is essential in individuals with LBP in order to maintain optimal biomechanics. To relieve LBP, considering the function of the m. psoas major, which is a flexion muscle, flexion movement in this region plays an important role in the biomechanics of LBP.

The findings of current study, which are supported by some studies in the literature (1,25–27), have displayed that ODI was found to be higher in females. A study with 600 participants comparing the associated factors of LBP between genders revealed that the prevalence of LBP in females is higher than in males (1). The result of this study showed the prevalence of LBP in females was nearly two times higher than in males. Another study conducted by Ferrari et al. (27) investigated clinical characteristics of non-specific LBP patients and relationships between disability and gender. They implemented the Roland-Morris disability Questionnaire on 310 outpatients, and the result of this study revealed a significant relationship between disability and being female (p= 0.018)(27). Females, therefore, seem to be more restricted in performing daily work activities compared to males (25). Consequently, females might be considered to be in the higher-risk group in terms of having higher ODI scores and experiencing limitations in daily life activities.

There is a lack of studies comparing both sides of lumbar muscle thickness in the literature (14,20). Although it can be thought that there may be differences in the muscle thickness of two sides depending on the use of the dominant side, comparison of the muscle thickness of both sides may still be important to draw attention to a possible pathology. There is some evidence in the literature that LBP patients showed imbalanced activity of lumbar muscles (12,13,28). Singh et al. (13) investigated the associations between lumbar parameters and LBP by measuring the cross-sectional area of trunk muscles at three levels of the intervertebral disc (L3–L4, L4-L5, and L5–S1). The result of this study was that the right side of the m. multifidus and the left side of the m. erector spinae were larger than those of the other side in LBP patients at the L3-L4 level. Additionally, a recently published study investigating muscle size and symmetry in dancers with LBP found a significant difference between right and left side m. multifidus thickness (29). They concluded that the difference in both side muscle thickness may be attributed to the leg dominance laterality preference of their participants. Similarly, in our study, a significant difference was found in the comparison of both side thicknesses except for the only m. erector spinae anterior-posterior thickness. The authors of the current study deem that this might be most likely due to the preferences of dominance. One of the factors' causing LBP is likely to be the significant difference seen between muscle thicknesses.

Menezes et al. (15), comparing LMT according to gender, emphasised that males had thicker muscles. On the other hand, in another study conducted with LBP patients and the control group, there was no statistically significant difference between genders in terms of thickness of m. paraspinalis, m. psoas major, and m. quadratus lumborum (30). In the current study, all muscle thicknesses, but not the right m. quadratus lumborum and the left m. erector spinae transverse thickness, were significantly different between males and females. Similarly, in a study conducted by Lim (2013), a significant difference was found between gender and thicknesses of m. erector spinae and m. multifidus. The result of Lim's study that males had significantly greater muscle mass than females supports the result in this study (9). One of the reasons of having thicker muscle may be that males have mostly greater BMI than females. In the current study, a positive relationship was found with BMI in the majority of LMT. As BMI increased, muscle size increased, and LMT of males was thicker than females. The relationship between LMT and BMI in this study is consistent with previous studies (9,15), implying a significant relationship between muscle size and BMI of individuals.

The relationships between LLA and LBP have shown diversity in previous studies (7,8). While Cho et al. (7) report that LLA is associated with LBP, Chun et al. (8) point out that LLA was lower in individuals with LBP compared to healthy controls. In this study, it was found that there was no relationship between LLA and ODI scores. In the literature, there is no optimal level for LLA, and it appears in a wide range, and it is affected by age and sex. This is due to the diversity of individual factors, the influence of ethnicity on body biomechanics, and reasons that might arise from the measurement method. These factors could be the reason why there was no relationship between LLA and ODI in this study.

There are studies showing that LLA is related to muscle thickness, especially m. erector spinae and m. multifidus (6,15–17). The results of the current study, which examined the relationship between LLA and bilateral m. erector spinae anterior-posterior and left-sided m. psoas major transverse thickness, support previous studies. Menezes et al. (15) reported that although there was no relationship between m. erector spinae and LLA, a relationship was found between LLA and the thicknesses of m. multifidus and m. psoas major. In addition, Jun et al. (17) emphasised that the thicknesses of m. multifidus and m. erector spinae are also associated with LLA. Individuals with increased LLA have a number of biomechanical adaptations. Also, it is known that the thickness of the muscle biomechanically tends to enlarge when a muscle fibril shortens (6). While the lumbar extensor and hip flexor muscles shorten, the abdominal muscles and hip extensor muscles, which are antagonists, tend to lengthen. This situation is seen as vice versa way in individuals with LLA decrease (31).

This study has some limitations. The study differed from the previous studies in that the healthy control group was not included in this study. In addition, since m. multifidus was difficult to distinguish from m. erector spinae in MRI, the two muscles were measured together and recorded as m. erector spinae. In this context, failure to measure m. multifidus and m. erector spinae independently may have created an obstacle in determining their relationship with LBP.

CONCLUSION

Given the inverse relationship between m. psoas major thickness and LBP disability, we think that m. psoas major, which might be ignored in the treatment of LBP, should be added to both evaluation and rehabilitation programs for optimal recovery. The imbalance of muscles between the right and left sides is another significant factor, and this result should be paid attention to for the treatment of LBP. In this current study, this imbalance was also seen on the m. psoas major, which is a pelvic flexor muscle, not only lumbar extensor muscles. In conclusion, we believe that the results of the current study would be helpful for clinicians in this field with regard to providing a more effective treatment option for patients.

On the other hand, females might be considered to be more susceptible to LBP-related disability since females had higher ODI scores than males, which means that they may be in the high-risk category for LBP. As in seen our study, females could be informed about for protection their body wellness, and also to be encouraged the participation of the LBP preventing exercise education.

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