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Original article

The relationship between cross-sectional area of multifidus muscle and disability index in patients with chronic non-specific low back pain

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A R T I C L E I N F O

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A B S T R A C T

Background: Nonspecific low back pain (NSLBP) is a common problem that may have an effect on the level of functional ability. Imaging techniques indicated the degeneration of multifidus muscles in patients with low back pain. But its relationship with disability in NSLBP is unclear.
Objective: To assess the relationship between changes in multifidus muscle morphology in MRI as paraclinical data with changes in the level of disability as clinical data in patients with CNLBP, whose MRI studies are normal. Moreover, the relationship between multifidus CSA and its thickness was determined.
Design: Cross-sectional study.
Methods: A total of 45 subjects with CNLBP participated in this study. Multifidus muscle thickness and cross-sectional area (CSA) for both sides in L4-L5 and L5-S1 levels were measured with MRI and Image J software. Level of disability was assessed with Roland-Morris disability index.
Results: There was no significant relationship between multifidus muscle's CSA or thickness variations among the L4-L5 and L5-S1 levels and disability index score. Furthermore, Pearson's test showed significant positive relationship between thickness and CSA of muscles ($p < 0.05$).
Conclusion: The relationship between lumbar multifidus Thickness and disability in CNLBP with normal MRI study, is not proven in this study. Multifidus muscle thickness in L4-L5 or L5-S1 level can be representative of its CSA in patients with CNLBP and normal MRI.

1. Introduction

Low back pain (LBP) is one of the most common reasons for patients to visit health centers (Clark et al., 2009; Deyo et al., 2006; Le Cara et al., 2014). Traditional diagnosis methods do not give the exact cause of LBP, and thus a large majority of patients are diagnosed with non-specific LBP (Le Cara, Marcus, 2014). The stability and balance of the lumbar spine are dependent on the paraspinal muscles. Also, muscle atrophy in this region can impair its stability (Ploumis et al., 2011). Due to its multiple and distinct attachments and unique innervations, multifidus muscle as a paraspinal muscle has attracted the attention of researches and practitioners (Barker et al., 2004; Ploumis et al., 2011).

Nowadays, the morphological factors of paraspinal muscles, such as multifidus muscle thickness (Battaglia et al., 2014; Chen et al., 2014; Danneels et al., 2000; Hides et al., 1995, 2008; Kamaz et al., 2007) and its probable relationship with the cause and treatment of LBP, are mostly focused on many studies (Battaglia et al., 2014; Chen et al., 2014; Fortin et al., 2015; Fortin and Macedo, 2013). LBP may have an effect on the level of functional ability. This feature plays an important role in related clinical studies. Questionnaires serve as means for assessing the level of subjective ability of patients with LBP (Mousavi et al., 2006).

Imaging techniques are capable of showing some of the morphological changes caused by multifidus muscle weakness in individuals with LBP (D'Hooge et al., 2012; Valentin et al., 2015), and CSA is one of the strength indices of muscle (Bamman et al., 2000). Also, there is a relationship between CSA and strength of paraspinal muscles in patients with chronic LBP (Lee et al., 2012). While the multifidus muscle CSA in men is greater than women (Cooper et al., 1992), lumbar multifidus atrophy is higher in female population than in men (Crawford and Filli, 2016; Ekin et al., 2016). To calculate the size of the multifidus muscle, certain methods, such as sonographic evaluation, computerized tomography (CT) scan, and magnetic resonance imaging (MRI) are used. They provide non-invasive and reproducible information (Hu et al., 2011; Ranson et al., 2006). Sonographic evaluation is limited to the evaluation of superficial muscles, while the use of CT scan leads to

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significant ionizing radiation exposure (Hides et al., 1995; Ranson et al., 2006). Hu et al. reported that the reliability of MRI is slightly higher than CT scan, and hence researchers recommend the use of MRI for the evaluation of paraspinal muscle morphology (Hu et al., 2011).

The assessment of the relationship between changes in multifidus muscle morphology in MRI (as paraclinical or subjective data) with changes in the level of disability (as clinical or objective data) can be useful. Many studies has reported multifidus weakness and its morphologic change in patients with LBP(Ploumis et al., 2011; Ranson et al., 2006). On the other hand LBP can effect on functional ability of individuals (Roland and Fairbank, 2000). The study hypothesis is existence the relationship between multifidus thickness and level of disability in patients with CNLBP. To date, no clinical and laboratory study has been conducted on the relationship between these two parameters in chronic non-specific low back pain (CNLBP) patients with normal lumbosacral MRI study. Moreover, multifidus muscle thickness has not been evaluated as a morphologic parameter using this method so far. The main objectives of this study were to evaluate and determine the thickness and CSA of multifidus muscle by MRI and its relationship with the disability score of the questionnaire in patients with CNLBP who showed normal lumbosacral MRI. Also relationship between multifidus CSA and its thickness was determined.

2. Materials and methods

2.1. Patients

The subjects for this study were selected from the patients referred to the Shafa MRI Center, Isfahan, Iran for a lumbar spine MRI study. A total of 45 patients (15 men and 30 women), who were diagnosed with non-specific LBP through clinical assessment and MRI results, were included. All these patients had a “normal study of lumbosacral spines” report.

The subject's age ranged between 30 and 55. The inclusion criteria were as follows: LBP for at least 12 weeks with mild to moderate pain (Chen et al., 2014; Kamaz et al., 2007; Le Cara, Marcus, 2014; Roland and Fairbank, 2000). Pain intensity was measured using the two-choice items pain subscale in the 36-item short-form (SF-36), which had been previously translated and validated (Montazeri et al., 2005; Roland and Fairbank, 2000; Von Korff et al., 2000).

The exclusion criteria were as follows: presence of spinal deformities, any surgery on the spine, myopathy, spinal fractures, spinal disc herniation, canal stenosis, spondylosis, spinal instability, polyneuropathy, recent pregnancy, systematic disease, and serious problems like presence of tumor, infection, or cauda equina syndrome.

This observational cross-sectional study was approved by the ethics committee of Isfahan University of Medical Sciences (IR.MUI.REC.1395: 3.285). The subjects who were eligible, completed the consent form, and their age, height, and weight were determined. Then, the patients were asked to complete the Roland-Morris Disability Questionnaire (RDQ) and the Baecke Physical Activity Questionnaire. Both of these questionnaires were translated into Persian and validated (ICC of RDQ: 0.86 – ICC of Baecke Q: 0.88) (Mousavi et al., 2006; Sadeghisani et al., 2016). In RDQ, a score of 0 indicates the lack of disability and a score of 24 indicates maximum disability (Mousavi et al., 2006). The Baecke Physical Activity Questionnaire was used in order to match the participants in terms of physical activity.

2.2. Magnetic resonance imaging and measurements

Images were produced using an MRI device with 1.5 T magnet and an 18-channel system (Siemens Magnetom Avanto, Berlin, Germany). Imaging was conducted on the patients in the supine position with a pillow under their knees and their body was positioned symmetrically. The reliability of MRI in the measurement of CSA of multifidus muscle was acceptable (inter-reliability = 0.858, intra-reliability = 0.823) (Hu et al., 2011). Images were acquired in both sagittal and axial sections.

In each area, four transverse T2-weighted images were produced and the most central image with the highest clarity was chosen for the measurements.

Finally, two transverse images of L4-L5 and L5-S1 areas were extracted from each patient's collection of images. Measurements were carried out using the ImageJ software (version 1.44), which has high reliability (ICC = 0.98) for the study of paraspinal muscle CSA (Fortin and Battié, 2012). Measurements in this software were performed by a researcher who was unaware of the disability score and demographic characteristics related to each image. The measured items consisted of the CSA and vertical diameter of the vertebra in each level, right and left side CSA, and thickness of the multifidus muscles in each level. To determine CSA of the muscle, its location of attachment with the fascia was manually marked using a freehand selection pointer and a touch screen pen on the touch screen monitor. The software automatically measured the area in square millimeter. Muscle thickness was measured using a straight pointer. The maximum distance between the anterior muscle fascia at its attachment to the vertebral laminae and posterior muscle fascia was calculated in millimeter as muscle thickness. (Figs. 1 and 2).

All measurements were taken by the same person. Measurements were repeated three times with a week interval between each measurement and the reliability of muscle thickness and CSA measures was tested. The intraclass correlation coefficient model 3, 3 ($ICC_{3, 3}$) were used to index reliability (Koo and Li, 2016; Shrout and Fleiss, 1979).

In order to decrease the effect of the participants' height, weight, and body shape (to standardize the measurements), CSA of the muscle was divided by CSA of the vertebra in the same level (Standardized CSA: SCSA) Muscle thickness was divided by vertical diameter of the vertebra in the same level (Standardized thickness: ST). (Chen et al., 2014, Lee et al., 2008).

Ultimately, data were transferred to the SPSS software (version 20, IBM Corporation, Armonk, NY, USA). To evaluate the association between multifidus muscle thickness or CSA, and a patient's disability index, the mean of three time measurements of muscle thickness and CSA was used for the final calculations. Linear regression analysis was performed with the patient's disability index as a dependent variable and muscle morphology as independent variable. The significance level in this study is 0.05. The standardized beta coefficient indicates whether the relationship between two variables is direct or inverse and determine the rate of this relationship.

3. Result

The study participants consisted of 15 men and 30 women.

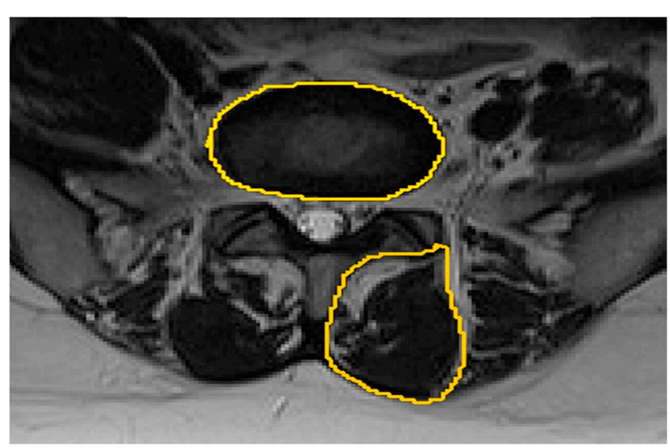

Fig. 1. Axial T2 weighted image of L5-S1 level of the a patient (total cross section area of the left multifidus muscle and cross section area of the S1 vertebra).

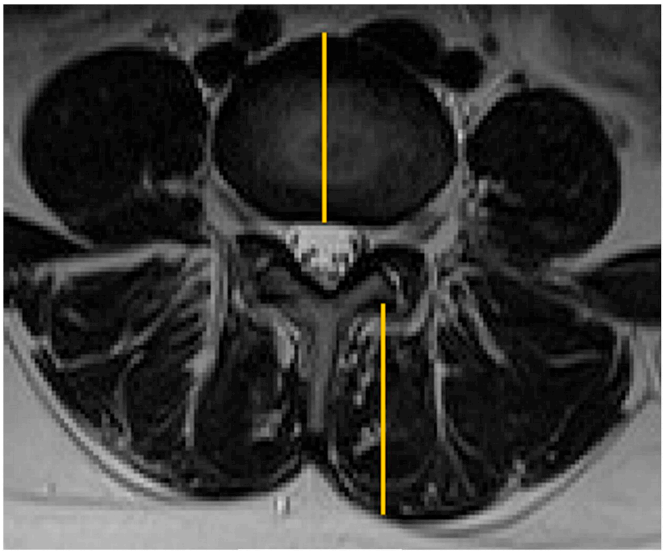

Fig. 2. *Axial T2 weighted image of the L4-L5 area of a patient (thickness of the left multifidus muscle and vertical diameter of the L5 vertebra).*

Demographic characteristics of the subjects have been presented in Table 1.

Evaluation of repeatability of the CSA and thickness measurements of multifidus muscles on both sides in two levels, and diameter and CSA of the vertebra in each level indicated an excellent correlation among the three measurements with a week interval between each measurement (Table 2).

Linear regression models indicated that there was no significant relationship between SCSA of multifidus muscle or ST variations in L4-L5 and L5-S1 with the disability index score of patients with CNLBP ($P > 0.05$). When the effect of other variables are controlled, the P-value indicates the level of significance within the relationship between CSA or thickness of multifidus and disability. Beta coefficient is a measure of the extent of influence each predictor variable has on the dependent variable (Table 3).

Moreover, Pearson correlation analysis indicated a positive significant relationship between thickness of multifidus muscle and CSA ($P < 0.05$) (Table 4).

4. Discussion

The aim of this research was to evaluate the relationship between lumbar multifidus muscle morphology and the disability index of patients with CNLBP whose lumbosacral MRI study was normal. Contrary to the hypothesis of this study, there wasn't any significant relationship between thickness or CSA of the multifidus muscles in L4-L5 and L5-S1 levels, and the disability index score of these patients. According to previous studies, muscle morphologic changes can be one of the reasons for muscle weakness (D'Hooge et al., 2012). Weakness can lead to pain, therefore patient will be suffer from disability caused by pain and weakness (Lee et al., 2012). The results resemble those of the study by Le-Cara et al., who also found no significant relationship between the multifidus muscle morphology and its functionality. Nevertheless, Le-Cara et al. did not assess the relation between muscle morphology and results of the Oswestry Disability Index (ODI) completed by the patients (Le Cara, Marcus, 2014). In their study, the patients had high levels of physical activity, which could have affected muscle functionality.

Studies conducted by Ploumis et al. and Barker et al. also showed that there is no significant correlation between CSA of the multifidus muscle and the ODI score in patients with unilateral LBP (Barker et al., 2004; Ploumis et al., 2011). Multifidus CSA in the affected side was significantly different than the unaffected side. Barker et al. stated that the use of ODI for patients with low disability index might be one of the reasons for the insignificancy of this statistical relationship. Therefore, in this study, the Roland-Morris Disability Questionnaire was used as it is more appropriate for patients suffering from LBP with low level of disability and mild to moderate pain (Roland and Fairbank, 2000). However, this amount of pain can also affect the results of the questionnaire or muscle morphology, as well as the relation between these two variables.

The results obtained in this study were not in agreement with those of the study by Chen et al., who claimed that multifidus muscle atrophy is a predictive factor in the functional ability of patients with spinal stenosis (Chen et al., 2014). Alaranta et al., who also studied multifidus muscles in CT images, found a positive correlation between the morphology of these muscles and the score of ODI among men, but reported a poor correlation among women. Some of their participants had undergone spinal surgery, also focus on intramuscular fat content, the participant's age, and lack of uniformity among the participants were probably some of the reasons for the positive correlation between muscle atrophy and patient disability index score in some studies. In fact, the lack of relationship between measurements and disability score

Table 1
Demographic and clinical characteristics of the patients.

Variable	Mean ± SD	Range
Age (year)	41.8 ± 7.5	(31–55)
BMI(kg/m^2)	27 ± 3.90	(20.20–37.18)
Disability index	8.4 ± 4.6	(0–19)
Physical activity score	2.6 ± 0.5	(1.812–3.875)

SD: Standard Deviation.

Table 2
Intra-class correlation coefficients of three repetitions of parameter measurements.

Measurements	Thickness $ICC_{3,\ 3}$		CSA $ICC_{3,\ 3}$	
	Right	Left	Right	Left
L5 Vertebra	0.997		0.998	
S1 Vertebra	0.990		0.997	
L4-L5 Multifidus	0.998	0.998	0.997	0.998
L5-S1 Multifidus	0.998	0.999	0.997	0.998

$ICC_{3,\ 3}$: Intra-class correlation model 3, 3.
CSA: Cross-sectional area.

Table 3
Linear regression analysis of the relation between multifidus standardized thickness and cross section area, and disability after controlling the demographic and clinical variables.

Variable	Standardized Beta coefficient	P value
RL5MST	0.216	0.155
LL5MST	0.363	0.219
RS1MST	−0.014	0.921
LS1MST	0.023	0.875
RL5MSCSA	0.193	0.174
LL5MSCSA	0.149	0.292
RS1MSCSA	0.046	0.749
LS1MSCSA	−0.027	0.852

P-value < 0.05.
RL5MST: Right L5 multifidus standardized thickness.
LL5MST: Left L5 multifidus standardized thickness.
RS1MST:Right S1 multifidus standardized thickness.
LS1MST: Left S1 multifidus standardized thickness.
RL5MSCSA:RightL5 multifidus standardized cross-sectional area.
LL5MSCSA: Left L5 multifidus standardized cross-sectional area.
RS1MSCSA:Right S1 multifidus standardized cross-sectional area.
LS1MSCSA: Left S1 multifidus standardized cross-sectional area.

Table 4
Pearson correlation between cross section area and thickness of L4-L5 and L5-S1 multifidus muscles.

Variable	RL5MSCSA		LL5MSCSA		RS1MSCSA		LS1MSCSA	
	r	P	r	P	r	P	r	P
RL5MST	0.68	< 0.001*	0.63	< 0.001*	0.33	0.03*	0.32	0.03*
LL5MST	0.56	< 0.001*	0.64	< 0.001*	0.34	0.02*	0.37	0.01*
RS1MST	0.34	0.02*	0.24	0.11	0.56	< 0.001*	0.55	< 0.001*
LS1MST	0.29	0.05	0.26	0.07	0.54	< 0.001*	0.60	< 0.001*

P-value < 0.05*.
RL5MST: Right L5 multifidus standardized thickness.
LL5MST: Left L5 multifidus standardized thickness.
RS1MST: Right S1 multifidus standardized thickness.
LS1MST: Left S1 multifidus standardized thickness.
RL5MSCSA:RightL5 multifidus standardized cross-sectional area.
LL5MSCSA: Left L5 multifidus standardized cross-sectional area.
RS1MSCSA: Right S1 multifidus standardized cross-sectional area.
LS1MSCSA: Left S1 multifidus standardized cross-sectional area.

in this paper may have one justification focus on the muscle quantity is not sufficient. Differentiation between muscle quantity and quality is important, as stated by D'Hooge et al. (D'Hooge et al., 2012). Although this study investigates tow parameters of muscle morphology (SCSA and S thickness), other morphological and functional measures of multifidus, such as fatty infiltration and electromyography, may have significant relationship with disability index.

Finally, the potential observation of this study is that evaluating changes in the muscle morphology can be a useful tool in aiding clinical decision making, especially for diagnosing the reason behind disability and pain in patients suffering from CNLBP with normal lumbosacral study. Of course, evaluating quality of muscle in this relationship is recommended for future studies.

In this study, the measurements of thickness and CSA had high validity. Moreover, there was a significant positive correlation between multifidus muscle thickness on each side (right and left) and it's CSA on the same side. This relationship was also observed with the muscle of the opposite side and muscles of other levels (L4-L5 and L5-S1). Hence, this method has been suggested for measuring multifidus thickness instead of calculating lumbar multifidus CSA. Also, this method is time saving, as well as easy.

5. Conclusion

It can be concluded that the thickness of multifidus muscle in L4–L5 or L5–S1 level can be representative of multifidus muscle CSA in patients with CNLBP from these two levels. But there is not any correlation between L4–L5 and L5–S1 multifidus muscle CSA or thickness with Roland-Morris disability index score in patients with CNLBP whose lumbosacral MRI study is normal.

6. Limitation

The limitation of the present study is the small sample size, although it was comparable with other similar studies. Different number of men and women is another limitation. It is recommended to investigate the gender difference in multifidus change and in muscle morphology-disability relationship.

Conflicts of interest

Declarations of interest: none.

Ethical approval

This study is approved by the ethics committee of Isfahan University of Medical Sciences (IR.MUI.REC.1395: 3.285).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.msksp.2019.03.005.

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