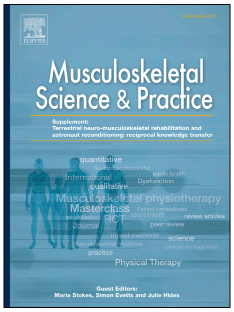

Neuromuscular morphometric characteristics in low back pain with unilateral radiculopathy caused by disc herniation: An ultrasound imaging evaluation

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PII: S2468-7812(19)30049-9

DOI: https://doi.org/10.1016/j.msksp.2019.01.016

Reference: MSKSP 1985

To appear in: *Musculoskeletal Science and Practice*

Received Date: 21 February 2018

Revised Date: 29 January 2019

Accepted Date: 31 January 2019

Please cite this article as: Sarafraz, H., Hadian, M.R., Ayoobi Yazdi, N., Olyaei, G., Bagheri, H., Jalaei, S., Rasouli, O., Neuromuscular morphometric characteristics in low back pain with unilateral radiculopathy caused by disc herniation: An ultrasound imaging evaluation, *Musculoskeletal Science and Practice* (2019), doi: https://doi.org/10.1016/j.msksp.2019.01.016.

Neuromuscular morphometric characteristics in low back pain with unilateral radiculopathy caused by disc herniation: An ultrasound imaging evaluation

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Background: Little is known about the neuromuscular morphometric characteristics in patients with sciatica.

Objective: To evaluate the possible changes of nerve and muscle structures in patients with low back pain with unilateral radiculopathy due to lumbar disc herniation by ultrasound imaging.

Design: A case-control observational study.

Methods: Forty individuals were divided into case (n=20; low back pain with unilateral radiculopathy due to disc herniation), and healthy control groups (n=20). The thickness of lumbar multifidus at L5 level, and of lower limb muscles (i.e., biceps femoris, medial gastrocnemius, and soleus) was measured during both rest and full contraction to calculate the rest/contraction ratio of these muscles. Additionally, the sciatic nerve cross-sectional area and the echogenicity of the nerve and muscles were measured based on ultrasound imaging. The association between severity of low back pain radiculopathy (i.e., pain and patients' perceived disability) and rest/contraction ratio was assessed.

Results: Patients with sciatica showed sciatic nerve enlargement, and different contraction ratios for multifidus (at L5) / ankle plantar flexors compared to the controls. The rest/contraction ratio for biceps femoris was similar between the two groups.

Conclusion: According to these findings, ultrasound imaging can be considered a useful tool to detect changes in the sciatic nerve and muscles due to disc herniation. Furthermore, regarding the observation of significant changes in muscle rest/contraction ratio in the multifidus and gastrosoleus, one might attribute these changes to the nerve root compression.

Keywords: Chronic Pain, Discopathy, Sciatica, Sciatic Nerve, Muscle Thickness, Ultrasonography

1. Introduction

Chronic low back pain (LBP) is among the leading causes of disability in the world (Hurwitz et al., 2018). Approximately 85% of the patients with this condition experience LBP with no evident anatomical pathology labeled as “nonspecific LBP." Furthermore, the patients with LBP with unilateral radiculopathy (LBP-R) with a clear anatomical diagnosis are considered “specific LBP” (Nijs et al., 2015). LBP-R due to disc herniation is defined as unilateral / bilateral leg pain, with numbness / paresthesia confined to the dermatomal / myotomal distribution of the sciatic nerve and usually distributed to the feet or toes (Arden et al., 2005). LBP-R has been associated with poor recovery, persistent pain and some degree of disability, imposing a financial burden on society (Becker et al., 2010). The side effects of LBP-R on muscle morphology as well as characteristics of nerves have been studied using Magnetic Resonance Imaging (MRI). Accordingly, few studies have indicated some degree of decrease in the cross-sectional area (CSA) as well as fat infiltration of the lumbar multifidus muscle (LMM) at L5 level (Ekin et al., 2016, Hyun et al., 2007, Kang et al., 2013). These studies focused on LMM at L5 level since LMM is the primary stabilizer of the lumbar spine, and its atrophy plays an essential role in maintaining and causing recurrent LBP and disability in chronic LBP (Freeman et al., 2010). Furthermore, mobility in the lumbar region occurs mostly at L4-S1 levels, and LMM has the largest diameter at L4- S1 levels, allowing for a better evaluation (Kader et al., 2000).

A negative association exists between pain and morphology of the sciatic nerve and disturbance in contractibility of the biceps femoris and gastrosoleus muscles innervated by the sciatic nerve. MRI studies have shown echotexture changes in the sciatic nerve, being consistent with the loss of the fascicular pattern due to intraneural edema, fibrosis, or fascicular alterations (Ahlawat et al., 2018, Garwood et al., 2018, Tagliafico and Tagliafico, 2014). Ultrasound (US) imaging has been suggested as a reliable alternative to MRI to investigate potential changes in the neuromuscular structures in LBP-R patients. Compared to MRI imaging, US is a more accessible, feasible and less expensive method providing useful information about the muscle and nerve function / dysfunction (Cartwright et al., 2013, Mayans et al., 2012, Sarafraz et al., 2018). A recent US study on the LBP-R population with low levels of pain and disability reported no difference in LMM thickening upon contraction and muscle quality at L3 level compared to the healthy controls; however, the authors found impaired muscle contraction of the soleus and the sciatic nerve swelling (Frost and Brown, 2016b). Moreover, increased CSA of the sciatic nerve has been reported (Kara et al., 2012). The sciatic nerve damage can cause delayed or impaired neuromuscular signals to the lower limb muscles (i.e., the biceps femoris and gastrosoleus muscles). Consequently, this could affect normal activation and efficient function of the muscles. US as a non-invasive method can detect muscle thickness changes and impaired muscle quality (i.e., altered echo intensity and homogeneity) (Küllmer et al., 1998, Maurits et al., 2003).

Accordingly, nerve and muscle structural changes in the lumbar region may adversely affect the trunk control, thereby causing perpetuation of pain and disability over the time of recurrent LBP (Hodges et al., 2006, MacDonald et al., 2009). Thus, the investigation of the muscle function and nerve morphology will shield light on muscle and nerve functions, and provide the fundamental knowledge for diagnosis and follow-up of the therapeutic intervention in patients with LBP-R. However, reviewing the literature revealed that little was known regarding the nerve and muscle changes in patients with LBP-R with high levels of pain and disability. High pain was defined as score of 4-10 in the numeric rating pain scale, and high disability was defined as 41-60 percentage disability according to the Oswestry Disability Index.

Therefore, this study aimed to investigate nerve and muscle morphology in individuals with chronic LBP-R with high levels of pain and disability. Accordingly, it was hypothesized that due to LBP-R, there would be the sciatic nerve swelling, a reduced thickening of the lower back and lower limb muscles upon contraction on the affected side. In this regard, it might be rational to compare the differences between the affected and unaffected sides of the patients and controls.

2. Material and Methods

2.1. Study design

A case-control observational study.

This study was conducted based on the Guidelines for Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (Von Elm et al., 2008).

2.2. Participants

G*power 3 was used to conduct a power analysis to calculate the sample size. The sample size of the 20 participants per group was capable of detecting a 20% difference in the CSA of the sciatic nerve and LMM contraction ratio between the cases and controls according to the pilot study assuming a standard deviation of 10%, a significance level of 0.05, and a power of 80%.

Twenty patients were recruited from a private physical therapy clinic and a neurosurgery clinic of a general hospital. During the same period, 20 healthy individuals by an announcement from the local community were included as the control group. The participants then underwent clinical and para-clinical (MRI of associated disc bulging or herniation and nerve root compression at L4-L5 and L5-S1 levels) examination by a neurosurgeon. Those participants were included in this study if they had pain, tingling, or numbness radiating down to the leg and / or foot by positive neurological integrity test (i.e., myotomal weakness, light-touch loss in a dermatomal pattern or reduced reflex), positive

SLR or slump test by reproducing the participants' symptoms aggravated or relieved by ankle dorsiflexion / release of ankle dorsiflexion. The neurosurgeon then established and reported the final diagnosis, and referred the participants to the researchers. This study was approved by the Ethical Committee at XXX University of Medical Sciences, and all the participants signed an informed consent form before their participation.

Inclusion criteria

All the participants were aged between 30 and 50 years old. The healthy controls with no history of LBP in the past six months, no musculoskeletal disorder or neurological deficits were included in the study and matched to the patients in term of age, gender, body mass index (BMI), foot dominance and physical activity score by MedCalc software (Table 1). The patients had to be diagnosed with LBP with unilateral radiculopathy (LBP-R), lasting for a minimum of three consecutive months with moderate to high disability and pain levels according to the Iranian version of the Oswestry Disability Index and the Numeric Rating Pain Scale (Hawker et al., 2011, Mousavi et al., 2006).

Exclusion criteria

The participants were excluded if they had any malignancy or bony defects in the lumbar region (e.g., structural scoliosis or spondylolisthesis), systemic myopathy or neuropathy, previous surgery in the assessment region, evidence of central sensitization in the mechanism of pain (diagnostic criteria by Nijs et al., 2015), inability to complete the questionnaires (e.g., illiteracy), follow simple orders (e.g., cognitive impairments) or inability to lie prone, stand and rise on toes.

2.3. Muscle-nerve ultrasound imaging

Imaging locations were determined based on the anatomical landmarks. All the participants laid in the prone position while extending their leg except the contracted state of gastrosoleus, which was done in standing position. Afterward, high-resolution US images were obtained using 2-6 MHz curvilinear probe for multifidus, and 6-12 MHz linear probe for the sciatic nerve, biceps femoris, medial gastrocnemius, and soleus muscles (Affiniti, 50 Philips, Netherlands). A physical therapist with 10 years of experience in musculoskeletal disorders, and one year US practice performed all the US measurements. The images were obtained first at rest and then with contractions. Standardized instructions were provided for each muscle contraction. Each contracted state was sufficiently held for the examiner to have a clear image of the muscle thickness (no more than 1 minute). For all the tests, right and left sides were randomly selected (side names picked from a bowel), and the examiner repeated all the US measurements three times. The measurements were later averaged across the three images in the final analysis. Muscle thicknesses in two rest and contracted states were measured in the longitudinal image (i.e., contraction ratio), while the transverse image by maximum region of interest (max ROI) was used for all the muscles and the sciatic nerve quality (i.e., echo intensity).

2.3.1. Imaging of the sciatic nerve and biceps femoris

The US scan of the sciatic nerve and biceps femoris muscle was performed at the level of lower ¼ on the posterior mid-thigh, along with a line from the ipsilateral iliac crest to the popliteal crease. Longitudinal scans were used to measure muscle thickness (Fig. 1a), and transverse scans provided a cross-sectional view of the biceps femoris and the sciatic nerve (Fig. 1b) (Cartwright et al., 2013, Kellis et al., 2009). The participants performed prone hip extension with a straight knee (i.e., leg extended and ankle in neutral, then the leg was held off the table to a height of ~15 cm) to activate the biceps femoris muscle (Frost and Brown, 2016b).

2.3.2. Imaging of medial gastrocnemius and soleus

The medial gastrocnemius and soleus muscles were captured at the point of lower 1/3 of the tibial length from the midpoint of medial malleolus to the popliteal crease. Longitudinal scans were used to record the thickness of soleus and medial gastrocnemius, while transverse scans provided only a cross-sectional view of medial gastrosoleus (Figs. 1c, 1d). The participants rose on the toes (5-cm heel lift) while standing to activate the soleus and medial gastrocnemius (Frost and Brown, 2016b).

2.3.3. Imaging of multifidus muscle

The multifidus muscle was imaged at the level of L5 vertebral, while the participants were in the prone position on a bed. Longitudinal images were taken approximately 2 cm lateral to the midline so that the spinal facet joints could be clearly identified in the image (Koppenhaver et al., 2011). In addition, axial images were taken by spanning the transducer across the spinous processes so that bilateral cross-sectional views of the multifidus muscles could be seen (Figs. 1e, 1f). Multifidus submaximal muscle activation was required to perform a unilateral prone arm rise with a 1-kg hand weight to activate the contralateral paraspinal muscle. This movement was previously shown to activate lumbar multifidus by 30% of the maximum amount (Kiesel et al., 2007).

2.4. Data analysis

The US image analyses were performed offline by a blinded and single assessor using image J software. The sciatic nerve CSA was measured by the tracing method and the echo intensity analysis. Nerve echo intensity has been reported to be capable of discriminating between healthy and pathological nerves, as intraneural edema results in increased hypoechoic areas (Böhm et al., 2014, Tagliafico and Tagliafico, 2014). Image analysis software (e.g., ImageJ) can be employed to generate histogram-based thresholds to differentiate between hypoechoic and hyperechoic areas; a higher proportion of the hypoechoic area is indicative of edema (Boom and Visser, 2012, Rbia et al., 2018). Longitudinal images of the multifidus, biceps femoris and gastrosoleus muscle under relaxed and contracted conditions were used to calculate contraction ratio (muscle thickness contracted/muscle thickness rest). This measure can provide information concerning motor control of the muscles. A higher contraction index indicates that the muscle is thickened more during contraction (Wong et al., 2013). Echo intensity was then defined as the mean level of gray within the ROI in 8-bit resolution images (gray levels from 0 to 255, where black 0 and white 255) (Santos and Armada-da-Silva, 2017).

2.5. Statistics

Normal distribution of data was determined by Kolmogorov-Smirnov and Shapiro-Wilk tests. Independent sample t-test and paired sample t-test were used to compare the two groups (control vs. sciatica and unaffected leg vs. affected leg), respectively, for each outcome measure. Spearman correlations were also calculated between the severity (ODI, pain) and each outcome measure.

3. Results

Table 1 summarizes the participants' characteristics. Independent sample t-test showed non-significant differences in the age, gender, weight, height, BMI or activity level between the patient and control groups.

3.1. The sciatic nerve CSA and echogenicity

Paired t-test showed that significant differences in CSA between the affected (51.39 mm^2, affected side) and unaffected (46.54 mm^2, unaffected side) sides of LBP-R group with the mean difference 4.82, effect size= 0.51; p= 0.03). However, the independent sample t-test did not show significant differences in the sciatic nerve CSA and echo intensity between the LBP-R and control groups (p= 0.29, effect size 1.02) (Fig. 3).

3.2. Muscle contraction Ratio

The multifidus and gastrosoleus contraction ratios were significantly lower on the affected side than both unaffected and control groups (p< 0.05, the effect sizes for multifidus, medial gastrocnemius and soleus were 3.67, 2.26, and 9.28, respectively). Biceps femoris did not demonstrate any differences between the groups in term of contraction ratio (p= 0.52, effect size 0.64) (Fig. 2).

3.3 Muscle quality

The independent sample t-test for mean echo intensity demonstrated no differences between the groups for multifidus, biceps femoris, medial gastrocnemius and soleus muscles (p> 0.05, effect size 0.12, 0.14, 0.15, 011, 016, respectively) (Fig. 2).

3.4. Correlation with severity

No significant associations were found between the severity (ODI and Pain) of LBP-R and all outcomes except for the multifidus (r= -0.48; p= 0.007).

4. Discussion

Considering nerve root compression in disc herniation, we aimed to investigate how local nerve or muscular function might be affected, given the evidence of local structural change in

LBP-R patients with moderate to high level of pain and disability. These structural changes may adversely affect trunk control, health, and wellbeing of the lumbar spine and balance disturbance. For this purpose, we assessed the sciatic nerve morphology (CSA and echo intensity) and its innervated muscle function (contraction ratio and echo intensity) using US in the patients with LBP-R compared to the healthy controls. The findings of the current study confirm the evidence of increased CSA of the sciatic nerve on the affected side, less gastrosoleus thickening and reduced contraction of lumbar multifidus at L5 level in the patients compared to the healthy controls.

4.1. The sciatic nerve

The sciatic nerve CSA on the affected side (at the mid-thigh level) was larger than the unaffected side; however, no difference was observed between the patient and control groups. Therefore, we must reject our hypothesis that the affected leg of LBP-R patients would have a larger sciatic nerve CSA compared to the matched healthy controls, as this difference was not significant. In this regard, it could be interpreted as there is no difference, or perhaps the sample size was small for any difference to be significant. Our findings are in agreement with two published studies measuring the sciatic nerve CSA in unilateral sciatica using US (Frost and Brown, 2016b, Kara et al., 2012). However, these studies have performed the US measurements in patients with mild LBP with unilateral radiculopathy (Frost and Brown, 2016b, Kara et al., 2012). Consequently, one might regard the sciatic nerve CSA as a quantitative measure to monitor the inflammation of the nerve in entrapment neuropathies. However, we found no significant correlation between the nerve CSA and severity (i.e., ODI and pain); therefore, it would not adequately reflect the level of disability in these patients.

In the event of a complete disc herniation, components from the nucleus pulpous escape from the annulus fibrosis and induce an inflammatory response that can result in nerve injury independent of mechanical compression (Cornefjord et al., 1996). Even if the mechanical compression is unilateral, the inflammatory state could have a bilateral impact. Therefore, it is important to compare not only to the unaffected side of the LBP-R patient but also to a healthy control group to verify that the unaffected leg can be used as a within-participant comparator. In this case, the sciatic nerve CSA is comparable between the healthy controls and the unaffected leg of LBP-R patients; therefore, a within-patient comparison is appropriate. At the apex of the popliteal space, the sciatic nerve is divided into the tibial nerve and the common peroneal nerve. It is important to note that the site of nerve bifurcation is variable (Yablon et al., 2016), which may affect the nerve CSA.

Regarding the nerve echo intensity, no difference was observed between the groups, which could indicate that echo intensity is not as sensitive as nerve density or thresholding methods, or poor visualization of the sciatic nerve due to echogenic properties of surrounding tissues, consequently; less clearly borders (Böhm et al., 2014). Alternatively, a less apparent change was found in the nerve fascicular structure in our LBP-R population than in the previously published studies in the upper arm neuropathies. The decrease in the sciatic nerve echogenicity on the affected side could be due to inflammation. Future studies should investigate additional methods of detecting alterations in the sciatic nerve quality.

4.2. Muscle contraction ratio

Needle electromyography (EMG) can detect denervation of the lumbar multifidus in patients suffering from severe leg pain at L4-L5 foraminal stenosis (Takeuchi et al., 2015). However, Kim et al. (2014) compared muscle thickness using US with its activity measured by EMG and reported the US measurement of thickness ratio of the LMM as a highly reliable and valid method to investigate its function (Kim et al., 2014).

A significant decrease was found in LMM contraction ratio at L5 level between the groups (control, affected leg, unaffected leg). Therefore, imaging of multifidus at L5 level may be more sensitive to detect the changes following LBP-R due to disc herniation. LMM is the only paraspinal lumbar muscle innervated by a single nerve root, and the nerve root has no collateral innervations (Zhao et al., 2000). For the first time, the present study shows an impaired muscle contraction ratio due to LBP-R at L5 level. Reduced contraction ratio in the multifidus in chronic LBP can be interpreted as impaired neuromotor control (Wallwork et al., 2009), and it may reflect inability of the voluntary activation of this muscle (i.e., the muscle spasm or reflex inhibition).

Overall, the data imply that the asymmetry of multifidus muscle morphology has a negative impact on the health of the spine. Additionally, the multifidus consists of more slow fibers than fast fibers, which better qualifies this muscle as a key lumbar spine stabilizer. According to Dedering et al. (2006), individuals with LBP due to disc herniation have a decreased concentration of type I fibers due to disc herniation and conversion of tonic into phasic fibers (Dedering et al., 2006). Fast-twitch muscle fibers are more susceptible to atrophy than slow-twitch (Wang and Pessin, 2013). In addition, one recent study by Romas et al. (2016) showed that participants with LBP-R had increased fatigue of lumbar multifidus due to disc herniation (Ramos et al., 2016). These findings may support the current clinical practice of using physiotherapeutic modalities to decrease multifidus alteration due to LBP-R in addition to voluntary multifidus contractions in pain-free positions.

Our results indicated a significant difference in the contraction ratio of biceps femoris between the affected and unaffected side, while no difference was found between the affected side and controls. Accordingly, based on these results, LBP-R probably affected the contractibility of biceps femoris muscle. In contrast to our findings, one recent study on patients with LBP radiculopathy with mild pain and disability has found that LBP-R does not affect the contraction ratio of biceps femoris (Frost and Brown, 2016b).

In radiculopathy patients, the sciatic nerve tends to move medially during knee extension. It may be due to the nerve root taking the shorter path to avoid greater excursion at the nerve root (forming the sciatic nerve). Due to overactivity (i.e., spasm) of the biceps femoris, the nerve may be pushed more medially (Ridehalgh et al., 2015). It has been previously reported that some significant differences exist between the radiculopathy group and the control participants regarding the muscle activation timing (i.e., longer in the radiculopathy group) (Frost and Brown, 2016a). Therefore, it may be hypothesized that some changes in the biceps femoris muscle occurred and consequently, some changes in muscle activation were observed. Concurrent investigation of the ultrasonography and kinesiologic electromyography evaluation is recommended to elucidate this hypothesis in future studies. Frost and Brown (2016) also reported an impaired contraction ratio in the soleus muscle with less soleus thickening during contraction on their affected side in LBP patients with radiculopathy in comparison to controls.

The results regarding gastrosoleus showed a significant decrease in the contraction ratio between the groups, indicating an inability to activate the muscle voluntarily. Although the medial gastrocnemius and soleus are different in muscle-fiber types (soleus with 68-80% slow oxidative fiber versus medial gastrocnemius with 50-58% slow oxidative twitch fiber), they are often considered anatomical and functional synergists and show similar activity patterns in functional tasks (Mehta and Prilutsky, 2014). In the current study, the contracted images were taken while the participants were in a standing position, raised on their toes so that their heel was 5 cm above the floor. The medial gastrocnemius muscle is bi-articular, and changes in knee and ankle angle in the standing position, which may impact the muscle architecture. However, the procedure was completed in the same manner for all the participants.

4.3. Muscle quality

No significant differences were found between the control and LBP-R groups for the mean echo intensity of the muscles measured on either side. Changes in the multifidus muscle have been reported to be influenced by duration of symptoms (i.e., chronicity) (Franke et al., 2009, Kang et al., 2013). Duration of the sciatica symptom in the current study was nearly one year in the patients. Thus, it seems that any atrophy or changes in the muscle quality of these muscles tend to occur in more chronic patients and longer symptom duration.

We suggest that the present study was not able to detect these differences / changes due to the following reasons: (1) there might be an alteration in muscle elasticity instead of muscle quality; therefore, further studies are needed to investigate this possibility through sonoelastography study of the muscles to explore any elasticity changes between the groups. As it has been suggested, the modulus changes of elasticity in multifidus by shear wave sonoelastography as a complementary method determine the mechanical characterization of multifidus in patients (Moreau et al., 2016). (2) Mean echo intensity might not be sensitive enough to detect the changes in muscle fat.

4.4. Correlation with severity

A significantly impaired muscle contraction was revealed only for the multifidus muscle at L5 level in the LBP-R patients. These findings indicate that the severity of pain may affect the amount of activation of multifidus and, in turn, causes a higher level of disability (i.e., our patients reported moderate to severe pain or disability). Thus, the severity of pain and disability might be considered a cause for muscle inhibition (Kiesel et al., 2008). A pain adaptation model and fear of avoidance beliefs lead to a decrease in muscle activation duration to avoid painful muscles (Moseley, et al., 2009). Thus, it might explain less muscle thickness in the presence of pain and inhibition of reflex mechanisms (van Dieën et al., 2017).

4.5. Limitation

The present study was conducted on non-trained (i.e., non-athletic) individuals affected by the sciatic radiculopathy, who may have less muscle bulk and physical activity score compared to the trained (i.e., athletic) population. Therefore, these results do not allow direct generalization of findings to the athletic population with LBP-R. Furthermore, the healthy control group had no pain during the assessment, whereas the patients had some degree of pain. Consequently, the examiner may have been aware of the participant grouping; thus, his expectations could influence the internal validity. However, we have analyzed captured images by ImageJ software for blinding. The participants in the present study were 30-50 years old. Therefore, the results cannot be extended to older adults who may experience age-related structural changes.

5. Conclusion

This study presented a body of evidence regarding the potential utilization of USI as a useful tool to detect muscle changes in patients with LBP-R. The USI of muscle and nerve may provide some evidence indicating neuromuscular structural changes and its relationship with the pain and disability in patients with lumbar disc herniation. We found that patients with LBP-R had a larger sciatic CSA and less biceps femoris thickening on the affected side compared to the unaffected side. Moreover, impaired multifidus at L5 level and the gastrosoleus muscle contraction may suggest some inhibitory pain effects on the muscles in lumbosacral radiculopathy due to disc herniation.

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Acknowledgments: This research was supported by Tehran University of Medical Sciences (Grant No: TUMS-IC36152). The authors would like to acknowledge the generous assistance of Mrs. Ahmadi, the staff of sonography unit at Emam Khomeini hospital, Tehran University of Medical Sciences.

Table 1
Characteristics (mean ± SD) of participants with unilateral LBP-R (n=20) and healthy controls (n=20)

Group	Age	Sex (F:M)	BMI	Physical activity score[1]	NPRS[2] back	NPRS leg	ODI[3] Range
LBP-R	42±14.1	5:10	24.07±8.26	3±0.12	4.76±1.86	5.76±164	35.65-40.11 ± 11.89-13.65
Control	41±13.9	5:10	23.6±7.98	3±0.12	-	-	0

[1] Tegner Activity Scale, score 0-10 where 0 represents sick leave or disability pension, and 10 is participation in competitive sports

[2] NPRS: Numeric Pain Rating Scale, on scale 0-10, A score1-3 indicates mild pain, 4-6 indicates moderate pain, 7-10 indicates severe pain

[3] ODI: Oswestry Disability Index, on a percentage scale, score from 0-20% indicate a minimal disability, 21-40% indicate a moderate disability, 41-60% severe disability, 61-80 % for crippled and 81-100%.

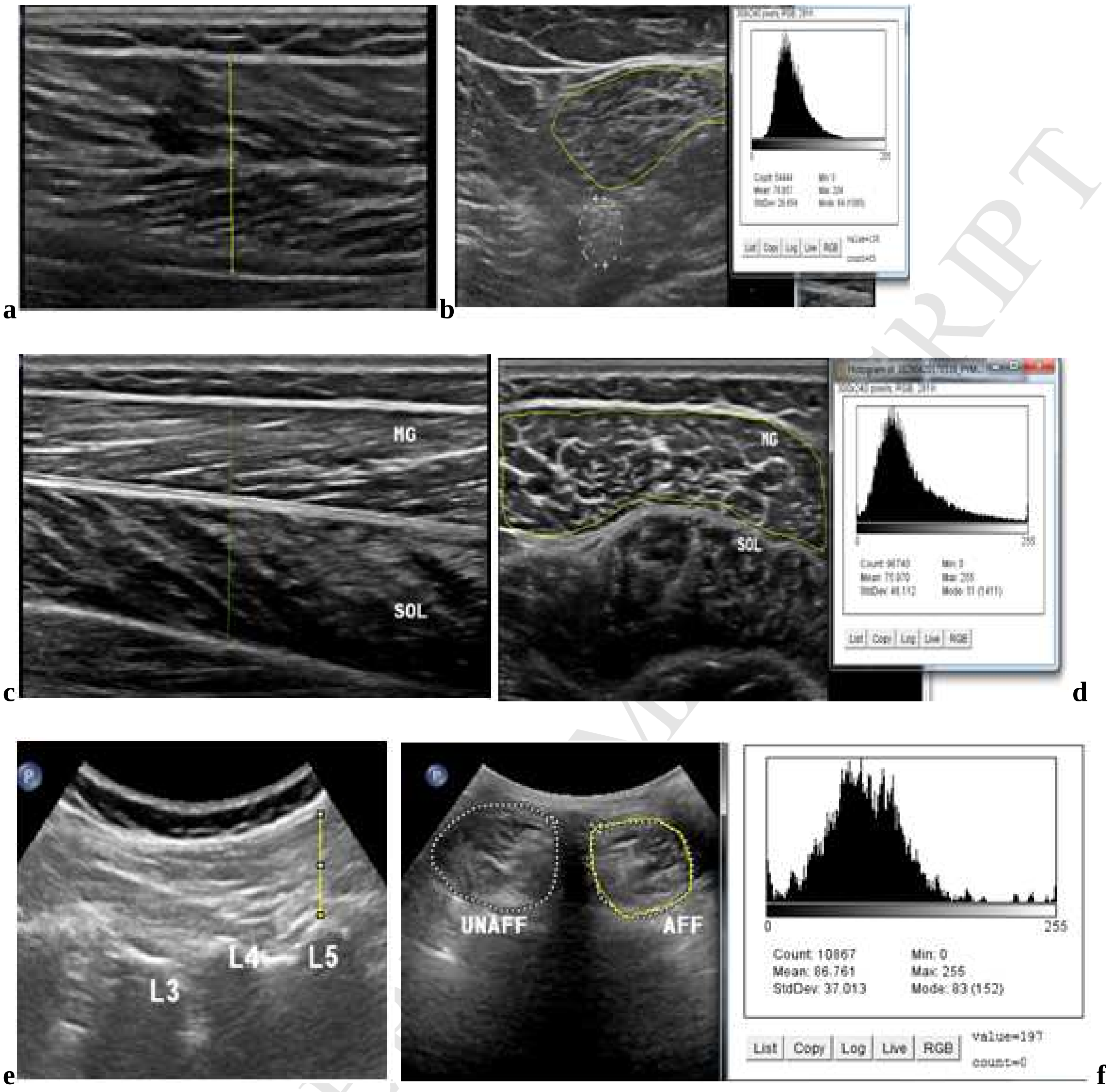
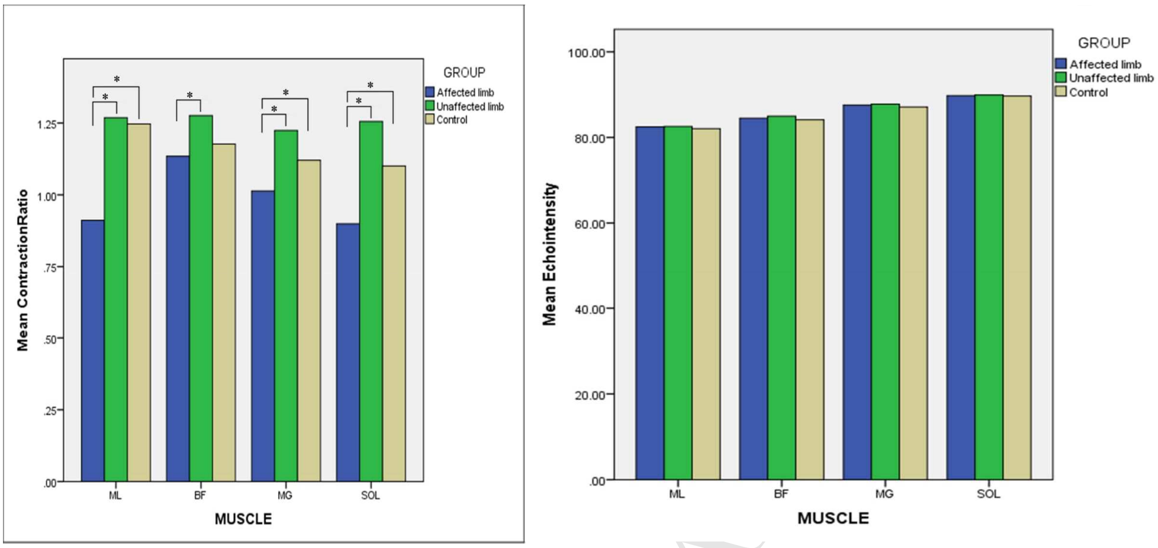


Fig. 1. Ultrasound images of (a) biceps femoris thickness in longitudinal scan, (b) biceps femoris region of interest (ROI) in the transverse scan and the sciatic nerve (dotted line) with echo intensity histogram, (c) the medial gastrocnemius and soleus in the longitudinal scan,(d) the medial gastrocnemius ROI and soleus in the transverse scan with echo intensity histogram, (e) the multifidus muscle in the longitudinal scan at L3-5 levels,(f) multifidus in the transverse scan in the affected and unaffected sides with echo intensity histogram. In the longitudinal scan, a yellow vertical line indicates the muscle thickness.



a **b**

Fig. 2. (a) Mean muscle contraction ratio, (b) mean muscle echogenicity for the control and LBP-R (affected and unaffected). a.u: arbitrary unit, ML: Multifidus, BF: Biceps Femoris, MG: Medial Gastrocnemius, SOL: Soleus, *: significant P< 0.05.

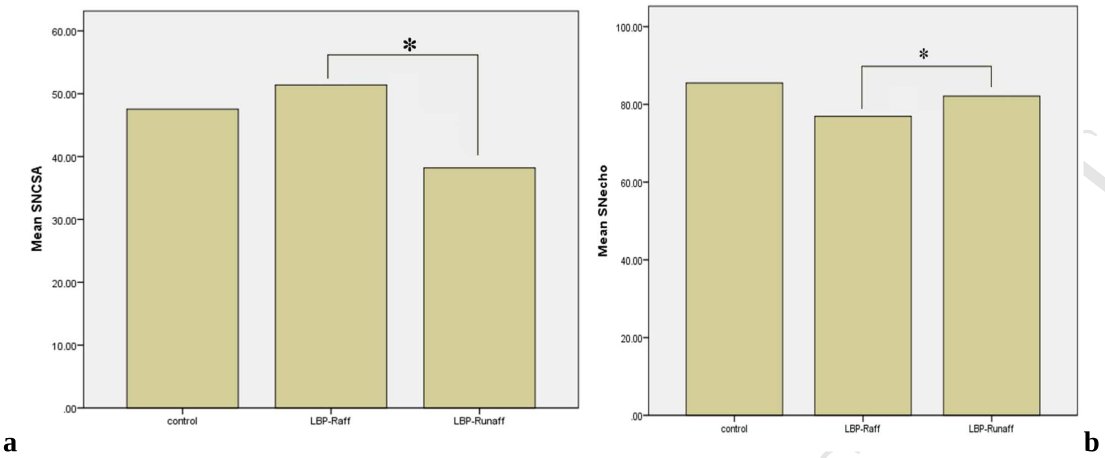


Fig. 3. (a) Mean the sciatic nerve cross-sectional area (mm^2) and (b) Mean echogenicity for the control and low back pain radiculopathy (LBP-R), and significant comparison between affected and unaffected; SNCSA: Sciatic Nerve Cross-Sectional Area, *: significant P< 0.05.

Highlights

- Ultrasonography is a promising tool to explore structural changes in the sciatic nerve
- Echogenicity of muscle and nerve structure is questionable
- Lumbar multifidus demonstrated a smaller thickening during contraction