

Reliability of Ultrasonography in Measuring Deep Abdominal and Lumbar Multifidus Muscle Dimensions in Patients with Unilateral Lumbar Disc Herniation

Neda Naghdi ^a, Mohammad Ali Mohseni Bandpei ^b, Morteza Taghipour ^a, Nahid Rahmani ^b

^a Department of Physiotherapy, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran; ^b Pediatric Neurorehabilitation Research Center, Department of Physiotherapy, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran

*Corresponding Author: Mohammad Ali Mohseni Bandpei Physiotherapy Department, the University of Social Welfare and Rehabilitation Sciences (USWR), Evin, Tehran, Iran. Po Box: 1985713834. Tel: +98-21 22180137; E-mail: Mohseni-Bandpei@Yahoo.Com

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Abstract

Introduction: The purpose of this study was to assess the within-day and between-day reliability of abdominal and lumbar multifidus muscle size in patients with unilateral lumbar disc herniation (LDH) using ultrasonography (US). **Materials and methods:** In this study, 15 patients with unilateral LDH (20-60 years old) were recruited. To assess within-day and between-day reliability, three images were taken with one hour and one week intervals respectively. The images were taken at rest and during contraction. **Results:** The within-day and between-day reliability of abdominal muscle thickness measurements using US in patients with unilateral lumbar disc herniation (LDH) in both rest and contraction state was found to be high with ICC=0.87 for within and ICC=0.75 for between-day rates of transverse abdominis (TrA) muscles at rest and ICC=0.78 and 0.75, respectively, in contraction state. For internal oblique muscles, ICC=0.70 at rest and 0.79 in contraction state and ICC=0.73 at rest and 0.77 in contraction state were found for within-day and between-day, respectively. Within-day and between-day reliability at rest with ICC=0.76 and 0.76 and in contraction state with ICC=0.75 and 0.74 were demonstrated for the external oblique muscle. Within-day and between-day reliability rates at rest with ICC=0.88 and 0.84, respectively, and in contraction state with ICC=0.84 and 0.80, respectively were demonstrated for the lumbar multifidus muscle. **Conclusion:** The results of the present study suggest that US is a reliable method for evaluating the thickness of the abdominal and lumbar multifidus muscles. However, further research is recommended to support the findings of the present study.

Keywords: Ultrasonography, disc herniation, abdominal muscles, lumbar multifidus muscle, reliability

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Introduction

Low back pain (LBP) is one of the most common musculoskeletal disorders related to one's occupation which includes most people in both industrialized and non-industrialized societies (1-3). The prevalence rates of LBP in Iran among nurses, pregnant women, and surgeons and dentists have been reported to be 62%, 84% and 84.8%, respectively (2, 4, 5). LBP is divided into the two categories of specific and nonspecific LBP (6). Lumbar disc herniation (LDH) is one cause of specific LBP that can result in pressure on the nerve root and lead to sensory and motor disorders (6, 7). Abdominal and lumbar multifidus (LM) muscles

play an important role in spinal stability (8-10). These muscles may become dysfunctional in patients with LBP and unilateral LDH. Low back injury can result in muscle inhibition and loss of control which may not be recovered spontaneously (11); specific exercises are required to stimulate recovery (12). Different methods are available to assess the function and morphology of these muscles and to evaluate the effectiveness of rehabilitation programs (13, 14). Ultrasound imaging has been shown to be a reliable and valid technique for measuring changes in muscle geometry and behavior and has been increasingly used both in research and as a clinical tool throughout the rehabilitative process (15, 16). Ultrasonography (US) has been validated to measure

Table 1. Demographic characteristics of study participants

Participants Variables Indicators	Statistical Indicators			
	Range	Variance	Standard Deviation	Average
Age (year)	20-60	158.21	12.57	39.27
Weight (kg)	58-93	124.05	11.13	74.94
Height (cm)	158-185	70.40	8.39	170.94
BMI (kg/m ²)	19.84-33.35	17.188	4.14	25.76

Table 2. Reliability correlation coefficient of abdominal muscles in at-rest and contraction conditions

Muscles		Reliability					
		(Within-Day)			(Between-Day)		
		ICC	SEM	MDC	ICC	SEM	MDC
Cross Section Area of Multifidus	Rest	0.88	0.38	1.05	0.84	0.46	1.28
	Contraction	0.84	0.44	1.22	0.8	0.47	1.3
Transverse abdominal	Rest	0.87	0.2	0.55	0.75	0.28	0.78
	Contraction	0.78	0.58	1.61	0.75	0.65	1.8
Internal oblique	Rest	0.77	0.56	1.55	0.73	0.59	1.64
	Contraction	0.79	0.75	2.08	0.77	0.82	2.27
External oblique	Rest	0.76	0.53	1.47	0.76	0.69	1.91
	Contraction	0.75	0.82	2.27	0.74	0.9	2.49

the morphology of abdominal and lumbar multifidus muscles through comparison with magnetic resonance imaging measurements (17) and as an indicator of muscle activation with indwelling electromyography (18, 19).

As a research and rehabilitative tool, the reliability of US in measuring muscle dimensions must be determined (20). The purpose of the current study was to evaluate within-day and between-day reliability of US in measuring the dimensions of the abdominal muscles (TrA - internal and external oblique) and the lumbar multifidus muscles in patients with LDH. It was hypothesized that US has acceptable reliability for measuring abdominal and lumbar multifidus dimensions in patients with unilateral LDH.

Material and methods

Study design and sampling: Following receipt of ethical approval from the Medical Ethics Board of the University of Social Welfare and Rehabilitation Sciences, 15 patients with unilateral LDH (male and female) were randomly recruited according to the inclusion and exclusion criteria of the study. Subjects were included if they had a history of unilateral LDH at the L4-L5 level, at least three months duration of pain, no history of lumbar surgery, and an age between 20-60 years.

Subjects were excluded if they had any history of a sacroiliac joint dysfunction, lumbar fracture, spinal deformity or scoliosis, rheumatologic or neurologic disease, orthopedic device in the spinal column, pregnancy, metabolic diseases, malignancies, or other major medical conditions or a sensitivity to gel. All subjects were given written information about the aims and plans of the study, and then they were asked to sign a consent form if they agreed to participate. The sample characteristics are summarized in Table 1.

Imaging Technique: Ultrasound images were obtained using ES500 ultrasound machine (Ultrasonix-ES500, Canada) with two probes (linear 7.5 MHZ and curvilinear 3.5 MHZ). The abdominal muscles were measured in the supine hook-lying position with the hand beside the trunk. The linear probe (7.5 MHZ) was placed at the level of the axial line between the iliac crest and the 12th rib and removed until the medial border of the muscle (Figure 1) was seen in the far medial side of the screen (21). At the end of expiration, the image was fixed and saved (22). The cross-sectional area of the LM was measured in the prone position (on a standard plinth to decrease the lumbar curve) and at the L4-L5 level (Figure 2). The spinous processes at the L4-L5 levels were identified by palpation and marked for reference. The linear probe was placed transversely over the spinous process (22). The cross-

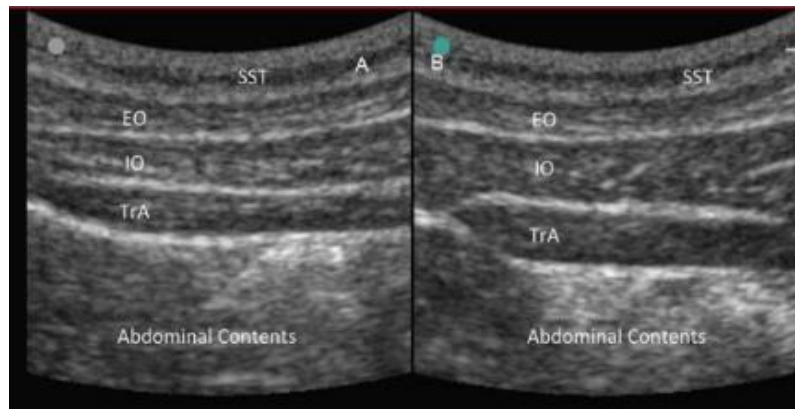


Figure 1. Ultrasonographic images of transverse abdominal, internal oblique, and external oblique muscles, at rest (A) and contraction (B)

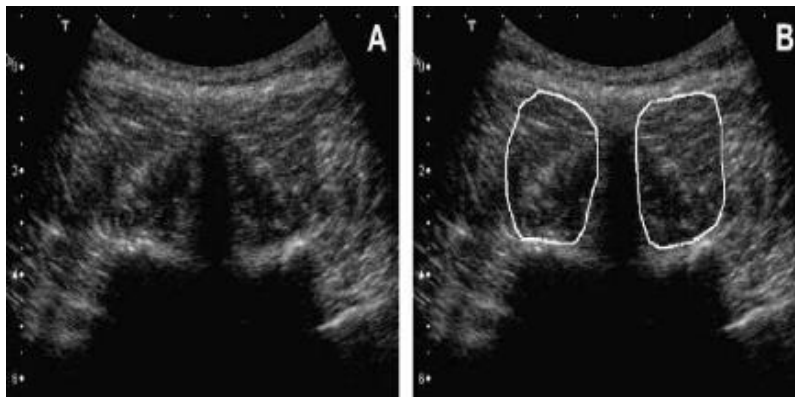


Figure 2. Ultrasonographic images of lumbar multifidus muscle, at rest (A) and contraction (B)

sectional area of the LM was measured at L4, because the image of this level was clearer than that of L5 using a curvilinear 3.5MHZ probe. Simultaneously, the measures of the left and right multifidus were obtained. All measurements were taken three times; the first and second were performed in one day with a half hour interval (for within-day reliability), and the third was performed after a one-week interval (for between-days reliability).

Statistical Analysis: Intraclass correlation coefficients (ICC), standard error of mean (SEM), and minimum detectable change (MDC) were used to assess within-day (between the first and second measures) and between-days (between the first and third measures) reliability.

Results

All data on the abdominal and LM muscles dimension of the 15 volunteers both at rest and contraction was analyzed. The within-day reliability (ICC) in both contraction and at-rest

conditions were obtained for the TrA in a range of 0.78 to 0.87, for the internal oblique muscle in a range of 0.77 to 0.79, for the external oblique muscles in a range of 0.76 to 0.79, and for the lumbar multifidus in the range of 0.84 to 0.88, respectively. Also, the between-day reliability (ICC) in both contraction and at-rest conditions were obtained for TrA in the range of 0.75 to 0.75, for the internal oblique muscle in the range of 0.73 to 0.77, for the external oblique muscles in the range of 0.76 to 0.77, and finally for lumbar multifidus in the range of 0.80 to 0.84, respectively, across days (Table 2). ICCs and SEM values (Table 2) indicated a good to high reliability for both within-day and between-days reliability.

Discussion

The present study confirmed that US and the method used in this study to assess abdominal and LM muscle can provide reliable measures of muscle dimensions in symptomatic patients with unilateral LDH. Previous investigations have also achieved

the same conclusions (23, 24). In line with the results of the present study, the reliability of US imaging of the abdominal muscles in different positions in asymptomatic subjects has been reported by Bounce *et al.* (25). Furthermore, an Iranian study has confirmed that US imaging may provide reliable measurements of abdominal muscle thickness in acute low back pain patients (26). The results of the current study support previous suggestions regarding the site where TrA thickness can be imaged and reliably measured (21). The authors emphasize that although ultrasound imaging is a reliable tool for measuring muscle size, the interpretation of the size changes to muscle activation should be made conservatively. More studies are needed to confirm the use of US to evaluate muscle activation during high levels of contraction, concentric or eccentric contractions, or during the tasks that have not been validated (20). Richman *et al.* (27) suggested reliability coefficient values of 0.80 to 1.00 as very reliable, 0.60 to 0.79 as moderately reliable, and 0.59 or less as questionably reliable, which support the fact that the measurements in this study have obtained a good to high level of reliability. To improve the generalizability of the results, it is suggested that studies with longer time intervals, larger sample sizes, and a comparison of the results between healthy people and patients be conducted. It is also recommended that the reliability of sonography in measuring other muscles be evaluated. The comparison of different protocols to find the most reliable way to evaluate abdominal and LM muscles is also suggested.

Limitations in this study were the small sample size, the use of only patient participants, and short time intervals between measurements.

Rehabilitative US can be used in clinical settings to measure muscle dimensions as a reliable and non-invasive instrument. The method used in this study seems to be a reliable way to measure lumbar stabilizing muscles.

The present study researched the within-day and between-days reliability of US in patients with unilateral LDH at rest and in contraction.

Conclusion

According to the results obtained in this study, US is a reliable tool for measuring the thickness of abdominal and lumbar multifidus muscles in patients with unilateral LDH. Because of its simplicity, quickness, minimal inconvenience, minimal invasiveness, and high reliability, US is recommended for measuring abdominal and lumbar

multifidus muscle thickness and assessing the effect of treatment interventions.

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Conflict of interest:

None

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Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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