



DIAGNOSTIC METHODS: RELIABILITY STUDY

Reliability of sonography in the assessment of lumbar stabilizer muscles size in healthy subjects and patients with scoliosis

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ABSTRACT

Objective: The purpose of the present study was to compare the reliability of sonography in the evaluation of abdominal and multifidus muscles size between healthy subjects and patients with scoliosis.

Methods: In this study, 20 healthy males and 20 male patients with scoliosis (20–50 years old) were recruited. Multifidus and abdominal muscles (transversus abdominis, internal and external oblique) size were assessed by sonography. Three images were recorded; the first and second images were taken on the same day with an hour interval to evaluate within-day reliability, and the third image was taken one-week later to assess between-day reliability.

Results: Intraclass correlation coefficient (ICC = 0.82–0.91) demonstrated high within-day reliability of sonography in the assessment of abdominal muscle thickness in both groups. In addition, high between-day reliability was observed for these muscles in both healthy and patient groups (ICC = 0.80–0.89). Within-day and also between-day reliability of multifidus muscle were shown to be high in the healthy group (ICC = 0.81–0.88) and the patient group (ICC = 0.78–0.85). Overall, within-day reliability was higher than between-day reliability and also the reliability of sonography in healthy subjects was greater than of those suffering from scoliosis.

Conclusions: According to the results, sonography was shown to be a highly reliable imaging technique for assessment of abdominal and multifidus muscle size in healthy males and those suffering from scoliosis.

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1. Background

Scoliosis is defined as 3-dimensional deviation of the spinal column associated with vertebral rotation (Grivas et al., 2003). The prevalence of scoliosis is reported to be 1–2% among adolescents and more than 50% among elder people after 60 years old (Carter and Haynes, 1987). Previous studies reported several causes for scoliosis including hemivertebra (Master, 1994), stabilizer muscles weakness and imbalance (Reames et al., 2011), and spine passive stabilizers dysfunction (McMaster, 1983). Different disorders

including scoliosis, cerebral palsy, hemiparesis, spinal muscle atrophy, muscle dystrophy, multiple sclerosis, low back pain (LBP), etc., may cause trunk muscles imbalance and asymmetry resulting in muscle contracture of concave side and stretching in convex side of the curvature (Kisner and Brody, 1998).

There are various methods, including electromyography (EMG) (Brown and McGill, 2010; Mohseni-Bandpei et al., 2000, 2014b), magnetic resonance imaging (MRI) (Hides et al., 2006, 2007; 2010), and sonography (US) (Ghamkhar et al., 2011; Rahmani et al., 2015, 2017) to evaluate different characteristics of stabilizer muscles. As EMG is an invasive method and is not tolerated very well, the non-invasiveness of US makes it especially appropriate for the assessment of skeletal muscles (Brockmann et al., 2007). The advantages of US as compared with MRI are that it is non-invasive, radiation-free, and a cost-effective approach that is also well tolerated by patients and is appropriate for serial follow-up (Fabrikant and Park,

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2011). Among these methods, sonography is reported to be an accessible, non-invasive, valid, and reliable imaging technique that is widely used to assess the size and shape of the muscles and surrounding tissues and to detect any pathological conditions including neuromuscular conditions, musculoskeletal disorders, inflammatory and non-inflammatory conditions, tumors, etc., in muscles (Javanshir et al., 2010; Mohseni-Bandpei et al., 2014a; Whittaker, 2008). There are also some limitations to be considered for the application of US such as operator dependent technology, lower tissue penetration for high-frequency transducers, long training period, and time consuming in examination of multiple joints (Naredo et al., 2006; Backhaus et al., 2009).

Among paraspinal muscles, transverse abdominis (TrA), lumbar multifidus (LM), internal oblique (IO), and external oblique (EO) have been of particular interest as active stabilizers of the lumbar spine. Unlike erector spinae and rectus abdominis (which seem to be involved in movement production), these muscles provide segmental stabilization by maintaining a neutral intervertebral position during functional activities. These muscles may be impaired and become dysfunctional in patients with scoliosis. As there was no published study investigating the reliability of sonography in the assessment of spine stabilizer muscle size in patients with scoliosis, the purpose of the present study was to evaluate and compare the reliability of sonography for the assessment of abdominal and multifidus muscle size between healthy males and male patients with scoliosis.

2. Methods

This study received ethical approval from the ethics committee of the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran. Twenty healthy males and those with scoliosis from Tehran province participated in the present study. All healthy subjects and patients with scoliosis were between 20 and 50 years old. Healthy subjects did not have any history of scoliosis in their X-ray or MRI, but patients with scoliosis were diagnosed and selected as scoliotic patients based on radiographic findings.

The exclusion criteria were: any history of sacroiliac joint dysfunction, respiratory and rheumatoid diseases, neurologic diseases, fracture or dislocation in lumbar spine, metabolic disorders, spondylolysis and spondylolisthesis that might have an influence on the spinal column and surrounded muscles separately, and sensitivity to the sonography gel. All diagnoses were made and inclusion and exclusion criteria were performed by a spine surgeon.

All subjects were given written information sheet about the purpose and the procedure of the present study. All subjects who were willing to participate in the study signed the consent form and then completed the demographic questionnaire. A portable sonography device (LEO-3000 XuZhou LEO Medical Equipment CO., Ltd) with linear and curved probes was used to take images and measure muscles dimension. All images were taken by a physical therapist with 5 years of experience. To evaluate abdominal muscles, subjects were asked to be in a crook lying position on a bed. Then linear probe of sonography, which was covered with ultrasound gel, was placed between 12th rib and iliac crest on the antrolateral abdominal wall (Langevin et al., 2009; Mannion et al., 2008; Whittaker, 2008) as it is considered to be the best location to obtain a clear image of the deep abdominal layers. The thickness of TrA, IO, and EO muscles were measured bilaterally and recorded at the end of exhalation (Mannion et al., 2008). In order to evaluate the LM cross-sectional area (CSA), subjects were asked to lie down on the examining bed in the prone position with a pillow under the abdomen while the examiner took an image from LM at the L5-S1 level, bilaterally. In order to identify the multifidus, the midpoint of

Table 1

Demographic characteristics of healthy subjects and patients with scoliosis.

Variables	Healthy (n = 20)			Patient (n = 20)		
	Mean	SD	Range	Mean	SD	Range
Age (year)	33.4	8.2	21–48	37.9	9.11	22–50
Height (cm)	174.62	5.8	165–182	169.00	5.12	162–180
Weight (kg)	73	9.41	62–98	70	7.62	51–88
BMI (kg/m ²)	23	2.80	21.10–33.40	24.50	2.51	18.20–28.25

SD: standard deviation, BMI: body mass index, cm: centimeter, kg: kilogram.

Table 2

Within-day and between-day reliability of measuring abdominal muscle thickness using sonography in healthy and patient groups.

Muscles	Sides	Healthy (n = 20)				Patient (n = 20)			
		Within-day reliability		Between-day reliability		Within-day reliability		Between-day reliability	
		ICC	SEM	ICC	SEM	ICC	SEM	ICC	SEM
TA	Right	0.91	0.032	0.89	0.038	0.89	0.038	0.87	0.031
	Left	0.88	0.042	0.85	0.048	0.86	0.045	0.83	0.036
IO	Right	0.86	0.057	0.83	0.054	0.82	0.048	0.80	0.045
	Left	0.87	0.038	0.85	0.032	0.84	0.043	0.81	0.038
EO	Right	0.89	0.034	0.86	0.031	0.85	0.032	0.82	0.031
	Left	0.88	0.047	0.85	0.044	0.83	0.046	0.81	0.042

ICC: intraclass correlation coefficient, SEM: standard error of measurement, TA: transversus abdominis, IO: internal oblique, EO: external oblique.

a line drawn between the highest level of the iliac crests was considered as the L5-S1 level. The probe of sonography was placed perpendicular on L5-S1 level (Hides et al., 2008).

Overall three images were recorded. The first and second images were taken on the same day with an hour interval to evaluate within-day reliability. The third image was taken one week later to assess between-day reliability. SPSS version 21 was used to analyze the data. In order to investigate the relative reliability, intra-class correlation coefficient (ICC) was utilized and the standard error of measurement (SEM) was used to evaluate the absolute reliability of measurements.

3. Results

Demographic characteristics of both healthy subjects and patients with scoliosis are presented in Table 1. The results of within-day and between-day reliability of abdominal muscles thickness and multifidus muscle CSA for both groups are shown in Table 2 and Table 3, respectively.

As demonstrated in Table 2, within-day reliability of sonography in the assessment of abdominal muscles thickness was high in both groups (ICC = 0.82–0.91). Also, high between-day reliability was found in both groups (ICC = 0.80–0.89).

The results of within-day reliability and also between-day reliability of the multifidus muscle (Table 3) was shown to be high in the healthy group (ICC = 0.81–0.88) and the patient group (ICC = 0.78–0.85). In general, within-day reliability was higher than between-day reliability and also the reliability of sonography in healthy subjects was greater than of those who were suffering from scoliosis.

4. Discussion

The purpose of the present study was to compare the reliability of sonography in the assessment of spine stabilizer muscle (abdominal and multifidus muscles) dimension between healthy

Table 3

Within-day and between-day reliability of measuring multifidus muscle CSA using sonography in healthy and patient groups.

Multifidus muscle	Sides	Healthy (n = 20)				Patient (n = 20)			
		Within-day reliability		Between-day reliability		Within-day reliability		Between-day reliability	
		ICC	SEM	ICC	SEM	ICC	SEM	ICC	SEM
AP dimension (cm)	Right	0.88	0.025	0.85	0.022	0.85	0.022	0.83	0.020
	Left	0.87	0.028	0.84	0.024	0.84	0.024	0.82	0.022
ML dimension (cm)	Right	0.86	0.048	0.83	0.043	0.83	0.043	0.81	0.037
	Left	0.87	0.046	0.85	0.041	0.84	0.042	0.80	0.039
CSA (cm ²)	Right	0.86	0.041	0.83	0.038	0.83	0.034	0.81	0.030
	Left	0.83	0.042	0.81	0.039	0.81	0.038	0.78	0.032

ICC: intraclass correlation coefficient, SEM: standard error of measurement, AP: antero-posterior, ML: mediolateral, CSA, cross sectional area, cm: centimeter.

and patients with scoliosis. The results of this study demonstrated that sonography was a highly reliable imaging technique to assess the spine stabilizer muscles' dimension in healthy subjects and those suffering from scoliosis. Previous studies have reported the reliability of sonography in the assessment of spine stabilizer muscles size in healthy subjects and patients suffering from LBP and neck pain (Fizez et al., 2016; Hides et al., 2006; Koppenhaver et al., 2009; Nabavi et al., 2014; Park, 2013; Wallwork et al., 2007).

Zapata et al. have investigated the reliability of sonography in the evaluation of paraspinal muscle size in adolescents with idiopathic scoliosis. The multifidus CSA was measured by sonography in 20 adolescents (10 healthy subjects and 10 patients with scoliosis). The results showed high reliability of sonography with $0.93 < \text{ICC} < 0.99$ when the measurements were performed by one assessor and the value of ICC reported to be lower when two assessors measured the CSA of the LM muscle ($0.83 < \text{ICC} < 0.99$) (Zapata et al., 2015). The differences between the measurements taken by one assessor and two assessors might be attributed to different factors including the experience of assessors, different time intervals, different equipment used, different muscle state, or different age range of study samples. The results of the present study were consistent with the findings of Zapata et al.'s study.

In a study carried out by Nabavi et al., the reliability of sonography in the assessment of TrA muscle size and multifidus muscle CSA was investigated in 15 healthy subjects (Nabavi et al., 2014). The results indicated that the reliability of sonography to assess TrA muscle size ($0.74 < \text{ICC} < 0.86$) was lower than the reliability values reported in the present study. The reliability of sonography in the evaluation of LM muscle CSA ($0.89 < \text{ICC} < 0.94$) was similar to the results of the present study. The reasons for different findings may be due to the different types of sonography devices used (in the present study a portable device was used), different subjects (adults vs adolescents), different muscles studied, different vertebral levels of lumbar spine, and different time intervals used between two measurements.

The reliability of sonography in the evaluation of TrA muscle size and LM muscle CSA in 42 healthy subjects and 56 patients with LBP during both rest and contraction by an expert and novice assessors was investigated by Djordjevic et al. A single measurement was made per day for three consecutive days. The results showed similar reliability values of sonography in healthy and patient groups for TrA muscle ($0.71 < \text{ICC} < 0.94$) and LM muscle ($0.84 < \text{ICC} < 1$) (Djordjevic et al., 2014). The results of the presents study were inconsistent with the findings of study conducted by Djordjevic et al.'s study. Possible reasons for different results may be attributed to the inequality of subjects in the two groups, possible abnormal muscle changes in patients with scoliosis, measuring muscle dimensions at different levels of lumbar spine, different genders studied, different measurements (one measure

per day for 3 days), ipsilateral measurements, and different imaging techniques.

4.1. Recommendations

In general, the results of the present study indicate that sonography has an acceptable reliability to evaluate abdominal and lumbar trunk muscles at rest and during contraction in subjects with scoliosis. An acceptable reliability is clinically valuable, as sonography is a safe and cost-effective method that can be reliably used for measurement of trunk muscles' dimensions compared with other methods including MRI and CT-scan. It can be applied both for the assessment of muscle morphology in different conditions and to monitor the effectiveness of interventions in a clinical setting. Ultrasound may be also useful to differentiate people with a certain condition and at risk of a condition from healthy subjects. Furthermore, using standard and consistent methods for parameters such as participant's position, determination of scanning point, and amount of contact pressure of transducer in different sessions may improve the results of rater reliability.

5. Conclusions

According to the results, sonography was shown to be a highly reliable imaging technique to evaluate abdominal and multifidus muscle size in healthy subjects and those suffering from scoliosis. Within-day and between-day reliability of sonography were high in both groups although the reliability value was lower in patients with scoliosis compared with healthy subjects.

Author disclosures

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Conflict of interest

There is no conflict of interest for this study.

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