Original Article

J Babol Univ Med Sci
Vol 19, Issu 8; Aug 2017. P:12-19

Comparing the Reliability of Abdominal Muscles Thickness Using Ultrasonography in Adolescents with Low Back Pain and Healthy Adolescents

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J Babol Univ Med Sci; 19(8); Aug 2017; PP: 12-19
Received: Feb 25th 2017, Revised: May 10th 2017, Accepted: Jun 20th 2017.

ABSTRACT

BACKGROUND AND OBJECTIVE: Low back pain (LBP) is one of the relative prevalent musculoskeletal disorders in patients which increases with increasing age. Therefore, the purpose of this study was to investigate reliability of sonography in the assessment of abdominal muscles thickness in adolescents with LBP in comparison to healthy subjects.

METHODS: This methodological study was carried out on thirty healthy girls and boys and 30 girls and boys with LBP. Transversus abdominis (TA), internal oblique (IO), external oblique (EO) and subcutaneous fat (SF) were evaluated in crook lying position using sonography at the end of exhalation. Two sets of images were taken on the same day to assess within-day reliability and the third measurement was taken one week later to evaluate between-day reliability.

FINDINGS: The values of intra-class correlation coefficient (ICC), within-day and between-day reliability were high in two groups (ICC>0.80). ICC values were lower in patients with LBP compared with healthy subjects. Generally, within-day reliability was higher than between-day reliability.

CONCLUSION: Reliability of sonography in the evaluation of abdominal muscles thickness and subcutaneous fat width was high in healthy adolescents and those who suffering from LBP.

KEY WORDS: *Adolescents, low back pain, reliability, abdominal muscles, sonography*.

Please cite this article as follows:

Rahmani N, Mohseni-Bandpei MA, Salavati M, Vameghi R, Abdollahi I. Comparing the Reliability of Abdominal Muscles Thickness Using Ultrasonography in Adolescents with Low Back Pain and Healthy Adolescents. J Babol Univ Med Sci. 2017;19(8):12-19.

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[DOR: 20.1001.1.15614107.1396.19.8.2.7]
[DOI: 10.22088/jbums.19.8.12]

Introduction

LBP is a musculoskeletal disorder and a relatively common complaint in patients referring to health systems (1-3). Lowe back pain causes activity limit in young and middle ages and is the second cause of sickness (4). It is also considered as a common cause of decreased activity in people under the age of 45 (5). Many studies have estimated the incidence of this disorder in children and adults. In the United States, it is the fifth cause of recourse to specialists (6).

It have been estimated and reported that in Iran, the prevalence is 17% in children aged 11 to 14 (7), 62% in nurses (8), 37% in teachers (9), 84% in pregnant women (10) and 84.8% during the lifetime in surgeons (11). The prevalence of low back pain in Iran is high, like other countries. The incidence of low back pain is relatively high in children, and as the age increases, the incidence of low back pain is higher. In a study by Mohseni-Bandpei et al., the prevalence of low back pain in 5,000 schoolchildren aged 11-14 years in Iran was estimated to be 4.17% (7).

One of the possible causes of pain in patients with low back pain is instability in the lumbar spine segments that occurs due to changes in muscle control and causes muscle spasms (12, 13). Injuries to the spine, with muscle weakness, or destruction of the intervertebral disc or surgery, all decrease stiffness and increase instability (14). Increasing the neutral region is considered as an indicator of instability, which should be compensated by the trunk's muscles to protect the mechanical stability of the lumbar region (15). The local muscles, given the short lever arm, have little role in motion production but are active in controlling the movement of the upper vertebrae in relation to the lower vertebrae and maintaining the stability (16).

These muscles include multiphydus, abdominal muscles (transverse abdomen, internal oblique and external oblique (17). There are several methods for evaluating the various characteristics and activity of the abdominal muscles and its surrounding tissues, in particular, fat in healthy people with low back pain, including electromyography (18-21), MRI (22-24) and ultrasound (25-27).

Among these methods, ultrasound is a cheap and non-invasive imaging technique that is widely used to evaluate the morphology of the muscles (shape and size) and soft tissues around them (28-30). It is not possible to directly assess the muscles of the lumbar stabilizer, but measurement of the dimensions of these muscles can be considered as an indirect measure the activity level of those muscles (31, 32). Various studies have evaluated the repeatability of ultrasound in healthy adults with low back pain (33-37), and in the age group of children and adolescents, ultrasonographic repeatability has been evaluated for assessing the upper and lower limb muscle size in healthy people and with neuromuscular disorders has been investigated (34, 38, 39).

Only two studies looked at the repeatability of ultrasound imaging techniques for measuring abdominal muscle size in healthy teens (35, 36) a study by Linek et al. on 32 healthy children aged 10 to 12 years to assess the repeatability of ultrasound in abdominal muscle evaluation in two resting and contraction conditions were performed, the results of the study showed that ultrasound repeatability was higher in the resting state for abdominal muscle thickness, but it was repeatable in contraction condition (36).

No study has found that the repeatability of this method for assessing muscle size in adolescents with low back pain. Therefore, the aim of this study was to investigate the repeatability of ultrasound apparatus in evaluating abdominal muscle and subcutaneous fat size in high school teens with low back pain and compare it with healthy teens.

Methods

This methodological study was approved by the Ethics Committee of University of Social Welfare and Rehabilitation Sciences with number of 122.1392IR.USWR.REC. On 30 male and female healthy students and 30 female and male students with non-specific chronic low back pain resident of Tehran who were studying in high school and were matched for age and body mass index, simple inertia sampling method was used.

All subjects were provided with all necessary information about the purpose of the study in writing all adolescents and one of their parents signed a consent form before agreeing to participate in the study. The healthy group included high school girls

[DOR: 20.1001.1.15614107.1396.19.8.2.7]
[DOI: 10.22088/jbums.19.8.12]

and boys aged 15 to 18 years old, healthy and without any history of back pain, and the affected group included high school students aged 15 to 18 years with non-specific chronic low back pain with pain, dryness, increased Muscle tightness or stiffness in the area between the margin to the top of the lower limb of the gluteal region, with or without foot pain that can not be attributed to a specific pathology and lasts for more than 12 weeks (40) and has had a history of back pain for at least 3 months (41). People with sacroiliac disorders, Scoliosis and other structural disorders of the spine, respiratory and rheumatic diseases, neurological diseases, fractures and dislocation in the waist, malignancies or other metabolic diseases, spondylolysis and spondylolysitis, and gel allergy after the visit Children were excluded from the study by a pediatrician.

The participant was lying on the bed and the physiotherapist researcher with 5 years of ultrasound work, using Portbelle ultrasound for the present study, measured the size of the transverse abdominal muscles, the internal oblique, the external oblique and the subcutaneous fat. In a repeatability study, twice daily measurements with two-hour interval from abdominal muscle and subcutaneous fat were performed by ultrasound in the supine position, which was titled intra-day repeatability, and then a third measurement with one-week interval of the first measurement was carried out as a repeatability between days .It was advisable do not exercise extreme sports a week or more until the final evaluation or during the assessment do not drink water.

To assess the size of the abdominal muscles and subcutaneous fat, the student was placed in a supine position with knee bends. The assessor sat on the seat next to the examiner and the assessment was performed from the same side, and for the assessment of each side, the examiner was placed on the same side, then a linear ultrasound probing impregnated with an ultrasound gel was placed between the 12th rib and the iliac corset on the front-to-side of the abdomen (33, 42). In this condition, the dimensions of transverse abdominal muscles, internal oblique, external oblique and subcutaneous fat at the end of exhalation (37 and 33) were measured and recorded.

SPSS software version 19 was used to analyze the data. The Intra-Class Correlation Coefficient (ICC) method was used to investigate the absolute repeatability and the Standard Error of Measurement (SEM) method was used to verify the relative repeatability. Minimal Detectable Changes (MDC) method was used to check the minimum measurement error and $p<0.05$ was considered significant.

Results

Healthy high school students with a mean age of 16.26±1.09 years and students with low back pain with a mean age of 15.85±1.03 years were matched based on age and body mass index (Table 1). The values obtained from muscle size and subcutaneous fat of the abdomen in the healthy group by ultrasonography had high repeatabilityinter and intra a day (ICC 80/0). The ICC, SEM, and MDC results ares presented by gender segregation for the healthy group in Table 2. In the low back pain group, the ICC values were lower than the healthy group. In general, the intra-day repeatability values were higher than the repeatability values inter the day. The ICC, SEM, and MDC results for the patient group are presented in table 3.

Table 1. Demographic characteristics of healthy teens and patients participating in the repeatability study (N=30)

Variable	Male				Female			
	Healthy		Patient		Healthy		Patient	
	Mean±SD	Domain	Mean±SD	Domain	Mean±SD	Domain	Mean±SD	Domain
Age (year)	16.26±1.09	15-18	15.8±1.03	15-18	16.13±1.06	15-18	16.3±1.15	15-18
Weight(kg)	71.06±10.97	50-86	69.9±7.57	59-88	56.86±8.21	45-69	64.6±6.67	56-73
Height (m)	1.75±0.06	1.63-1.86	1.71±0.057	1.64-1.81	1.66±0.056	1.52-1.75	1.67±0.05	1.58-1.78
BMI (Kg/m2)	23.11±3.02	17.37-27.85	23.8±2.5	20.75-26.86	22.56±3.19	15.76-27.7	23.12±2.79	21.08±25.86

[DOR: 20.1001.1.15614107.1396.19.8.2.7]
[DOI: 10.22088/jbums.19.8.12]

Table 2. ICC, SEM, and MDC values for inter-day and intra-day repeatability in healthy groups (N=30)

Variable / Repeatability		intra-day			inter-day		
Muscle (mm)	Evaluation side	ICC(mm)	SEM(mm)	MDC(mm)	ICC(mm)	SEM(mm)	MDC(mm)
Transverse abdomen	Right	0.93	0.2	0.4	0.82	0.22	0.44
	Left	0.9	0.14	0.28	0.81	0.2	0.4
internal oblique	Right	0.95	0.28	0.55	0.91	0.24	0.48
	Left	0.96	0.28	0.55	0.95	0.3	0.59
external oblique	Right	0.85	0.3	0.59	0.87	0.28	0.55
	Left	0.9	0.28	0.55	0.88	0.3	0.59
subcutaneous fat	Right	0.98	0.14	0.28	0.96	0.17	0.34
	Left	0.97	0.14	0.28	0.98	0.1	0.2

Table 3. ICC, SEM, and MDC values for inter-day and intra-day repeatability in patients with low back pain (N=30)

Variable / Repeatability		intra-day			inter-day		
Muscle (mm)	Evaluation side	ICC(mm)	SEM(mm)	MDC(mm)	ICC(mm)	SEM(mm)	MDC(mm)
Transverse abdomen	Right	0.9	0.17	0.34	0.86	0.2	0.4
	Left	0.79	0.26	0.52	0.8	0.3	0.59
internal oblique	Right	0.93	0.14	0.28	0.89	0.2	0.4
	Left	0.92	0.14	0.28	0.89	0.17	0.34
external oblique	Right	0.9	0.22	0.44	0.89	0.2	0.4
	Left	0.98	0.1	0.2	0.97	0.17	0.34
subcutaneous fat	Right	0.98	0.1	0.2	0.94	0.22	0.44
	Left	0.96٠/	0.17	0.34	0.91	0.2	0.4

Discussion

According to the results of the present study, intra-day and inter-day repeatability was high in both healthy and patient groups, intra-day repeatability was higher than inter-day repeatability, and also the results showed that in patients with low back pain, the repeatability values of ultrasonography were lower than normal people. Many studies looked at the repeatability of ultrasound in evaluating spinal stabilization muscles in healthy people and those with low back pain and neck pain (25, 33-39).

Ghamkhar et al., in an examination of the repeatability of ultrasound in evaluating abdominal muscle thickness in healthy adults and those with low back pain, showed that ultrasound is a high repeatability imaging technique for measuring muscle size (42). Also, Hides and colleagues showed high repeatability between testers by ultrasound assessment of abdominal muscle size during adult Valsalva maneuver. The ICC reported in this study was 0.97 (27). The results of the present study in teenagers were in line with the results of previous studies in adults and intra day repeatability values (ICC=0.92-0.97) and inter day repeatability (ICC=0.087-0.96) have been high. Repeatability of an ultrasound device for evaluation of local abdominal muscles in adults with low back pain has also been reported.

Previous studies showed that (33,37) in the control group ICC values were high for most muscle thickness parameters (ICC<80). In the Patientgroup, the ICC values were slightly lower than the control group (ICC=0.77). In the study of Mannion et al., which determined the inter day repeatability of ultrasonic abdominal musclesvalues in valsalva maneuver condition in healthy people and others with low back pain, showed in both groups, the accuracy of measurement of muscle thickness and relative changes in muscle thickness during valsalva maneuver, was acceptable. SEM values for various thicknesses in the control group were about 0.41 to 1.03 mm and in the group with low back pain it was reported 0.27 to 1.25 mm (43). Oliveria et al. reviewed the ultrasound repeatability for the evaluation of abdominal muscle thickness, muscle activation, and muscle thickness

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changes in post-treatment in patients with low back pain. They had reported high repeatability values for muscle thickness (ICC=0.97, SEM=0.04, MDC=0.11), mean values of muscle thickness changes (ICC 0.72, SEM 15%, MDC 41%). Comparing the results of this study with previous studies, it can be concluded that the repeatability of studies in patients with low back pain was approximately the same as in studies in healthy subjects (44).

The results of this study are in line with the results of some previous studies in adults with low back pain and the value of repeatability of ultrasonography in teenagers with low back pain was lower than healthy adolescents. The ICC value in adolescents was between 0.79 and 0.98, which is lower than the ICC that was about 0.85 to 0.98 in the healthy group. SEM value was similar in both groups and was about 0.1 to 0.2 for those with low back pain and 0.1 to 0.3 for healthy subjects.

Previous studies on the evaluation of the repeatability of the amounts of muscle size in children by ultrasound were performed in patients with neuromuscular disorders and healthy children on upper and lower muscles (34, 38, 39), and so far, a study to investigate repeatability of the ultrasound method to assess the size of the local muscles of the abdomen and the size of the subcutaneous fat of children has not been found. Pillen et al. reported ultrasound sensitivity about 0.92 and specialty about 0.90 that were high for diagnosis of musculoskeletal pathologies and differentiation among healthy subjects (39).

Another study by Pillen et al. with the aim of determining the sensitivity of ultrasound to diagnose children with mitochondrial dysfunction was done, that the sensitivity of ultrasound to detect mitochondrial dysfunction was low (25 to 46%), but a higher sensitivity for the diagnosis of mitochondrial disorders 5 years and older of healthy children has been reported (38). The results of this study to evaluate the repeatability of ultrasound in the evaluation of local abdominal muscles are in line with the results of other studies in teenagers. The results of this study showed that sonography can be used as a high repeatability measurement method for evaluating abdominal muscles in healthy teenagers and others with low back pain. The most important factors affecting the repeatability of an ultrasound machine to measure the local muscles of the abdomen and subcutaneous fat include: the probe position of the ultrasound machine, the applied pressure on the probe of the ultrasound machine during the measurement, the position of the tester and the patient that may affect the accuracy of the images and inhale and exhale status. In addition, the high ICC value is important in repeatability studies, but the low standard error of measurement (SEM) is also useful (45).

Because the minimum discriminating difference (MDC) value is obtained from the SEM-based muscle size. The MDC value is equal to at least twice the SEM value, or more precisely, its value is calculated from the u of the SEM ridge at 96/1 (45). In the study of Springer and his colleagues, the SEM value for transverse abdominal muscle at rest position was reported at a rate of about 0.31 mm during three times measurement (46).

In the present study, the SEM values for intraday measurement were about 0.05-0.41 mm and for interday measurement were about 0.1 to 0.3 mm. In general, we can conclude from this study that the repeatability of ultrasound to measure and evaluate the local muscles of the abdomen and subcutaneous fat was high in high-school adolescents and others with chronic nonspecific low back pain. Future studies with a higher sample size and other age groups such as children in elementary schools and primary schools are recommended. It is also suggested that the repeatability of the ultrasound device to evaluate the size of other lumbar stabilization muscles, such as multiphydus, as well as in both resting and contraction conditions.

Acknowledgments

Hereby, we would like to thank the Department of Education in Tehran and Education Departments of various districts of Tehran, and physical education managers and teachers of the high schools that were sampled, as well as from all healthy high school adolescents and others with low back pain and their parents to cooperate in the investigation.

[DOR: 20.1001.1.15614107.1396.19.8.2.7]
[DOI: 10.22088/jbums.19.8.12]

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[DOI: 10.22088/jbums.19.8.12]