

Ultrasonography in The Assessment of Abdominal Muscles Thickness in Adolescents: A Reliability Study

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Abstract

Objective The purpose of this study was to investigate the reliability of ultrasound in the assessment of abdominal muscles thickness in healthy adolescents.

Materials and Methods: Thirty healthy adolescents (15 girls and 15 boys) with the age range of 15-18 years were selected through a sample of convenience method. Abdominal muscles thickness (including transverse abdominis, internal oblique and external oblique) was measured at both right and left sides using US. 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.

Results: Data analysis demonstrated high within and between-day reliability with high Intra-class Correlation Coefficient values (ICC) 0.86 to 0.96 for within-day measurements and 0.80 to 0.95 for between-day measurements and high level of agreement between measurements. Moderate between-day reliability was found for right side of transverses abdominis in boys (ICC=0.72) and left side of transverses abdominis in girls (ICC=0.70).

Conclusions: The results revealed that US can be considered as a highly reliable tool to assess abdominal muscles thickness when measurements are taken in healthy adolescents by the same investigator.

Keywords: Abdominal muscles; Adolescents; Reliability; Ultrasonography; Pediatrics

Spine stability is believed to be controlled by deep stabilizer muscle especially abdominal (transverse abdominis, internal oblique and external oblique) and multifidus muscles (Hodges et al). In patients with LBP, the abdominal and multifidus muscles thickness may decrease and muscle atrophy can be recorded (Hides). Some imaging techniques such as magnetic resonance imaging (MRI) (Hides), electromyography (EMG) (McMeeken, Mohseni-Bandpei), and ultrasonography (US) (Rahmani), are available to detect these changes. Many studies demonstrated that among these instruments, US was shown to be a more accessible, reproducible, not expensive and accurate means to evaluate abdominal muscles thickness in healthy adults and those who experienced LBP (Nabavi).

Previous studies investigated the reliability of US in the assessment of skeletal muscles in healthy children, and those who were suspected to neuromuscular diseases (Pillen). Through searching all available databases, only two studies (Linek) were found investigating the reliability of US in the assessment of abdominal muscles thickness in adolescents.

However, no published study was identified conducted on abdominal muscles in Iranian adolescents. Consequently, the purpose of this study was to investigate the intra rater reliability of US in the evaluation of abdominal muscles thickness in healthy adolescents.

Material and methods

Participant

Thirty healthy adolescents (15 girls and 15 boys) with the age range of 15 to 18 years, from high schools in Tehran province, voluntarily participated in this study. The study was received ethical approval from the Medical Ethics Board at the University of Social Welfare and Rehabilitation Sciences. All participants were provided written information sheet explaining the aim and purpose of the study and then they were asked to sign a consent form if they were willing to take part. Subjects were included if they were between 15-18 years old and distinguished to be in a healthy condition according to the physical examination and history taking without any experience of LBP. The exclusion criteria for all subjects were any history of spinal fracture, spinal deformity like scoliosis or lumbar hyper lordosis and thoracic kyphosis, any neurologic disorder, respiratory disease,

Introduction

Low back pain (LBP) is one of the most complicated and costly musculo-skeletal disorders (Airaksinen, Hill and Keating). Some studies showed that LBP is a relatively high prevalent condition in many countries (Mohseni-Bandpei), in children (Mohseni-Bandpei) and adult populations (Mohseni-Bandpei). Mohseni-Bandpei et al reported that the prevalence rate of LBP in children (11-14 years old) was relatively high with a prevalence rate of 17.4% (Mohseni-Bandpei).

rheumatoid arthritis and children above 18 years old. All screening program was performed by an experienced physician.

Imaging technique

A real time ultrasound (Ultrasonix, Medical Corp., ES 500, Canada) with a linear probe (7.5 MHZ) was used to measure abdominal muscles including transversus abdominis (TrA), internal oblique (IO) and external oblique (EO) thickness. As it is addressed by Pillen et al 2008, diagnostic frequencies lie in the range of 2–20 MHZ, with corresponding wavelengths of 0.8–0.08 mm. To achieve the best resolution, transducers with a high frequency are preferable. However, the depth of penetration is correlated inversely with frequency. Generally, 5- or 7.5-MHZ probes are used in muscle ultrasound studies, to ensure sufficient depth penetration. One qualified examiner (NR) with 4-year experience of working with US who was blind to the subjects has taken all images. The investigator (NR) was involved in measuring abdominal muscles thickness in a big project including children and adults. Therefore, she was kept blind and did not know which group of participants belonged to which project.

The second examiner (IA), who was also blind to the images, measured all saved images and the third one (MAMB) performed data analysis. Each subject was positioned in a relaxed crook lying position. The linear probe of US was rubbed to the ultrasonic gel and placed 25 mm antero-medial to the midpoint between the 12th rib and the iliac crest at the ending of exhalation phase to obtain the best image from three mentioned abdominal muscles (Linek). Application of US was reported to be a valid and reliable tool in other population (Ghamkhar, Mohseni Bandpei, Rahmani). The US measurements were made bilaterally. In order to test within-day and between-day reliability of US, three images were taken. Two images were obtained in one day with the period of 1 hour to assess within-day reliability and the third image was recorded after one week to assess between-day reliability (Rosner). All images were saved and presented on the computer for further analysis. In order to prevent the effect of food and fluid consumption on the abdominal muscles thickness, subjects were asked not to eat and drink anything after having breakfast and then, all images were taken between 10 to 12 am.

Statistical analyses

The Intra-class Correlation Coefficient (ICC) and Standard Error of Measurement (SEM) were used to evaluate within-day and between-days reliability of measuring abdominal muscles and subcutaneous fat thickness using sonography. Richman et al (Richman et al 1980) suggested that the reliability coefficient values of 0.80-1.00 indicate high, 0.60-0.80 moderate and less than 0.59, questionable reliability. In this study the results of above study were used to determine the quality of the reliability coefficient values.

The Bland and Altman method was used to investigate the amount of agreement between two sets of data. It means that high correlation does not indicate the high agreement as correlation shows the strength of a relation between two data. In this method, 95% confidence interval (CI) of the range of

differences between two measurements was used (Bland and Altman).

Results

The demographic data of all subjects are shown in Table 1.

Table1: The demographic characteristics of all subjects.

Girls		Boys		
Range	Mean (SD)	Range	Mean (SD)	Variable
15-18	16.13 (1.06)	15-18	16.26 (1.09)	Age (Years)
45-69	56.86 (8.21)	50-86	71.06 (10.97)	Weight (Kg)
1.52-1.75	1.66 (0.056)	1.63-1.86	1.75 (0.06)	Height (Meter)
15.76-27.75	20.56 (3.19)	17.37-27.85	23.11 (3.02)	BMI (Kg/M2)

BMI: body mass index, SD: standard deviation

Table 2 demonstrates the ICC and SEM values of within-day and between-day reliability of US in the assessment of abdominal muscles thickness and subcutaneous fat width. The results for all muscles and subcutaneous fat at both sides showed a high within-day and between-day reliability with ICC values greater than 0.80. The between-day reliability for all muscles and subcutaneous fat was less than within-day reliability but the results still showed excellent reproducibility.

Table2: Within-day and between-days reliability of measuring abdominal muscle thickness using ultrasound

	Between-days reliability			Within-day reliability	
SEM	ICC	SEM	ICC	Sides	Muscles
1.49	0.83	0.86	0.92	Right	Transversus abdominis
1.18	0.8	0.64	0.9	Left	
4.88	0.92	2.44	0.95	Right	Internal oblique
2.79	0.95	2.45	0.96	Left	
2.58	0.87	2.69	0.86	Right	External oblique
2.71	0.89	2.36	0.91	Left	
1.09	0.97	0.61	0.98	Right	Subcutaneous fat
0.56	0.98	0.69	0.97	Left	

ICC: intra-class correlation coefficient, SEM: standard error of measurement

The results of within-day and between-day reliability of US in the assessment of abdominal muscles and subcutaneous fat in girls and boys were demonstrated in Table 3. The ICC values for

within-day reliability of all measurements, for both sides in girls and boys, were high except for left side of TrA muscle in girls which demonstrated moderate reliability. The results also demonstrated high between-day reliability with high ICC values in all measurements except for TrA muscle at right side in boys and TrA muscle at both right and left side in girls which demonstrated moderate reliability (Table 3).

Table3: Within-day and between-days reliability of measuring abdominal muscle thickness using ultrasound in boys and girls separately

ICC: intra-class correlation coefficient, SEM: standard error of measurement

Between-days reliability		Within-day reliability		Boys/ Girls	Sides	Muscles
SEM	ICC	SEM	ICC			
1.03	0.72	0.41	0.87	Boys	Right	Transversus abdominis
0.45	0.88	0.39	0.91	Girls		
0.54	0.78	0.22	0.93	Boys	Left	
0.53	0.7	0.37	0.73	Girls		
2.86	0.85	1.38	0.92	Boys	Right	Internal oblique
1.85	0.86	1.05	0.91	Girls		
2.07	0.93	0.98	0.97	Boys	Left	
0.7	0.93	1.43	0.87	Girls		
1.15	0.87	1.19	0.83	Boys	Right	External oblique
1.35	0.84	1.49	0.85	Girls		
1.47	0.89	1.41	0.89	Boys	Left	
1.1	0.77	0.63	0.87	Girls		
0.29	0.98	0.23	0.98	Boys	Right	Subcutaneous fat
0.77	0.95	0.37	0.97	Girls		
0.26	0.98	0.31	0.98	Boys	Left	
0.29	0.98	0.37	0.97	Girls		

Figures 1 to 3 are examples which display an agreement between measurements taken on different occasions, for TrA muscle. The limits of agreement were defined as the mean difference of the two measurements +2 standard deviations. As suggested, the mean difference should be zero or no significant difference between two means. For example, Figure 1 shows a comparison of muscle thickness between first (RtTrA1) and second (RtTrA2) measurements for right side of TrA muscle. The mean difference is -0.03 with 95% CI of -0.50 to 0.47 cm which indicates a high level of agreement between two measurements

(Bland an Altman, 1986). Results revealed that there was a high level of agreement between measurements except for right side of TrA in boys and both sides of the same muscle in girls which were found moderately reliable. As it can be seen in Figure 3, the mean difference is -0.07 with 95% CI of -0.56 to 0.38 cm which indicates a moderate level of agreement between two measurements.

Figure1: Differences between pairs of measures plotted against the mean of those pairs for transversus abdominis muscle thickness on the

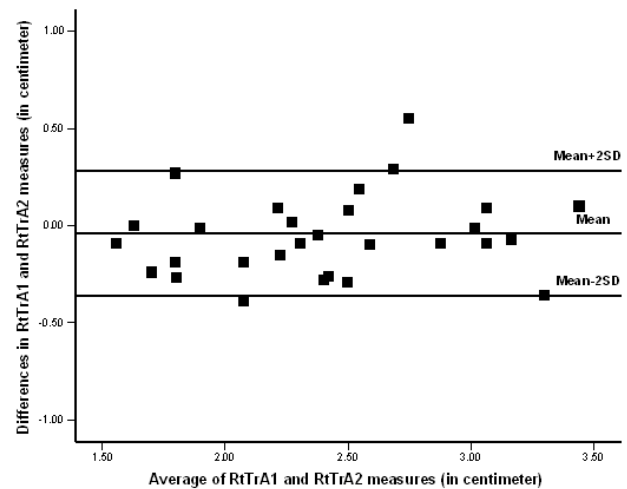


Figure2: Differences between pairs of measures plotted against the mean of those pairs for transversus abdominis muscle thickness over

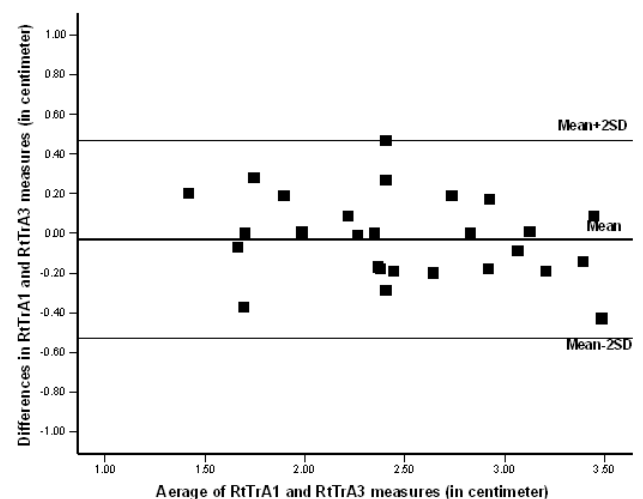
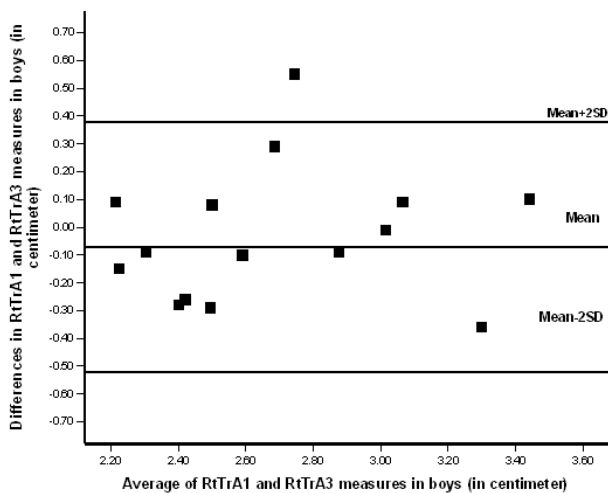


Figure3: Differences between pairs of measures plotted against the mean of those pairs for transversus abdominis muscle thickness in boys over seven days



Discussion

The results of the present study showed that US is a highly reliable imaging technique to evaluate abdominal muscles and subcutaneous fat dimension in healthy adolescents at rest. This study, is the first study of its kind, investigated the reliability of US in the assessment of abdominal muscles thickness in Iranian adolescents.

Many studies were performed on the reliability and validity of US in the evaluation of spine stabilizer muscles (abdominal and multifidus muscles) in healthy adults and patients with LBP and neck pain (Gnat, Javanshir, Koppenhaver). For example, Ghamkhar et al in a systematic review reported that US was a reliable and valid technique to assess abdominal muscles thickness in healthy subjects and patients with LBP (Ghamkhar). Also, in the study carried out by Hides et al on the intra-rater reliability of US to evaluate abdominal muscles during abdominal hollowing maneuver in adults, a high intra-rater reliability of US with ICC greater than 0.97 was reported (Hides). The results of the present study in adolescent population are in agreement with the studies carried out in adult population.

As regards with the implications of less than high correlation values for the right TrA in boys and left TrA in girls, detailed analysis demonstrated that the confidence interval (CI) of these two ICCs were at the same range and covered each other. Therefore, it was considered that these two ICCs have an acceptable level of reliability. The CI for between-day reliability of right TrA in boys was 0.54-0.84 which was well within the range of CI for between-day reliability of left TrA (0.44-0.97). The CI for between-day reliability of right TrA in girls was 0.49-0.92 which was well within the range of CI for between-day reliability of left TrA (0.41-0.94).

Previous studies mainly were conducted on the reliability and application of US in the assessment of skeletal muscles thickness in children suffered from neuromuscular diseases (Pillen,). Pillen et al investigated the sensitivity and specificity of US in detection of children with and without neuromuscular diseases compared to visual assessment. They reported that US had high sensitivity (92%) and high specificity (90%) to detect muscle pathology and to differentiate between children with and

without neuromuscular diseases (Pillen). Another study conducted by Pillen et al in order to determine the sensitivity of US in the assessment of children with mitochondrial disorder. They showed that the sensitivity of US was relatively low (25-46%). According to their conclusion, US was not an appropriate method to evaluate children with mitochondrial disease but the diagnostic value of US was higher in children over five years (Pillen). The results of this study demonstrated that US can be considered as a reliable tool to assess abdominal muscles and subcutaneous fat thickness in healthy adolescents. It can also be used as an index to monitor the effect of different interventions and to detect any abnormalities of abdominal muscles in children.

The results of two recent studies carried out with the purpose of the investigation of reliability of sonography on abdominal muscles thickness in healthy adolescents showed that sonography was a reliable method to assess muscle thickness in adolescent population (Linek). In a study conducted by Linek et al to determine the reliability of abdominal sonographic measurements in adolescents in different positions, indicated that sonography was a high reliable technique to assess TrA and IO thickness in different body positions and there was a satisfactory reliability for EO sonographic measurements only in the supine position (Linek). Another study carried out by Linek et al, the reliability of sonography in the assessment of abdominal muscles thickness in children and adolescents at rest and during the active leg raise (ASLR) test was investigated. The results revealed that US was a reliable imaging technique in children and adolescents, at rest and during exercise (Linek). The findings of the present study are consistent with the results of these two studies.

Limitations

The current study might suffer from some limitations which are as follows: a) this study was carried out on healthy children and the measurements were taken at rest state which can be considered as limitations of the study; b). Although this study conducted on 30 healthy children (15 boys and 15 girls) and the sample size seemed sufficient but it is considered as small sample size which might be a shortcoming of the present study; c) The study was carried out only in healthy children and not in children with musculoskeletal disorders. Although measurements were taken two hours after breakfast and subjects were asked not to eat between, the conditions of subjects' bladder were not checked which might have an effect on the thickness of abdominal muscles.

Clinical applications

The results of the present study provide basic information for those researchers who are interested in investigating abdominal muscles morphology using sonography in adolescent population. The findings can also be applied to monitor the effect of different rehabilitation approaches in the treatment of children and adolescents with LBP.

Future studies with appropriate designs are recommended to investigate the reliability of US in the assessment of other stabilizer muscles in healthy children and also in children suffering from different types of musculo-skeletal disorders

including LBP. Also further studies are needed to demonstrate the reliability of US in children younger than 15 years old.

Conclusion

The results demonstrated that US is a highly reliable and reproducible imaging tool to measure abdominal muscles size in children. In addition to being non-invasive, accessible, and not expensive, it is one of the most favorable techniques for children because of producing no pain and consuming less time.

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