J. Phys. Ther. Sci.
27: 1373–1375, 2015

Original Article

Reliability of ultrasound imaging of the transversus abdominis muscle in asymptomatic subjects

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Abstract. [Purpose] The purpose of this study was to assess intra-rater and inter-rater procedural reliability of ultrasound imaging measurements of transversus abdominis thickness. [Subjects] Thirty therapists who attended the B Hospital in Hwaseong participated in the study. [Methods] Two examiners assessed transverse abdominis thickness at rest and during contraction. Intra-class correlation coefficient with 95% confidence interval and, standard error of measurement were calculated. [Results] The intra-rater procedural reliability of ultrasound imaging measurements of transverse abdominis thickness, assessed using the intra-class correlation coefficient, was 0.65–0.86 (within-day, 0.65–0.86; between-day, 0.77–0.85). The inter-rater procedural reliability of ultrasound imaging measurements of transverse abdominis thickness, assessed using the intra-class correlation coefficient, was 0.72–0.86 (within-day, 0.72–0.86; between-day, 0.82–0.83). [Conclusion] Ultrasound imaging can be used as a reliable method for measurements of transverse abdominis thickness.
Key words: Reliability, Transversus abdominis, Ultrasound imaging

(This article was submitted Dec. 2, 2014, and was accepted Jan. 11, 2015)

INTRODUCTION

The transversus abdominis (TrA) and lumbar multifidus are deep trunk muscles that play a very important role in spinal stabilization[1, 2)]. Defects in these muscles make anticipatory postural adjustment difficult, which may result in damage to the spinal structure[3)]. In cases where there is a concern that spinal stability may be impacted by an unstable force, the time required for abdominal muscle activation is an indication of the level of low back motor control[4)].

The rehabilitative strategy for treatment of low back pain is alleviation of clinical symptoms, reduction of pain and functional disability, and prevention of recurrence of low back pain by recovery of muscle function in patients with functional abnormality of the lumbopelvis[5)]. In researching clinical rehabilitation approaches and strategies, reliable and sensitive measurement is important to provide precise and meaningful information on special functional goals using intervention methods. In particular, there has been little research on performance of functional tasks based only on muscle strength and improved endurance relating to abdominal muscle adjustment and coordination. Therefore, rehabilitation methods using ultrasound imaging may be the solution[6)].

The evaluation and rehabilitation of abdominal muscles using ultrasound imaging can reveal the morphology and functioning of deep muscles such as the TrA and offer a new direction in the kinematic management of low back and pelvic pain[7)]. In rehabilitation using ultrasound imaging, the process of contraction and relaxation in muscle activation needs to be assessed; thus, accuracy when taking measurements at different time points is crucial[8)].

This study aimed to measure the TrA thickness in healthy adults using ultrasound imaging and assess intra-rater and inter-rater reliabilities based on the results.

SUBJECTS AND METHODS

Subjects

The subjects in this study were 30 physical therapists (males: 20, females: 10) working in B Hospital located in Hwaseong. The age, height, and weight of the subjects were 28.78 ± 7.93 years old, 166.71 ± 10.67 cm, and 61.12 ± 9.39 kg, respectively. The exclusion criteria included prior low back surgery, inability to assume supine or prone positions, and diagnosis of cauda equina syndrome, fracture, cancer, infection, or a systemic disease. The subjects listened to an explanation of the study and voluntarily signed an agreement to participate. The experimental protocol was in compliance with the ethical standards of the Declaration of Helsinki.

Methods

The thickness of the TrA was measured using an ultra-

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Table 1. Intra-rater reliability data of ultrasound imaging for measurement of TrA thickness

	Mean±SD (cm)	ICC(3,2) (95% CI)	SEM
Within-day reliability			
Rest	0.32±0.02	0.65 (0.26–0.83)	0.015
Contraction	0.41±0.04	0.86 (0.70–0.93)	0.015
Between-day reliability			
Rest	0.32±0.02	0.77 (0.52–0.89)	0.013
Contraction	0.40±0.03	0.85 (0.69–0.93)	0.015

TrA: transversus abdominis; SD: standard deviation; ICC: intra-class correlation coefficients; 95% CI: 95% confidence interval; SEM: standard error of measurement

Table 2. Inter-rater reliability data of ultrasound imaging for measurement of TrA thickness

	Mean±SD (cm)	ICC(3,2) (95% CI)	SEM
Within-day reliability			
Rest	0.32±0.02	0.72 (0.41–0.87)	0.011
Contraction	0.41±0.04	0.86 (0.71–0.94)	0.008
Between-day reliability			
Rest	0.33±0.02	0.83 (0.63–0.92)	0.014
Contraction	0.41±0.04	0.82 (0.62–0.91)	0.015

TrA: transversus abdominis; SD: standard deviation; ICC: intra-class correlation coefficients; 95% CI: 95% confidence interval; SEM: standard error of measurement

sound imaging system (LOGIQ e Portable, GE Inc., Tempe, AZ, USA) and a 7.5 MHz linear probe. TrA thickness was measured based on the image using the Image J software (National Institute of Mental Health, Bethesda, MD, USA).

In order to photograph the same measurement areas of the subjects, an ultrasound transducer was positioned on the right superior iliac crest along the mid-axillary line[9]. To measure the TrA during the resting state, the subjects were instructed to assume a hook-lying position and extend their arms bilaterally beside their trunks. To measure the TrA during contraction, the subjects were asked to extend their hips and knees in the supine position and raise and hold their legs 20 cm from the table[8]. The TrA was measured three times. The first two measurements were taken at one-hour intervals (for within-day reliability), and the third measurement was taken after one week (for between-day reliability). The thickness of the TrA was measured from the superficial line to the deep hyperechoic fascial lines. The facial lines that appeared during measurement were the external oblique muscle in the highest location, the internal oblique muscle in the middle location, and the TrA muscle in the lowest location. The upper and lower distances of the third facial line were measured. In order to prevent order effects and fatigue, one researcher took the measurements and the other researcher obtained the images and measured the thickness of the images on the screen.

The demographic characteristics and TrA thickness of the subjects were expressed as average and standard deviation. In order to evaluate TrA thickness, intra-rater reliability and inter-rater reliability using ultrasound imaging, the intra-class correlation efficient, 95% confidence interval, and standard error of measurement were analyzed. A reliability coefficient smaller than 0.4, higher than 0.4 and lower than 0.75, and 0.75 or higher indicated poor reproducibility, good reproducibility, and excellent reproducibility, respectively[10]. Statistical analysis was performed using SPSS (ver. 18.0 for Windows, IBM/SPSS Inc**.,** Chicago, IL, USA).

RESULTS

The intra-rater reliability for measurement of TrA thickness during the resting state and during contraction was between 0.65 and 0.77 with good reproducibility and between 0.85 and 0.86 with excellent reproducibility, respectively (Table 1). The inter-rater reliability was between 0.72 and 0.83 with good reproducibility during the resting state and between 0.82 and 0.86 with excellent reproducibility during contraction (Table 2).

DISCUSSION

Functional damage and weakening of the TrA and multifidus muscles is a cause of low back pain, and the TrA plays a crucial role in spinal stability[11]. Low back pain patients have reduced TrA thickness compared to healthy individuals[12].

This study involved 30 adults in their 20s. TrA thicknesses were measured during resting and contraction states using ultrasound imaging three times at first, three times one

hour later on the same day, and three times on a different day to measure intra-rater and inter-rater reliabilities.

Research on ultrasound imaging of the TrA and multifidus muscles has shown high reliability[13–15]. Tahan et al.[13] measured the TrA during the resting state and during contraction using ultrasound imaging, noting a high correlation. Critchley et al.[16] identified increases in the thickness of the deep muscles in comparative research on chronic low back pain patients and healthy individuals. Park[17] studied the abdominal drawing-in maneuver during contraction and assessed the intra-rater reliability of TrA thickness. The intra-rater reliability was 0.55 during the resting state and 0.82 during contraction, and the inter-rater reliability of the TrA thickness was 0.77 during the resting state and 0.90 during contraction. The reason for a low intra-rater reliability was that measurements were taken during different sessions. The results of the present study show that the intra-rater reliability was 0.65–0.77 during the resting state and 0.85–0.86 during contraction, and the inter-rater reliability was 0.72–0.83 during the resting state and 0.82–0.86 during contraction, similar to the results of previous studies.

Based on the results of the present study, measuring the thickness of the TrA using ultrasound imaging is a highly reliable method and can be recommended as a useful tool to identify the recovery process of weakened muscles by evaluating the functioning of the deep muscles in the rehabilitation of patients with low back pain. The limitations of the present study are as follows. The subjects were all in their 20s, making it difficult to generalize the results to all age groups; different deep muscles were not measured; and patients with low back pain were not included. Future research should compare the reliability of ultrasound imaging after patients with low back pain have performed rehabilitation exercises.

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