

Reliability of Ultrasound Imaging of the Transversus Deep Abdominal, Internal Oblique and External Oblique Muscles of Patients with Low Back Pain Performing the Drawing-in Maneuver

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Abstract. [Purpose] The purpose of this study was to investigate the reliability of ultrasound imaging (USI) measurements of muscle thicknesses of patients with low back pain (LBP) performing the abdominal drawing-in maneuver (ADIM) [Subjects] Twenty patients with LBP were the subjects. [Methods] Muscle thickness measurements of transversus abdominis (Tra), internal obliques (IO), and external obliques (EO) muscles were measured using ultrasound imaging at rest and during performance of the ADIM. [Results] The intra-examiner reliability estimates ranged from 0.55 to 0.97 in the rest position, and from 0.82 to 0.95 during ADIM. The inter-examiner reliability estimates ranged from 0.77 to 0.98 in the rest position, and from 0.86 to 0.98 during ADIM. [Conclusion] ADIM thickness measurements of the Tra, IO, and EO muscles in patients with LBP based on the mean of 2 measures are highly reliable when taken by a single examiner and adequately reliable when taken by different examiners.

Key words: Reliability, Abdominal drawing-in maneuver, Ultrasound imaging

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INTRODUCTION

Low back pain (LBP) is one of the major health problems in western industrial societies with a life time prevalence of 84%¹⁾. One hypothesis for the development of LBP is that there is a dysfunction in the control of the abdominal and back muscles²⁾. Richardson et al.³⁾ suggest that this change in spinal control is due in part to dysfunction in local segmental muscles, such as the transversus abdominis. Most reliability studies have used a volitional task known as the abdominal drawing-in maneuver (ADIM)^{4, 5)}. Two aspects of muscle function that can be assessed using imaging techniques are muscle size (MRI, CT, ultrasound imaging) and muscle contraction (ultrasound imaging). The clinical relevance of these techniques is that they allow documentation of morphology and dynamic muscle function in both healthy subjects and those with acute and chronic low back pain⁶⁾. Hodges et al.⁷⁾ found strong correlations between muscle thickness changes of Tra and IO, and EMG activity at less than 20% of maximum voluntary contraction, but found no correlation for EO. Hodges and Richardson suggested using rehabilitative ultrasound imaging, a non-invasive and low-cost method, to observe the changes in the deep abdominal muscles⁸⁾.

However, there exist no previous studies of USI of the Tra, IO and EO muscles. The purpose of this study was to assess the intra- and inter-rater reliabilities of Tra, IO and EO ultrasound image (USI) measures in a suitable sample

of subjects with LBP (n =20) using the generalizability theory as a framework .

SUBJECTS AND METHODS

A convenience sample of 20 LBP subjects (mean \pm SD age = 28.83 \pm 11.13 years, height = 166.83 \pm 12.50 cm, weight = 61.17 \pm 9.60 kg, duration = 13.65 \pm 10.24 months) volunteered for this study at a local orthopedic clinic. Subjects had pain scores ranging from 5 –7 on a visual analogue scale, and scores of 40–60% on the Korean version of the Oswestry disability index. LBP was defined as current symptoms of pain and/or numbness between the twelfth rib and buttocks with or without symptoms in one or both legs that limited function⁹⁾. Participants were excluded if they had received lumbar surgery were unable to lie prone or supine for a minimum of 20 minutes or presented with potentially serious conditions such as cauda equina syndrome, major or rapidly progressing neurologic deficit, fracture, cancer, infection, or systemic diseases.

This study used ADIM to draw in and hold the lower abdomen at maximum expiration in a supine position. Verbal instructions for the ADIM were “Draw your belly inward and upward while breathing normally, then hold the contraction for 10 seconds.” ADIM was performed 3 times, with 10 second rest periods¹⁰⁾. Before progressing to the main experiment, the subjects were educated in the method of ADIM and practiced 3 sets to decrease errors arising from incorrect performance.

Rest and ADIM thicknesses of the Tra, IO and EO were

obtained using a LOGIQ P5 (GE Healthcare, USA) with a 7.5-MHz linear probe. Conductive gel was placed between the transducer and subjects skin. The measurements were taken as described by Richardson et al. with the subjects in the supine hook lying position with the transducer placed just superior to the iliac crest along the axillary line¹¹). The transducer head location was marked on the right-hand side of each subject midway between the lowest rib and the apex of the ilium. This has been shown to be the thickest point of the Tra, and demonstrates the clearest simultaneous images of Tra, IO and EO¹²). The thickness of each of the 3 muscles (Tra, IO, and EO muscles) was measured at the center line of the image.

The average of the 3 trials was used in the analysis. In processing data, the version 12.0 program was used. In order to assess the intra-examiner and inter-examiner of the ultrasound imaging intra class coefficients (ICC) were computed.

RESULTS

The intra-rater reliabilities of measurements of Tra, IO and EO were assessed at Rest and during ADIM with subjects in the hook-lying position, Tra at rest had the lowest ICC, 0.55, and EO at rest had the highest ICC, 0.97. Standard error (SEM) ranged from 0.14 to 0.50. For the ADIM, Tra also had the lowest ICC, 0.82, and EO also had the highest ICC, 0.95. SEM ranged from 0.28 to 0.61 (Table 1).

The intra-rater reliability was assessed with Rater1, Rater2 and Rater3, three physical therapists with over 10 years of clinical experience. At rest, the ICCs of Tra, IO and EO ranged from 0.77–0.98 displaying a high level of reliability for Rest. SEM ranged from 0.15 to 0.27. During ADIM, the

ICCs ranged from 0.86–0.98 indicating a high level of reliability. SEM ranged from 0.20 to 0.68 (Table 2).

DISCUSSION

In this study of 20 male and female adults with low back pain, the reliability of USI was assessed using an inter-examiner and intra-examiner test-retest method for measurements of Tra, IO and EO at rest and during ADIM in a supine position. This was conducted through comparison thickness of Tra, IO and EO which used a base of lumbar stabilizer.

Many previous studies have conducted investigations of ultrasound imaging of Tra, IO and EO. Critchley et al.¹² reported abdominal muscle contraction thickness of chronic LBP patients was reduced compared to healthy subjects during the ADIM in a cross-sectional study. Hides et al.¹³ reported the reduced IO contraction thickness in a US sample population may represent a clinically relevant finding, as compared to healthy subjects, increased IO muscle activity with increasing load is reported in LBP patients.

Several reliability studies have investigated the ultrasound imaging of the Tra and lumbar multifidus muscle¹⁴. Most of these studies have shown very high reliabilities (ICC>0.90) and good precision. The results of our present study are in agreement with these of these previous studies.

Inter-rater reliability was better than intra-rater reliability. Consequently, it is much better to use three raters to make ultrasound image measures. In the present study, the intra-rater measurement errors were possibly greater than in previous studies because the raters carried out measures during different sessions, although within the same day.

In this study, even though the factors mentioned above

Table 1. Intra-rater reliabilities of USI measurements of the Tra, IO and EO muscles

Muscle	State	Mean±SD (mm)		ICC (95% CI)	SEM (mm)
		Session 1	Session 2		
Tra	Rest (supine)	3.02±0.65	3.29±0.96	0.55 (0.15–0.79)	0.14
	Contracted (ADIM)	4.49±1.27	4.62±1.16	0.82 (0.60–0.92)	0.28
IO	Rest (supine)	7.61±2.24	7.76±2.38	0.92 (0.82–0.97)	0.50
	Contracted (ADIM)	9.16±2.75	9.43±3.13	0.94 (0.86–0.97)	0.61
EO	Rest (supine)	5.09±1.75	5.05±1.99	0.97 (0.93–0.98)	0.39
	Contracted (ADIM)	4.16±1.34	4.00±1.36	0.95 (0.87–0.98)	0.30

ICC intraclass correlation coefficient; CI confidence interval; SEM standard error of measurement

Table 2. Inter-rater reliabilities of USI measurements of the Tra, IO and EO muscles

Muscle	State	Mean±SD (mm)			ICC (95% CI)	SEM (mm)
		Rater1	Rater2	Rater3		
Tra	Rest (supine)	3.04±0.68	2.93±0.70	3.08±0.68	0.77 (0.59–0.89)	0.15
	Contracted (ADIM)	4.59±1.10	4.70±1.14	4.51±1.24	0.90 (0.81–0.95)	0.24
IO	Rest (supine)	7.92±2.18	8.04±2.28	7.72±2.33	0.98 (0.95–0.99)	0.27
	Contracted (ADIM)	9.72±3.06	9.94±2.98	9.38±3.10	0.98 (0.97–0.99)	0.68
EO	Rest (supine)	5.05±1.24	5.20±1.24	4.89±1.24	0.86 (0.73–0.93)	0.27
	Contracted (ADIM)	3.84±0.93	3.71±0.97	3.69±0.99	0.86 (0.74–0.94)	0.20

ICC intraclass correlation coefficient; CI confidence interval; SEM standard error of measurement

were not completely controlled, the USI measurement of Tra, IO and EO at rest and during ADIM was reliable and offers empirical information about the abdominal muscle thicknesses of low back pain patients.

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