



Original Research

Reliability of Ultrasound Imaging Measures of Transverse Abdominis and Lumbar Multifidus in Various Positions

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Abstract

Objective: To determine the reliability of measurement of muscle activation via ultrasound imaging measures of the transverse abdominis (TrA) and lumbar multifidus (LM) in tabletop, seated, standing, and walking conditions.

Design: Descriptive laboratory study.

Setting: University research laboratory.

Participants: Sixteen healthy participants (age, 20.4 ± 1.8 years; height, 167.7 ± 9.0 cm; mass, 65.1 ± 10.8 kg).

Interventions: None.

Main Outcome Measurements: The activation ratio (AR) of TrA and LM and preferential activation ratio of TrA in tabletop, seated, standing, and walking positions were assessed by the same examiner during 2 ultrasound imaging sessions 24-72 hours apart. Statistical analysis included determination of intraclass correlation coefficients (ICCs) using analysis of variance for each muscle and position between sessions.

Results: Excellent reliability was found in TrA AR between sessions for healthy participants in the tabletop position ($ICC_{3,k} = 0.903$), and acceptable to excellent reliability was found in seated ($ICC_{3,k} = 0.613$), standing ($ICC_{3,k} = 0.553$), and walking ($ICC_{3,k} = 0.737$) positions. LM AR was fair in the tabletop position for these participants ($ICC_{3,k} = 0.264$). The preferential activation ratio for healthy participants was substantially reliable in tabletop and seated positions ($ICC_{3,k} = 0.668, 0.684$) and showed fair reliability for walking ($ICC_{3,k} = 0.455$).

Conclusions: Ultrasound imaging is a reliable method of measuring muscle thickness across multiple positions in healthy persons. This measure may be used to compare abdominal muscle thickness across populations or after interventions. LM AR was only found to be reliable in the tabletop position.

Introduction

The transverse abdominis (TrA) and lumbar multifidus (LM) muscles provide local spinal stabilization for the lumbopelvic region [1]. These muscles are commonly grouped with the global movers in this same area, including the external and internal obliques, as key components for overall core stability [1,2]. Reduced activation of the TrA and LM muscles has been linked to persons with low back pain (LBP), which can plague many individuals, including those who lead an active lifestyle [3-5]. The failure of LBP to resolve presents a problem that can manifest as episodic pain—that is, resolution of symptoms followed by their return, resulting in another active episode of pain [6]. Persons

with LBP and other chronic conditions may have this reduced activation of spinal stabilizing musculature, which could lead to increased pain and decreased neuromuscular function and performance [7-9].

Ultrasound imaging (USI) has been used as a method of estimating activation by measuring muscle thickness of the TrA and LM muscles between rested and contracted states [10]. Most of the current literature focuses on collecting these images in a tabletop position and in healthy persons [11,12]. However, it is important to measure muscle activation in more functional positions such as while seated and standing when the lumbopelvic region experiences loading conditions that are associated with recurrent episodes of nonspecific LBP and other related conditions [13,14].

Reliability of USI measures has been shown to be strong in tabletop positions in both the TrA and LM musculature [12,14]. The reliability of USI measures in loaded, stationary positions has been explored recently but has only included TrA or LM muscles independent of one another or measurement of both muscles in healthy persons only [11,14,15]. Determining reliability of USI measures in progressive postures, culminating in reliability during walking, would provide valuable information for future research. Reliability of methods to calculate muscle activation of the TrA and LM, such as the activation ratio (AR) and preferential activation ratio (PAR) [14,16], also should be considered in addition to the thickness measure reliability. Those calculations aim to isolate the TrA from other abdominal wall measures and attempt to normalize for resting muscle thickness. If thickness measures are shown to be reliable, then the formulas that are based on thickness measures should also be reliable. However, inclusion of the calculations and comparison of the formulae have not often been incorporated into previous reliability studies on the lumbopelvic stabilizing musculature [14]. Before research is able to support any group differences in more functional positions between healthy persons and patients with LBP, the method of measurement must be shown to be reliable.

The purpose of this study was to determine inter-session reliability of muscle thickness measures through USI of the TrA and LM muscles during different positions in healthy persons.

Methods

A descriptive laboratory study was used to examine the between-session reliability for changes in muscle thickness of the TrA and LM muscles during tabletop, seated, standing, and walking conditions. Measures were taken by one assessor (LCM) during 2 different sessions 24-72 hours apart.

Participants

Sixteen healthy persons with no history of LBP or lower extremity injury participated in this study (Table 1). Participants who self-reported a history of more than 3 episodes of LBP within the past 3 years or a minimum of 5 LBP episodes over their lifetime were excluded from this study [17]. Participants reporting pain (ie, >8/10 on a visual analog scale), a history of lumbar surgery, disk diseases, or any other LBP that was previously diagnosed as a specific disease by a physician were also excluded. All participants provided informed consent that was approved by our University's Institutional Review Board for health sciences research.

Table 1
Participant demographics

	Healthy (N = 16) Mean (SD)	Median [Minimum-Maximum]
Age, y	20.4 (1.8)	
Height, cm	167.7 (9.0)	
Mass, kg	65.1 (10.8)	
BMI	23.0 (2.1)	
VAS	0.3 (0.8)	
Godin	54.8 (30.7)	
ODI-S1	0.4 (1.1)	
ODI-S2	0.3 (0.7)	
Frequency of pain		0 [0-0]
Tegner		6 [3-10]
RM-S1		0 [0-0]
RM-S2		0 [0-0]

SD = standard deviation; BMI = body mass index; VAS = Visual Analogue Scale; Godin = Godin Leisure-time Exercise Questionnaire; ODI = Oswestry Disability Index; S1 = session 1; S2 = session 2; Tegner = Tegner Activity Level Scale; RM = Roland Morris Disability Questionnaire.

Instruments

A portable LOGIQ Book XP (GE Healthcare, Waukesha, WI) ultrasound unit with an 8-MHz linear transducer was used to obtain and visualize USI of the TrA and LM muscles during an unloaded tabletop position, as well as during 3 other functional gravity-dependent positions. The Biodex Gait Retainer treadmill (Biodex Medical Systems, Shirley, NY) was used for the walking portion of data collection.

Testing Procedures

Participants reported for 2 testing sessions 24-72 hours apart. A single examiner (LCM) recorded images bilaterally from the lateral abdominal wall and lumbar paraspinal region in several positions and in the following order—tabletop, seated, standing, and walking—to simulate a progression toward more loaded positions that coincide with a typical clinical rehabilitation progression. The order of measurements (right or left, TrA or LM) was randomized.

Positions

After the starting muscle and side were determined via randomization, the participant was positioned on the tabletop either supine for TrA or prone for LM, depending on the starting muscle. Each position is depicted in Figure 1A-H. For tabletop measures, the participant was supine in a hook-lying position with a foam roller under both knees for TrA and prone for tabletop LM image collection. In the seated position, participants sat on a backless stool with feet flat on the floor and knees flexed at 90° and were instructed to sit up straight. Participants were instructed to stand up straight with their arms relaxed at their sides for the

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