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Technical and measurement report

Measuring ultrasound images of abdominal and lumbar multifidus muscles in older adults: A reliability study

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ABSTRACT

Measurement reliability of the L4/5 lumbar multifidus (MF) muscles is high in older adults, but few studies have investigated measurement reliability of the abdominal and upper lumbar MF muscles in this age group.

Objectives: To determine measurement reliability of abdominal and lumbar MF muscles from a single ultrasound (US) image in older adults.

Methods: Resting thickness of rectus abdominis and obliquus externus, resting and contracted thickness of obliquus internus, transversus abdominis and lumbar MF, and resting cross-sectional area (CSA) of MF levels (L2-5) were obtained from US images of 92 community-dwelling older adults (aged 65–89 years). Measurements of images were undertaken by an experienced rater and repeated 7–10 days later for intra-rater, and by a second expert rater for inter-rater calculations. Intra-rater reliability was estimated for all muscles. Inter-rater reliability was estimated for all abdominal muscles and for L5 multifidus. Reliability was estimated by intraclass correlation coefficients (ICC).

Results: Intra-rater ICC(3,1) and inter-rater ICC(2,1) of resting thickness measures of all muscles and CSA of MF were ≥0.86. The ICCs for percentage thickness change were ≥0.76 for the abdominal muscles, and ≥0.42 for MF.

Conclusions: Measurement reliability of US imaging for abdominal and MF muscle thickness and MF CSA was high, and consistent with previous findings for younger adults. Reliability of percentage thickness change was lower suggesting caution is needed when using this as an outcome measure or study factor among older adults.

1. Introduction

Ultrasound imaging (USI) is increasingly used in physiotherapy to quantify abdominal and lumbar muscle performance (Critchley and Coutts, 2002), assess clinical outcomes and provide biofeedback during functional re-education (Hides et al., 2001; Macedo et al., 2009). Reliability of ultrasound (US) measurements is well established for younger adults (Rankin et al., 2006; Hides et al., 2007; Norasteh et al., 2007; Wallwork et al., 2007; Teyhen et al., 2011), but information for older adults remains sparse (Stetts et al., 2009; Sions et al., 2014). Sions examined L4/5 multifidus (MF) only, whilst Stetts examined the lateral abdominals – no paper to date has examined the rectus abdominis or the upper levels of lumbar MF in the older adult. Measuring older adults may be problematic due to age-related changes including increases in the subcutaneous fat layer, or fatty infiltrates between the muscle fibres, which may lead to an increase in echogenicity (Whittaker, 2007). For clinical and research purposes it is important to know if these measurements are sufficiently consistent to have low measurement error under these circumstances.

This study aimed to determine the intra- and inter-rater reliability for the measurement of muscle thickness from stored US

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images of the abdominal and lumbar MF muscles at rest and on contraction, and cross-sectional area (CSA) of the lumbar MF muscles in a sample of community-dwelling older adults.

2. Methods

2.1. Participants

Participants, aged between 60 and 86 years in 2006, were recruited by random selection from the southern Tasmanian electoral roll for a longitudinal cohort study conducted between 2005 and 2011 examining associations between cognition and gait. The only exclusion criteria were living in residential care and presence of any contraindications to Magnetic Resonance Imaging as required by the larger study. The images of participants in the longitudinal study were randomly selected for assessment in this reliability sub-study until 40 complete sets for each muscle group were obtained, which required images from 92 participants. The study was approved by the Human Research Ethics Committee (Tasmania) Network. Participants provided informed consent.

2.2. Instrumentation and image capture

The abdominal and lumbar MF muscles were imaged on both sides in brightness (B) mode using a Phillips HDI 5000 US machine (ATL Ultrasound, Washington, USA) with a hand held curved array transducer. For each participant, USI was performed by one of two operators, a medical specialist (obstetrician) and a senior physiotherapist, both of whom received specialised training in ultrasound imaging of older adults from JH.

2.2.1. Imaging the abdominal muscles

Participants lay supine with pillows under their knees and hips flexed to 45°. Images for rectus abdominis (RA) and obliquus externus (OE) muscles were taken at rest, and images for obliquus internus (OI) and transversus abdominis (TrA) taken at rest and with contraction. Standardised instructions were given for muscle contraction asking participants to 'take a relaxed breath in and out, hold the breath out and then draw in the lower abdomen without moving the spine" (Hides et al., 2007).

Imaging of RA was performed over the anterior abdominal wall immediately above and slightly lateral to the umbilicus, with the muscle centred on the screen (Rankin et al., 2006). Imaging of the lateral abdominal muscles was performed along a line midway between the iliac crest and the inferior angle of the rib cage, and level with the umbilicus. The US transducer was aligned perpendicularly to the anterolateral muscles with the anterior fascial insertion of the TrA muscle aligned approximately 2.0 cm from the medial edge of the US image when the participant was relaxed (Ferreira et al., 2004; Hides et al., 2007).

2.2.2. Imaging the lumbar multifidus

Participants lay in prone with pillows placed under the abdomen to minimise the lumbar lordosis. The lumbar spinous processes were palpated and marked with a pen prior to imaging and then confirmed by imaging them in the sagittal plane using the sacrum as a reference point. Participants were instructed how to perform an isometric contraction of the MF muscle after exhaling. To capture MF muscle thickness the transducer was placed in a longitudinal plane over the spinous process of the marked lumbar spine and moved laterally with the transducer angled medially to capture the zygoapophyseal joints in the lower part of the screen (Wallwork et al., 2009). Image capture for CSA of the relaxed lumbar MF muscles was taken in the transverse plane at each vertebral level from L2–L5.

2.3. Image analysis

Images were saved and measured off-line using ImageJ software 1.36b (http://imagej.nih.gov/ij/) by research physiotherapists who were not involved in image capture. Following 20 h of supervised training by an experienced physiotherapist (JH) with more than 10 years of USI experience, three physiotherapists performed the intra-rater measurements with one rater per muscle grouping (abdominals, lumbar MF linear measurements and lumbar MF CSA). Each image was measured by the same rater on two occasions 7–10 days apart. The order of images was randomly assigned and the rater blinded to image identification and their previous result. For inter-rater reliability, measurements were performed by three expert physiotherapists each with more than 3 years of experience in USI. They were blinded to the original measurer's results. For logistical reasons, inter-rater reliability of lumbar MF measures was only performed at L5.

Measurement of RA was made at the widest part of the muscle and perpendicular to the orientation of the fascia between its inner borders (Fig. 1). A split screen (with resting and contracted images side-by-side) was used to measure thickness of the lateral abdominals and lumbar MF muscles between the inner borders of the fascia at the widest point of the muscle belly (Figs. 2 and 3). CSA measurements of the lumbar MF muscles were taken by tracing the inner borders of the muscle at each vertebral level (Hides et al., 2008) (Fig. 4).

2.4. Data analysis

Percentage thickness change was calculated as 100*(thickness of muscle contracted − thickness at rest)/thickness at rest. Measurement reliability was assessed from the mean difference between pair of measurements, intraclass correlation coefficients (ICC) using (3,1) form for intra-rater and (2,1) form for inter-rater reliability measurements (Shrout and Fleiss, 1979), with the standard error of measurement (SEM) (De Vet et al., 2006), and the minimal detectable change (MDC) (Weir, 2005) calculated. Bland and Altman plots were inspected to identify any systematic patterns in the differences related to the size of the measurements (Bland and Altman, 1986). Stata version 12 was used to analyse the data.

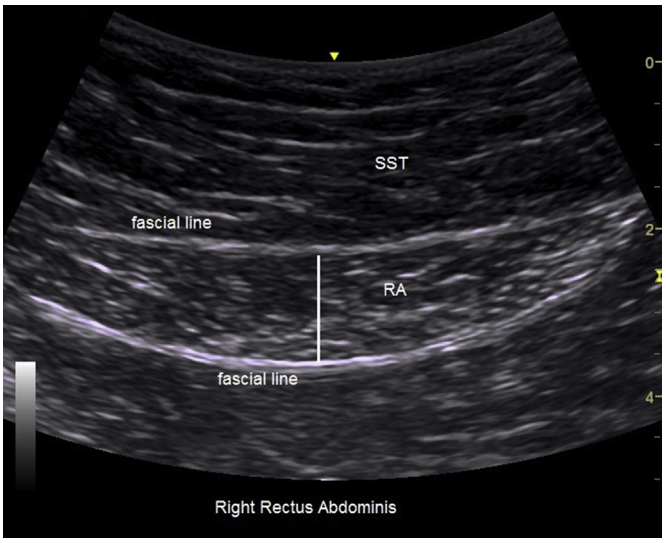

Fig. 1. Ultrasound image of Rectus Abdominis (RA) muscle. SST = superficial soft tissue. Image taken at end of expiration, and measured between inner borders of fascia at the widest part.