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Original Contribution

RELIABILITY OF PANORAMIC ULTRASOUND IMAGING IN SIMULTANEOUSLY EXAMINING MUSCLE SIZE AND QUALITY OF THE HAMSTRING MUSCLES IN YOUNG, HEALTHY MALES AND FEMALES

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Abstract—The purpose of this study was to examine the reliability of ultrasound (US) measures of cross-sectional area (CSA), muscle thickness (MT) and echo intensity (EI) of the hamstrings, with comparisons between males and females. In 20 healthy participants (10 males, 10 females), CSA, MT and EI were measured from panoramic US scans of the hamstrings on 2 separate days. The intra-class correlation coefficients and standard errors of measurement as a percentage of the mean for CSA, MT and EI ranged from 0.715 to 0.984 and from 3.145 to 12.541% in the males and from 0.724 to 0.977 and from 4.571 to 17.890% in the females, respectively. The males had greater CSAs and MTs and lower EIs than the females (p = 0.002–0.049), and significant relationships were observed between CSA and MT (r = 0.714-0.938, $p \leq$ 0.001–0.023). From an overall reliability standpoint, these findings suggest that panoramic US may be a reliable technique for examining muscle size and quality of the hamstrings in both males and females. (E-mail: brennan.thompson@ttu.edu) © 2015 World Federation for Ultrasound in Medicine & Biology.

Key Words: **Cross-sectional area, Echo intensity, Muscle thickness, Gender, Biceps femoris, Semitendinosus, Semimembranosus.**

INTRODUCTION

Examining muscle size *in vivo* is an effective and useful strategy for assessing changes associated with training (Ahtiainen et al. 2010), aging (Roth et al. 2001), immobilization (Abe et al. 1997) and neuromuscular diseases (Moreau et al. 2009). Previous studies have shown that training-induced increases in functional strength-related performances, including standing (Onambélé-Pearson et al. 2010), running (Abe et al. 2005; Cormie et al. 2010) and jumping (Cormie et al. 2010), are accompanied by architectural increases in muscle size. As a result, it has been suggested that muscle size measurements, such as cross-sectional area (CSA) and muscle thickness (MT), may be used as an indirect method to predict changes in maximal and/or explosive strength (Cormie et al. 2010). Measurements of muscle quality, such as echo intensity (EI), are indicative of a muscle's fat and fibrous tissue content (Pillen et al. 2009) and may also be potentially useful for assessing training-induced increases in strength-related performances (Cadore et al. 2014; Fukumoto et al. 2013; Radaelli et al. 2014). For example, Cadore et al. (2014) recently reported that increases in maximal torque production after 6 wk of isokinetic training were significantly related to improvements in EI, which suggests that training-induced increases in muscle quality are linked to improvements in maximal strength. In light of these findings and given the potential contribution of CSA, MT and EI to measures of maximal and explosive strength and other functionally important parameters, recent research studies have heavily focused on identifying highly sensitive and reliable non-invasive imaging techniques for assessing muscle size and quality measurements (Caresio et al. 2014; Melvin et al. 2014; Rosenberg et al. 2014; Strandberg et al. 2010).

The majority of previous research examining muscle size and quality non-invasively have used highly

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advanced imaging techniques, such as computed tomography (CT) and magnetic resonance imaging (MRI) (Holmbäck et al. 2002; Strandberg et al. 2010; Visser et al. 2002). Although MRI and CT have been reported to be reliable and effective devices for examining muscle size and quality (Housh et al. 1995; Strandberg et al. 2010), these imaging technologies are expensive, time consuming and inaccessible to most researchers and clinicians (Ahtiainen et al. 2010; Rosenberg et al. 2014). The need for a more cost-effective and readily accessible technique to quantify muscle size and quality in both laboratory and clinical settings has been suggested by previous studies that have used brightness-mode (B-mode) ultrasound (US) imaging devices during various muscle assessments of the upper and lower extremities (Arts et al. 2010; Caresio et al. 2014). B-Mode US has been found to be a reliable and useful imaging technique for discriminating between muscle size and quality measurements in different groups of elite athletes with different training and/or competition programs (Sipilä and Suominen 1991, 1993). Moreover, the use of US technologies to detect age- and disease-related changes in muscle size and quality has greatly increased in recent years in many research laboratories and clinics (Arts et al. 2010; Melvin et al. 2014; Moreau et al. 2009), as these methods are easy to use and can potentially offer valid and rapid data analyses of structural changes caused by sarcopenia and other neuromuscular disorders (Rezasoltani 2003; Verhulst et al. 2011).

The limited depth and field-of-view capabilities of the US devices used by previous studies have prevented investigators from capturing cross-sectional images of large muscle groups (*i.e.,* quadriceps, plantar flexors, hamstrings) for measuring CSA (Ahtiainen et al. 2010; Rosenberg et al. 2014). However, recent advancements in US technology, including the development of an extended field-of-view (panoramic) function, have now provided investigators with the ability to simultaneously examine the size and quality of large muscle groups from the same panoramic cross-sectional image (Rosenberg et al. 2014). Recently, many studies have reported that using panoramic US to measure muscle size and quality from the same image provides a time-efficient and reliable technique for examining muscle morphology of the quadriceps and plantar flexors in young and older males and females (Melvin et al. 2014; Rosenberg et al. 2014; Scanlon et al. 2014; Wells et al. 2014). However, although these studies included both males and/or females as participants, interestingly, they did not compare the reliability between genders. Although there have been a few studies that have compared the reliability of muscle size between genders using US (Weiss 1984, 1987), it remains unclear whether gender contributes to differences in the reliability of muscle quality. Because males have been reported to have larger and higher-quality muscles than females (Arts et al. 2010; Caresio et al. 2014), it is possible that these gender-related differences may yield varying results between males and females for CSA, MT and EI reliability. Knowledge of the potential variations in reliability of muscle size and quality between genders may aid researchers on sample size estimates and interpretation issues when examining CSA, MT and EI in studies involving both male and female participants.

Despite numerous research studies examining the reliability of US to measure muscle architecture of the locomotor-related lower body muscles such as the quadriceps and plantar flexors (Jajtner et al. 2013; Melvin et al. 2014; Rosenberg et al. 2014; Scanlon et al. 2014; Wells et al. 2014), interestingly, we are aware of only a few studies to date that have examined the reliability of US to measure muscle architecture of the hamstring muscle group (*i.e.,* biceps femoris [BF], semitendinosus [ST], semimembranosus [SM]) (Chleboun et al. 2001; Kellis et al. 2009; Timmins et al. 2014). Specifically, Chleboun et al. (2001), Kellis et al. (2009) and Timmins et al. (2014) reported that US was a valid and reliable assessment tool for examining MT, fascicle length and/or pennation angle of the BF and ST. However, these authors did not examine the reliability of CSA and EI measurements, nor did they compare the reliability between genders. Moreover, the data used in their studies were limited to the BF and ST, and thus, it remains unclear whether potential differences exist between the reliability of the size and quality of the BF and ST and those of the SM. Because the BF, ST and SM have been reported to differ in size and architecture (Kellis et al. 2012), the reliability of US to measure these parameters and muscles may also differ, which could lead to sample size estimate and interpretation errors for future researchers examining the size and quality of these muscles. On that basis, it may be of great importance to examine the reliability of panoramic US to measure the size and quality of the BF, ST and SM such that future studies can determine the minimum sample sizes necessary for observing real differences with adequate statistical power. Moreover, it may also be of great value to examine the relationships between CSA, MT and EI of the BF, ST and SM. Although the correlations between EI versus CSA and MT have rarely been examined, the relationships between CSA and MT have garnered recent attention (Larrie-Baghal et al. 2012), especially since some US units are incapable of measuring CSA (Rezasoltani 2003), and therefore, measuring MT may be the only way these devices can estimate muscle size (Larrie-Baghal et al. 2012; Rezasoltani 2003). Thus, given the importance of these relationships to estimates