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● *Original Contribution*

RECTUS FEMORIS ECHO INTENSITY CORRELATES WITH MUSCLE STRENGTH, BUT NOT ENDURANCE, IN YOUNGER AND OLDER MEN

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Abstract—We examined correlations between echo intensity and muscle strength and endurance. Rectus femoris echo intensity, maximal voluntary contraction (MVC) force and time to task failure during a 50% MVC task were determined for 12 younger (mean age = 25 y) and 13 older (mean age = 74 y) men. Bivariate correlations between echo intensity and normalized MVC force were similar for younger and older men, but was only statistically significant for the latter (younger $r = -0.559$, $p = 0.059$; older $r = -0.580$, $p = 0.038$). When all patients were combined, the correlation was significant ($r = -0.733$, $p < 0.001$). Significant correlations were not observed for time to task failure (younger $r = -0.382$, $p = 0.221$; older $r = -0.347$, $p = 0.246$; all patients $r = -0.229$, $p = 0.270$). Rectus femoris echo intensity is associated with muscle strength, but not endurance, in younger and older men. (E-mail: matt.stock@ucf.edu) © 2017 World Federation for Ultrasound in Medicine & Biology.

Key Words: **Muscle quality, Quadriceps femoris, Maximal voluntary contraction, Dynapenia, Ultrasonography.**

INTRODUCTION

Many researchers in human anatomy and neuromuscular physiology have come to rely on musculoskeletal ultrasonography because of its combination of affordability, improvements in image quality, and portability, as well as the lack of access to magnetic resonance imaging at many institutions. Investigators are increasingly using not only muscle thickness or cross-sectional area as a measure of skeletal muscle size, but echo intensity as a measure of tissue quality. Echo intensity is thought to be reflective of a muscle's adipose and fibrous tissue infiltration (Pillen et al. 2009; Reimers et al. 1993; Young et al. 2015), and is quantified by examining the darkness of a selected region of interest, with black and white being indicative of high and low muscle quality, respectively. Initial echo intensity research illustrated its ability to effectively distinguish healthy versus diseased skeletal muscle in humans (Pillen et al. 2003) and animals (Pillen et al. 2009). Results from other studies have suggested that echo intensity may be useful for tracking changes associated with eccentric exercise-induced muscle damage (Damas et al. 2016; Nosaka and Sakamoto 2001) and adaptations to resistance training (Cadore et al. 2014; Jajtner et al. 2013; Wilhelm et al. 2014a). More specifically, muscle damage and chronic resistance training have been reported to increase (Damas et al. 2016; Nosaka and Sakamoto 2001) and decrease (Cadore et al. 2014; Jajtner et al. 2013; Wilhelm et al. 2014a) echo intensity values, respectively. It should, however, be noted that the mechanisms underlying changes in echo intensity associated with various exercise interventions are not well understood. Such changes could be attributed to differences in skeletal muscle glycogen and/or intracellular water concentrations (Jenkins 2016).

Aging is associated with a number of neuromuscular changes that lead to decrements in force-generating capacity and an eventual loss of independence. Such alterations include a reduction in the number of fast-twitch muscle fibers (Lexell et al. 1988), motor cortex hypo-excitability (Clark et al. 2015) and structural changes to the neuromuscular junction (Deschenes et al. 2010). Aging also leads to a greater loss in muscle strength than what can be accounted for by the decline in muscle size (Goodpaster et al. 2006). Because aging is associated with increased skeletal muscle lipid content (Delmonico et al. 2009),

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several researchers have proposed that echo intensity may be useful for examining muscle function in older adults (Cadore et al. 2012; Fukumoto et al. 2012; Rech et al. 2014). These investigations have revealed significant negative correlations (*i.e.,* lower echo intensity values associated with better performance) between quadriceps femoris echo intensity and cardiovascular fitness (Cadore et al. 2012), isometric strength (Cadore et al. 2012; Fukumoto et al. 2012; Rech et al. 2014) and performance during activities of daily living (Rech et al. 2014). To our understanding, however, no previous studies have examined both echo intensity and local muscular endurance. This is notable because fatigue resistance is affected by the aging process, with older patients usually outperforming their younger counterparts (Christie et al. 2011).

For echo intensity to be widely accepted in gerontology research, it is important to determine if its association with functional outcomes is consistent across the life span. Similarly, additional data on both younger and older adults are needed to ascertain which measures are most highly correlated with echo intensity. To date, no previous studies have compared associations between echo intensity and measures of muscle strength and endurance for different age groups. Thus, the purpose of the present investigation was to examine correlations between echo intensity and maximal voluntary contraction (MVC) force and time to task failure in both younger and older men.

METHODS

Patients

Twelve younger (age = 25 ± 3 y [mean ± SD], 21–30 [range]; body mass = 65.2 ± 8.8 kg) and 13 older (age = 74 ± 6 y, range = 65–88; body mass = 80.6 ± 10.4 kg) men with a body mass index ≤30 kg/m^2 participated in this study. All patients were Caucasian, which is worth mentioning because racial differences in echo intensity have been reported previously (Melvin et al. 2014). Patients were recruited from the local community *via* advertisements, flyers and word of mouth. Preliminary screening was conducted over the telephone to qualify patients based on the study's inclusion criteria. Potential patients who had undergone surgery on the hip or knee joints or who required an assistive walking device within the previous year were excluded. Men with known neuromuscular or metabolic disease(s) were also excluded, as were those who had experienced a myocardial infarction within the previous year. Additionally, men who had been diagnosed by a physician with osteoarthritis of the knee were not allowed to participate. During the 6 mo before study admittance, enrolled patients refrained from lower-body resistance training (fewer than three times monthly) or other structured exercise (*e.g.,* jogging, aerobics) more than 30 min/d, three times per week (Lanza et al. 2007). Potential patients were disqualified if their primary care physician advised them not to engage in exercise for other medical reasons. The study procedures were approved by the Texas Tech University Human Research Protection Program. All patients provided written informed consent and completed health history questionnaires before enrollment. Low levels of physical activity outside of the study were objectively verified for a 7-d period with the use of a triaxial accelerometer (ActiGraph GT3 X+, ActiGraph, Pensacola, FL, USA).

Familiarization session

To minimize the influence of learning on MVC force and time to task failure measurements, patients were familiarized with the study procedures during a separate laboratory visit before the data collection trial. Multiple practice contractions were performed to ensure that patients were comfortable with the physical demands of the study. A minimum of 24 h after the familiarization session, patients returned to the laboratory for data collection. Additionally, patients were asked to refrain from physically demanding tasks (*e.g.,* aerobic exercise, yard work and recreational sports) for the 24 h leading up to their data collection trial.

Ultrasonography measurements

On arrival at the laboratory for the data collection trial, patients rested in the supine position for ≥10 min before the ultrasound measurements to allow for redistribution of bodily fluids (Berg et al. 1993). All assessments were performed while patients rested supine on a table with the right leg positioned in extension. Images were acquired with a portable B-mode imaging device (GE Logiq e BT12, GE Healthcare, Milwaukee, WI, USA) equipped with a multifrequency linear-array probe (12 L-RS, 5–13 MHz, 38.4-mm field of view; GE Healthcare). The images were taken in the sagittal plane over the belly of the right rectus femoris at one-half the distance between the anterior superior iliac spine and the superior border of the patella. Ultrasound settings were optimized (frequency: 12 MHz, gain: 50 dB, dynamic range: 72) and kept consistent among patients. Image depth varied for each subject depending on tissue thickness and clarity, as our previous work had revealed no significant difference in echo intensity values with varying image depths (Stock et al. 2017). A generous amount of water-soluble transmission gel (Aquasonic 100 ultrasound transmission gel, Parker Laboratories, Fairfield, NJ, USA) was applied to the skin such that the probe surface was immersed in the gel during testing to enhance acoustic coupling. All ultrasonography imaging was performed by the same investigator.