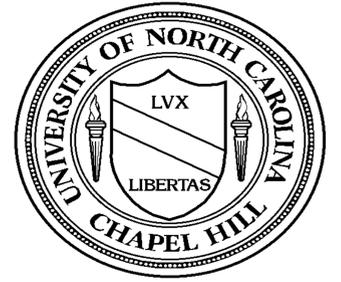


The Relationship Between Muscle Quality and Age: Influence of Pennation Angle

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ABSTRACT

Purpose: The purpose of this study was to examine the relationship between muscle quality obtained through panoramic brightness mode ultrasound (US) imaging and age when controlling for pennation angle. **Methods:** Fifteen young (mean \pm SD) (age, 22 ± 2 years; height, 175.3 ± 7.8 cm; body mass, 76.5 ± 9.8 kg) and 15 old (age, 70 ± 3 years; height, 177.2 ± 6.0 cm; body mass, 83.0 ± 12.3 kg) healthy, recreationally active males participated in this research study. PA and EI of the MG were measured by panoramic brightness mode ultrasonography. PA was assessed as the angle between the fascicle and a line parallel to the deep aponeurosis, while EI (a gray-scale value) was assessed from a cross-sectional scan of the MG. **Results:** A significant relationship was observed between age and EI ($r=0.77$; $P<0.001$), which was unaffected when controlling for PA ($r=0.64$; $P<0.001$). **Conclusions:** These results indicate that age-related changes in EI reflect alterations in tissue quality (i.e. increase in connective and adipose tissue) rather than changes in PA.

INTRODUCTION

Previous studies have suggested that echo intensity (EI; a measure of muscle quality) increases with aging (Arts et al., 2010; Fukumoto et al., 2012). However, because of the anisotropic nature of muscle, it is possible that this relationship is due to pennation angle (PA) rather than muscle quality (Strasser et al., 2013). In principle, reflection of acoustic wave is strongest, when the propagation direction of the wave is perpendicular to the surface of an object. Thus, the smaller the pennation angle of the muscle, the greater the expected echo intensity of the muscle region. Although muscle quality may appear as a promising clinical tool, factors that influence this measure warrant further evaluation.

PURPOSE: The purpose of the present study was to examine the influence of PA on the relationship between EI and aging in the medial gastrocnemius (MG) muscle in young and old men.

METHODS

PARTICIPANTS: Fifteen healthy, recreationally active young (mean \pm SD): age, 22 ± 2 years; height, 175.3 ± 7.8 cm; body mass, 76.5 ± 9.8 kg. and older males: age, 70 ± 3 years; height, 177.2 ± 6.0 cm; body mass, 83.0 ± 12.3 kg

PROCEDURES: Transverse and longitudinal ultrasound images of the medial gastrocnemius (MG) at 30% limb length of the right limb were obtained with a portable B-mode ultrasound imaging device (GE Logiq e; WI, USA) and a multi-frequency linear-array transducer (38.4-mm FOV; 12L-RS) using LogicView™ software. A region of interest from the MG was selected to include as much of the muscle as possible without any surrounding fascia (Fig. 3). PA was assessed as the angle between the fascicle and a line parallel to the deep aponeurosis and the average value of 2 separate fascicles was used for all analyses. EI was determined using the standard histogram function and gray-scale analysis in Image-J software (National Institutes of Health, USA). Mean EI of the region of interest was expressed as a value between 0 and 255 (black = 0; white = 255).

STATISTICAL ANALYSIS: Correlations between EI and age were calculated using Pearson's correlation coefficients. Partial correlations were used to examine the effects of PA on the relationship between age and EI. Independent samples t-tests were performed to examine differences between all variables, with an analysis of covariance (ANCOVA) performed to control for pennation angle between both groups. All data were analyzed using SPSS version 20.0 (SPSS, Inc., Chicago, IL, USA).



Figure 1: An example of participant and probe positioning for the muscle quality panoramic ultrasound imaging assessment of the medial gastrocnemius.

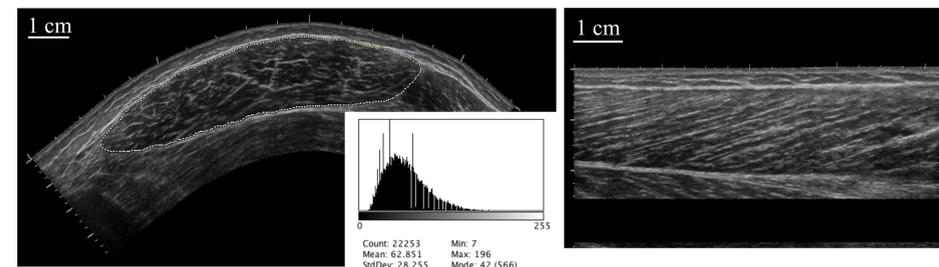


Figure 2: An example of a transverse panoramic ultrasound image of the medial gastrocnemius (MG) of a young male. Echo intensity values were determined by manually tracing the border of the MG, excluding the surrounding fascia using Image-J software. An example of the corresponding gray scale histogram values are provided.

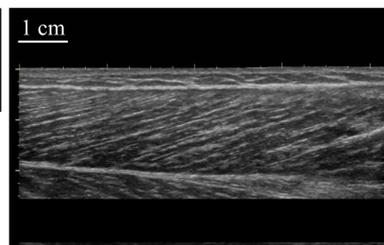


Figure 3: An example of a longitudinal panoramic ultrasound image of the medial gastrocnemius pennation angle in a young male.

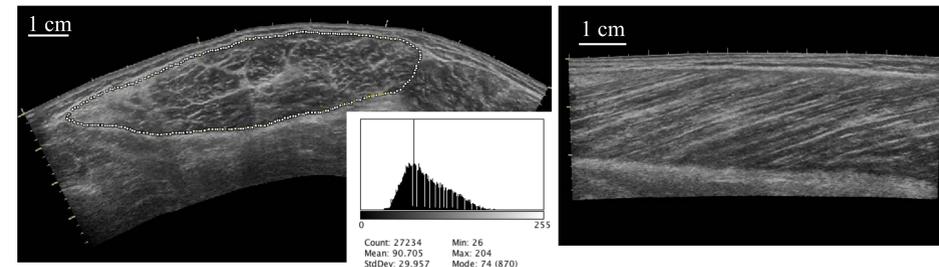


Figure 4: An example of a transverse panoramic ultrasound image of the medial gastrocnemius (MG) of an older male. Echo intensity values were determined by manually tracing the border of the MG, excluding the surrounding fascia using Image-J software. An example of the corresponding gray scale histogram values are provided.

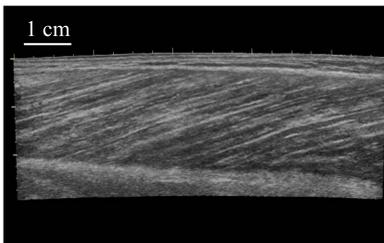


Figure 5: An example of a longitudinal panoramic ultrasound image of the medial gastrocnemius pennation angle in an older male.

RESULTS

A significant relationship was observed between age and EI ($r=0.77$; $P<0.001$), which was unaffected when controlling for PA ($r=0.64$; $P<0.001$). The results of the ANCOVA showed a significant difference between age and EI ($P<0.001$) when controlling for PA.

Table 1: Participant anthropometrics and muscle characteristics.

Parameters	Young Males	Older Males
n	15	15
Age (years)	22 ± 2	$70 \pm 3^*$
Height (cm)	175.3 ± 7.8	177.2 ± 6.0
Body Mass (kg)	76.5 ± 9.8	83.0 ± 12.3
PA (deg)	20.7 ± 3.0	$16.2 \pm 2.4^*$
EI (a.u.)	74.3 ± 5.6	$91.3 \pm 8.5^*$

EI: echo intensity; PA: pennation angle; *: Significant difference between groups ($P \leq 0.05$)

CONCLUSION

There was a positive relationship between muscle quality (i.e. EI) and age, which was not influenced by pennation angle. Rather, other mechanisms associated with the aging process appear to be responsible for the reductions in muscle quality observed within the medial gastrocnemius. These findings indicate that age-related changes in EI reflect alterations in tissue quality (i.e. increase in connective and adipose tissue) rather than changes in pennation angle.

PRACTICAL APPLICATIONS: Future studies may use EI derived muscle quality to examine the influence of exercise interventions, pathological adaptations, and/or age-related alterations in various populations.

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