Regional variation in passive stretch response of the isolated biceps femoris long head from a Thiel's cadaver: A pilot study

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Summary

This study investigated regional variations in the passive stretch response of an isolated biceps femoris long head (BFlh) from a Thiel's cadaver using shear wave elastography (SWE). Four BFlh specimens were secured to a mechanical testing machine, with a tensile load applied to the distal tendon. The shear modulus was measured using SWE in the proximal, middle, and distal regions of the BFlh. The slack length and slope of the increase in shear modulus were determined using a piecewise exponential model fitted to the shear modulus-strain data. Linear mixed models revealed that the distal region exhibited a shorter slack length and steeper slopes in the shear modulus increase compared with other regions. These findings demonstrate regional differences in the passive mechanical properties of the BFlh, contributing to the development of accurate musculoskeletal models. Further studies with larger sample sizes are required to confirm these findings.

Introduction

The BFlh is highly susceptible to strain injuries, particularly in the proximal region. Understanding regional variations in the passive stretch response of the BFlh is fundamental for providing insights into muscle mechanics and musculoskeletal modeling. Although the shear modulus quantified by SWE has been used to evaluate the localized passive stretch response in vivo, the shear modulus is influenced by the surrounding tissues (e.g., deep fascia), preventing direct assessment of intrinsic muscle properties. Therefore, this study investigated regional variations in the passive stretch response of an isolated BFlh from a Thiel's cadaver using SWE.

Methods

Four BFlh specimens from three cadavers were secured to the mechanical testing machine, with a tensile load applied to the distal tendon. Initial muscle length (ML_0) was determined at the onset of the tensile load. The muscle was then incrementally displaced from -1% ML_0 to +2% ML_0 in 0.25% steps. Shear modulus was measured using SWE in the proximal (25%), middle (50%), and distal (75%) regions along the muscle length. Five repeated measurements were obtained for all locations at each displacement step. The slack length (the muscle length at which the shear modulus began to increase) and the increase in the slope of the shear modulus were calculated for each region by fitting a piecewise exponential model to the shear modulus-strain data. A linear mixed model was used, with the measurement region as a fixed effect and the specimen/trial as random effects.

Results and Discussion

The slack length was 0.23 ± 0.70%, 0.53 ± 0.54%, and 0.76 ± 0.60% ML_0 (mean ± SD) for distal, middle, and proximal regions, respectively (Figure 1). The linear mixed model revealed a significant effect of region on slack length ($F(2, 54) = 8.0$, $p < 0.01$). Post-hoc tests showed that the distal region exhibited a shorter slack length than the middle ($p = 0.039$) and proximal regions ($p < 0.01$). The increase in the slope of the shear modulus was 0.315 ± 0.067, 0.170 ± 0.096, and 0.134 ± 0.072 for distal, middle, and proximal regions, respectively (Figure 1). The slopes varied significantly by region ($F(2, 54) = 48.4$, $p < 0.001$), with the distal region showing steeper slopes than the middle ($p < 0.01$) and proximal regions ($p < 0.01$). The distal region exhibited earlier and steeper tension development than the other regions. These regional variations observed in the isolated specimens suggest intrinsic mechanical properties of the muscle tissue itself. Additionally, delayed development of tension in the proximal region may explain the previously reported higher tissue strain in this region [1].

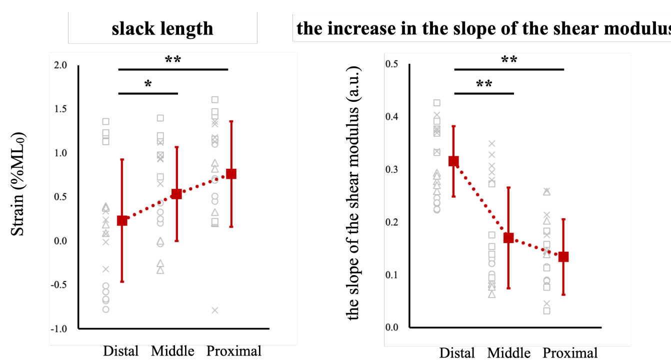

Figure 1: Mean values ± SD of the slack length (left) and the increase in the slope of the shear modulus (right). Gray markers indicate individual specimen data (n = 4), with different marker types representing different specimens. *$p = 0.039$, **$p < 0.001$.

Conclusions

These findings demonstrate regional differences in the passive mechanical properties of the BFlh and provide insights into muscle mechanics. Further investigations with larger sample sizes are needed to draw more robust and generalizable conclusions.

References

[1] Rehbein CO et al. (2024). *J Strength Cond Res*, **38**: 1860-1866.