

DISTAL AND PROXIMAL FASCICLE LENGTH CHANGES IN ACTIVE AND PASSIVE HUMAN GASTROCNEMIUS MUSCLE

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INTRODUCTION

Skeletal muscle is composed of structural units of decreasing size, with muscle fascicles as the largest unit and sarcomeres as the smallest unit [1]. Fascicles define the overall muscle architecture. Because architecture is specific to individual muscles, knowing fascicle length is essential for understanding contraction and force production. Ultrasound imaging allows for in vivo studies of fascicle lengths.

Muscle architecture has been studied extensively in the human gastrocnemius at the mid-belly region [2]. However, the mid-belly might not reflect muscle architecture accurately across the entire muscle. Therefore, the objective of this study was to measure human gastrocnemius fascicle lengths at a distal and a proximal location.

METHODS

Fifteen healthy male subjects were tested (age: 25±5yrs; height: 177±8cm; weight: 69±8kg). Each subject was positioned in an isokinetic dynamometer with the right knee joint at full extension. The ankle joint was fixed at -10° dorsiflexion and 0, 10°, 20°, 30°, and 40° plantar flexion. Ankle torque and fascicle length were measured at rest (passive) and for maximum voluntary isometric plantar flexion (active) contractions, with an ultrasound probe close to the myotendinous junction of the gastrocnemius (distal). All testing was then repeated with the probe positioned close to the knee joint (proximal).

A three way ANOVA was used to assess fascicle length with the main factors: torque (passive and active), location (distal and proximal), and ankle joint angle (-10°, 0, 10°, 20°, 30°, 40°) at a level of significance of $\alpha=0.05$. Bonferroni post-hoc testing was performed when indicated.

RESULTS

Passive fascicle length was greater in more dorsiflexed positions than plantarflexed positions at distal and proximal locations ($P<0.001$). There was significant fascicle shortening from passive to active states ($P<0.001$). Passive fascicle lengths were greater at 0°, 10°, and 20° plantar flexion at the distal compared to the proximal location

($P<0.05$; Fig. 1). Distal and proximal active fascicle lengths were the same at all ankle angles. (Fig 1).

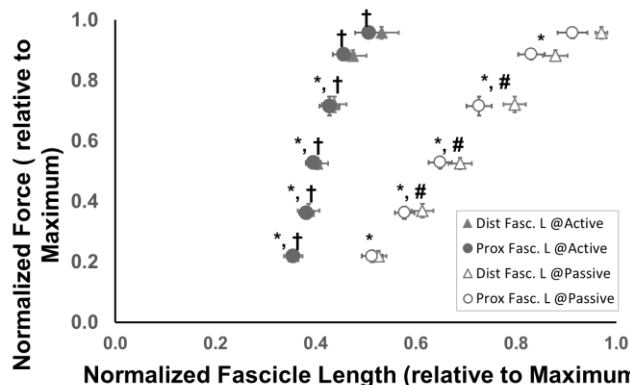


Figure 1: Mean (± 1 SE) normalized force vs. normalized fascicle length for passive (filled) and active (empty); proximal (o) and distal (Δ) locations across ankle joint angles. Lengths at passive were given the same force as active to show shortening. ‘*’: compares to -10° joint angle. ‘†’: compares passive to active. ‘#’: compares proximal and distal values.

DISCUSSION AND CONCLUSIONS

Active fascicle lengths were the same at distal and proximal locations across all ankle angles. Passive fascicle lengths were longer distally compared to proximally, suggesting that the relative fascicle shortening from passive to active states depends on location along the muscle. Therefore, absolute sarcomere lengths must differ between distal and proximal fascicles, at least for some conditions. This result brings into question the long-held belief that sarcomere lengths in a given muscle are the same at all locations and independent of the instantaneous contractile conditions. Careful analysis of this result is required for generalization of the current results across other muscles.

REFERENCES

1. Nigg & Herzog. *Biomechanics of the Musculo-Skeletal System*. 2006.
2. Kawakami et al. *J Appl Physiol*. **85**:398-404, 1998.