SONOGRAPHIC MEASURES OF GASTROCNEMIUS LENGTH WITH TWO-JOINT PASSIVE MOVEMENTS

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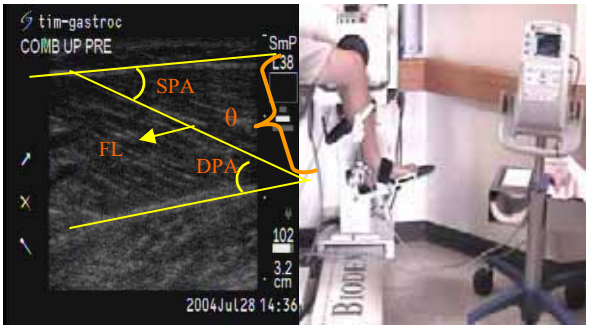
INTRODUCTION

In-vivo ultrasound is a non-invasive method to identify gastrocnemius (GAST) length changes with passive and active movements.[1-3] Predicted ratios of ankle movement, relative to knee movement, can be varied to generate conditions where the GAST will homogeneously elongate, shorten or where the GAST will heterogeneously maintain its length.[4] The purpose of this study is to determine, with 95% confidence, the feasibility of sonographic imaging to derive quantifiable measures of GAST length in order to identify conditions when the GAST homogeneously shortens, elongates, or a condition when there are heterogeneous or minimal changes in GAST muscle length during knee and ankle movements.

METHODS

Ten subjects were seated on a Biodex (*Biodex Inc., Shirley NY*) with their legs positioned in a custom-made foot/ankle apparatus, controlled by a linear actuator (*Ultramotion, Inc, Mattituk, NY*), that passively extended knee and plantar flexed ankle, respectively. A 7.5 MHz linear transducer (*SonoSite, Bothell, WA*) imaged the mid-third of the GAST in the longitudinal plane. The transducer array was set in a jig, attached to the Biodex arm, and held in place with an elastic wrap to maintain image planes of site GAST targets during



A. **B.**

Figure 1: A) Ultrasound image with angles to calculate: SPA, IPA, and θ. B) Biodex and Linear actuator, with custom foot plate to move the knee and ankle.

data acquisition.[1] As the knee was extended (60°-20° at 2 °/s) the ankle rotated (0°-6.4° at 0.32°/s) for med GAST measurements or rotated (0°-10.8° at 0.54 °/s) for lateral GAST measurements. Off-line ultrasound measures, aquired every 10° of knee angle (α) included: muscle fiber length (FL); superficial and deep pennation angle (SPA, DPA) and the angle between the superficial and deep aponeuroses (θ).(Fig.1) Commercial software enabled calculation of muscle fiber length (*Carnoy. Schols, P.&E. Smets.2001*) and pennation angle(*Photoshop8,Adobe,Seattle,WA*). Mean values from three trials for each condition were used to calculate a linear regression, with 95% confidence interval, and descriptive data for each movement (*Statistica,StatSoft,Ltd. Tulsa, OK*).

RESULTS AND DISCUSSION

Med GAST FL increased (p<0.05) as the knee extended (FL= 9.1-0.05α: r=-0.32). Lat GAST demonstrated a non-significant trend (p=0.051) to shorten with knee extension (FL=9.2+ .014α: r =0.052). (Figure 2) Greater variability of the lateral GAST FL data warrants reporting pennation angles. (Table 1) During knee extension, increased pennation angles support the trend of GAST shortening during combined knee and ankle movements.

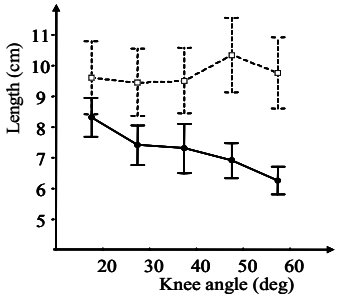


Figure 2: Mean med GAST (—■—) and mean lat GAST (--- □ ----) FL, with 95% confidence interval, relative to α.

Because sonographic techniques are highly user-dependent, future reliability studies are needed to determine accuracy of quantification of muscle length data for estimating forces and muscle function involving two joint movements.

CONCLUSIONS

This is the first study to use sonographic techniques to identify how two joint movements affect GAST muscle fiber length. Homogeneous elongation of the GAST was demonstrated at the predicted ratios of knee and ankle movement. However, heterogeneous changes in the GAST length are apparent with the reported insignificant trend of FL measures. Shortening of lateral GAST would occur with increased plantar flexion velocity, relative to given knee movements.

REFERENCES

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Table 1: Lateral GAST Pennation angle: ***Knee Angle (deg)***

	20	30	40	50	60
SPA	6.4+/-3.8	6.5+/-4.1	6.2+/-3.6	5.7+/-3.6	5.4+/-2.9
DPA	10.3+/-3.2	11.1+/-4.1	10.1+/-4.1	9.1+/-4.1	7.7+/-3.2
θ	5.7+/-2.3	5.6+/-2.3	5.1+/-2.1	4.5+/-2.3	3.6+/-1.9