VARIABILITY IN ISOMETRIC FORCE AND TORQUE GENERATING CAPACITY OF GLENOHUMERAL EXTERNAL ROTATOR MUSCLES

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INTRODUCTION

Glenohumeral external rotator muscles possess varying ability for generating forces and torques due to differences in muscle architecture, moment arm, and the interaction of these two factors. Previous authors have measured muscle architecture [1], and moment arms [2,3] at the shoulder. Due to parameter covariance, it is advantageous to utilize parameters from a unique dataset rather than from disparate sources. This study's purpose was to determine a complete dataset of parameters for predicting the length-tension (L-T) dependence and torque generating capacity of infraspinatus, supraspinatus and teres minor for shoulder external rotation.

METHODS

Data were collected from 10 normal cadaver specimens for supraspinatus (SSP), infraspinatus (INF), and teres minor (TM) muscles. SSP and INF were divided into 3 and 4 sub-regions respectively. Muscle-tendon units were dissected from the specimens. Tendon length, muscle belly length and muscle fascicle length were measured with a digital caliper. Muscle volume was measured via water immersion. Pennation angle was measured with a goniometer. After muscle fixation, fascicles were dissected and sarcomere lengths measured via laser diffraction. Tendon area, PCSA, optimal muscle length and optimal fascicle length were determined from empirical data. Tendon excursion relative to humeral head rotation was measured with a custom instrument from 45° internal to 45° external rotation with the humerus at 10° abduction. Muscle moment arms were determined as the derivative of tendon excursion versus rotation angle [4]. Inelastic tendon was assumed, and fascicle excursion as a function of joint angle was calculated from tendon excursion and pennation angle. Rigor was assumed to develop with the humerus in neutral rotation and abduction. Length-tension relationships were determined by normalizing fascicle excursion to optimal fascicle length [5]. Maximum isometric rotation torque generating capacity was estimated as the product of PCSA, maximum moment arm, and cosine of pennation angle, at 10° and 60° abduction. ANOVA models were used to determine if muscle sub-regions were operating on different portions of the length-tension relationship, and to test the effect of abduction angle, cuff condition and muscle sub-region on maximum torque capacity.

RESULTS AND DISCUSSION

The muscles demonstrated differences in their maximum isometric torque capacities (Figure 1), and length tension relationships (Figure 2). Abduction angle ($p<0.001$) and muscle sub-region ($p<0.01$) had a significant effect on maximum isometric torque capacity. Cuff condition did not have a significant effect on maximum torque capacity. Sub-regions of INF were operating on different portions of the L-T relationship ($p<0.001$), but SSP was operating over the same L-T region ($p=0.49$).

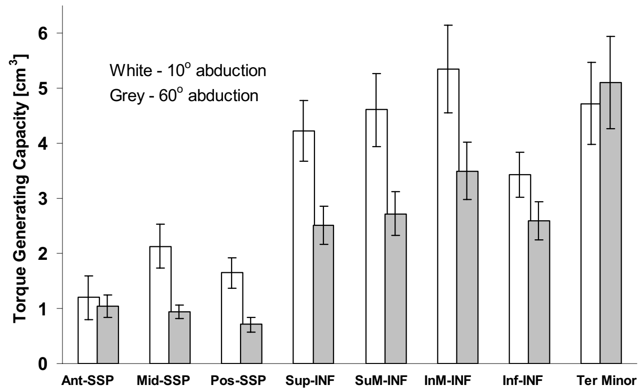

Figure 1: Maximum isometric rotation torque generating capacity (mean±standard error).

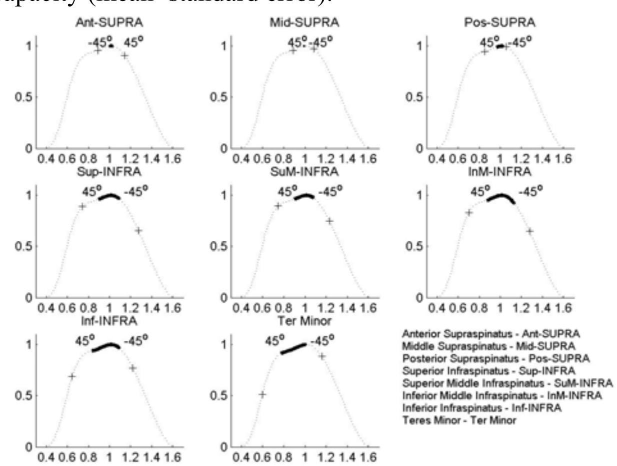

Figure 2: Normalized force versus normalized fascicle length. (Mean (+) S.D.) [5].

CONCLUSIONS

Functional capabilities of these muscles depend on muscle architecture and moment arm and their combined effects. Significant variability was detected between specimens. Parameter covariance can be determined from this unique dataset and is important for probabilistic modeling.

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