# ARCHITECTURAL PARAMETERS OF THE TRICEP BRACHII DURING ISOMETRIC CONTRACTIONS

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## INTRODUCTION

Measures of muscle architecture such as muscle thickness, pennation angle, and muscle fascicle length are used to describe a muscle's function (e.g., 1). In musculoskeletal models, muscle thickness is assumed to remain constant [2] and the force a muscle fascicle transmits to its tendon is a function of its location on the force-length curve and the cosine of the pennation angle. In complex muscles such as the Tricep Brachii, multiple muscle heads may complicate this relationship. Blazevich et al. [1] described enough muscle architecture variability in the four quadriceps muscles, such that one or two measures could not be used to predict the architecture of the entire knee extensor complex. The purpose of this study was to determine the architecture of the long head of the Triceps Brachii muscle during isometric muscle contractions throughout its range of motion.

## METHODS

Six male subjects (mean height: 148 ± 8 cm, mass: 75 ±13 kg, age: 22 ±2 years) completed a maximal isometric contraction test following the protocol of a Biodex machine similar to that of Hatze [3]. All subjects voluntarily gave informed consent. Subjects were strapped to the Biodex machine over their chest and waist in order to minimize unwanted movements. Subjects were asked to perform maximal isometric contractions of the Tricep Brachii five times for each of the five different elbow flexion angles (0, 30, 60, 90, and 120 degrees). Shoulder angles were held constant at 45 degrees and the forearm was held in a neutral position for all subjects. The subjects were asked to hold their maximal contractions for five seconds during which ultrasound images were taken of the long head of the Tricep Brachii using a frame grabber board (LG-3, Scion Image) and ultrasound machine (SSD-900, ALOKA, USA) with 7.5 MHz linear probe operating in B-mode. Biodex data were sampled at 100 Hz using LabView (National Instruments, Texas, USA). Subjects were given a thirty second rest period to reduce effects of fatigue between each contraction and a one minute rest between elbow angles.

Following subject testing, a custom written MATLAB(version 7.4.0, The MathWorks, Natick, USA ) program was used to analyze the data. The mean of the three highest moments recorded at each joint angle were averaged to determine the maximum moment.

Ultrasound images of the trials with the highest moments were digitized for each joint angle by a trained operator. They were digitized in Scion Image, and measurements made of pennation angle and muscle thickness. Means for each subject were calculated for the pennation angles and muscle thicknesses for each elbow angle.

Based on a planimetric model of pennated muscle [2], the fascicle lengths of the long head of the Triceps were computed by dividing each muscle thickness by the sine of its respective pennation angle (Figure 1).

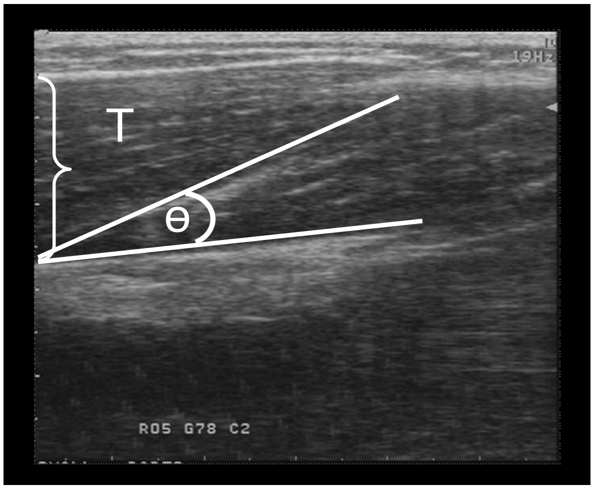

**Figure 1:** Ultrasound image showing for the long head of the Triceps Brachii muscle the thickness (T) and pennation angle (ϴ).

## RESULTS AND DISCUSSION

Muscle thickness remained relatively constant throughout the range of motion for all subjects, with a mean coefficient of variation of 6.5 ± 1.8%. This corresponds to the primary assumption in the planimetric model of muscle used here [2].

At zero degrees elbow flexion the pennation angle was 12.9 ± 0.5 degrees, which is smaller than values reported in the literature [4]. The trend was for pennation to decrease with increasing joint angle and therefore increasing muscle length. A regression line fit to these data indicated a negative slope (-0.03 ± 0.02) which averaged across all subjects corresponded to a 3.3 degree change in pennation angle through the range of joint motion examined

The trend was for fascicle length to increase with increasing joint angle (Figure 2). In some of the subjects this increase was not monotonic, yet with this would be anticipated based on muscle force-length properties. The fiber length in only one of the three heads of the Triceps was tracked, albeit the one with largest physiological cross-sectional area [4]. If the fascicles of the long head of the Triceps Brachii shorten, then the tendons attached to the Triceps Brachii must presumably be stretched by the a change in force of one or both of the other heads of the Triceps. This would suggest that the force-length curves for the three heads are not synchronous, either because of different expressions of the force-length properties of three heads or differences in activation patterns.

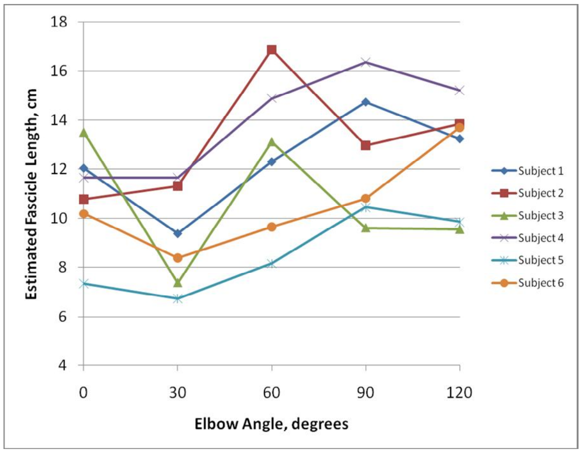

**Figure 2:** Estimated fascicle length versus elbow angle for the Triceps Brachii.

This complexity in the interaction between architecture and muscle function illustrates the need to measure all the architectural parameters of a muscle and not to rely on one or two parameters to describe a muscle's function.

## REFERENCES

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