# FORCE-LENGTH PROFILES FOR THE TRICEPS BRACHII

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## INTRODUCTION

The force-length curve of muscle is an important factor in many musculoskeletal models (e.g., Zajac [1]). For certain muscles it is feasible to determine the force-length properties *in vivo*, for example by exploiting the fact that some muscles are biarticular [1, 2]. Many models of the musculoskeletal system assume that each muscle acts at or near the plateau of its force-length curve [3]. While this assumption may be correct for some muscles Herzog et al. [2] demonstrated that is not the case for the Rectus Femoris. Their study demonstrated that speed skaters and cyclists used different portions of their force-length curve than runners for the Rectus Femoris. If such variability can exist it cannot always be valid to assume muscles act on the plateau region of the force-length curve. Using *in vivo* methods to determine muscle force-length properties will help guide in model formulation.

Although the Triceps consists of three distinct heads in many musculo-skeletal models they are functionally lumped together (e.g., 5, 6). Given this assumption the *in vivo* operating range of the Triceps was assessed. Therefore, the purpose of this study was to investigate the variability of the force-length curve of the Triceps Brachii.

## METHODS

Six male subjects (mean height: 148 ± 8 cm, mass: 75 ±13 kg, age: 22 ±2 years) volunteered and provided informed consent for this study. Each subject performed isometric elbow extensions using their dominant arm. The testing protocol consisted of a five second maximum contraction at the specific elbow angle, followed by a thirty second rest period. After five contractions at the specific elbow angle, a one minute rest was given before proceeding to the next elbow angle. Subjects performed contractions at 0, 30, 60, 90, and 120 degrees of elbow flexion.

All testing was performed in a Biodex dynamometer. The participant's flexion/extension shoulder angles were standardized at 45 degrees, and the forearm was held in a neutral position. Subjects were secured to the Biodex using lap and shoulder straps, to stabilize the subject and minimize unwanted movement during contractions. The elbow joint center was aligned with the axis of rotation of the Biodex.

The moment produced by the subjects for each trial was sampled at 1000 Hz using LabView (National Instruments, Texas, USA). The mean of the three highest moments recorded at each joint angle were averaged to determine the maximum moment. The moment data was converted into tendon force data using the non-linear equation described in Ramsay et al. [7].

For each subject tendon force-joint angle plots were determined. These curves were then analyzed using the method of Winter and Challis [2]. This method distinguishes between force-length curves as acting of the ascending, descending, or plateau region of the force-length curve. Throughout this analysis elbow joint angle is assumed to reflect muscle length.

## RESULTS

The force-joint angle (length) profiles for the six subjects demonstrated differences with regards to the section of the force-length curve that they operated on (Figure 1). Three of the six subjects operated on the ascending limb of the force-length curve, two on the plateau, and one on the descending limb.

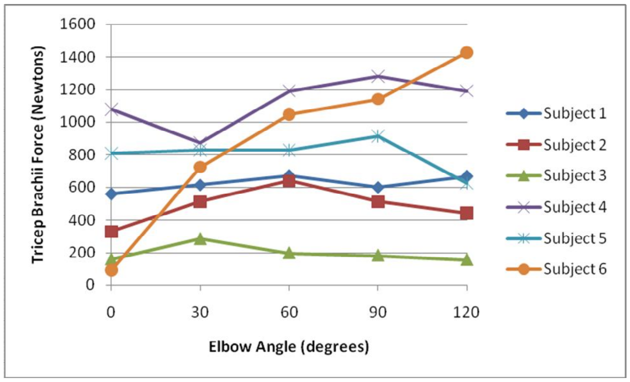


**Figure 1**: The Triceps force elbow joint angle curves for the six subjects.

If the force-joint angle curves are normalized with respect to the greatest force in the curve this is an indication of variability between subjects (Figure 2). The subjects whose Triceps Brachii operates on the asceding limb of the force-length curve would produce increasing force through a longer range of motion then those subjects who operate on the plateau of the force-length curve.

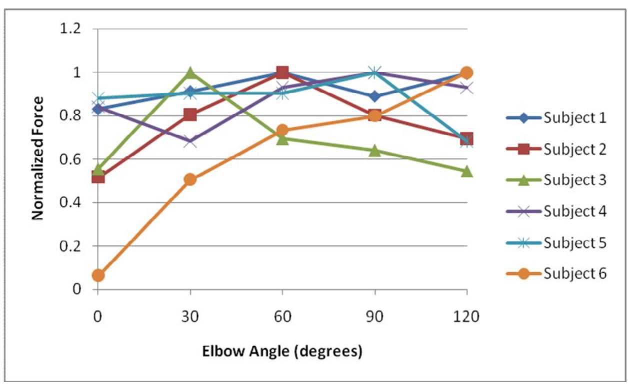


**Figure 2**: The Triceps force elbow joint angle curves for the six subjects.

## DISCUSSION

The purpose of this study was to investigate the variability of the force-length curve of the Triceps Brachii. There some variability between the subjects which reflect patterns seen in other muscles [2, 3]. This variability indicates the problems that can arise in musculoskeletal models, where between subject variability may not be accounted for. The procedure to collect data for estimating the force-length curves took approximately 20 minutes to complete; a short time considering the potential applications of musculoskeletal models.

There are a number of assumptions in this study. The Triceps has three heads all of which may behave different to their net effect. But for the subjects with descending force-length curves at least one of these heads must be operating on the same portion of the force-length curve as determined in this study. Joint angle was used as a surrogate for muscle length, and while this is a non-linear relationship as the elbow angle increases this corresponds to Triceps length increases. Finally the tendon of the Triceps would stretch as muscle force is applied to it, so for those muscles operating on the ascending limb of the force-length curve as muscle force increases with increasing joint angle the tendon would be stretched more by the increase in force thus deminishing the length change in the muscle fibers.

## REFERENCES


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