INCLUDING THE EFFECT OF BIARTICULAR MUSCLES IN TORQUE GENERATOR MODELS

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INTRODUCTION
Computer models of human movement typically incorporate either individual muscle models or single-joint torque generators. Muscle parameter values defining the force-length and force-velocity relationships for individual muscles are usually derived from the literature which may introduce many sources of error [1]. Subject-specific parameters for single-joint torque generators are usually determined from isovelocity torque data collected on a subject in order to express maximum voluntary torque as a function of joint angle and angular velocity [2, 3]. A single-joint torque generator representation does not incorporate the effect of movement at a secondary joint on the torque produced by biarticular muscles. The purpose of this study was to determine subject-specific parameters for a two-joint torque generator of ankle plantar flexor torques incorporating the joint kinematics of the ankle and knee.

METHODS
A Contrex Multi-Joint isovelocity dynamometer (CMV AG, Switzerland) was used to collect maximum voluntary isometric and isovelocity ankle plantar flexion torques over a range of ankle angles (θ_A) and five knee joint angles (θ_B) with a single subject (figure 1). A 19 parameter two-joint torque generator was developed from an existing 9 parameter single-joint torque generator model [2, 3] in order to express maximum voluntary ankle plantar flexor torque as a function of angle and angular velocity at the ankle and knee. The 19 parameters were determined by minimising a weighted RMS difference between the experimental torque data and the 19 parameter torque surface.

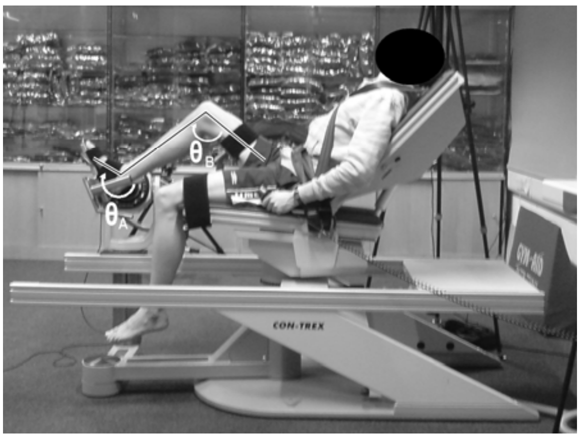

Figure 1: Experimental set-up.

RESULTS AND DISCUSSION
Fitting the experimental data using a two-joint torque generator model resulted in a weighted RMS difference of 10 Nm while using a 9 parameter single-joint torque generator model resulted in weighted RMS differences ranging from 12 Nm to 51 Nm for the five different knee angles. Using a two-joint torque generator model resulted in a much closer fit to the experimental ankle plantar flexion torques over a range of ankle and knee angles than the single-joint torque generator. In the most flexed knee position (figure 2a) the biarticular plantar flexors are only capable of contributing torque towards the extreme end of subject dorsi flexion (4.5 – 4.6 radians), where the physiological range is 3.4 – 4.6 radians. For full knee extension (figure 2b) the biarticular muscles are able to contribute torque from an ankle angle representative of 11° plantar flexion (4.04 radians) to the limit of subject dorsi flexion.

a)

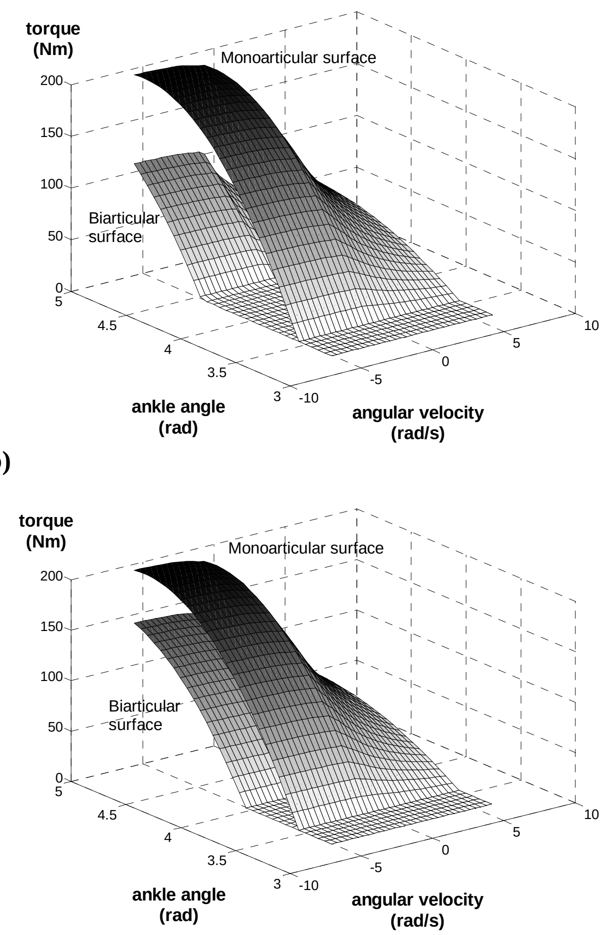

Figure 2: Monoarticular and Biarticular torque surfaces with a) Flexed knee; 111°, b) Full knee extension; 180°.

CONCLUSIONS
Future studies will investigate the effect of using single-joint and two-joint torque generator representations in whole body simulation models of human movement.

REFERENCES
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