DETERMINING SUBJECT SPECIFIC TORQUE-VELOCITY RELATIONSHIPS WITH THE INCLUSION OF HIGH VELOCITY TORQUE DATA

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INTRODUCTION

Modelling of the muscle force-velocity relationship normally utilizes a Hill type function in the concentric phase and a rapid increase to a plateau region in the eccentric phase. Muscle experiments in humans show depression in eccentric and low velocity concentric torque production [1], they have also been limited to joint angular velocities of less than $\pm 400\ ^{o}s^{-1}$. The introduction of a 'differential activation' function [2] explains a possible mechanism for the force suppression observations. However without high concentric velocity torque data the bounds chosen for maximal velocity of contraction can have an important influence on the final fit of the curve to the experimental data.

The aim of this paper is to examine the variation of a Hill type 4 parameter function, and a 7 parameter function, including differential activation, when maximal velocity torque data are included.

METHODS

Measurements were taken on an elite martial artist, height 1.78 m, weight 90 kg, the protocols were approved by Loughborough University Ethical Advisory Committee.

Isovelocity torque data in concentric-eccentric cycles were collected in 50 $^{o}s^{-1}$ intervals up to a crank angular velocity of 450 $^{o}s^{-1}$ for flexion and extension of the knee and hip. Corrections for weight and differences between crank and joint angle were calculated. Peak isovelocity torques were determined for 17 angular velocities. High speed video (500 Hz) was used along with subject specific anthropometrics to determine joint torques during unloaded maximal flexion and extension of single joints. Joint torque near maximal velocity was used to provide an 18th torque-velocity value.

The Direct Optimization routine [3] was used to calculate the 4 and 7 parameter values that gave the best fit to the 17 data points. The upper bound for maximal angular velocity was set sufficiently high that it was not reached. The error between the 18th data point and that predicted by the two functions was calculated. The parameters were then re-optimized including 18 data points and its effect examined.

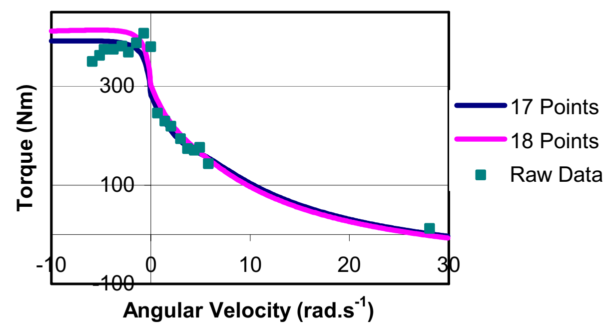

Figure 1: Torque profiles for knee extension using a 7 parameter function

RESULTS AND DISCUSSION

As expected the 7 parameter function produced better fits to the dynamometer data than the 4 parameter function. The average RMS error for the 7 parameter fits was 24 % and for the 4 parameter fits 45 %. The 7 parameter function using 17 data points was better at predicting torque at higher angular velocities, 13 % error, than the 4 parameter function, 38 % error (Table 1). Optimizing for the 18 point dataset improved the 4 parameter error at high velocity to 8.9 % and the 7 parameter to 6.5 %. The 7 parameter function appears more robust at extrapolating to higher velocities when only dynamometer data are available.

CONCLUSIONS

The 7 parameter function gives a better fit to the data than the 4 parameter function. It also extrapolates more accurately to predict high velocity data. The 7 parameter function is less sensitive to the maximum voluntary contraction bounds. The use of a 7 parameter function with dynamometer data should be used rather than a 4 parameter function even if eccentric data are not required.

REFERENCES

1. Westing et al. J. App. Physiology. **58**,100-104 1988.
2. Yeadon et al. *J Biomech* **38**, in press.
3. Finkel. CRSC, N.C. State University, March 2003

Table 1: Difference between the 18th data point and that predicted by the optimized curve.

Movement	**RMSD (percentage of maximum torque)**			
	Four parameters 17points	**Seven Parameters 17points**	**Four parameters 18points**	**Seven parameters 18points**
Hip Extension	30.15	23.47	5.28	3.02
Hip Flexion	6.12	4.02	2.06	2.22
Knee Extension	79.21	1.00	7.27	1.83
Knee Flexion	37.81	24.21	20.79	19.03
Mean Average	38.32	13.17	8.85	6.53