EFFECT OF STRETCH OR SHORTENING AMPLITUDE ON SUBSEQUENT ISOMETRIC MUSCLE FORCE

Sharon Bullimore, Tim Leonard, Dilson Rassier and Walter Herzog
Human Performance Lab, Faculty of Kinesiology, University of Calgary, Canada.
email: sbullimore@kin.ucalgary.ca

INTRODUCTION

It is well-known that the force that a muscle can develop during an isometric contraction is influenced by its contractile history [1]. Active stretch increases the force developed during a subsequent isometric contraction ('force enhancement', FE), while active shortening decreases subsequent isometric force ('force depression', FD). The mechanisms underlying these two phenomena are not well understood, although a number of possibilities have been suggested and the causes of FE and FD are thought to be different [2]. In order to be able to choose between proposed mechanisms, it is necessary to have a detailed knowledge of the characteristics of FE and FD. Here we determine the relationship between the amount of FE or FD and the amplitude of stretch or shortening, respectively. We hypothesised that the nature of this relationship would be different for FE and FD.

METHODS

The experiments were performed using seven cat soleus muscles, as described previously [3]. The muscles were isolated *in situ* and were activated through electrical stimulation of the tibial nerve. An isometric force-length relationship was obtained and optimal length was defined as the length at which active muscle force was highest.

The isometric force developed at a muscle length 9mm longer than optimal length was measured following active stretches of between 3 and 24mm. Total FE was defined as the difference between the isometric force developed after stretch and the force during a purely isometric contraction at the same length. Passive FE [4] was defined as the difference between passive force following a stretch trial and passive force following a purely isometric trial at the same length.

The isometric force developed at a muscle length 9mm shorter than optimal length was measured following shortening contractions of between 3 and 18mm. FD was defined as the difference between the isometric force developed after shortening and the force during a purely isometric contraction at the same length.

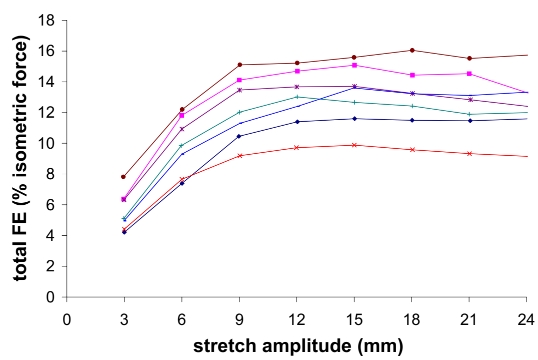

Figure 1: Relationship between total force enhancement (FE) and stretch amplitude in seven cat soleus muscles.

RESULTS AND DISCUSSION

As hypothesised, FE and FD showed different relationships to stretch/shortening amplitude. Total FE increased with stretch amplitude up to approximately 9mm stretch and then levelled off (Figure 1). Passive force enhancement increased with stretch amplitude up to approximately 9mm, then decreased. The relationships of total and passive FE to stretch amplitude were well-fitted by third order polynomials ($R^2 > 0.96$). FD increased with shortening amplitude without levelling off (Figure 2). The relationships of FD to shortening amplitude were well-fitted by second order polynomials ($R^2 > 0.94$). These differences in the behaviour of FE and FD support the hypothesis that they arise from different causes. Any mechanism that is proposed to explain FE must be able to account for the fact that FE increases with stretch only over a limited range of amplitudes before the effect appears to become saturated. Further investigation of the passive component of FE is important for understanding this behaviour.

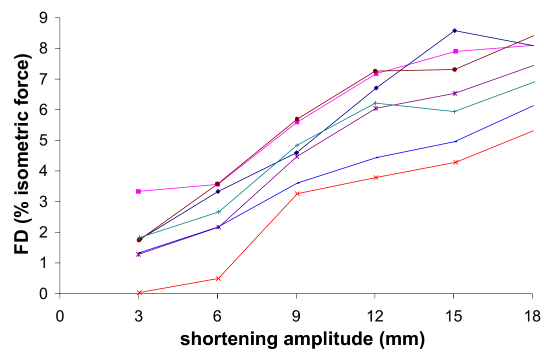

Figure 2: Relationship between force depression (FD) and shortening amplitude in seven cat soleus muscles.

REFERENCES

1. Abbott BC, Aubert XM. *J Physiol* **117**, 77-86, 1952.
2. Rassier DE, Herzog W. *J Appl Physiol* **96**, 419-427, 2004.
3. Herzog W, Leonard TR. *J Biomech* **30**, 865-872, 1997.
4. Herzog W, Leonard TR. *J Exp Biol* **205**, 1275-1283, 2002.

ACKNOWLEDGEMENTS

We thank the Natural Sciences and Engineering Research Council of Canada, the Canada Research Chairs Program and the Alberta Heritage Foundation for Medical Research for financial support.