QUANTIFICATION OF THE HISTORY DEPENDENCE OF FORCE PRODUCTION IN RABBIT *M. SOLEUS*

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Introduction

The description of history-dependent effects of force production in skeletal muscles is not possible by the two basic models of muscle contraction (Hill-type [1938] and cross-bridge [1957] model). Two history-dependent phenomena exist. On the one hand, skeletal muscles show force depression (FD) following shortening. That means the resulting force after shortening contractions is depressed compared to isometric reference contractions at the same muscle length. On the other hand, muscles generate more force after a stretch than the purely isometric force at the corresponding muscle length, which is called force enhancement (FE). However, so far structural reasons for both effects have not been sufficiently explained. Therefore, experiments with regard to the dependence (1) to the shortening and stretching velocity and (2) to the working range of the muscle are needed to broaden the understanding about these history-dependent effects. This is essential for the modelling of FD and FE.

Methods

In situ experiments were performed on the isolated rabbit *M. soleus* [Böl, 2013]. After identifying the active force-length relationship of the muscle the dependence of the history effects to the speed of shortening and stretching was determined at three different velocities (5, 10 and 20 mm/s) by tetanic stimulation of the tibial nerve. In order to check the history dependence of force production on the working range, isokinetic eccentric contractions were done at varied starting positions (at the ascending and the descending limb of the force-length relation).

Results

FE is independent of the stretching speed. Contrary to that, the rabbit *soleus* FD observed in all experiments depends on the speed of shortening. Furthermore the magnitudes of FE (15.0 ± 2.2%) and FD (15.5 ± 3.3%) are comparable for the determination 0.5 s after the stretch or the shortening. The tension increase in isokinetic eccentric contractions starting from different muscle lengths at the active force-length relation was identical in both cases, the ascending and the descending limb (Figure 1).

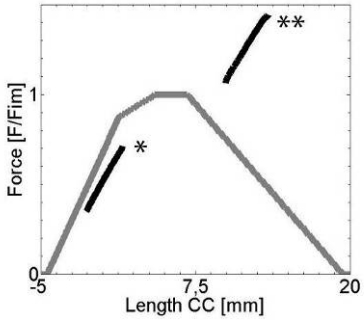

*Figure 1: Normalized active force-length relation of the contractile component (grey) and tension increase (black) in isokinetic eccentric contractions starting from different muscle lengths (*ascending and **descending limb)*

Discussion

The results regarding the velocity dependence of FE and FD are in good agreement with the literature. The observed independence of the tension increase in isokinetic eccentric contractions for different starting lengths of the force-length relation was also established by Till [2008]. A potential explanation for that can be the extension of the activation-dependent titin-induced 'sticky-spring' mechanism [Rode, 2009]. The incorporation of the simple 'sticky-spring' mechanism model into a Hill-type model offers the explanation for the history dependence of force production. This improves our understanding about the history-dependent effects and is fundamental for realistic modelling.

References

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