PASSIVE FORCE ENHANCEMENT AFTER STRETCH IN SINGLE MUSCLE FIBERS

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INTRODUCTION

The force produced by skeletal muscle after stretch is higher than the force produced during purely isometric contractions at the corresponding length (Edman et al., 1982; Herzog and Leonard, 2002; Julian and Morgan, 1979). It has been suggested that force enhancement may be partially accomplished by the engagement of a passive element. Consistent with this hypothesis, it has been observed that, when the stretch starts at long muscle lengths, force enhancement is accompanied by a long-lasting increase in the passive force after deactivation (Herzog and Leonard, 2002). This phenomenon is referred to as "passive force enhancement", and has never been observed in single muscle cells. This study was designed to evaluate if passive force enhancement occurs in single muscle cells, and furthermore to evaluate if the passive force enhancement is a function of slow detaching cross-bridges, or if it is associated with the engagement of a passive element upon activation and stretch.

METHODS

Single fibers isolated from the flexor brevis muscle of frog (n = 8) were placed at a length 25-30% above the plateau length of the force-length relationship. Passive and active stretches were performed with amplitudes of 5% and 10% of optimal fiber length, and at a velocity of 40% fiber length/s. Isometric contractions at the corresponding initial and final lengths were also performed for comparison. All contractions had a duration of 4 s, and were performed in regular Ringer's solution, and with 2 mM, 5 mM and 10 mM of 2,3-butanedione monoxime (BDM) added to the solution. BDM is a drug that inhibits cross-bridge attachment to actin and force generation (Horiuti et al., 1988). Passive force enhancement was calculated as the difference in force obtained after active stretch and subsequent deactivation of the cells, and after passive stretch at the corresponding lengths.

RESULTS AND DISCUSSION

After active stretching, active and passive forces were higher than the corresponding active and passive forces obtained at the same final length during isometric contractions and after passive stretches (Fig. 1). Therefore, total force enhancement and passive force enhancement were observed in this study. After BDM treatment, isometric forces decreased in a dose-dependent fashion. Total force enhancement and passive force enhancement were still observed (Fig. 2). The level of passive force enhancement was similar or higher than before BDM treatment. These results suggest that the passive force enhancement is not a function of slow cross-bridge detachment, but must be related to a passive element that is engaged upon muscle activation and stretch.

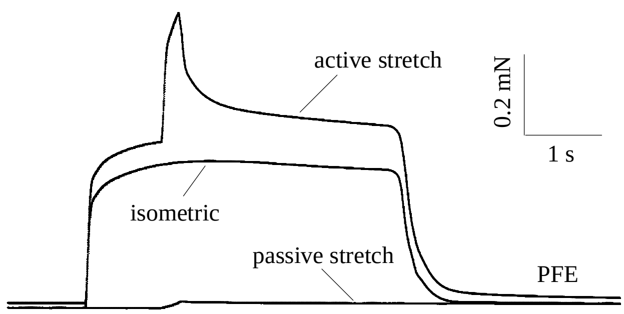

Figure 1: Total and passive force enhancement (PFE) after stretch (amplitude: 10% fiber length, speed: 40 fiber length/s) in regular Ringer's solution.

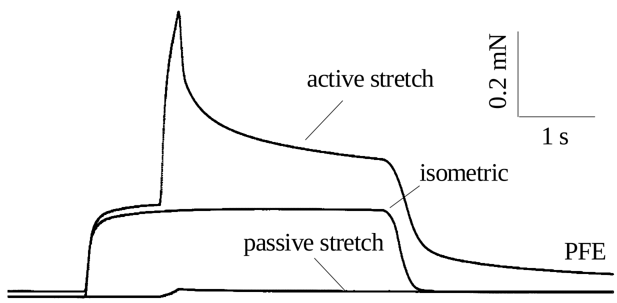

Figure 2: Total and passive force enhancement (PFE) after stretch (amplitude: 10% fiber length, speed: 40 fiber length/s) in Ringer's solution containing 5 mM BDM.

REFERENCES

Edman, K.A.P. et al. (1982). *J. Gen. Physiol.* **80**, 769-784.
Herzog, W., Leonard, T.R. (2002). *J. Exp. Bio.* **205**, 1275-1283.
Horiuti, K. et al. (1988). *J. Muscle Res. Cell Motil.* **9**, 156-164.
Julian, F.J., Morgan, D.L. (1979). *J. Physiol* .**293,** 379-392.