PHASE TRANSITION OF FORCE DURING RAMP STRETCH OF MUSCLE FIBERS WITH BDM

Dilson E. Rassier and Walter Herzog
Human Performance Laboratory, Faculty of Kinesiology
University of Calgary (AB), Canada; email:rassier@kin.ucalgary.ca

INTRODUCTION

When muscle fibers are stretched while activated, force increases in two phases: a fast steep increase, and a slow increase. It has been proposed that the breakpoint between phases and the increase in force is due to weakly-bound cross-bridges [1], that do not produce substantial isometric force, but contribute significantly to force when stretched. We tested this hypothesis by stretching muscle fibers while biasing cross-bridges towards a weakly-bound state. If the hypothesis was correct, stretch forces would increase relative to the isometric forces when cross-bridges are biased into a weakly-bound state.

METHODS

Single fibers were dissected from lumbrical muscles of the frog and suspended between a force transducer and a motor arm in an experimental chamber. Fibers were stimulated to produce maximal isometric force, and stretched 5% and 10% of optimal fiber length (L_o) at different velocities, starting at a length 20% above L_o. Experiments were performed at 9ºC in Ringer solution, and with 2, 5 and 10 mM of 2,3 Butanodione-monoxime (BDM). BDM is known to bias cross-bridges into a weakly-bound state [2], preceding phosphate release and the power stroke. Force values were evaluated before and at the end of stretch (peak forces), as well as at the point of transition between the fast and the slow phases of force increase during stretch (critical forces).

RESULTS AND DISCUSSION

When active muscle fibers were stretched while fully activated, force increased significantly. This increase could be divided into a fast rise and a slow rise in force (Fig 1). Increasing concentrations of BDM significantly decreased the isometric force, the absolute forces measured at the end of stretch, and the force at the transition between the fast and the slow phases of force increase. However, BDM significantly increased the peak force and the force at the transition point relative to the isometric force before stretch (Fig. 1). This result was confirmed statistically in 10 fibers, with 5 and 10% fiber length stretches (Fig. 2). Since BDM places a large proportion of cross-bridges in a weakly-bound state [2], we conclude that the force obtained during stretch is caused by weakly- and strongly-bound cross-bridges, while the isometric force is produced only by strongly-bound cross-bridges.

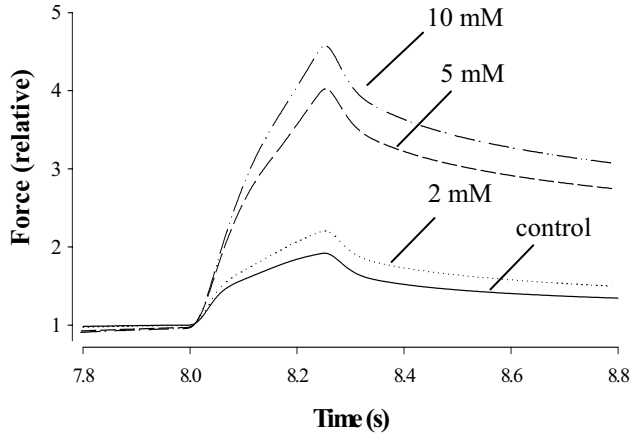

Figure 1: Force during stretch without (control), and with 2, 5 and 10 mM BDM.

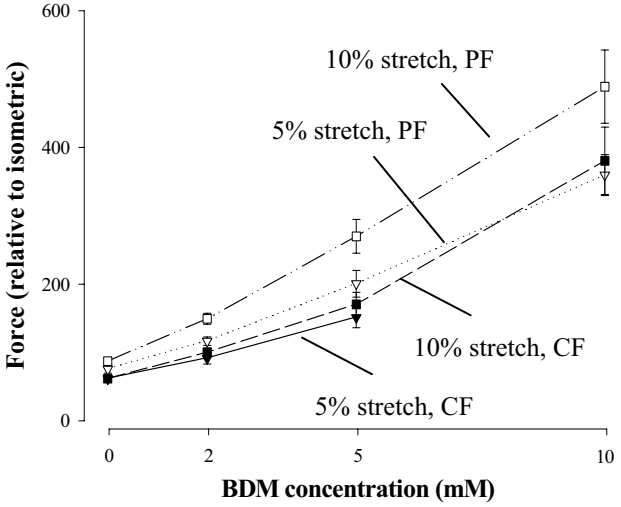

Figure 1: Peak forces (PF) and critical forces obtained at the transition between the fast and the slow phases of force increase during stretch (CF) during stretch, without (control), and with 2, 5 and 10 mM BDM

REFERENCES

1. Getz ,EB et al. *Biophys.J.* **75,** 2971-2983, 1998.
2. Regnier,M et al. *Am.J.Physiol* **269,** C1532-C1539, 1995.

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