TEMPERATURE-DEPENDENT MECHANICAL PROPERTIES OF HUMAN SOLEUS MUSCLE FIBERS

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INTRODUCTION

Temperature-dependent mechanical properties of different skeletal muscle fibers (slow and fast) are related to the differences in their crossbridge kinetics [1]. Previous studies have employed complex multi-state crossbridge models for analysis of temperature-dependent mechanical properties, mostly in isometric condition and for shortening contractions. There has been no study of the variations in contractile properties during lengthening contractions at different temperatures. This study will record the lengthening and shortening force-velocity (F-V) data from human type I fibers at different temperatures to examine the variations in these properties within the context of a simplified Huxley's two-state crossbridge model [2]. Also, this study will serve as the experimental basis of how to utilize data obtained at lower temperatures to extend the model to *in vivo* temperatures.

METHODS

Single fibers were chemically skinned and dissected free from biopsies of human Soleus muscles. Institutional Review Board approval was obtained for these procedures. Fibers were attached between the force transducer and motor hooks via aluminum foil T-clips. The initial sarcomere length of all fibers in relaxing solution was set to 2.2 µm, and each fiber is maximally activated in a Ca++ solution at a specific test temperature (10, 15, and 20^0 C). A perturbation was then applied as a linear change in force (force ramp) for both lengthening and shortening contractions to measure the F-V behavior. For this study, a total of 15 type I fibers have been measured. Each fiber was later analyzed by gel electrophoresis for myosin heavy chain type.

RESULTS AND DISCUSSION

Figure 1 shows the averaged F-V curves for human Soleus fibers during lengthening and shortening contractions across all trials at 10^0 C (n=5), 15^0 C (n=5) and 20^0 C (n=5). In all these fibers, a good homogeneity of the sarcomere pattern was maintained after repeated activations. These experimental curves clearly demonstrate that the mechanical properties of both shortening and lengthening contractions are quite sensitive for changes in temperature. A temperature rise from 10^0 C to 15^0 C causes an increase of ~43% in the maximum shortening velocity during shortening and an increase of ~135% during lengthening, thereby affecting the muscle's peak power production. A similar trend can also be observed among these properties at higher temperature steps.

By simulating the Huxley's crossbridge model for these ramp pertubations, it is possible to estimate the model parameters (crossbridge attachment rate, *f* and detachment rate parameter,

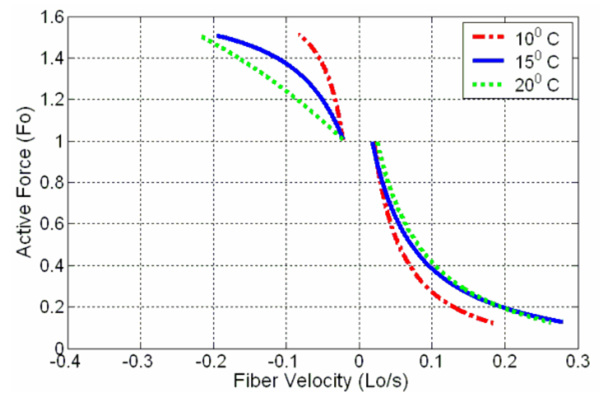

Figure 1: Averaged F-V curves at 10^0 C, 15^0 C and 20^0 C. Positive velocity is shortening.

g) [3]. These analyses provide valuable information about how crossbridge kinetics at the microscopic level influences macroscopic behavior. Also, these data at lower temperatures can be used to extrapolate *in vivo* function at physiological temperature. Furthermore, this study can be extended to investigate the temperature-dependent mechanical behavior of fast (Type II) fibers. These data would be critically important in understanding the differences of distinct muscle fiber types at both the microscopic and macroscopic levels [4].

SUMMARY

Mechanical properties of human Soleus (type I) muscle fibers are found to be highly-temperature sensitive. Specifically, both the lengthening and shortening force-velocity relationships were found to vary with the test temperature. These data will be used with a simplified crossbridge model to tie the temperature controlled biophysical experimental data to macroscopic force predictions. A need to further extend this study to *in vivo* temperatures is also justified in order to better understand the differences in contractile properties among various fiber types.

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