

Scientific Paper:

The Journal of Experimental Biology 210, 2843-2850, 2007

## **Effects of stretch on work and efficiency of frog (*Rana pipiens*) muscle**

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### **Abstract:**

Applying a small stretch to active muscle immediately before shortening results in an increase in force and work done during subsequent shortening. The basis of the increase is not fully understood, having important implications for work and efficiency, and how they are influenced through stretch. We used the anterior tibialis muscle of leopard frogs (*Rana pipiens* complex) to measure the oxygen consumed and work done during shortening contractions that were immediately preceded by either a brief stretch (5% muscle length over 25 ms) or an isometric contraction (25 ms duration). Work done by the muscle while shortening following stretch was about 28% greater than work done following an isometric contraction ( $P < 0.001$ ). However the net work done during the entire contraction (i.e. accounting for the work required to stretch the muscle) was reduced by 13% if stretch preceded the shortening phase ( $P = 0.003$ ). The energy (oxygen) used during a stretch–shorten cycle was the same as for an isometric–shorten contraction ( $P = 0.34$ ). Likewise, the efficiency of net work (net work/energy used) was only marginally different between shortening contractions preceded by stretch or an isometric phase ( $P = 0.07$ ). Thus, under conditions that were intended to mimic what might occur during animal movement, a stretch that immediately preceded shortening enhanced work during shortening but did not impart a net mechanical or energetic benefit to the contraction. These observations could indicate that stretch simply extends compliant elements that recoil subsequently with some loss of mechanical energy in the process and/or that stretch results in an increase in the number of, and hence work done by, cross bridges during muscle shortening accompanied by a proportionate increase in energy consumed.

Key-words: Muscle, stretch, shortening, isometric, efficiency, contraction work, net work, oxygen, energy, leopard frog