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The Molecular Mechanism of Skeletal Muscle Visco-Elasticity

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Abstract

The molecular spring titin is the primary structure providing passive force in skeletal muscle sarcomeres[1], and titin has been said to hold the key to the visco-elastic properties of muscles[2]. Specifically, it has been argued that unfolding/refolding of the Ig domains of titin causes the visco-elastic behavior, but Ig domain refolding only occurs at specific sarcomere lengths and forces[2]. Therefore, the purpose of this study was to test the hypothesis that muscle is highly visco-elastic in regions of Ig domain unfolding/refolding while it is virtually elastic when refolding is prevented. Ten myofibrils from rabbit psoas were isolated and prepared for mechanical testing as described previously[3]. Testing involved passive stretch release cycles of various magnitudes. First, three stretch shortening cycles were performed between average sarcomere lengths of 2.6 to 4.6 μm. Then, myofibrils were rested for ten minutes at slack length (1.8 μm) and the initial stretch-shortening cycles were repeated two more times. Following another rest of ten minutes, myofibrils were stretched to an average sarcomere length of approximately 4.6 μm and then shortened and stretched by 0.5, 1.0, or 1.5 μm/per sarcomere ten times. When stretched and released from 2.6 to 4.6 μm and back, myofibrils exhibited a highly visco-elastic behavior and Ig domain un/refolding is known to occur[2,3]. However, when myofibrils were cycled ten times by a short magnitude (e.g 0.5 μm) starting at an average sarcomere length of 4.6 μm, titin behaved virtually elastic and Ig domain refolding was prevented[2,3]. We conclude from these results that myofibrils behave visco-elastically in regions where Ig domain unfolding/refolding is known to occur, while they behave essentially elastic when operating in regions where Ig domain refolding is prevented. Therefore, a muscle's passive properties may change from highly visco-elastic to virtually purely elastic depending on the kinetics of Ig domain un/re folding.

References

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