A Simple Physical Model Replicates Two Behaviors of Passive Skeletal Muscle

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BACKGROUND Perimysial connective tissue, which surrounds individual muscle fascicles, has been described as a network of well organized, helically wound sleeves of collagen. The geometric arrangement of these sleeves has been shown to change as a function of muscle length [1], and mathematical modelling suggests that this reorientation should also be accompanied by changes in each sleeve's internal capacity. The volume of muscle fibers inside each sleeve, however, remains constant regardless of muscle length.

APPROACH To explore the implications of this potential volumetric conflict between collagen sleeves and the muscle fibers they surround, we built a simple physical model of a helical sleeve encompassing a constant volume balloon. We then compared the mechanical properties of this model to those of isolated bullfrog (*Lithobates catesbeianus*) muscles.

RESULTS In response to strain, tension and internal fluid pressure rose simultaneously in both the model and isolated muscles. In the model, tension and pressure rise exponentially at lengths where reorientation of the sleeve component is impeded by the constant volume of fluid held within.

Figure: The physical model and its components.

CONCLUSION Understanding muscle fascicles as helically wound sleeves of collagen surrounding constant volume groups of fibers provides a mechanistic explanation for the rise of internal fluid pressure observed at long muscle lengths. Additionally, it reveals the relationship between sleeve and fiber volume to be an important determinant of how collagen will contribute to passive muscle tension.

REFERENCES: [1] Purslow, 1989. Strain-induced reorientation of an intramuscular connective tissue network: implications for passive muscle elasticity. J. Biomechanics 22: 21-31.

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