Assessing the effects of muscle disease on force generation using multi-scale muscle model

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Computational muscle model is a common tool used for simulating muscle behavior and investigating its structural and functional properties. To be used for investigating and predicting the influence of various disorders and diseases on muscle functional behavior those models must integrate physical and biochemical properties across multiple length and time scales. They must be expressive in terms of describing intrinsic biophysical processes which can be separately defined for each subcomponent in the complex muscle structure. Single-scale muscle models, both biophysical and phenomenological, cannot comply. To address these demands, multi-scale muscle model must be used.

We present the methodology for multi-scale muscle modeling and its usage in predicting functional behavior of a disordered muscle. We use two-scale model which describes macroscopic muscle mechanics using finite element method, while the material attributes of the muscular tissue comply to the Huxley model, employed at the microscopic scale. To demonstrate the methodology, we use a simplified 2D geometry of a muscle body for simulations of physiological tasks of a muscular organ in health and disease. We simulated *mdx* mouse effect on a healthy muscle model. The *mdx* mouse model is a model of Duchenne muscular dystrophy (DMD) used to study the disease mechanisms and potential treatments. We demonstrate how the disease affects mobility of the muscle and assess its effects on force generation in comparison with healthy muscle behavior.

References

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