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Extracting low-velocity concentric and eccentric dynamic muscle properties from isometric contraction experiments. (English) Zbl 1346.92016

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Summary: Determining dynamic properties of mammalian muscles, such as activation characteristics or the force-velocity relation, challenges the experimentalist. Tracking system, apparatus stiffness, load oscillation, force transducer, other sensors, and additional measuring devices may be incorporated, integrated and evaluated in an experimental set-up. In contrast, isometric contraction experiments (ICEs) are less challenging, but are generally not considered to reveal dynamic muscle properties. Yet, a sensitivity analysis of our muscle model discloses the influence of concentric, eccentric and activation parameters on isometric force development. Accordingly, we used solely experimental ICE data to identify muscle model parameters that generally describe concentric as well as eccentric muscle performance. In addition, we compared two different activation dynamics in regards to their physiological relevance to improve model-fits to ICE data. To this end, we optimized different combinations of such dynamic parameter subsets with respect to their influence on contraction solutions. Depending on muscle length in our optimized model, the contractile element reached shortening peaks during activation in the range 9–39% of its maximum contraction velocity, and about 8–25% during lengthening when deactivated. As a first result, we suggest one formulation of activation dynamics to be superior. Second, the step in slope of the force-velocity relation at isometric force was found to be the least influential among all dynamic parameters. Third, we suggest a specially designed isometric experimental set-up to estimate this transition parameter. Fourth, because of an inconsistency in literature, we developed a simple method to determine switching times of the neural stimulation and thus electro-mechanical delay (EMD) values from measuring muscle force in ICEs only.

MSC:

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Keywords:

biomechanical optimization; striated muscle model; sensitivity analysis; electro-mechanical delay; experimental design

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paper as accurately as possible without claiming the completeness or perfect precision of the matching.