Exploring the limitations of a proposed muscle fatigue model through static and dynamic experiments

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Abstract

In this work, a muscle fatigue model is proposed. It is based on the three-compartment model to simulate muscular fatigue, which considers the resting, active and fatigued states of each muscle, along with the differential equations that govern their evolution. Moreover, muscle fibers are divided into two groups: group A (high and moderate fatigue resistance), formed by fibers type I (slow oxidative) and type IIa (fast oxidative); and group B (low fatigue resistance), formed by fibers type IIx (fast glycolytic). Therefore, each modeled muscle is split into two parts. The effect of muscular fatigue in the force-sharing problem is taken into account through the decay of the maximum isometric force, which affects the boundaries of each muscle force in the optimization. The effect of muscular fiber distinction comes through the presence of the fatigue parameter of each muscle in the cost function of the optimization, which causes that group A is recruited first. To assess the accuracy of the proposed approach, two experiments are carried out and their results compared with those obtained from computational analysis. In the first experiment, static, the subject holds a dumbbell in his hand, with the arm flexed at a certain angle, until failure. In the second experiment, dynamic, the subject performs series of forearm flexion/extension movements with the dumbbell in his hand (hammer curl), followed by resting periods. The conclusions of the study are: (i) the accurate results obtained for the static case; (ii) the insufficient torque predicted by the model at some particular instants for the dynamic case, which demands a more precise calibration of muscle parameters; (iii) the necessity of modeling the effect of muscular potentiation; (iv) the need of improving the three-compartment model to avoid reaching situations of unrealistic constant fatigue in exercise-resting cycles.