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# A FULLY INVERSE DYNAMICS APPROACH TO STUDY HOW THE MUSCLE DYNAMICS INFLUENCES THE SHOULDER MUSCLE FORCE SHARING PROBLEM

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**Summary:** Due to numerical challenges related to the optimization methods applied, inverse dynamic simulations of the human movement hardly ever consider the muscle dynamics. Recently, a novel method was proposed to overcome the limitations of the commonly applied optimization methods and allow the analysis of complex biomechanical models including the muscle dynamics, i.e., the activation and muscle-tendon contraction dynamics. Considering that the influence of the muscle dynamics on the muscle force predictions is not fully understood, the aim of this study is to evaluate how the shoulder muscle force sharing problem changes due to the muscle dynamics using a musculoskeletal model of the upper limb. The biomechanical model applied is composed of 7 rigid bodies that present 9 degrees-of-freedom. The mechanical behavior of 22 muscles, described by 74 bundles, is described by a three-element Hill-type muscle model. Depending on the simulation of the activation and muscle-tendon contraction dynamics, four musculotendon models are defined. Kinematic and EMG data were acquired synchronously at the Laboratory of Biomechanics of Lisbon for abduction and anterior flexion motions of the upper limb. The optimization problem associated with the solution of all muscle and joint reaction forces was formulated as the minimization of the muscle metabolic energy consumption subjected to the boundary constraints of the muscle activations, to the equilibrium of the equations of motion, and to the stability of the shoulder and scapulothoracic joints. Boundary constraints on the muscle excitations were also defined when the activation dynamics was simulated. The results showed no major differences on the solutions of the muscle force sharing problem for all four muscle models, which suggests that the muscle dynamics on the shoulder joint can be neglected without compromising the muscle force sharing problem when slow-speed, standard movements of the upper limb are studied.