

Determination of the strategy for solving the muscle force sharing problem in patients suffering ACL rupture

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ABSTRACT

The “force sharing problem” associated with the overactuation of musculoskeletal systems (more muscles than DOF) has been addressed by many authors. To overcome the indeterminacy, different optimization methods with different cost functions have been proposed [1]. The cost function represents a physiological variable that the central nervous system (CNS) minimizes when activating the muscles. In the case of healthy subjects, the strategy followed by the CNS to activate muscles has been widely studied. However, little research has been done for the case of injured patients.

The main goal of this study is to discuss the strategy followed by the CNS of an injured subject when activating the lower limb muscles. To this end, the gait of a 59-year-old male subject suffering from an ACL rupture at the right knee has been captured in a biomechanics lab. A musculoskeletal system with 7 segments (9 DOF) and 8 muscles has been used to model the human body. In order to apply inverse dynamics, the kinematics of the joints has been recorded by means of 18 infrared cameras and foot-ground contact forces have been measured using two force plates. Electromyography (EMG) data have also been acquired in order to validate the results.

Once the joint torques are calculated, a two-step optimization problem is formulated to obtain muscle forces. In this study, we hypothesize that the patient minimizes joint pain and so, muscles are not treated equally in the cost function: muscles have been grouped in 4 sets (knee monoarticular, hip-knee biarticular, knee-ankle biarticular, hip and ankle monoarticular) and a different weighting factor has been given to each group. A total of 85 sets of weighting factors have been considered in order to investigate the combination leading to muscle activations closer to the EMG signal. The best results are obtained when the cost function penalizes the hip-knee biarticular muscles. Fig. 1 shows the rectus femoris (RF) activation (using the “healthy” and the “best” cost functions) and its measured EMG signal. These results support the hypothesis that the CNS of the patient activates muscles in a way to decrease knee pain, since lower activity of the hip-knee muscles avoids the displacement of the proximal end of the tibia, which is in accordance with Berchuck *et al.* [2].

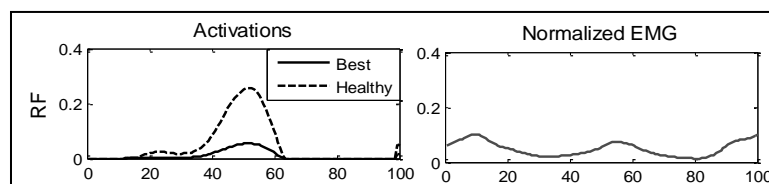


Fig. 1 Activation of the rectus femoris using the “best” cost function and the one for “healthy” subjects and normalized EMG signal.

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