Adaptations in Mono- and Bi-articular Muscle Coordination with Motor Learning

Christopher J. Hasson, Richard E.A. Van Emmerik, and Graham E. Caldwell

Biomechanics and Motor Control Laboratories
Department of Kinesiology
University of Massachusetts Amherst

Purpose: While it has been suggested that bi-articular muscles have a specialized role in directing external reaction forces, it is unclear how humans learn to coordinate mono- and bi-articular muscles to perform force-directing tasks.

Methods: Subjects were asked to direct pedal forces in a specified target direction during one-legged cycling. We expected that with practice, performance improvement would be associated with specific changes in joint torque patterns and mono- and bi-articular muscular coordination. Nine male subjects practiced pedaling an ergometer with only their left leg, and were instructed to always direct their applied pedal force perpendicular to the crank arm (target direction) and to maintain a constant pedaling speed. Subjects participated in a single practice session consisting of sixteen 30-second trials of one-legged pedaling.

Results: Over the course of the practice session, the mean error between the applied and target pedal force directions decreased significantly. This improved performance was accompanied by a re-organization of lower extremity joint torques, with a decrease in ankle plantarflexor torque and an increase in knee and hip flexor torques. Changes were seen in both mono- and bi-articular muscle activity patterns. The mono-articular muscles exhibited greater alterations, and appeared to contribute to both mechanical work and force directing. With practice, a loosening of the coupling between bi-articular thigh muscle activation and co-regulation of hip and knee torques was observed.

Conclusion: The results demonstrated that subjects were able to learn a complex and dynamic force-directing task by changing the direction of their applied pedal forces through a re-organization of joint torque patterns and mono- and bi-articular muscle coordination. This information will be used to develop a musculoskeletal model to further explore the properties of bi-articular muscles, and will be useful in future research concerning the rehabilitation of patients who must re-learn basic patterns of muscular coordination.