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The effect of knee joint angle on neuromuscular changes after an exercise-induced muscle damage

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Introduction

It has been well established that performing a bout of unaccustomed, predominantly eccentric exercise may result in a short (immediately post: *fatigue*) and long-lasting (> 24 h: *muscle damage*) muscle function deficit and neuromuscular function (NMF) alterations. The peripheral (i.e., muscle) changes are mainly assessed by electrical stimulation of motor nerves at rest. The characteristics of the evoked response to electrical stimulation could inform about the mechanical and contractile state of the muscle. These mechanical and contractile properties are known to be modified by joint angle (short vs. long muscle lengths). However, the effect of joint angle on NMF alterations evaluated after fatiguing and/or damaging exercise is currently debated, possibly because of differences of resting stiffness across muscles and lengths. The first aim of the present study was to investigate whether the most commonly NM function assessments were differently affected by the articular joint angle after a fatiguing/damaging exercise. We hypothesized that NMF would be less affected at long muscle length compared to short muscle length owing to the higher resting stiffness and greater force transmission. The second aim was to investigate whether the muscle-tendon complex, within a muscle group, would be differently modified by articular joint angle after exercise.

Methods

12 participants performed a 45-min downhill walking (DW) on a treadmill with a load 30% of the body mass, at a 25%-gradient and a velocity of 4.5 km.h-1. NMF assessments, delayed-onset muscle damage (DOMS), knee range of motion (ROM), muscle architecture and ultra-fast imagery parameters, creatine kinase (CK) and myoglobin (Mb) were assessed before (PRE), within 1h (POST) and 4h after the exercise (POST), and the days after exercise (24h, 48h, 72h and 168h). Maximal voluntary contraction and evoked torque of the knee extensors (KE) were measured from the participant's right leg which was fixed at 40∘ (SHORT), 90∘ (NEUTRAL), 120∘ (LONG). Peripheral properties of the KE muscles were assessed from the amplitude of potentiated responses to single (Tw) and low/high frequency double (Db10Hz and Db100Hz)

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electrical stimulations at rest. Rate of torque development (RTD) and contraction time (Ct) were also calculated for Tw. Muscle architecture and muscle stiffness were evaluated using B-mode ultrasound and ultra-fast sequences among different KE muscles.

Results

A significant time x angle interaction effect was found for Db10/Db100, Db10hz, RTD and Ct. Db10/Db100 was significantly different between LONG (-20.6 ± 7.6%) and SHORT/NEUTRAL (-33.6 ± 20.2%, -31.0 ± 14.6%; respectively) only at POST. Db10 was significantly different between SHORT (-46.1 ± 19.3%) and LONG (-34.4 ± 14.1%) only at POST. RTD was significantly different between LONG (-6.4 ± 14.8%) and SHORT/NEUTRAL (-41.2 ± 20.9%, -31.0 ± 15.1%, respectively) only at POST. Ct was significantly different between SHORT (+1.1 ± 8.7%) and LONG (-23.9 ± 12.0%) only at POST. Biological and imagery parameters analysis are in progress.

Conclusion

Our results showed that peripheral alterations are less pronounced at LONG compare to SHORT immediately after the exercise, possibly because of the mechanical state of the muscle-tendon unit. NMF should be evaluated at several articular joint angles in order to better understand changes of the mechanical state of the muscle after fatiguing/damaging exercises.

Keywords: neuromuscular fatigue, eccentric, exercise, induced muscle damage, elastography, ultrasound