EVALUATION OF SKELETAL MUSCLES AFTER STRENUOUS EXERCISE WITH MAGNETIC RESONANCE IMAGING AND ULTRASONOGRAPHY

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Introduction

Several studies have investigated muscle damage induced by strenuous exercise with eccentric muscle contraction (1, 2). Although eccentric muscle contraction frequently causes delayed onset muscle soreness (DOMS) (1), time-course changes in damaged muscles with DOMS have not been sufficiently evaluated. This study aimed at assessing the physiological and structural changes by using T2-weighted, diffusion-weighted, and diffusion-tensor imaging as well as the biomechanical and functional changes by using ultrasonography in skeletal muscles after strenuous exercise.

Methods

The medial and lateral gastrocnemius and soleus muscles of 7 men (mean age, 21.7 years) were studied. Transverse axial diffusion-weighted (for apparent diffusion coefficient [ADC] assessment), diffusion tensor (for fractional anisotropy [FA] assessment), and T2-weighted (for T2 assessment) images of the right leg were obtained using a 1.5-T magnetic resonance (MR) device with a Quadknee coil. The images were obtained before as well as 1, 2, 3, 5, and 8 d after strenuous ankle plantar flexion exercise with eccentric muscle contraction. The maximal movement of the myotendinous junction (MTJ) of the medial gastrocnemius muscles and maximal isometric force (MIF) during maximal voluntary ankle plantar flexion were also determined by ultrasonography and a specially designed muscle strength measurement system, respectively. Moreover, plasma creatine kinase (CK) level and visual analog scale scores (100 mm scale; a score of 0 indicated no pain, whereas a score of 100 indicated agonizing pain that did not allow the subject to walk) were assessed as parameters of muscle damage and muscle soreness, respectively. Time-course changes in these parameters were analyzed using repeated measure analysis of variance followed by the Dunnett test ($P < 0.05$).

Results

Only the medial gastrocnemius muscle exhibited significantly increased T2 (from 32.6 to 43.0 ms) and ADC (Fig. 1) as well as decreased FA (Fig. 2) at 3 d postexercise. The movement of MTJ significantly decreased at 1 d postexercise. Although the MIF of ankle plantar flexion decreased slightly at 2 and 3 d postexercise, it did not change significantly throughout this study. The CK and muscle soreness levels peaked at 3 d (from 142.7 to 6150.0 U/L) and 2 d (from 0 to 81 mm) postexercise, respectively ($P < 0.05$).

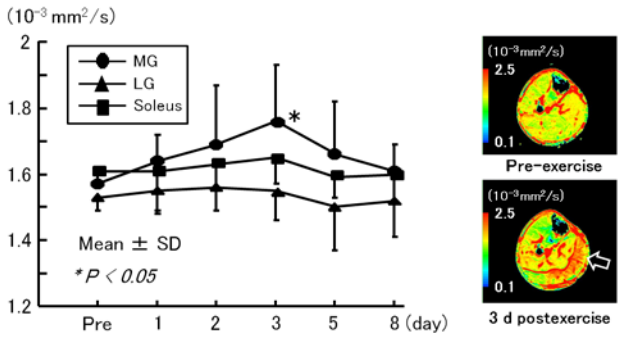

Figure 1. Time-course changes in the apparent diffusion coefficient (ADC) values in triceps surae muscles and representative ADC maps before and 3 d after exercise. MG and LG denote medial and lateral gastrocnemius muscles, respectively. The asterisk indicates the ADC value that is significantly higher than the value at rest. The arrow on the ADC map obtained at 3 d postexercise indicates increased ADC in MG.

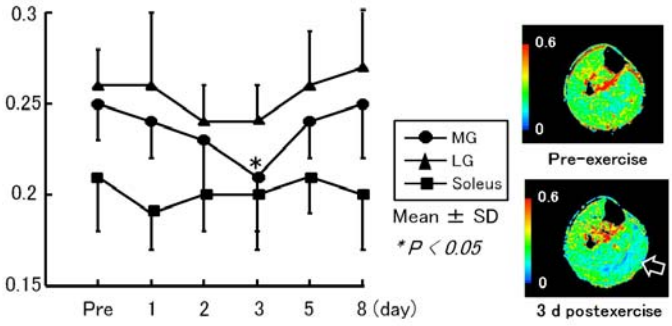

Figure 2. Time-course changes in the fractional anisotropy (FA) values in triceps surae muscles and representative FA maps before and 3 days after exercise. MG and LG denote medial and lateral gastrocnemius muscles, respectively. The asterisk indicates FA value that is significantly lower than the value at rest. The arrow on the FA map obtained at 3 d postexercise indicates decreased FA in MG.

Conclusion

Eccentric muscle contraction causes a microinjury (structural damage) to skeletal muscles (1, 2); this damage should increase the CK and muscle soreness levels (DOMS). Muscle damage frequently causes temporal and delayed edema (1, 2), which probably contributed to the significant changes in the ADC, FA, and T2 values of the medial gastrocnemius muscle after exercise. Moreover, the decreased movement of the MTJ suggests the decreased contribution of the medial gastrocnemius muscle among the triceps surae to the MIF during ankle plantar flexion.

References

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