INTRODUCTION

Mechanomyogram (MMG) is a mechanical manifestation of muscle contraction. Previous studies have indicated that MMG amplitude might represent not only motor unit (MU) recruitment and firing rate but also its contractile properties (Orizio et al., 1996; Yoshitake et al., 1999; Bichler, 2000). The present study examined the possibility of revealing the time-course changes in human muscle contractile properties by performing the MMG amplitude analyses in various experimental conditions. First, the MMG amplitude evoked by repetitive stimulation was experimentally studied in normal and hypothermia condition to validate the relationship between muscle contractile properties and MMG amplitude. In the second, as a practical purpose, the MMG amplitude analysis was applied to examine the changes in muscle mechanical behavior during fatiguing voluntary contraction. The medial gastrocnemius (MG) and soleus (SOL) muscles, which have different muscle fiber distribution, were examined to help the interpretation of the result.

METHODS

Two identical microphone sensors (10 mm diameter, mass 5g, bandwidth 5-2000Hz) for MMG recording were fixed to the center of the belly of MG and SOL. EMG recording electrodes (Ag/AgCl, 8 mm diameter, 35mm inter-electrode) were placed to line-up with the microphone on the longitudinal axis of each muscle, respectively.

In the first experiment (N=8), the single twitch and repetitive percutaneous nerve stimulation (10Hz, 8sec) were performed during room temperature and hypothermia condition (15, 20, and 25°C of intramuscular temperature). In the second fatiguing experiment at room temperature (N=6), the subject was instructed to keep the plantarflexion torque at 50%MVC for as long as possible. The torque produced was simultaneously feed-backed to the subject through the oscilloscope. The test was ended when the torque production was reduced to 40%MVC. The EMG, MMG and plantarflexion torque were simultaneously recorded. The EMG and MMG signals were band-pass filtered at 5Hz-1kHz and 5Hz-100Hz, respectively. Each signal was sampled at 2KHz before storing on a desktop computer (DOS/V). In the first experiment, each signal in the middle 2sec was analyzed during the repetitive stimulation and the RMS (root mean square) value was calculated. Then, force signal was performed the A-C coupling to evaluate its fluctuation properties by RMS values. For the subsequent fatigue test, the RMS (root mean square) values in MMG and EMG signal were calculated over each 10% of total contraction time (TCT) and averaged among the subjects.

RESULTS AND DISCUSSION

The M-wave peak-to-peak amplitude was significantly increased in colder condition in each muscle (p<0.01). The significant reduction in the muscle contractile properties (peak force, maximal rate of force development and relaxation, contraction and half-relaxation times etc.) caused by hypothermia resulted in significant reductions in force amplitude with subsequent fusion at 10Hz stimulation frequency. This change was almost mirrored by the similar and significant reductions in the MMG amplitude in both MG and SOL (Figure 1). In addition, the power spectrum analysis revealed that peak frequency components of MMG and fluctuation of force was almost matched with the stimulation frequency in every temperature condition. These results strongly suggest that MMG amplitude analysis during repetitive stimulation could be employed to study the changes in muscle contractile properties.

![Figure 1: Changes in force fluctuation and MMG root mean square (RMS) values in each muscle during 10Hz stimulations under cooling conditions. Values are mean ± SE. *P<0.01, significantly different from control.](image)
new insight into the MU activation strategies together with the corresponding time-course changes in MU contractile properties.

REFERENCES


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