MECHANOMYOGRAPHIC AND ELECTROMYOGRAPHIC RESPONSES TO ISOKINETIC MUSCLE ACTIONS

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INTRODUCTION

Mechanomyography (MMG) records and quantifies the low frequency lateral oscillations of active skeletal muscle fibers. It has been suggested that MMG is the mechanical counterpart of the motor unit electrical activity as measured by electromyography (EMG). Thus, simultaneous measurements of MMG and EMG may provide insight into the mechanical and electrical components of muscle function. MMG has been used to discriminate between muscle fiber types, monitor strength training, and identify changes in force production and muscle action velocity. Clinically, MMG may be useful for examining muscle diseases and controlling external prostheses. Simultaneous measurements of MMG and EMG have been used to monitor the dissociation between the electrical and mechanical events (excitation-contraction coupling) that occurs with fatigue and examine factors related to electromechanical delay. Most previous studies have examined the MMG responses to isometric muscle actions, however, little is known about the MMG response to isokinetic muscle actions. Recently, we have examined the MMG and EMG responses of the superficial muscles of the quadriceps femoris during maximal concentric and eccentric isokinetic muscle actions as well as passive leg extension movements at velocities ranging from 30-300 $^{\circ}\cdot s^{-1}$.

METHODS

Isokinetic Measurements
Isokinetic muscle actions were performed on a calibrated Cybex 6000 dynamometer. Peak torque (PT) and mean power (MP) were calculated by the Cybex 6000 software.

MMG Measurements
The MMG signals were detected by piezoelectric crystal contact sensors (HP 21050A) placed between the active EMG electrodes on the vastus lateralis (VL), rectus femoris (RF), and vastus medialis (VM). A stabilizing ring, double-sided foam tape, and microporous tape were used to ensure consistent contact pressure of the MMG sensor.

EMG Measurements
A bipolar surface electrode (Quinton Quick Prep silver-silver chloride) arrangement was placed over the muscle belly of the RF, VL, and VM muscles of the dominant leg. For all EMG measurements, the reference electrodes were placed over the iliac crest. Interelectrode impedance for each muscle was kept below 2000 Ohms by shaving the area and careful skin abrasion. The EMG signals were preamplified (gain 1000X) using a differential amplifier (EMG 100, Biopac Systems Inc).

Signal Processing
The raw MMG and EMG signals were stored on a personal computer. The

sampling frequency was 1000 points per second for all signals. The MMG and EMG signals were bandpasss filtered from 5-150 Hz and 10-500 Hz, respectively, by software (Acqknowledge III, Biopac Systems, Inc.).

RESULTS AND DISCUSSION

Concentric Muscle Actions (Ebersole et al. 2000, 2001; Cramer et al. 2001; Evetovich et al. 1997)

There were velocity-related dissociations between PT, MP, and MMG amplitude. As expected, PT decreased across velocities ranging from 60 to 300° s^{-1}. MMG amplitude and MP, however, increased up to 240° s^{-1} and then decreased from 240 to 300° s^{-1}. Thus, MMG amplitude may be more closely related to MP than PT during maximal, concentric, isokinetic muscle actions. EMG amplitude increased up to 240° s^{-1} for the VL, remained unchanged across velocities for the RF, and increased up to 300° s^{-1} for the VM. These findings suggest that the velocity-related increases in MMG amplitude were due to decreases in muscle stiffness, increases in the rate of actin-myosin cycling, and/or limb movement.

Eccentric Muscle Actions (Cramer et al. 2001)

During eccentric muscle actions ranging from 60 to 180° s^{-1}, there was no change in PT, but increases in MP and MMG amplitude. The EMG amplitude remained unchanged from 60-120° s^{-1}, but decreased from 120-180° s^{-1}. Thus, as with concentric muscle actions, MMG amplitude may be more closely related to MP than PT. The dissociation between MMG and EMG from 120 to 180° s^{-1} suggests that during maximal eccentric muscle actions, changes in the recruitment patterns (slow vs. fast-twitch) may have resulted in decreased muscle stiffness, thereby, increasing MMG amplitude.

Passive Leg Extension Movements (Ebersole et al. 2001)

When the leg was passively moved through leg extension at velocities of 30, 90, and 150° s^{-1}, the EMG amplitude was not different from those values recorded at rest. The MMG amplitude, however, increased with an increase in velocity. These findings suggest that limb movement, independent of muscle activation, may account for a portion of the velocity-related increase in MMG amplitude during isokinetic muscle actions. It is possible that during isokinetic muscle actions, the MMG amplitude is influenced by factors such as turbulences of the intracellular and extracellular fluid mediums and/or cross-talk from the hamstring muscles.

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