Introduction
The decline of joint torque over repeated contractions results from decreases in the force of synergist muscles, which are caused by central and/or peripheral fatigue of individual muscles (Kawakami et al. 2000). This study aimed to clarify the influence of central and peripheral fatigue of synergist muscles (medial gastrocnemius: MG and soleus: SOL) to plantar flexion on the torque decrease over repeated contractions, based on the observation of neural activities and tendon elongation that represents the magnitude of force exerted by each muscle.

Methods
Seven subjects lay prone with their right ankle positioned at 10° of dorsiflexion and the knee joint fully extended. First, they performed a ramp isometric plantar flexion up to maximal voluntary contraction (pre-ramp). Then, they exerted maximal isometric plantar flexions intermittently with a 2-s contraction followed by a 2-s of rest that were repeated 60 times (fatigue test). For every 10th contraction, electrical stimuli were imposed during and the following rest period (rest twitch torque). The voluntary activation (VA) was calculated as the central fatigue of triceps (Allen et al. 1995). The peak value of the rest twitch torque was defined as an index of peripheral fatigue. Fascicle lengths and pennation angles of MG and SOL during pre-ramp and fatigue test were measured by ultrasonography. The tendon elongation of each muscle was estimated from the changes in fascicle length and pennation angle during contractions (Kawakami et al. 1998). EMG activities were simultaneously recorded from the bellies of the MG and SOL using bipolar surface electrodes, and mean EMG amplitude (mEMG) for each contraction was computed.

Results & Discussion
The plantar flexion torque decreased over time during the fatigue test. A statistical difference from the initial stage (1-5th contraction) in torque was observed after 11-15th contraction, but the torque did not significantly decrease from 41-46th contraction through 56-60th contraction. In an early stage of fatigue test (1-20th contraction), the rest twitch torque significantly decreased from the initial stage, while VA did not change. The tendon elongation of MG significantly decreased indicating that the force of MG decreased. Thus, the decline of torque in the early stage was attributed to the change in peripheral fatigue of MG. In the middle stage (21-40th contraction), decreases from the initial stage were observed for the rest twitch torque and the VA. The tendon elongation of MG significantly decreased from the initial stage, while that of SOL did not change. Furthermore, the mEMG of SOL for a given torque was greater than that in pre-ramp. In contrast, the relationship between mEMG of MG and plantar flexion torque remained unchanged. The present results suggest that central and peripheral fatigue is operative differently in the process of force decline, the timing and magnitude of which are muscle-dependent.

Keywords: Tendomuscular Mechanics -session, Fatigue, Electrical/Mechanical Stimulation

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