SHORTENING VELOCITY OF HUMAN PLANTAR FLEXORS IN VIVO AND ITS RELATION TO CONTRACTION INTENSITY AND KNEE ANGLE

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INTRODUCTION

To measure the intrinsic shortening velocity of human muscles in vivo, we have recently developed a technique, the principle of which is based on the 'slack test' developed by Edman [1] for single muscle fibers. Using this technique, the unloaded shortening velocity (V_0) of contractile component can be determined without an effect of the recoil of series elastic component (SEC).

The purpose of this study is to measure V_0 of human plantar flexors at varied levels of contraction intensity. In consideration of the biarticular structures of medial and lateral gastrocnemius muscles, we also examined if a change in knee angle affects V_0.

METHODS

Eight male subjects participated in the present study. Each subject performed voluntary contractions on a custom-designed ankle dynamometer, with which high angular velocities (up to 20 rad s^{-1}) can be attained. During the testing session, the subject's right foot was attached firmly to the footplate by using inelastic straps.

Isometric plantar flexion force was measured during maximum voluntary contraction (MVC) at an ankle angle of approximately 10-15º dorsiflexion. Then, while the subject performed an isometric contraction with a given force level (10%, 50%, and 80% of MVC), the footplate was released and rotated at a high speed (quick-release movement). The distance of release (ΔL) ranged between 35º and 50º, which is above the SEC strain of plantar flexors during MVC estimated in the previous studies [2,3].

Since a considerable ankle rotation occurs even during an isometric plantar flexion [4], ΔL was corrected for the ankle rotation during an isometric contraction preceding the release by using an electrical goniometer. In addition, the force signals were corrected for passive force and inertia by using a transfer function. After correction, the time between the onset of release and the beginning of force redevelopment (Δt) was determined (Figure 1). Relations between Δt and ΔL for varied release distances were fitted with a linear regression, the slope of which provided V_0 of plantar flexors.

All the subjects completed two testing sessions with the knee extended or flexed, which were taken on separate days. In the flexed knee position, the knee was flexed 120º, at which the biarticular gastrocnemius muscles can transmit negligible contractile forces to the calcaneus, as suggested previously [5]. Even in the extended knee position, the knee was slightly flexed (within 20º) to prevent pain or discomfort due to immoderate stretch of the gastrocnemius muscles.

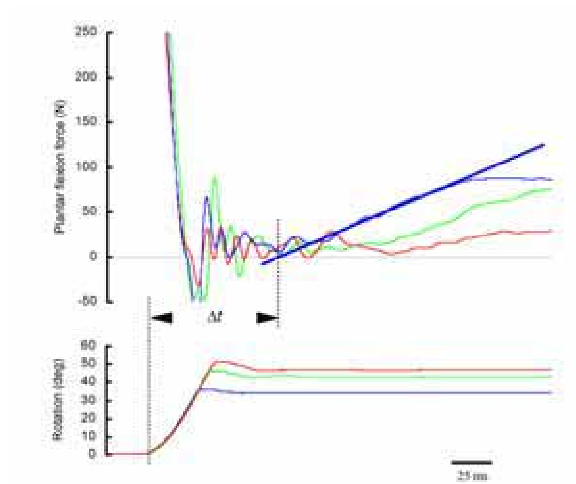

Figure 1: Superimposed force and angle recordings from three quick releases with different release distances.

RESULTS AND DISCUSSION

Representative results from one subject (Figure 2) showed that V_0 increased with contraction intensity in the extended knee position, suggesting progressive recruitment of faster motor units. In the flexed knee position, however, such a tendency was not observed. This may be due to the ineffectiveness of the gastrocnemius, which has a higher percentage of fast-twitch fibers and longer fascicles, to produce and transmit muscle forces.

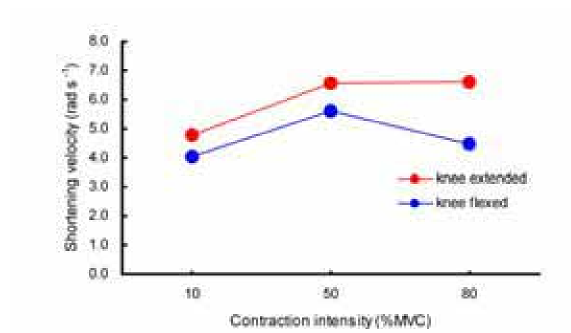

Figure 2: Representative relations between contraction intensity and V_0.

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