RECRUITMENT OF SOLEUS AND GASTROCNEMIUS WITH RESTRICTED AND UNRESTRICTED ANKLE MOTION

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INTRODUCTION

Marsh and Martin [1] showed that the gastrocnemius and soleus muscles responded differently to cadence manipulations during cycling. Gastrocnemius excitation increased with increasing cadence whereas soleus did not. Subsequently, Sanderson et al. [2] repeated their experiment and presented data on muscle lengthening and EMG activity for gastrocnemius and soleus where cadence was manipulated (50 – 110 rpm in 15-rpm increments). They postulated that the difference in sensitivity to cadence manipulations between these two muscles was associated with their mechanical properties. To assess this postulate individual ankle-foot orthoses that kept the ankle joint at 90° of flexion, or the neutral position were worn as cyclists pedaled a series of cadence conditions at a fixed power output (200 W). In doing so the opportunity for soleus to contribute to pedal force was removed. We postulated that this would result in an increase in gastrocnemius excitation to compensate for the loss of the soleus contribution. Further, with the ankle joint fixed at 90° we would be able to separate the influence of ankle joint ankle changes on gastrocnemius length – i.e. it would solely be determined by knee-joint motion.

METHODS

Participants (n=3) expert cyclists (2M, 1F), with a mean (SD) age of 29 (11) years, mass 68 (2) kg, and height 176 (5) cm.) rode for a minimum of 2.5 minutes at each of five randomly presented cadences (50, 65, 80, 95, and 110 rpm) at a constant nominal power output of 200 W while EMG from soleus and gastrocnemius muscles and lower-limb sagittal-plane video were recorded. Data collection occurred in the final minute of the test protocol and lasted for six revolutions of the crank per collection period. Marker kinematics were used first to compute the angle of the knee and ankle joints and then the muscle lengths of the soleus and gastrocnemius muscles using equations developed by Hawkins and Hull [3] over the complete pedaling cycle. EMG data were normalized to the 50-rpm condition. We used data from Martin et al [4] to provide a baseline condition.

RESULTS AND DISCUSSION

Wearing the ankle-foot orthosis reduced ankle angle motion from a range of 18° to a range of 3° which was consistent with the flexion of the brace. Knee motion range was reduced from 71° to 61°. This was a surprise because with the now limited ankle motion we had anticipated that knee extension would increase. Examination of the motion of the vertical component of hip marker revealed that there was increased hip vertical motion. The cyclists dropped their hip on the down stroke to make up for this shorter leg. Because there was no change in the overall knee-joint range of motion and the limited affect of the ankle joint, the length change of gastrocnemius did not change between conditions. It was concluded that perhaps the strategy was to keep gastrocnemius operating within a specific range. This is consistent with the earlier postulate that the mechanical properties of muscle to some extent dictate their recruitment. Another effect of wearing the ankle-foot orthosis was that both muscle EMG patterns were substantially reduced for all cadence conditions and the sensitivity to cadence shown in gastrocnemius disappeared. Soleus excitation was reduced on average by 48% whereas gastrocnemius excitation was NOT increased by rather decreased by 28%. As we anticipated, the effect of wearing the brace was more marked on soleus. The 28% reduction in gastrocnemius excitation indicated that its activity was primarily affected by knee motion and that this two-joint nature masked any increased loading on the gastrocnemius might have experienced as a result of the reduced contribution by soleus. This project suggests that further work is required to understand fully the interaction of the muscles within the triceps surae complex.

REFERENCES

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3. Hawkins, D. & Hull, M. *J Biomech* **23**, 497-494, 1990.
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Figure 1. Mean (SD) normalized EMG for each muscle. Data were normalized to the peak EMG at 50 rpm. Exp.1 refers to data from Martin et al. [4]. Expt. 2 NB refers to data from this study, no brace condition, and Exp. 2 B refers to data from this study, when the cyclists wore the ankle-foot- orthosis.