Feline Soleus and Lateral Gastrocnemius self-reinnervation results in increased ankle extensor activity but no change in ankle extensor moment during upslope locomotion

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INTRODUCTION

Clinically, humans do not fully recover function in many cases following repair of a transected peripheral nerve [1]. This may be the consequence of altered afferent feedback [2], central drive and/or muscle properties resulting in changed motor patterns. Locomotor adaptations during upslope walking immediately following nerve cut and repair of selected ankle extensors in the cat have been reported. Before denervated muscles recover innervation, the mechanical output of the ankle is preserved due to increased activity of intact synergists and functionally appropriate hindlimb kinematic changes (an enhanced ankle yield and reduced knee flexion during stance [3,4]). After reinnervation of injured muscles (between 5-12 weeks; Gregor et al., unpublished data), kinematic and ground reaction force data were recorded during locomotion as described previously [3,4,6,7]. After collection of locomotion baseline data, the nerves supplying SO and LG of the right hindlimb were cut and repaired under sterile conditions [3,4,7]. Each cat had multiple walking trials recorded and analyzed before and at least 12 weeks after nerve cut and repair. In the terminal experiments, the absence of stretch reflexes in self-reinnervated muscles was verified [7] and the mass of individual ankle extensors from both hindlimbs was measured.

EMG intensity was normalized to the maximum mean intensity recorded during upslope walking pre-reinnervation. SO and LG fascicle and muscle-tendon unit length (MTL) were normalized to the half of muscle length range in level walking cycle [6]. ANOVA was applied to analyze the effects of self-reinnervation (pre and 12 weeks post) on mean EMG intensity of the ankle extensors, mean and peak of ankle moment and mean length and velocity of fascicles and MTL of SO and LG in stance.

METHODS

All experimental and surgical procedures were approved by the Georgia Tech Institutional Animal Care and Use Committee. For the purpose of this study, four female adult cats were investigated. Each cat was trained to walk along an upslope (+27°) walkway with embedded force plates. Under sterile conditions and isoflurane anaesthesia, medial gastrocnemius (MG), SO, LG (in 4 cats) and plantaris (PL, in 2 cats) were implanted with fine wire EMG electrodes and SO (in 4 cats) and LG (in 1 cat) were implanted with sonomicrometry crystals [4,6]. Prior to recordings, small retroreflective markers were placed on the anatomical landmarks of the right hindlimb. EMG, sonomicrometry, kinematic and ground reaction force data were recorded during locomotion as described previously [3,4,6,7]. After collection of locomotion baseline data, the nerves supplying SO and LG of the right hindlimb were cut and repaired under sterile conditions [3,4,7]. Each cat had multiple walking trials recorded and analyzed before and at least 12 weeks after nerve cut and repair. In the terminal experiments, the absence of stretch reflexes in self-reinnervated muscles was verified [7] and the mass of individual ankle extensors from both hindlimbs was measured.
However, the results indicated that there was no associated increase in the muscle moment. This may have been the result of a decreased moment arm or/and increased co-activation of ankle antagonists. However, as the joint angles [7], MTLs of ankle extensors (Fig. 2) and reciprocal activation of antagonistic muscles (unpublished observations) did not change significantly, it is unlikely the ankle muscle moment arms and coactivation changed [7].

**Figure 1:** Normalized mean SO fascicle (FL) and MTL lengths, peak ankle moment (in N/kg) and the mean extensor muscle EMG intensity in stance of upslope walking in 4 cats.

The force generated by a muscle is dependent on a number of factors including fascicle length and velocity, muscle physiological cross sectional area (PCSA) and muscle fiber composition. Results showed that overall there was no significant change in fascicle length and peak shortening velocity after reinnervation (Fig 2). There was no difference in mass of ankle extensors between the hindlimbs with intact and self-reinnervated muscles, suggesting that PCSA has not changed after self-reinnervation. We have previously presented findings that following self-reinnervation, the mean EMG frequency decreased suggesting a greater contribution of slow motor units to activity of ankle extensors [8]. This change in motor unit recruitment may result in reduced force production by ankle extensors. Thus, the dissociation between the increased ankle extensor mean EMG and no changes in ankle joint moment after self-reinnervation could result from changes in the fiber type composition and/or recruitment patterns of ankle extensors.

**Figure 2:** Exemplar plots for Cat 2 showing mean soleus EMG activity, ankle moment, soleus fascicle length and velocity and MTL length in a cycle.

**REFERENCES**


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