MOTOR ADAPTATION DURING WALKING WITH A POWERED ANKLE FOOT ORTHOSIS

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INTRODUCTION

The extent of motor adaptation possible during locomotion is unclear. The nervous system routinely alters muscle activity patterns in response to environmental factors (surface incline, surface compliance) and task demands (speed, direction, posture) to achieve purposeful locomotion. However, the limits of locomotor adaptation are debatable. Several studies have indicated that there may be limits to neural reorganization for locomotor control. Some of the most influential works supporting this view are animal studies in which muscle attachment sites were surgically altered to change their functional roles (e.g. flexor muscles became extensors (Sperry 1945; Loeb 1999)). These studies showed little or no change in EMG patterns of the altered muscles, suggesting that much of the neural control for locomotion is hardwired. The purpose of this study was to examine human locomotor adaptation in a controlled manner. We recorded gait mechanics while a healthy subject walked wearing a powered ankle foot orthosis (AFO). The AFO was fitted with a myoelectrically controlled, artificial pneumatic muscle attached externally to the rear of the orthosis. Activation of the subject’s soleus muscle resulted in real-time proportional activation of the artificial plantar flexor muscle. In effect, the AFO amplified force production of the soleus muscle. We hypothesized that subjects wearing the powered AFO would adapt their muscle activation patterns to achieve gait kinematics similar to normal.

METHODS

One healthy female subject was fitted with a custom-made carbon fiber AFO for her left lower leg. The AFO allowed flexion and extension at the ankle joint and had an artificial pneumatic muscle attached externally to the rear of the orthosis. Activation of the subject’s soleus muscle resulted in real-time proportional activation of the artificial plantar flexor muscle. In effect, the AFO amplified force production of the soleus muscle. We hypothesized that subjects wearing the powered AFO would adapt their muscle activation patterns to achieve gait kinematics similar to normal.

RESULTS AND DISCUSSION

The subject initially greatly decreased soleus activation and increased tibialis anterior activation when walking with the powered AFO (Figure 1). By the end of the three-week training period, soleus activation had returned to ~60% of normal and tibialis anterior activation had decreased back to normal. Ankle torque produced by the AFO decreased and became focused at the end of the stance phase during the three-week training period.

SUMMARY

These findings suggest that humans can readily adapt their muscle activation patterns during walking to control a powered orthosis. As a result, it may be possible to use myoelectrically controlled, powered orthoses to help shape muscle activation patterns during gait rehabilitation. Current studies in our laboratory are extending this project to examine a greater number of healthy and neurologically impaired subjects.

REFERENCES


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