ANKLE PLANTAR FLEXOR FORCE CONTROL IS IMPROVED AFTER GAIT AND BALANCE REHABILITATION IN INDIVIDUALS WITH MULTIPLE SCLEROSIS

INTRODUCTION

Multiple sclerosis (MS) is a demyelinating disease that occurs in young adults and often affects the control of the leg musculature. It has been well established that individuals with MS have significantly weaker muscles, and that their musculature fatigues at a faster rate. Recent research has displayed that an intensive gait and posture rehabilitation protocol has the potential to reduce fatigue, and improve the posture and the mobility of individuals with MS [2]. However, it is currently unknown if these improvements may be a result of increased strength or improved control of the leg musculature.

Control of the lower extremity musculature performance is evident by the amount of variability or error in the steady-state isometric muscular force [4]. It has been demonstrated that a greater amount of postural sway is associated with a greater amount of variability in the ankle joint’s submaximal steady state force production [4]. This suggests that improvements in postural control should be a result of improved control of the ankle plantar flexor muscles. In spite of these novel insights, it is unknown if the current rehabilitation strategies used with individuals with MS can improve the motor control of the ankle musculature.

The purpose of this study was to determine whether 14-weeks of an intensive gait and balance rehabilitation protocol can improve the muscular control of the ankle plantar flexor muscles of individuals with MS. A secondary purpose of this study was to determine whether the rehabilitation protocol would also improve the postural control and walking speed.

METHODS

Ten adults with relapsing-remitting or secondary progressive MS participated in this investigation (Age: 51.7 ± 8 years). The participants had an average Kurtzke Extended Disability Status Score of 5.3 ± 0.9, which indicated that on average the patients could walk independently for at least 100 meters. Twenty normal, healthy adults acted as a control group (Age: 45.1 ± 14.1 years). The MS group completed testing before and after completing the rehabilitation protocol and the control group completed one testing session.

Muscular control of the ankle plantar flexor muscles was measured using an isokinetic dynamometer (Biodex, Inc., Shirley, NY). The MS group used their most affected leg for the testing, while the control group used their dominant leg. Two maximal isometric voluntary contractions were completed, and the highest maximal voluntary torque (MVT) was used to calculate 20% of the MVT. At least one minute of rest was allowed in between all trials. Two submaximal steady state isometric contractions at 20% MVT were held for 30 seconds each. A custom LabVIEW program was used to display the target and actual force in real-time on a computer screen ~1 m in front of the participants. The middle 15 seconds of each trial was utilized in order to ensure that a steady state contraction had been reached. The coefficient of variation (CV) for each trial was calculated, and the two trials were averaged together for each subject.

Postural control of the MS group was additionally measured based on the composite score from the Sensory Organization Test (SOT) (NeuroCom® International, Clackamas OR), where a higher score...
indicated a lower amount of postural sway. A fast-as-possible walking velocity was measured using a GAITRite® system (CIR Systems Inc., Sparta, NJ). Two trials were completed and they were averaged together.

The initial two weeks of the rehabilitation program were completed on the UNMC campus under close supervision of a licensed physical therapist. The therapy was conducted twice a day for five days each week. Each session consisted of 20 minutes of static balance training and 20 minutes of dynamic balance training. The sessions focused on learning strategies for static and dynamic postural control. For example, the static balance training included standing on foam or standing with eyes shut, whereas exemplar dynamic balance training included exercises like walking on a treadmill while focusing on foot placement, walking sideways overground or stepping over obstacles. After the initial two weeks, the remaining 12-weeks of training were completed at home twice a day, and were monitored by the physical therapist through weekly phone contact.

RESULTS AND DISCUSSION

The CV of the ankle plantar flexor muscles for the individuals with MS was greater than the controls before the rehabilitation (p=0.03; Figure 1). This suggests that the individuals with MS initially had greater errors in their ability to match and sustain the target value with their ankle joint musculature. However, after rehabilitation, the CV was markedly reduced (p=0.027; Figure 1), and was not significantly different from the CV of the controls (p=0.78). This indicates that the rehabilitation protocol improved and normalized the motor control of the ankle musculature. It has been previously demonstrated that the firing rates of the motor units are diminished and more variable in individuals with MS [1]. Although the specific neural adaptation for improved ankle force control cannot be determined from our data, we suspect that the changes in variability of the motor unit discharge rates and/or changes in the synchrony of common motor units that serve the gastrocnemius and soleus musculature are possible mechanisms [3,5].

Following the rehabilitation protocol, the composite score on the SOT increased (Pre: 51.6 ± 5, Post: 70.8 ± 2; p=0.01), indicating that the amount of postural sway was reduced after rehabilitation. Thus, postural control was improved after rehabilitation. Furthermore, our results showed that the fast-as-possible walking velocity improved as well (Pre: 0.97 ± 0.07 m/s, Post: 1.2 ± 0.09 m/s; p=0.01). There was a significant negative correlation between CV and SOT scores (r= -0.45; p=0.047) indicating that a better SOT score was associated with less error in the ankle force control. The CV was not correlated with the walking velocity (r= 0.05; p= 0.83). Our results indicate that improved muscular control of the ankle joint has the potential to improve the postural balance of individuals with MS. Based on our results, we suggest that rehabilitation protocols that focus on improving the muscular control of the ankle joint will likely augment clinically relevant improvements in the postural balance of individuals with MS.

![Figure 1: Coefficient of variation ankle plantar flexor muscles (CV) before and after rehabilitation. *p<0.05.](image)

REFERENCES