THE EFFECT OF A NOVEL REHABILITATION DEVICE ON MUSCLE ACTIVATION DURING GAIT IN PERSONS WITH MULTIPLE SCLEROSIS

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This study examined the acute effect of a novel rehabilitation device, NewGait™, on muscle activation in persons with Multiple Sclerosis. Through electromyography, muscle activation of the vastus medialis (VM), gastrocnemius lateralis (GL) and tibialis anterior (TA) was measured in seventeen patients. Three trials were conducted in each condition: a 10 m control walk and 10 m NewGait™ walk. Results showed a non-significant change in muscle activity with moderate effect sizes in the right VM (increase of 39.72% MVC, p=0.082, d=0.626) and right TA (decrease of 12.71% MVC, p=0.069, d=0.427). No change in muscle activation was seen when wearing the NewGait™ device. Future research should use a larger sample and differentiate between stance phases to accurately measure the outcomes of the NewGait™ device on muscle activation.

KEYWORDS: Electromyography, NewGait™, muscle weakness, vastus medialis, gastrocnemius lateralis, tibialis anterior

INTRODUCTION: Multiple Sclerosis (MS) is a chronic immune mediated disease of the central nervous system in which there is demyelination, impairing nerve signaling (Koch-Henriksen & Sorensen, 2010; Zwibel & Smrtka, 2011). In the United States, there is a prevalence of approximately 400,000 people affected while 2.1 million people are affected worldwide (Dilokthornsakul et al., 2016). People diagnosed with MS will suffer from impairment in functionality and a decreased quality of life (LaRocca, 2011). The most prominent symptoms of MS are walking gait impairments, poor balance and muscle weakness. LaRocca (2011) states that persons with MS will require a walking assistance 10 years from onset of the disease.

Persons with MS suffer from various gait abnormalities such as reduced joint movement, decreased velocity, decreased step length and decreased cadence (Saggini et al., 2017). To limit these impairments, various rehabilitation treatments have been developed. As described by Dalgas et al. (2008), physical exercise and therapy in general is an important non-pharmacological tool in MS rehabilitation as it induces beneficial effects to the patient as it improves disability and maintains functional status. In general, there are no observations as far as improved walking performance. Another approach to improving patients' walking gait is robot-assisted gait training (RAGT), a machine assisted device in microgravity conditions. During RAGT, an overall greater improvement in walking temporal parameters such as velocity, cadence, walking distance and knee-extensor strength is measured (Saggini et al., 2017; Beer et al., 2008). However, the device is not practical in use since it is machine assisted, therefor it is cumbersome for the physical therapists and is unpractical for patients to be used at home due to its high expense and unavailability.

Due to the muscle weakness associated with MS, muscle activation of the lower extremities is also affected. Persons with MS tend to compensate for their muscle weakness by keeping the muscles active for a longer time. The increased muscle activation likely increases fatigue in the patient and may therefore alter the walking gait. This results in smaller muscle activation in the loading response and a greater activation during the late push-off compared to healthy individuals (Lencioni et al., 2016). Similar to this study, Ketelhut et al. (2015) found that the trunk muscles of the less-affected side of the patient are activated more causing an imbalanced activation during walking gait. During unstable gait conditions, the central nervous system prolongs the duration of basic muscle activation patterns, causing higher muscle activations (Martino et al., 2015).

The combination between muscle activation and rehabilitation in MS patients has not been widely investigated. However, Hidler and Wall (2005) found that depending on the movement performed, muscle activation of the lower limbs increases or decreases during robotic-assisted walking. A novel rehabilitation device, NewGait™ (a clinical adaptation of the SpeedMaker™), that is being used in the present study has not been investigated before. The NewGait™ is a device that strategically places elastic bands according to the patient's needs, to help assist the lower extremities with hip and knee flexion difficulties, which allows for increased stride length and frequency (Elite Athlete Products, n.d.). The authors found that there were no differences in muscle activity in athletes following acute use of the Speedmaker™ device (Meidinger, Jensen, Clarke & Clark, 2017).

In the case of MS patients, this NewGait device could enhance the patient's quality of life by improving their walking gait. The purpose of this study was to examine the acute effect of the NewGait™ rehabilitation device on muscle activation in persons with MS. It was hypothesized that there would be a reduced muscle activation in the analyzed muscles when wearing the device due to the assistance provided by the resistance bands.

METHODS: Seventeen patients who have been diagnosed with MS by a neurologist (height = 1.65 ± 6.49 meters; body mass = 76.65 ± 21.97 kg; age was not recorded) volunteered to participate as subjects for the study. Participants were recruited for the current study if they had a Expanded Disability Status Scale (EDSS) (Kurtzke, 1983) score of between 5-7 and the diagnosis of MS. Participants were excluded if they were considered to be in an unstable phase of the disease, i.e. relapsing-remitting MS with a relapse in the last three months. Once accepted, the participants all completed an informed consent form. The study was approved by the university's Institutional Review Board (HS 17-870).

Upon arrival in the laboratory, wireless EMG sensors were put on the vastus medialis (VM), the gastrocnemius lateralis (GL) and the tibialis anterior (TA) on both legs according to Seniam Guidelines. The participants then performed three trials of the 10-meter walk without the NewGait™ device. A certified physical therapist and/or certified prosthetist then fit the device to the patient. The fit was standardized to each patient but slightly adjusted in a specific way that addressed their gait abnormalities with the added resistance bands. The participant performed another set of three trials of 10-meter walks with the device on. Participants received consistent instructions for all walking trials "walk as quickly and safely as possible". Following the 10-meter walk, they rested for a minimum of 30 s in a wheelchair to minimize fatigue; or when they were ready to perform the next trial. At completion of the NewGait™ walks, a five-second maximum voluntary contraction (MVC) was used to normalize the muscular activation and allow comparison across the muscles in both conditions. The EMG muscle activity was analyzed using the Noraxon Desktop DTS Wireless EMG system hardware and the Noraxon MR3.10 Analysis Software (Noraxon, Scottsdale, AZ, USA). The data were rectified and smoothed to the RMS algorithm at 100 ms (Meyer et al., 2013) and normalized to the MVC of each muscle that was analyzed. Markers were set using a rise/fall using the onset and the offset of the muscle at a 25% threshold, respectively. Standard amplitude reports were made that used the previously set markers and calculated the mean muscle activation per muscle as a percentage of the MVC. The average mean over the three trials per condition was calculated per muscle for statistical analysis purposes. Comparisons of the mean activation of the VM, GS and TA between the control and the NewGait™ conditions were calculated using a paired t-test to calculate the two-tail p-value. Alpha level was set at $p<0.05$. In addition to the paired t-test, effect size (small = 0.2, moderate = 0.5, and large = 0.8) was analyzed with a Cohens d analysis (Cohen, 1988).

RESULTS: Due to technical issues, data were not available for all participants on all muscles. The number of participants for each muscle is provided in Table 1. In general, no change in muscle activation was noted when wearing the NewGait™ device compared to the control trials. Paired t-tests showed that there was a non-significant change in muscle activity with moderate effect sizes in the right VM (increase of 39.72% MVC, p=0.082, d=0.626) and right TA (decrease of 12.71% MVC, p=0.069, d=0.427) as demonstrated in Table 1.

Table 1. Average mean ± SD for muscle activation relative to % MVC, probability and effect size for the VM, GL, and TA across three control and three NewGait™ trials.

	AVERAGE MEAN MUSCLE ACTIVATION ± SD		DIFF	P-VALUE	EFFECT SIZE (d)
	CONTROL	NEWGAIT™			
VM RIGHT (n=7)	132.90 ± 55.61	172.62 ± 70.43	+ 39.72	0.082	0.626
VM LEFT (n=8)	100.55 ± 47.82	77.29 ± 36.80	- 23.26	0.181	0.545
GL RIGHT (n=10)	56.56 ± 28.11	61.71 ± 29.57	+ 5.15	0.275	0.177
GL LEFT (n=14)	60.28 ± 21.42	62.84 ± 27.47	+ 2.20	0.523	0.104
TA RIGHT (n=8)	81.68 ± 34.58	68.97 ± 23.97	- 12.71	0.069	0.427
TA LEFT (n=12)	54.91 ± 21.10	54.30 ± 23.55	- 0.61	0.857	0.027

DISCUSSION: The present study investigated the acute effect of the NewGait™ rehabilitation device on muscle activation during gait in persons with MS. Due to the assistance provided by the device, the researchers hypothesized that there would be a lower muscle activation when wearing the NewGait™. The main finding of the current research indicates that there was no significant change in muscle activation when wearing the NewGait™ device. However, moderate effect sizes were noted for VM and TA muscles indicating that future research with enhanced power may demonstrate some changes in activation. There was no general trend showing increases or decreases in muscle activation with the use of the NewGait™.

Previous research indicates different observations in muscle activation in persons with MS. Lencioni et al. (2016) mentioned that there is a greater activation during the late push-off in persons with MS. Another study found that the muscles of the less-affected side of the patient has a higher muscle activation (Ketelhut et al., 2015). Similar to the small changes observed in our study, Hidler and Wall (2005) found that there was an increase in muscle activity of the right VM muscles and a decrease in muscle activity in the TA during robot-assisted gait walking. Interestingly there was an opposite response in the left VM with decreases in activity when wearing the device. The rehabilitation devices used in RAGT (Hidler & Wall, 2005) and the current study limit the movement of the pelvis and prevent leg abduction movements, resulting in higher muscle activity levels in the quadriceps muscles. The patients in the current study were primarily right side impaired with NewGait™ assistance focused on the right side. This may explain the opposing response where the right side responds in a similar fashion to that of the stimulus imposed by RAGT. The foot lifters utilized in both studies contribute to assisting in ankle dorsiflexion causing lower muscle activation of the TA (Hidler & Wall, 2005). In the current study, similar non-significant changes in muscle activation were noted with the NewGait™ device but the absolute changes noted were far smaller than those reported by Hidler & Wall (2005). This indicates that the less expensive and more user friendly NewGait™ device may be providing similar style of assistance to that of the robotic assisted gait, but with a lesser magnitude of assistive force.

A limitation of the current study was the use of the averaging analysis method where phases of gait were not integrated in the EMG analysis, in addition there was also a limitation due to the small sample. It is also worth mentioning that every patient experiences muscle weakness to different extents and on different parts of the body, this required varied use of the NewGait™ device inducing a range of potential responses. The current paper is a subanalysis of a larger ongoing project and future publications will include a larger group of participants. Future work is also planned assessing the effectiveness of this device in patients with other neuromuscular diseases.

CONCLUSION: When considering the acute effect the NewGait™ rehabilitation device has on muscle activation in persons with multiple sclerosis, no significant changes in muscle activation were noted with this small subgroup of participants. There were non-significant changes with moderate effect sizes noted in the muscle activation of the TA and VM muscles when wearing the NewGait™ device. The NewGait™ device may be providing similar style of assistance to that of the robotic assisted gait, but with a lesser magnitude of assistive force. Physical therapists can consider using the device in their neuromuscular disordered patients as it may provide valuable assistance to weakened musculature.

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