STEP WIDTH, GLUTEUS MEDIUS ACTIVATION AND POSTURAL SWAY RESPONSES TO A NOVEL GAIT TREATMENT: A PILOT STUDY

Maddison G. Misiak, Stacy E. Ruotsala, Olivia D. Perrin and Sarah Breen

School of Health & Human Performance, Northern Michigan University, USA

The current study explored the acute effect of a novel rehabilitative device (NewGait™) on several interrelated variables associated with gait. Participants completed an eight-minute walking treatment wearing the NewGait™. Postural sway (center of pressure velocity), step width, and gluteus medius (GM) muscle activity were measured before during and after the treatment. No significant changes were noted in step width or GM activity during the treatment. Step width narrowed significantly after the treatment (p=0.02) and postural sway improved in the eyes open condition (p=0.02). These results indicate gait changes in healthy participant's following use of the NewGait™ device. However, due to the acute nature of this investigation, it is unclear if balance improvements noted are due to the walking activity alone or walking while wearing the NewGait™ device.

KEYWORDS: NewGait™, gait training, electromyography, rehabilitation

INTRODUCTION: Falls, and unstable balance rank high among the serious clinical problems faced by older adults, and are a cause of substantial rates of mortality, morbidity, and immobility (Rubenstein, 2006). Fall risk factors are often placed into two categories; extrinsic factors, such as footwear changes, and intrinsic factors, such as increased postural sway and decreased muscular strength. Due to the physically dependent nature of center of pressure (COP), it is used as an objective measure of an individual's maintenance of balance (Takeda, et al., 2017.).
Muscles linking the spine, femur and pelvis are the main actuators for postural control (Jiang, Nagasaki, You & Zhou, 2006). The hip abductor muscle group, including the gluteus medius (GM), gluteus minimus, and tensor fascia latae play an important role in pelvic stabilization during gait (Flack, Nicholson, & Woodley 2012). The GM connects the pelvis to the femur, and has a strong influence on hip abduction, causing increased step width during midstance through terminal swing phases of gait. In support of this notion, prior research has found a clear relationship between step width and increased GM activity during prescribed walking trials (Kubinski, McQueen, Sittloh, & Dean 2015). Kubinski also reported that walking with wider steps decreased the control and precision needed to maintain balance (Kubinski, et al., 2015).
Physical Therapists are constantly searching for effective ways to cue proper gait mechanics in patients. Previous research has investigated the use of rehabilitative devices such as the NewGait™ (Mylle et al., 2018) which uses elastic bands to cue gait mechanics (https://www.thenewgait.com/). Previous research supports the interaction between step width, lower limb muscle activation and gait stability (Kubinski, et al., 2015) when step width is increased consciously. It is unclear if this same relationship exists when a device cues these changes in step width. In addition the potential interaction with GM activation and improvements in postural control have not been explored.
The purpose of the current study was to observe the acute response in walking gait and static balance to an short treatment using of a novel rehabilitation device (NewGait™). It was hypothesized that participants would walk with a wider step width following use of the NewGait™ device (when elastic bands were secured in the hip abductor region). It was also hypothesized that a wider step width may result in higher activity, therefore improving static balance.

METHODS: One male and seven female participants (1.70 ± 0.06 m; 81.87 ± 30.09 kg) participated in the current study. Approval for this study was granted by the Institutional Review Board of Northern Michigan University (IRB# HS20-1087). Participants were required to be free of any medical conditions or prior injuries that severely affect gait and be aged 18-35 years. All participants completed a Par-Q questionnaire and an informed consent prior to participation.

Figure 1. Testing Protocol & Measured Variables

Figure 2. NewGait™ Fit

The general testing protocol for each participant is outlined in Figure 1. Prior to the initiation of testing participant preparation included fitting of the EMG electrodes, maximum voluntary contraction (MVC) testing and warm up. EMG electrodes (Noraxon, Scottsdale, AZ, USA) were placed on the left and right GM (http://seniam.org/). MVC testing of the GM required participants to resist downward pressure placed at the ankle for five seconds when laying on their side; top hip extended and the bottom hip and knee flexed. Two MVC trials were recorded for each leg; the participants' highest MVC was noted for later normalization purposes using Noraxon software (Noraxon, MR3.10, Scottsdale, AZ, USA). Participants were then fitted with the NewGait™ rehabilitation device in accordance with manufacturer guidelines as shown in Figure 2. Next, participants were guided through a three-minute dynamic warm up that included single knee to chest marching, walking lunges, side stepping, and monster walking. The bands of the NewGait™ were unclipped during this process. Constant application of the NewGait™ cuffs assured that the only varying condition was the abduction bands. After completion of the dynamic warm up, participants completed device familiarization and two sets of balance tests. Participants performed these sets in a randomized order; once with the NewGait™ bands clipped in and once without the bands clipped in. Balance tests required the participants to stand with either their eyes open (balance test 1) or closed (balance test 2), arms crossed over the chest, and their feet hip-width apart, on a force plate (AMTI, Watertown, MA, USA; 100 Hz) for ten seconds. The stance width for each participant was marked on the floor for consistency. Participants were also given a focal point to control visual input during the eyes open tests. Both balance tests were performed three times. Immediately following the balance tests, participants completed three separate walking assessments. Participants were video recorded (Casio, EXF1, Tokyo, Japan; 30 Hz) from the posterior view while walking on an oversized Fitnex, treadmill (Fitnex, Houston, Texas, USA) at a speed of 1.12 m/s and 0% incline. Markers were placed on the calcaneus of both feet for the calculation of step width using Kinovea software. GM activity was also recorded during each walking assessment. Immediately following the post-walk test, participants completed the set of balance tests again without the abduction bands clipped in.

Step width was calculated as the horizontal distance between each consecutive heel strike, the average of the middle 50 steps were reported from each walking assessment. Step width was normalized to leg length (Step Width /Leg Length) and reported as %LL. GM activity was rectified, smoothed (RMS over 100 ms window) and normalized prior to the calculation of average activation across the duration of each walking assessment. Threshold analysis (>20% MVIC) was used to identify periods of analysis for each step. Center of pressure velocity (COPv) was calculated to characterize postural sway ($COPv = \frac{\sum_{i=2}^{n} \sqrt{(x_i - x_{i-1})^2 + (y_i - y_{i-1})^2}}{n * \Delta time}$). The best balance performance from the three balance trials was used in each condition. Statistical analyses were completed with Microsoft Excel. Paired t-tests assessed population means between test conditions. Cohen's *d* was also reported as a measure of effect size. Interpretations were based on the scale for effect size classification of Hopkins (2000): <0.04=trivial, 0.041-0.249=small, 0.25-0.549=medium, 0.55-0.799=large, and >0.8=very large. The alpha level was set at p<0.05.

RESULTS: As noted in Tables 1 and 2 significant changes were present in step width and postural sway. These changes did not conform to the stated hypothesis with no increase in step width during the NewGait^{TM} treatment. However, improvements in balance were still noted.

Table 1. Average ± Standard Deviation of Center of Pressure Velocity (COPv) are reported along with Effect Size (*d*) and p-values for between condition comparisons. Large effects and significant differences are **highlighted.**

	Pre	Post	*d*	p
Eyes Open COPv (cm/s) *Without NewGait*	0.73 ± 0.18	0.64 ± 0.14	**0.57**	**0.02**
Eyes Closed COPv (cm/s) *Without NewGait*	1.06 ± 0.31	1.03 ± 0.26	0.11	0.36

Table 2. Average ± Standard Deviation of Step Width (%LL) and Gluteus Medius (GM) Activation are reported along with Effect Size (*d*) and p-values for between Baseline (BL), Treatment (TR) and Post (PT) condition comparisons. Large effects and significant differences are **highlighted.**

	BL	TR	PT	BL-TR		BL-PT	
				d	p	*d*	p
Step Width (%LL)	9.76% ± 3.12%	10.76% ± 3.11%	7.94% ± 2.73%	0.37	0.16	**0.73**	**0.02**
Dominant GM Activity (%MVIC)	26.74 ± 19.47	34.15 ± 25.59	32.04 ± 13.42	0.42	0.19	0.44	0.26
Non-Dominant GM Activity (%MVIC)	25.56 ± 17.16	32.85 ± 28.31	31.93 ± 26.16	0.32	0.06	0.29	0.05

DISCUSSION: The purpose of the current study was to observe the acute response in walking gait and static balance to an short treatment using of a novel rehabilitation device (NewGait™). It was hypothesized that participants would walk with a wider step width following use of the NewGait™ device (when elastic bands were secured in the hip abductor region). It was also hypothesized that a wider step width may result in higher activity, therefore improving static balance. Results indicated no significant increase in step width while wearing the NewGait™. However, participants experienced significantly narrower step width immediately following the treatment. Interestingly, no significant increases in GM activity were measured between any of the conditions. Finally, researchers observed that COPv was significantly improved following NewGait™ treatment, but only in the eyes open condition.

Similar to the current study, an acute assessment of the NewGait™ device with persons with multiple sclerosis, (Mylle et al., 2018) found no significant changes in vastus medialis and tibialis anterior muscle activation with the use of the NewGait™ device during walking. When comparing the magnitude of change in step width in the current study (BL-TR +1% LL, BL-POST -2%LL) with previous research (+15%LL or -10%LL) (Kubinski, et. al. 2015), it is clear that the NewGait^{TM} device elicits much smaller changes in gait than what has been seen when participants are asked the walk consciously with a wider or narrower step. The small changes in step width reported in the current study are well within the normal ranges (Kubinski, et. al. 2015) and unlikely to elicit a change in muscular activation.

It is understood that the adductor and abductor muscle groups work antagonistically to stabilize the pelvis and control postural sway. It was proposed by Winter et al. (1998) that muscles behave as springs that simultaneously act upon the COP and the center of mass as the body sways.

Balance with eyes open improved following the NewGait™ treatment, though step width decreased, and GM activity did not increase significantly at any point in the current study. The researchers theorize that while the assistive nature of the abduction bands created no significant change in abductor activity, stimulated adductor activation during treatment may explain both the decrease in step width in addition to the improvement in eyes open balance tests post treatment. Further research investigating the theoretical model proposed will require researchers to determine the activity of the antagonist musculature corresponding to NewGait™ attachment sites.

Finally, researchers found no significant decrease in COPv displacement following the NewGait™ treatment when participants completed the eyes closed balance tests. Explaining this phenomenon, several studies have suggested that vision impairment can increase postural instability. In addition, the interaction between the central nervous, muscle and peripheral sensory systems are fundamental for adjusting balance (Tomomitsu, et al. 2013). Because balance is heavily reliant on visual input as well as the vestibular and proprioceptive mechanisms in the body, it is logical to conceive that omitting the visual field from a balance task would elicit a varied and insignificant response in participants. The researchers encourage quantitative investigation of proprioceptive mechanisms while wearing the NewGait™ to explore this notion further.

Limitations of the current study include; participants selection did not consider familiarity with treadmill walking, EMG analysis was not performed on the adductor musculature, and while extra measures were taken to reduce artifact, the location and set up of the NewGait™ device (Figure 2) may have resulted in unwanted noise. The current paper reports the findings of the acute results of an ongoing chronic study involving the NewGait™ device.

CONCLUSION: Taking the acute effects of the NewGait™ on the current population into consideration, no significant changes were discovered in the relationship between step width and GM activity. Opposed to the researchers' hypothesis, step width did not increase during the NewGait™ treatment, but decreased afterwards. Additionally, postural sway improved in the eyes open condition only following NewGait™ treatment. These findings evoke optimism in ongoing research with the NewGait™ device, as the results of the current study suggest that balance is positively affected following a single use of the device. This provides useful insight for clinicians working with individuals affected by pathological gait patterns, lack of balance, and lower extremity weakness.

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