

RESEARCH PAPER

Effects of dynamic balance training during standing and stepping in patients with hereditary sensory motor neuropathy

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Accepted February 2006

Abstract

Purpose. To quantitatively evaluate the effects of dynamic balance training in patients with hereditary sensory motor neuropathy (HSMN).

Methods. Sixteen patients with HSMN were randomly assigned to either an experimental or control group. The intervention session consisted of passive stretching, muscle strengthening and dynamic balance training during standing and stepping, which differed in that the experimental group used commercially available balance training mechanical apparatus while the patients from the control group were physically managed by a physiotherapist. The intervention period was 12 days. Balance and mobility functions were assessed by means of Berg Balance Scale, Up&go test and 10-m walk test before and after the intervention period.

Results. The within-group comparison (1-way repeated measures ANOVA) for the experimental group showed statistically significant improvement ($p < 0.05$) in Berg Balance Scale, Up&go test and 10-m walk test, while within-group comparison for the control group showed statistically significant improvement only in Berg Balance Scale ($p < 0.05$). The between-group comparison (2-way ANOVA) showed larger improvement in the experimental group, however, these differences were not statistically significant.

Conclusion. Dynamic balance training is useful training modality for patients with HSMN. When exercised in the balance training mechanical apparatus used in this study enables efficient balance and mobility training without requiring physical assistance from a physiotherapist or a caregiver, which opens new possibilities for continuing and more frequent physical exercise and mobility training of patients with HSMN also at their homes.

Keywords: *Posture, mobility, sensory-motor coordination, muscular dystrophy*

Introduction

Hereditary sensory motor neuropathy (HSMN) results in a slowly progressing decline in patients' postural and walking abilities. Even though most of the patients are able to walk throughout their lives their condition leads to impaired postural control and walking, which is characterized with frequent tripping and spraining ankles [1]. Training and exercise is important for patients with HSMN to maintain posture and mobility in order to maximize existing capabilities and prevent further loss of motion that may develop primarily due to muscle contractures. Therefore, daily stretching exercises are important combined with recreational activities such as riding a bicycle or swimming [2]. The provision of

the treatment in most cases represents a significant burden to a family or caregivers, therefore development and testing of novel approaches to enhance everyday physical activity in patients with HSMN that requires minimal involvement of the family or caregivers is warranted [3].

In the recent years we have developed mechanical apparatus and methodology, which enables fall-safe balance training during standing [4,5]. The device enables also balance training while practicing different components of walking such as accomplishing the whole step where the sequence of push-off, swing and weight acceptance of one extremity and complementary stance phase weight bearing activity of the other extremity is repetitively executed. Since the training with the developed apparatus is safe and

represents sub maximal effort training paradigm it might be suitable for patients with HSMN, which have diminished capacity for exercise.

The aim of the present study was to evaluate the effects of dynamic balance training while standing on the developed mechanical apparatus and compare them to the effects of dynamic balance training where the developed mechanical apparatus was not used.

Methods

Subjects

Sixteen subjects with HSMN type I were included in the study. All the subjects could walk without using assistive devices and were admitted to the facilities of the Slovenian Muscular Dystrophy Society at the Slovenian coast for the period of 14 days during summer 2004 for restorative rehabilitation. The subjects, who represent a sample of convenience, were randomly assigned to the experimental and control groups. The mean age of participants in the experimental group (3 men and 5 women) was 38.5 ± 13.7 years (range 14–60). The mean age of participants in the control group (4 men and 4 women) was 37.6 ± 13.5 years (range 16–58). All the subjects completed the study. The Slovenian National Ethics Committee approved the study protocol and the participating subjects gave informed consent.

Intervention

The intervention was delivered in 12 sessions (6 days of training, one day of rest, 6 days of training). Within a single session, both groups received physical therapy consisting of the exercises aimed at maintenance of a range of motion in the joints – passive stretching (10 min), muscle strengthening program (10 min) and balance training during standing (20 min). The first two training activities (passive stretching and muscle strengthening) were identical for both groups. The third activity differed in that the experimental group exercised balance training procedures while standing on the mechanical apparatus for dynamic balance training, which are described in detail in the following two subsections, while the control group exercised dynamic balance training procedures while being physically managed by a physiotherapist. These procedures consisted of practicing several tasks during standing: transferring a ball from one hand, positioned in the height of the eyes, to the other hand, positioned in the height of the knees; turning the body to the left and right with gaze following the direction of turning; performing controlled weight transfer during parallel

and tandem stance, simulating push-off and weight acceptance while standing in tandem stance.

Device

The subjects from the experimental group were standing on commercially available mechanical apparatus Balance Trainer (medica Medizintechnik GmbH, Hochdorf, Germany, www.thera-trainer.de). Balance Trainer looks very much like an ordinary standing frame. It consists of two parallel bars that are connected to a base plate via two degrees of freedom mechanical joint. This joint consists of two helical springs positioned within two steel cylinders. Another cylinder made of durable plastic material slides between the inner walls of the steel cylinder and the outer walls of the spring. By changing the vertical position of the plastic cylinder we also change the active length of the spring, thereby changing also the effective length and stiffness of the whole joint. One end of the helical spring is firmly mounted on the base plate while the other connects to the vertical bar. Knee support bar and the pelvis support table are connected to both parallel bars via simple hinge joints. By the way of described mechanical joints, the device allows for physiological movement of a standing person while standing as well as performing a single step.

Training procedures

An overview of the applied balance training procedures is encapsulated in nine photographs as shown in Figure 1. All the photographs show a neurologically intact subject while performing various tasks during standing on Balance Trainer and a physiotherapist guiding, correcting and facilitating movement and proper posture of the trunk. Figure 1a shows a parallel stance, which is an initial and final posture for all training tasks. Figure 1b shows inclination of the subject to the right while therapist monitors the posture of the trunk. In a similar manner the subject can incline also to the left, forward and backward. Thus, the device enables circular movement of pelvis in the transversal plane. Described movement of lower extremities can be complemented with associated movement of upper extremities as shown in Figure 1c and 1d. Figure 1e and 1f show training of a functional activity during parallel stance. In all six described exercises, the knee pelltots were adjusted equally for both extremities. They can be displaced to control the degree of allowable knee flexion. However, the knee pelltots can also be positioned in such a way to allow for a tandem stance of both extremities, thereby creating a posture which is similar to a double stance during walking. Similar exercises as shown in Figure 1a–1f can be exercised



Figure 1. Dynamic balance training procedures while standing on the dynamic balance training apparatus.

as well in tandem stance, which facilitates weight shifting activities. The last three photographs show a situation where the knee pellet bar is completely removed, which allows a standing subject to practice the whole step. Figure 1g shows a push-off of the left lower extremity and gradual weight acceptance of the right extremity. Pelvis and the trunk are held in the upright posture. In Figure 1h the left lower extremity proceeds into a swing phase, while the right lower extremity fully supports the body weight. Hip abductors and extensors control the posture of pelvis and trunk in the frontal and sagittal planes, respectively. Figure 1i shows the conclusion of the step with beginning of the weight acceptance of the left leg. The training procedures as outlined in the Figure 1 can be exercised with an adjustable level of mechanical support, originating from the action of adjustable stiffness action of both two degrees of freedom mechanical joints. The judgment on the needed level of mechanical support for each individual patient resides on a physiotherapist.

Outcome measures

Before (Test 1) and after (Test 2) the intervention the subjects in both groups were tested through the following outcome measures: Berg Balance Scale

(BBS), the rater was blinded to the outcome of the randomization procedure; Up&go test, an average time to accomplish the task from three consecutive trials was used; and 10-m walk, an average time to accomplish the task from three consecutive trials was used. The reliability and validity of Berg Balance Scale was demonstrated in the elderly [6] and was also used in previous study on balance training in people with muscular dystrophy [7]. Up&go and 10-m walk tests are simple, reliable and valid and were shown to relate strongly with balance [8].

Statistical analysis

Leven's test for equality of variances was used to investigate whether the variances between the two groups were comparable [9]. 1-way repeated measures ANOVA (test: Test 1, Test 2) was used to test for within-group differences in all outcome measures, while 2-way ANOVA (group: experimental, control; test: Test 1, Test 2) was used to test for between-group differences in all outcome variables.

Results

Both groups that underwent the intervention period were comparable at the first testing session, with no

statistically significant pretest differences on any of the outcome variables.

Table I shows scores for both groups for all outcome measures measured before (Test 1) and after (Test 2) the intervention period. In both groups (within-group difference) the mean score for BBS increased after the intervention. This increase was statistically significant for both groups, however a larger increase was observed for the experimental group. Similarly, the performance of both groups improved (within-group difference) for the Up&go and 10-m walk tests with more pronounced and statistically significant changes only in the experimental group. The statistical analysis does not show statistically significant differences in the outcome of the treatment between both groups.

Discussion

The main purpose of the present study was to explore the viability of balance training while using the developed balance training mechanical apparatus and to compare the treatment effects with the similar balance training where the balance training apparatus was not used—instead, the physical management of the patient was done by a physiotherapist.

The results of the study show that the two treatment programs bring about similar effects. The subjects in both groups have improved outcome measures scores at the end of the treatment period. From this limited sample size study, it appears that training while standing on the balance training apparatus results in slightly better improvement as judged from the BBS and 10-m walk tests change scores. However, the most important benefit of training while standing on the mechanical apparatus is that it can be accomplished with minimal or no physical assistance from the part of caregiver or

family member; therefore it might represent a viable training modality for everyday training and exercise for the patients with HSMN. This is particularly important for more functionally disabled patients where a substantially greater physical effort is needed from the physiotherapist or a home-based caregiver.

The literature addressing the issues of balance training and measurement in muscular dystrophy is relatively scarce. We are aware only of the study of Wennenberg et al. [7] who investigated effects of a 3-month Qigong practicing period on balance function in a randomized controlled trial involving 31 subjects diagnosed with myotonic dystrophy and distal muscular dystrophy. Both diseases are from a mobility function point of view similar to HSMN, but more progressive [10]. Wennenberg et al. [7] used BBS and reported that mean value of change score in the control group, which did not receive treatment, was -1.3 ± 1.9 . Even if the progressive nature of disease, which gradually decreases balance and mobility abilities, is not accounted for due to 3-month period that was between the test-retest, the results of Wennenberg et al. [7] indicate high test-retest reliability of BBS also for muscular dystrophy. The changes in BBS between two testing conditions for both groups in our study are well above the values reported by Wennenberg et al. [7] for their control group which indicates that the observed increase in BBS score is due to treatment and not due to repeated testing. Since the 10-m walk and Up&go tests were shown to be well correlated with balance function [8], we may assume that the outcome of the two time-measuring tests also reflect improvement in functional mobility.

The changes in the outcome measures before and after the treatment are relatively small but still much larger (3.4 ± 2.7 for our experimental group and 2.1 ± 1.6 for our control group) as compared to

Table I. Results for both groups before and after the intervention. 1-way repeated measures ANOVA (factor Test: Test 1, Test 2), 2-way ANOVA (factors Group: Experimental, Control; Test: Test 1, Test 2).

	<i>Berg Balance Scale (0–56 points)</i>						
	Test 1		Test 2		Change score Mean (SD)	1-way repeated measures ANOVA <i>p</i> value	2-way ANOVA <i>p</i> value
	Mean (SD)	Range	Mean (SD)	Range			
Experimental group	43.5 (10.4)	25–55	46.9 (8.7)	29–55	3.4 (2.7)	0.01*	0.84
Control group	43 (8.9)	32–53	45.1 (8.5)	35–56	2.1 (1.6)	0.01*	
	<i>Up & go (seconds)</i>						
Experimental group	13.6 (5)	8.8–22.9	12 (3.9)	7.3–21.1	– 1.6 (1.6)	0.04*	0.95
Control group	15.1 (7)	6.5–26.7	13.5 (4.9)	6.1–18.7	– 1.6 (2.8)	0.13	
	<i>10-m walk (seconds)</i>						
Experimental group	13.7 (5.7)	9.7–23.0	11.5 (3.9)	7.6–18.1	– 2.1 (1.7)	0.01*	0.75
Control group	14.2 (6.7)	7.3–28.2	13.1 (5.1)	7.1–12.4	– 1.1 (1.9)	0.17	

* $p < 0.05$.

the study that investigated efficacy of Qigong for improving balance in people with muscular dystrophy [7] (0.2 ± 3.4). This observation is consistent with the nature of pathology where little quantitative functional improvement is observed after intensive physiotherapy [1]. However, the changes in the outcome scores after the treatment period can still be clinically meaningful as HSMN patients are generally ambulatory and any progress in their balancing and walking abilities is beneficial and may decrease incidence of tripping and prevent likelihood of falling during mobility activities.

Possible reasons for the observed improvement in balance and mobility outcome measures in both groups that practiced dynamic balance training could be linked to training effects that improved utilization of compensatory balance and movement strategies of proximal muscle groups of lower extremities that are needed due to decreased muscle strength, particularly of the distal muscles of lower extremities.

One limitation of the study is a small sample size, which is mainly due to the limited number of available ambulatory patients with HSMN. Also, the number of treatment sessions was limited, because the patients stayed at the sea-side facility of the Slovenian muscular dystrophy society only for 14 days. Since this period was a combination of restorative rehabilitation as well as summer holidays, the patients were during the day also swimming and walking. Since the amount of these activities was not controlled it may have influenced the results of the study. However, these limitations do not invalidate the conclusion that both treatment programs applied in this study are comparable in terms of treatment effects while the treatment program that uses balance training mechanical apparatus requires minimal or no physical assistance, which makes it suitable for use in home environment. This can significantly increase the amount of training, which presumably maintains the level of functional competence or at least decelerates the progression of functional competence decay in patients with HSMN. As such a balance training program that uses balance training apparatus used in the present study opens new

possibilities for continuing physical therapy and care of patients with HSMN that could be delivered much more frequently. The apparatus is relatively inexpensive (costs are within the range of home bicycle ergo meters) and could be either a personal training device or could be a part of training equipment of muscular dystrophy societies' facilities where a potential user would need to undergo a short demonstration on correct training in the device before using it independently at home.

Acknowledgements

The authors express their gratitude to the volunteer subjects and Ms Tatjana Peterle, PT, who managed treatment procedures. Financial support of Agency for Research, Republic of Slovenia is gratefully acknowledged.

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