J. Phys. Ther. Sci.
27: 1593–1596, 2015

Original Article

Effect of space balance 3D training using visual feedback on balance and mobility in acute stroke patients

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Abstract. [Purpose] The purpose of the study was to determine the effects of balance training with Space Balance 3D, which is a computerized measurement and visual feedback balance assessment system, on balance and mobility in acute stroke patients. [Subjects and Methods] This was a randomized controlled trial in which 52 subjects were assigned randomly into either an experimental group or a control group. The experimental group, which contained 26 subjects, received balance training with a Space Balance 3D exercise program and conventional physical therapy interventions 5 times per week during 3 weeks. Outcome measures were examined before and after the 3-week interventions using the Berg Balance Scale (BBS), Timed Up and Go (TUG) test, and Postural Assessment Scale for Stroke Patients (PASS). The data were analyzed by a two-way repeated measures ANOVA using SPSS 19.0. [Results] The results revealed a nonsignificant interaction effect between group and time period for both groups before and after the interventions in the BBS score, TUG score, and PASS score. In addition, the experimental group showed more improvement than the control group in the BBS, TUG and PASS scores, but the differences were not significant. In the comparisons within the groups by time, both groups showed significant improvement in BBS, TUG, and PASS scores. [Conclusion] The Space Balance 3D training with conventional physical therapy intervention is recommended for improvement of balance and mobility in acute stroke patients.
Key words: Balance training, Visual feedback, Acute stroke patients

(This article was submitted Jan. 5, 2015, and was accepted Jan. 31, 2015)

INTRODUCTION

Stroke results from occlusion or hemorrhage of a major artery in the brain[1)] and is a major cause of severe disability[2)]. Stroke survivors have difficulty in postural control for standing upright because of asymmetric posture, abnormal body imbalance, and a deficiency in weight transfer[3)]. Stroke patients suffer from difficulties in balance, mobility, activities of daily living, and task performance caused by loss of postural control[3)]. Previous studies have demonstrated the particular importance of balance and walking in stroke patients[4, 5)].

Various therapeutic methods have been used for treatment of stroke patients such as the Bobath approach, proprioceptive neuromuscular facilitation (PNF) technique[6)], auditory feedback training[7)], strengthening exercise, ball exercise, and visual biofeedback training[8)]. Among the various therapeutic methods, visual biofeedback training is effective for recovery of upright standing and symmetric posture in stroke patients[9)]. The use of visual biofeedback training increases patient motivation and individualizes exercise difficulty according to a patient's current status[10)]. Also, visual biofeedback training using a NeuroCom Balance Master with force plates was significantly effective for improvement of balance function in stroke patients when compared with conventional standing balance training[11)].

Visual biofeedback training has often been used for ordinary people such as the elderly and women, but there is little evidence regarding the effectiveness of visual biofeedback training in stroke patients with hemiparesis[12)]. In the study cited above, there were some limitations, including a small number of subjects and absence of a control group. Space Balance 3D, which can be used for fixation of a patient's trunk, is more convenient and suitable for balance training and testing in acute stroke patient at high risk of falling.

The purpose of the present study was to investigate the effects of visual biofeedback training using Space Balance 3D on balance and mobility function in acute stroke patients.

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SUBJECTS AND METHODS

We selected 56 acute stroke patients who were 18–65 year old and had been diagnosed with stroke within the last 6 months (Table 1). The inclusion criteria were; 1) able to walk more than 10 meters without or with assisting devices such as orthotics, a walker, or a cane; 2) no symptoms with any lower motor neuron lesion and orthopedic diseases; 3) a score higher than 24 points on the MMSE; and 4) able to read the words on a monitor 60 cm away at eye level. We explained the purpose of this study and got their consent. The study's protocol was approved by the institutional review board (IRB) of Sahmyook University in Seoul, Republic of Korea.

This study was performed over the course of 3 weeks. The balance training was implemented with the Space Balance 3D programmed for 30 minutes per session, 5 times a week, for 3 weeks. The subjects were assessed before and after 3-week interventions. Fifty-two subjects were randomly assigned to either an experimental group (n=26) or a control group (n=26). The experimental group was treated with 30-min sessions of Space Balance 3D training and conventional rehabilitation exercise for a total 15 sessions. The control group was treated with conventional rehabilitation exercise only. The examiner assessed the balance and gait function of subjects with the BBS (Berg Balance Scale) and PASS (Postural Assessment Scale for Stroke Patients), and TUG (Timed Up and Go) test before and after the intervention.

The Space Balance 3D training system is equipped with two wireless force plates. It can check the distribution of weight on four plates placed under the left and right forefeet and heels. The degree of tilting is assessed by a tilt sensor in the front of the apparatus. Three kinds of balance training were implemented using Space Balance 3D, which can be used for both training and testing. According to the subjects' movement, the real-time tilting angle and foot plates are indicated on a computer screen. Horizontal exercise is used as a training program for left and right balance. In this exercise, the patient moves in the left or right direction to "hit" a predetermined target. This exercise is for improving control of left and right balance. Vertical exercise is used as a training program for forward and backward balance. In this exercise, the patient moves in the forward or backward direction to hit a predetermined target. This exercise is for improving control of forward and backward balance. A horizontal exercise program is more difficult than a circle exercise program. In this exercise, the patient moves horizontally in a pattern to hit a predetermined target. In this program, deviation of the movement of the patient from the line indicates decreased balance function.

The 14-item BBS identifies and evaluates balance impairment in stroke patients[13]. When a patient was unable to independently complete a test, the patient was instructed 3 attempts, and the best score was recorded. A total score for all attempts was determined for each patient (maximum score=56 points). This measure has been reported to have excellent intrarater reliability (ICC=0.99)[14]. The PASS was developed to assess balance function in patients with stroke. The PASS contains 12 four-point items that evaluate a patient's balance function in situations of varying difficulty, namely, maintaining or changing a lying, sitting, or standing position. The range of its total score from 0 to 36[15]. For the TUG test, the patients were seated in a chair with armrests and then instructed to stand and walk as quickly and as safely as possible a distance of 3 meters, and turn around, walk back, turn around, and sit down again. The time from the point at which the patient's spine left the chair until they returned back to that same sitting position was recorded. This was followed by 3 trials. The average time of the 3 test trials was calculated. The TUG test has been shown to have high interrater (ICC=0.99) and intrarater (ICC=0.99) reliability[16]. Podsiadlo and Richardson suggested that the TUG test has content validity in that it evaluates a well-known series of measure used in daily living and that it has suitable concurrent validity because this measurement is well correlated with data corrected with more extensive measurements of gait speed, balance, and functional abilities[16, 17].

Table1. General characteristics of the subjects

Parameters	Experimental group (n=26)	Control group (n=26)
Gender (male/female)	20/6	16/10
Age (years)	48.1 ± 4.4	45.3 ± 4.2
Height (cm)	169.1 ± 4.4	164.3 ± 4.2
Weight (kg)	61.4 ± 6.2	53.5 ± 6.7
Stroke type (Ischemic/hemorrhagic)	16/10	14/12
Right plegia/Left plegia	12/14	10/16

Values represent the mean ± SD

All statistical tests were performed with SPSS version 21.0. Two-way repeated measures ANOVA for the interaction effect between group and time period was used to compare differences in balance ability between the control and experimental group. A value of $p<0.05$ was taken indicate to statistical significance.

RESULTS

After completion of the 3-week intervention, the results revealed a nonsignificant interaction effect between group and time period for both groups before and after the interventions in the BBS score, TUG score, and PASS score. In addition, the experimental group showed a more improvement than the control group in the BBS, TUG and PASS scores, but the differences were not significant. In the comparisons within the groups by time, both groups showed significant improvement in BBS, TUG, and PASS scores (Table 2).

DISCUSSION

Static and dynamic balance are essential functions of the human body that affect walking function and activities of daily living. Therefore, static and dynamic balance training programs are an important part of rehabilitation[18].

Recently, many studies have demonstrated the effects of visual feedback training on postural balance in stroke patients[9]. Visual information may compensate for the loss

Table 2. Changes in BBS, PASS, and TUG scores before and after the interventions

Test		Experimental group	Control group
BBS	Before	36.6 ± 15.0	21.1 ± 18.1
	After	49.8 ± 8.7*	37.0 ± 14.8*
PASS	Before	27.0 ± 6.4	18.1 ± 9.7
	After	33.2 ± 3.1*	26.8 ± 7.6*
TUG	Before	26.7 ± 20.9	41.5 ± 25.3
	After	15.8 ± 14.2*	25.2 ± 14.5*

Values represent the mean ± SD.
*Significant difference between before and after training in each group ($p<0.05$)

of somatosensory function and facilitate the human motor program in the brain; thus it would increase the effectiveness of treatment[19]. Shumway-Cook et al.[20] suggested that visual feedback of body weight while standing can reduce an asymmetry of body alignment and be a more effective balance training method than auditory or tactile feedback. Also, Winstein et al.[21] reported that a stroke rehabilitation program using foot force plates led to improvement of symmetry while standing. Sackley et al.[22] demonstrated that visual biofeedback training with symmetric distribution of body weight had a benefit for symmetry standing recovery in hemiplegic patients. Accordingly, visual feedback training can be a powerful therapeutic method for improvement of standing balance and gait function in stroke patients[9].

However, many previous studies had some limitations, including a small number of subjects and no control group in the experimental procedures, so it is difficult to secure objective data about the effectiveness of visual biofeedback. In addition, the training methods applied to the patients varied greatly.

Our study was implemented to investigate the effect of balance training with Space Balance 3D, which is consisted of visual biofeedback using force plates, on balance and mobility in acute stroke patients.

In this study, BBS, PASS, and TUG tests were performed before and after 3 weeks of training. In comparison of the results from before and after training, all test results were improved after the 3 weeks of training in both groups. Also, an unexpected finding of our study was that there were no statistical differences in the changes in any outcome measures between the control group and the experimental group. It is conceivable that the conventional therapy was sufficient to enable the patients to maximize their potential or that the patients recovered spontaneously, which has been shown to mostly occur in the first 3 to 6 months after a stroke[23]. Also, all subjects received specialized care such as occupational therapy and gait training in the rehabilitation unit. However, the differences in the changes in all outcomes showed that the experimental group was more improved than the control group, but the differences was not statistically significant. In previous studies in stroke patients, visual biofeedback training with foot force plate was significantly effective for improvement of a balance function[24] and walking speed[21]. Also, it has been reported that visual feedback training using a NeuroCom Balance Master was significantly effective for the improvement of balance compared with conventional balance training in chronic stroke patients[25]. However, the NeuroCom Balance Master had a limitation with respect to application to acute stroke patients. In our study, the Space Balance 3D, which is similar to the NeuroCom Balance Master but equipped with a trunk fixing device, was suitable for balance assessment and training of acute stroke patients with decreased dynamic balance ability.

It appears that Space Balance 3D training using visual biofeedback can be safely applied for improvement of balance and mobility function in acute stroke patients. A limitation of this study is that we could not determine the effects of a long period of training because our study was a short-term study lasting for 3 weeks. We suggest that further study is needed with a longer term so that the training period is long enough to determine if there are any improvements in balance.

ACKNOWLEDGEMENT

This study was supported by Sahmyook University.

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