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Original Article

Effect of Training with Whole Body Vibration on the Sitting Balance of Stroke Patients

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Abstract. [Purpose] The purpose of this study was to determine the effects of task-oriented training with whole body vibration (WBV) on the sitting balance of stroke patients. [Subjects] The subjects were 30 stroke patients who were randomly divided into experimental (n_1=15) and control (n_2=15) groups. [Methods] Subjects in both groups received general training five times per week. Subjects in the experimental group practiced an additional task-oriented training program with WBV, which was performed for 15 minutes, five times per week, for four weeks. The center of pressure (COP) path length and average velocity were used to assess subjects static sitting balance, and the Modified Functional Reach Test (MFRT) was used to assess their dynamic sitting balance. The paired t-test was performed to test the significance of differences between before and after the intervention. The independent t-test was conducted to test the significance of differences between the groups. [Results] Following the intervention, the experimental group showed a significant change in MFRT. [Conclusion] The results of this study suggest that task-oriented training with WBV is feasible and efficacious for stroke patients.
Key words: Balance, Stroke, Whole body vibration

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INTRODUCTION

Impaired sitting balance is a common problem for stroke patients[1], yet a sitting position is essential for safe execution of a variety of movements[2]. Many studies have shown that sitting balance influences functional outcome after a stroke[1]. Recovery of sitting balance is therefore a therapeutic goal for most stroke patients[3].

Several interventions have been devised to improve balance, including task-oriented training[4] and treadmill training[5]. Dean and Shepherd demonstrated that task-oriented training was effective at improving reach while sitting[6]. Recently, whole-body vibration (WBV) exercise has been developed as a new modality for physical therapy[7]. Previous studies have suggested that WBV exercise increases muscle strength and improves muscular performance and balance[8, 9], and the positive effects of WBV on muscle performance should help to improve balance[10, 11]. WBV acts through repetitive sensorimotor stimulation and therapies with WBV have been conducted for elderly patients as well as patients with cerebral palsy, multiple sclerosis, and stroke[12–15]. Some authors have reported WBV training combined with other physical therapies improves balance[16–18], and WBV was shown to positively influence the postural control and mobility of chronic hemiparetic stroke patients[11].

Recently, studies have emphasized the importance of sitting balance for stroke patients and have recommended various balance training methods for its improvement. However, physical therapies for improved sitting balance are underpinned by little empirical evidence[19]. Some studies have focused on the use of WBV, but no study has been conducted to verify the effects of WBV for stroke patients in the sitting position. Therefore, we investigated the effects of task-oriented training with WBV on the sitting balance of stroke patients. We hypothesized that a group of stroke patients performing task-oriented training with WBV would show greater improvement of sitting balance than a control group that performing task-oriented training alone.

SUBJECTS AND METHODS

The subjects were chronic stroke inpatients of the D Rehabilitation hospital. The inclusion criteria were history and clinical presentation (hemiparesis) of stroke (>6 month post-event); ability to sit independently for at least 10

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minutes; no participation in any balance training program during the previous six months; no orthopedic problems, such as a fracture, deformity, or severe osteoarthritis; and sufficient cognitive ability to participate in the training: Korean version of Mini-Mental State Examination (MMSE-K) scores of 21 or higher. The exclusion criteria were comorbidity or disability other than stroke, and an uncontrolled health condition for which vibration is contraindicated. Participation in the study was voluntary and the subjects fully understood the contents of this study. After providing an explanation of the study purpose, as well as the experimental method and processes, written informed consent to participation in the study was obtained from all the subjects. The study was approved by the Daejeon University institutional review board.

Static sitting balance was evaluated using analysis of center of pressure (COP). Subjects sat, with their feet unsupported, on a Wii Balance Board (Nintendo, Kyoto, Japan) and were asked to keep their arms folded across their chests. Their thighs were kept parallel, with 75% of their length supported on the Wii Balance Board. Data were acquired at 100 Hz, and the mean value of three measurements collected over 30 seconds was used. COP total path length and average velocity were the outcome measures used in this study. Higher values indicate lower balance ability[20].

Dynamic sitting balance was assesed using the Modified Functional Reach Test (MFRT). This was performed using a level yardstick mounted on a wall at the height of each subject's acromion of the nonparetic side, while sitting on a chair with no back or arm rests. The subjects were seated with their hips, knees, and ankles positioned at 90° of flexion, with their feet positioned flat on the floor. Three measurements were made under each of the following conditions: (1) sitting with the nonparetic side near the wall and leaning forward, (2) sitting with the back to the wall and leaning toward the nonparetic side, and (3) sitting with the back to the wall and leaning toward the paretic side. The subjects were instructed to lean as far as possible in each direction without rotating or touching the wall. The furthest position of the fifth finger was marked on the yardstick. If the patient could not raise the paretic arm, the distance covered by the acromion during leaning was used.

Thirty people fulfilled the inclusion criteria and voluntarily agreed to participate in this study. The participants were randomly assigned to the experimental group ($n_1 = 15$) or the control group ($n_2 = 15$). Both groups received conventional therapy. The intervention comprised 4 weeks of inpatient treatment. Both groups performed one session (15 minutes) a day (5 days/week) of task-oriented training in the sitting position. The experimental group received WBV during task-oriented training (Galileo Pro; Novotec Medical GmbH, Germany). The control group performed only task-oriented training. The WBV frequency (15–22 Hz) and amplitude (0–5.8 mm) were adjusted relative to subjects' physical abilities[10]. Participants were instructed not to hold onto the table during training. The four exercise tasks were (1) sitting alone at a table and correcting body alignment; (2) reaching in different directions for objects located beyond arm's length using the nonparetic side; (3) reaching in different directions for objects located beyond arm's length using the paretic side; and (4) a bilateral reaching task, such as throwing a ball, lifting a box, and inserting a ring. Each exercise session was 15 minutes in duration, and subjects practiced each of the four tasks for 3 minutes with a 1-minute rest in between. Investigators supervised each session and were responsible for ensuring that the amount and intensity of the exercise at each exercise station was graded to each subject's level of functioning.

Table 1. General characteristics of subjects

	Experimental group (n_1=15)	Control group (n_2=15)
Gender		
Male/Female	9/6	7/8
Paretic side		
Right/Left	6/9	5/10
Age (year)	62.8±9.0*	65.1±15.7
Weight (kg)	63.3±6.2	58.0±9.0
Height (cm)	162.7±6.2	161.1±6.5
Duration (month)	13.0±5.4	12.6±5.7

*Mean±SD

All collected data were analyzed using SPSS version 18.0. The independent t-test was used to compare differences between group means and changes in values, and the paired t-test was used to test differences in continuous variables within groups. Differences between categorical variables were analyzed using the χ^2 test. Statistical significance was accepted for values of $p<0.05$.

RESULTS

All patients completed the intervention and assessments. There were no significant differences in gender, paretic side, age, weight, height or duration of onset between the groups (Table 1). Differences in static sitting balance are presented in Table 2. There were no significant differences in the average velocity and total path length of COP sway between the groups.

Differences in dynamic sitting balance are presented in Table 3. After intervention, anterior, non-paretic and paretic reach were significantly higher in the experimental group ($p<0.05$). After the intervention, anterior reach was significantly higher ($p<0.05$) in the control group. There were no significant differences in non-paretic and paretic reach in the control group. Differences in total length of COP between pre- and post-intervention differed significantly between the two groups ($p<0.05$).

DISCUSSION

In this study we investigated the effect of task-oriented training with WBV on the sitting balance of stroke patients. Average velocity and total path length of COP sway were used to evaluate the static balance of the sitting position. Force platforms have previously been used to investigate the balance control of unsupported sitting of post-stroke individuals through analysis of the COP sway[21, 22]. Previous

Table 2. Comparison of COP results between pre- and post-test

	Experimental group (n_1=15)	Control group (n_2=15)
VA (cm/s)		
Pre	3.0±0.2*	3.0±0.3
Post	2.9±0.2	3.0±0.3
Change	−0.6±0.1	0.1±0.1§
TL (cm)		
Pre	89.5±6.9	89.4±9.3
Post	87.8±6.9	91.1±8.7
Change	−1.7±3.2	1.6±4.1§

VA: Velocity Average of COP, TL: Total path Length of COP
*Mean±SD
§p<0.05

Table 3. Comparison of MFRT results between pre- and post-test

	Experimental group (n_1=15)	Control group (n_2=15)
MFRT-A (cm)		
Pre	26.0±9.9*	21.0±11.4
Post	32.1±8.0	23.5±10.7§
Change	6.1±5.9	2.4±4.2
MFRT-N (cm)		
Pre	10.9±5.4	13.6±4.9
Post	16.6±5.7	15.5±6.2
Change	5.7±4.1	1.9±4.8§
MFRT-P (cm)		
Pre	9.9±4.4	10.7±5.6
Post	13.2±3.9	12.1±5.6
Change	3.4±3.4	1.3±4.2

MFRT-A: Modified Functional Reach Test-Anterior reach
MFRT-N: Modified Functional Reach Test-Non-paretic reach
MFRT-P: Modified Functional Reach Test-Paretic reach
*Mean±SD
§p<0.05

research reported that a leg exercise with WBV group and a leg exercise group without WBV showed similar improvements in the average velocity of COP in a standing position[23] with no significant difference between them. These results were similar to our present results, as we found no significant differences in average velocity or total path length of COP sway between the groups. It is possible that the training was not sufficiently intense or long enough to elicit improvements in the subjects; it is also possible that the sensitivity of the assessment method was insufficient.

In the current study, the MFRT was used to evaluate improvements in dynamic balance in the sitting position. The average anterior and lateral reach distances of adults between 60 and 70 years old are 346 mm and 206 mm, respectively[24]. In our study, the anterior, nonparetic, and paretic reach of both groups were below the normal averages at pretest, indicating that both groups had impaired sitting balance. However, at posttest, the experimental group showed significant improvements ($p<0.05$) in the anterior, nonparetic, and paretic reach, demonstrating that task-oriented training with WBV in a sitting position is a useful intervention for improving the dynamic sitting balance of stroke patients. Vibration is a useful method for stimulating proprioception and is capable of long-lasting postural improvement[25]. Other effects of vibration include modification of correcting movements and increased postural sway. The applications of vibration and predictability of stimuli can influence the physiologic effects[26].

The control group showed significant improvements ($p<0.05$) only in anterior reach. This demonstrates that task-oriented training is a useful intervention for improving anterior reach while sitting. In the experimental group, the horizontal sinusoidal wave of WBV effectively improved side reach.

Our study suggests that task-oriented training with WBV in the sitting position has beneficial effects on some aspects of sitting balance of chronic stroke patients. We anticipate that this training method will be used in physical therapy at stroke patient care centers as it is an effective form of training for balance functions. Further research is needed with larger numbers of subjects to confirm and generalize our present findings.

REFERENCES

1) Wade DT, Wood VA, Hewer RL: Recovery after stroke—the first 3 months. J Neurol Neurosurg Psychiatry, 1985, 48: 7–13. [Medline] [CrossRef]
2) Henley S, Pettit S, Todd-Pokropek A, et al.: Who goes home? Predictive factors in stroke recovery. J Neurol Neurosurg Psychiatry, 1985, 48: 1–6. [Medline] [CrossRef]
3) Löfgren B, Nyberg L, Österlind PO, et al.: In-patient rehabilitation after stroke: outcome and factors associated with improvement. Disabil Rehabil, 1998, 20: 55–61. [Medline] [CrossRef]
4) Bayouk JF, Boucher JP, Leroux A: Balance training following stroke: effects of task-oriented exercises with and without altered sensory input. Int J Rehabil Res, 2006, 29: 51–59. [Medline] [CrossRef]
5) Duncan PW, Sullivan KJ, Behrman AL, et al. LEAPS Investigative Team: body-weight-supported treadmill rehabilitation after stroke. N Engl J Med, 2011, 364: 2026–2036. [Medline] [CrossRef]
6) Dean CM, Shepherd RB: Task-related training improves performance of seated reaching tasks after stroke. A randomized controlled trial. Stroke, 1997, 28: 722–728. [Medline] [CrossRef]
7) Kawanabe K, Kawashima A, Sashimoto I, et al.: Effect of whole-body vibration exercise and muscle strengthening, balance, and walking exercises on walking ability in the elderly. Keio J Med, 2007, 56: 28–33. [Medline] [CrossRef]
8) Torvinen S, Kannu P, Sievänen H, et al.: Effect of a vibration exposure on muscular performance and body balance. Randomized cross-over study. Clin Physiol Funct Imaging, 2002, 22: 145–152. [Medline] [CrossRef]
9) Bosco C, Iacovelli M, Tsarpela O, et al.: Hormonal responses to whole-body vibration in men. Eur J Appl Physiol, 2000, 81: 449–454. [Medline] [CrossRef]
10) Semler O, Fricke O, Vezyroglou K, et al.: Preliminary results on the mobility after whole body vibration in immobilized children and adolescents. J Musculoskelet Neuronal Interact, 2007, 7: 77–81. [Medline]
11) van Nes IJ, Geurts AC, Hendricks HT, et al.: Short-term effects of whole-body vibration on postural control in unilateral chronic stroke patients: preliminary evidence. Am J Phys Med Rehabil, 2004, 83: 867–873. [Medline] [CrossRef]
12) Cheung WH, Mok HW, Qin L, et al.: High-frequency whole-body vibration improves balancing ability in elderly women. Arch Phys Med Rehabil, 2007, 88: 852–857. [Medline] [CrossRef]
13) Ahlborg L, Andersson C, Julin P: Whole-body vibration training compared with resistance training: effect on spasticity, muscle strength and motor performance in adults with cerebral palsy. J Rehabil Med, 2006, 38: 302–308. [Medline] [CrossRef]
14) Schuhfried O, Mittermaier C, Jovanovic T, et al.: Effects of whole-body vibration in patients with multiple sclerosis: a pilot study. Clin Rehabil, 2005, 19: 834–842. [Medline] [CrossRef]

15) van Nes IJ, Latour H, Schils F, et al.: Long-term effects of 6-week whole-body vibration on balance recovery and activities of daily living in the postacute phase of stroke: a randomized, controlled trial. Stroke, 2006, 37: 2331–2335. [Medline] [CrossRef]
16) Rees SS, Murphy AJ, Watsford ML: Effects of whole body vibration on postural steadiness in an older population. J Sci Med Sport, 2009, 12: 440–444. [Medline] [CrossRef]
17) Bruyere O, Wuidart MA, Di Palma E, et al.: Controlled whole body vibration to decrease fall risk and improve health-related quality of life of nursing home residents. Arch Phys Med Rehabil, 2005, 86: 303–307. [Medline] [CrossRef]
18) Bautmans I, Van Hees E, Lemper JC, et al.: The feasibility of whole body vibration in institutionalised elderly persons and its influence on muscle performance, balance and mobility: a randomised controlled trial [ISRCTN62535013] . BMC Geriatr, 2005, 5: 17. [Medline] [CrossRef]
19) Sackley CM, Hill HJ, Pound K, et al.: The intra-rater reliability of the balance performance monitor when measuring sitting symmetry and weight-shift activity after stroke in a community setting. Clin Rehabil, 2005, 19: 746–750. [Medline] [CrossRef]
20) Preuss RA, Popovic MR: Quantitative analysis of the limits of stability in sitting. J Appl Biomech, 2010, 26: 265–272. [Medline]
21) Genthon N, Vuillerme N, Monnet JP, et al.: Biomechanical assessment of the sitting posture maintenance in patients with stroke. Clin Biomech (Bristol, Avon), 2007, 22: 1024–1029. [Medline] [CrossRef]
22) van Nes IJ, Nienhuis B, Latour H, et al.: Posturographic assessment of sitting balance recovery in the subacute phase of stroke. Gait Posture, 2008, 28: 507–512. [Medline] [CrossRef]
23) Lau RW, Yip SP, Pang MY: Whole-body vibration has no effect on neuromotor function and falls in chronic stroke. Med Sci Sports Exerc, 2012, 44: 1409–1418. [Medline] [CrossRef]
24) Thompson M, Medley A: Forward and lateral sitting functional reach in younger, middle-aged, and older adults. J Geriatr Phys Ther, 2007, 30: 43–48. [Medline] [CrossRef]
25) Priplata AA, Niemi JB, Harry JD, et al.: Vibrating insoles and balance control in elderly people. Lancet, 2003, 362: 1123–1124. [Medline] [CrossRef]
26) Haas CT, Turbanski S, Kessler K, et al.: The effects of random whole-body-vibration on motor symptoms in Parkinson's disease. NeuroRehabilitation, 2006, 21: 29–36. [Medline]