J. Phys. Ther. Sci. 29: 2022–2025, 2017

The Journal of Physical Therapy Science

Original Article

The effects of whole body vibration combined biofeedback postural control training on the balance ability and gait ability in stroke patients

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Abstract. [Purpose] The purpose of this study was to examine the effect of biofeedback postural control training using whole body vibration in acute stroke patients on balance and gait ability. [Subjects and Methods] Thirty stroke patients participated in this study and were divided into a group of 10, a group for biofeedback postural control training combined with a whole body vibration, one for biofeedback postural control training combined with an aero-step, and one for biofeedback postural control training. Biorescue was used to measure the limits of stability, balance ability, and Lukotronic was used to measure step length, gait ability. [Results] In the comparison of balance ability and gait ability between the groups for before and after intervention, Group I showed a significant difference in balance ability and gait ability compared to Groups II and III. [Conclusion] This study showed that biofeedback postural control training using whole body vibration is effective for improving balance ability and gait ability in stroke patients.

Key words: Whole body vibration, Biofeedback, Stroke

(This article was submitted Jul. 17, 2017, and was accepted Aug. 30, 2017)

INTRODUCTION

Stroke patients suffer from reduced and loss of proprioceptive sensation and sense of balance, making it difficult to regulate normal posture, thus reducing balance[1, 2)]. Gait disturbance is common in stroke patients, and it is often caused by direct neurological damage associated with the lesion, secondary physical inactivity or nonuse, which also makes it difficult to walk due to weakness of the muscles, loss of sensation, dystaxia, soft tissue contracture, etc[3, 4)]. In previous studies, various methods have been used to improve the functional ability of stroke patients. Among them, whole body vibration is a new form of somato-sensory stimulation in the rehabilitation of stroke patients, which is a safe treatment for patients with limited mobility[5, 6)]. Therapeutic intervention using biofeedback has advantages such as relatively easy control of the environment compared with other intervention methods, provision of training according to ability through gradual control of task difficulty, provision of accurate sensory feedback, and provision of self-learning opportunities in a safe environment[7, 8)]. Application of the training method used in this research can be suggested as a rehabilitation approach for acute stroke patients in clinic, and application of this method on recovery process of acute stroke patients would promote functions for daily life and fast functional recovery of acute stroke patients.

SUBJECTS AND METHODS

Subjects were selected from 30 patients with a chronic stroke that occurred not less than 3 months ago, hospitalized at

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Table 1. General characteristic subjects

Variable	WBV+BPCT (n=10) M ± SD	AS+BPCT (n=10) M ± SD	BPCT (n=10) M ± SD	p
Height (cm)	170.85 ± 7.23	171.21 ± 6.13	170.33 ± 6.86	0.782
Age (years)	47.01 ± 3.21	49.12 ± 4.11	48.23 ± 3.96	0.764
Weight (kg)	69.31 ± 6.19	70.21 ± 6.85	69.09 ± 7.01	0.355
Gender (male/female)	8/2	7/3	7/3	0.612
Paralyzed side (Rt/Lt)	7/3	6/4	6/4	0.632

M ± SD: mean ± standard deviation
WBV+BPCT: Whole body vibration + Biofeedback postural control training; AS+BPCT: Aero-step + Biofeedback postural control training; BPCT: Biofeedback postural control training

J hospital in M, Jeon-nam province. 30 patients gave written consent to participate in the experiment based on sufficient understanding on this study. In this study, 30 patients who were diagnosed with stroke and admitted to hospitals were selected (Table 1). The criteria for selection were as follows: hemiplegia patients who were diagnosed with stroke within 3 months, who scored more than 24 points in the Korean Mini-Mental State Examination, able to communicate, who were able to walk more than 10 m independently, and those without musculoskeletal diseases that could affect the experiment. The 30 subjects who were sampled before the experiment were randomized into three groups of 10 persons each, and the intervention was performed for 8 weeks. In this study, 30 stroke patients were sampled and divided into 3 groups: whole body vibration combined biofeedback postural control training (Group I), aero-step (TOGU, Germany) combined biofeedback postural control training (Group II), and biofeedback postural control training (Group III). After 8 weeks of intervention, the balance ability and gait ability between groups were examined. BioRescue (RM Ingenierie, France) was used to measure balance ability, and movement distance and moving area of the center of pressure were measured. In this study, the limit of stability was measured. To analyze the change of stride among the temporal and spatial variance, the change of step length was analyzed by using LUKOtronic motion capture system (Lutz-Kovacs Electronic, Austria) on PC with Diagnostic software: whole body gait analysis (GaitLab). The measured data were analyzed through SPSS 19.0 for Windows. One-way ANOVA was used to test for similarities and changes within the group and two-way repeated measures ANOVA was used to compare changes between groups. Tukey was used for the post-hoc comparison. The statistical significance level was α=0.05. This study was approved by bioethics Committee of Sehan University Center (institutional review board, IRB) (Approval number: SH-IRB 2017-11) on June 26, 2017.

RESULTS

In the result of differences in limits of stability within the groups, one-way ANOVA showed that there was a statistically significant difference in the groups I, II, and III ($p<0.05$, $p<0.001$) (Table 2). Two-way repeated measures ANOVA showed significant differences in time, time * group, and individual effects between groups I, II, and III ($p<0.05$). Tukey, a post-hoc test, showed the difference in limits of stability was higher in group II and I than in group III (Table 3).

In the result of differences in step lengths within the groups, one-way ANOVA showed statistically significant differences among groups I, II, and III ($p<0.05$, $p<0.001$) (Table 4). Two-way repeated measures ANOVA showed significant differences in time, time*group, and individual effects between groups I, II, and III ($p<0.05$). Tukey, a post-hoc test, showed that the difference in step lengths was higher in group I than in group III and group II (Table 5).

DISCUSSION

This study showed that whole body vibration combined biofeedback postural control training was effective in improving balance and gait ability of stroke patients. Yang et al.[9] compared treadmill with biofeedback training groups and general treadmill training groups in 14 stroke patients. In the biofeedback training group, a significant improvement was observed in front·rear center of pressure movement distance and left·right center of pressure movement distance. In this study, all groups using biofeedback showed a significant improvement in the limits of stability, measurement using center of pressure, but the whole body vibration group showed a greater improvement than the other two groups. This is because during the biofeedback intervention, the whole body vibration transmits continuous shrinking information to the spinal cord, stimulating the muscular nervous system which seems to have influenced factors related to balance ability. Neurological impairment due to stroke affects all cycles at the step of patients with hemiplegia, resulting in decreased temporal and spatial variables and asymmetry[10]. Wang et al.[11] compared 30 patients with knee degenerative joint disease over the age of 60 years, who underwent muscle quadriceps femoris strengthening training using whole body vibration for 12 weeks, 5 times a week for 30 minutes a day with a control group who underwent normal muscle quadriceps femoris strengthening training. In their study, the whole body vibration group had a significant effect on the step length. In this study, the biofeedback postural control training group using whole body vibration had a significant effect on step length compared to two other groups. This

Table 2. Comparison of limited of stability within subject group (unit: cm^2)

Group	LOS			p	Post-hoc
	Pre M ± SD	4 week M ± SD	8 week M ± SD		
Group I (n=10)	93.12 ± 8.31	114.32 ± 9.04	153.86 ± 9.42	0**	0,4<8
Group II (n=10)	92.99 ± 8.74	113.16 ± 8.31	151.85 ± 9.03	0**	0,4<8
Group III (n=10)	92.85 ± 8.97	111.95 ± 8.97	148.39 ± 8.45	0.009*	0,4<8

LOS: limited of stability
Group I: WBV+BPC, Group II: AS+BPCT, Group III: BPCT
*p<0.01, **p<0.001

Table 3. Comparison of limited of stability between subject group

	Source	SS	df	MS	p	Post-hoc
LOS	Within-subject factor					
	Time	58,641.124	2	28,986.142	0.008*	
	Time* group	2,641.107	4	656.125	0.006*	
	Error	58.125	54	2.194		
	Between-subject factor					
	Group	3,299.435	2	1,619.412	0**	$G_{III}<G_{II}, G_I$
	Error	322.874	27	11.994		

LOS: limited of stability; SS: Sum of squares; df: Degress of freedom; MS: Mean squares
*p<0.01, **p<0.001

Table 4. Comparison of step length within subject group (unit: cm)

Group	SL			p	Post-hoc
	Pre M ± SD	4 week M ± SD	8 week M ± SD		
Group I (n=10)	24.71 ± 3.97	27.12 ± 3.81	29.98 ± 3.15	0**	0,4<8
Group II (n=10)	24.61 ± 2.91	26.32 ± 3.86	28.01 ± 3.64	0.002*	0,4<4,8
Group III (n=10)	25.03 ± 3.27	26.86 ± 3.34	27.99 ± 3.10	0.005*	0,4<4,8

SL: step length
Group I: WBV+BPC, Group II: AS+BPCT, Group III: BPCT
*p<0.01, **p<0.001

Table 5. Comparison of step length between subject group

	Source	SS	df	MS	p	Post-hoc
SL	Within-subject factor					
	Time	504.124	2	257.151	0.008*	
	Time* group	69.312	4	16.974	0.000*	
	Error	28.314	54	0.965		
	Between-subject factor					
	Group	65.669	2	32.835	0.004*	$G_{III},G_{II}<G_I$
	Error	202.193	27	7.489		

SL: step length; SS: sum of squares; df: degress of freedom; MS: mean squares
*p<0.01, **p<0.001

suggests that when biofeedback and whole body vibration are applied at the same time, the positive effect is greater for the gait ability of stroke patients. These results suggest that whole body vibration combined biofeedback postural control training has a positive effect on the balance and gait ability of acute stroke patients. In the future, the use of the intervention method used in this study may be suggested as a rehabilitation training approach for acute stroke patients in clinical practice.

ACKNOWLEDGEMENT

The research has been conducted by the research grant of Sehan University in 2017.

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