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Original Article

The effects of whole body vibration combined computerized postural control training on the lower extremity muscle activity and cerebral cortex activity in stroke patients

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Abstract. [Purpose] The purpose of this study was to examine the effect of computerized postural control training using whole body vibration on lower limb muscle activity and cerebral cortical activation in acute stroke patients. [Subjects and Methods] Thirty stroke patients participated and were divided into groups of 10, a group of the computerized postural control training using whole body vibration (Group I), the computerized postural control training combined with aero step (Group II) and computerized postural control training (Group III). MP100 was used to measure lower limb muscle activity, and QEEG-8 was used to measure cerebral cortical activation. [Results] Comparison of muscle activity and cerebral cortical activation before and after intervention between groups showed that Group I had significant differences in lower limb muscle activity and cerebral cortical activation compared to Groups II and III. [Conclusion] This study showed that whole body vibration combined computerized postural control training is effective for improving muscle activity and cerebral cortex activity in stroke patients.
Key words: Stroke, Cortex activity, Muscle activity

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INTRODUCTION

Damage to the motor cortex and pyramidal tract caused by stroke results in hemiparesis. In addition, postural, muscular tension, and abnormal voluntary movements cause dystaxia[1)]. Hemiparesis causes weakness or the inability to move one side of the body such as an arm, leg and trunk, and most cases show weakness of leg muscles[2)]. In stroke patients, the goal of treatment is to restore the lost function by enhancing the plasticity of the brain, thereby restoring normal posture and movement, and reducing the abnormalities of posture and muscle tension, so as to have effective movement[3)]. The whole body vibration exercise is a training method to strengthen the nerve root by promoting the spinal reflex of the central nervous system through vibration stimulus. Repeated stimulus induces muscle contraction and relaxation to sensitize the nerve root to increase the rate of muscle response, and activate the muscle and nervous systems[4, 5)]. The computerized treatment method refers to the control of normal or abnormal responses of the body through visual and auditory feedback by using a specific device. This treatment is considered as an appropriate evaluation and training method for stroke patients since it can be learned through self-repetitive exercises, and it immediately shows the results of the task performance and the results of the evaluation objectively[6)].

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SUBJECTS AND METHODS

Thirty 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. The criteria for selection were as follows: hemiplegic 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 (Table 1). In this study, 30 stroke patients were sampled and divided into 3 groups: computerized postural control training using whole body vibration (Group I), computerized postural control training combined with an aero-step (Group II), and computerized postural control training (Group III). After 8 weeks of intervention, lower limb muscle activity and cerebral cortical activation between groups were examined. 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. MP100 surface electromyography system (Biopac System Inc., USA) was used to measure lower limb activity. The attached muscle was vastus lateralis and the positive and negative electrodes were attached to the muscle belly of each muscle in parallel with the muscle fiber direction. %RVC was used to standardize muscle activity. Electroencephalograms were collected using QEEG-8 (LXE3208, LATHA Inc., Korea) and electrodes were attached at the center (central z, Cz). The relative band power (RBP) method was used by performing a fast fourier transform (FFT) on stored electroencephalograms to convert data to frequency. 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 $\alpha=0.05$. This study was approved by Bioethics Committee of Sehan University Center (institutional review board, IRB) (Approval number: SH-IRB 2017–12) on June 26, 2017.

RESULTS

In the result of differences in lower limb muscle activity, 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 ($p<0.05$) (Table 3). Tukey, a post-hoc test, showed the difference in activity of vastus lateralis was higher in group I than in groups III and II.

In the result of differences in Czβ-SMR wave %RBP between groups, one-way ANOVA showed that there was a statisti-

Table 1. General characteristics of the subjects

Variable	WBV+BPCT (n=10) M ± SD	AS+BPCT (n=10) M ± SD	BPCT (n=10) M ± SD
Height (cm)	168.85 ± 4.90	170.33 ± 5.65	169.07 ± 4.41
Age (years)	51.01 ± 2.97	52.39 ± 3.75	49.82 ± 3.55
Weight (kg)	69.31 ± 6.19	70.21 ± 6.85	69.09 ± 7.01
Gender (male/female)	6/4	5/5	6/4
Paralyzed side (Rt/Lt)	6/4	6/4	5/5

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

Table 2. Comparison of changes in vastus lateralis muscle activity within subjects groups (unit: %)

Group	VL%RVC Pre M ± SD	4 week M ± SD	8 week M ± SD	post-hoc″
Group I (n=10)	34.13 ± 4.04	38.41 ± 3.55	42.64 ± 3.86**	0,4<8
Group II (n=10)	33.95 ± 3.11	35.35 ± 2.98	38.97 ± 4.16*	0,4<8
Group III (n=10)	34.45 ± 4.24	36.24 ± 3.98	38.88 ± 3.07*	0,4<8

VL%RVC: vastus lateralis % reference voluntary contraction.
Group I: WBV+CPCT, Group II: AS+CPCT, Group III: CPCT.
″Tukey.
*p<0.05, **p<0.001.

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DISCUSSION

This study showed that computerized feedback postural control training using whole body vibration was effective in improving lower limb muscle activity and cerebral cortical activation of stroke patients. Yo-han Uhm et al.[7] compared the experimental group that had computerized postural control training and the control group that had dynamic balance training without biofeedback for 5 weeks, 5 times a week for 30 minutes a day. In their study, the experimental group that had computerized postural control training showed significant improvement in leg muscle activity compared to the control group. This

Table 3. Comparison of changes in vastus lateralis muscle activity between subjects groups

	Source	SS	df	MS	post-hoc″
VL	Within-subject factor				
%RVC	Time	584.975	2	342.144**	
	Time* group	79.196	4	24.864*	
	error	34.125	54	0.01	
	Between-subject factor				
	group	82.315	2	43.163**	G_{III},G_{II} < G_I
	error	194.412	27	7.352	

VL%RVC: vastus lateralis % reference voluntary contraction.
″Tukey.
SS: Sum of squares, df: Degress of freedom, MS: Mean squares.
*$p<0.05$, **$p<0.001$.

Table 4. Comparison of Czβ-SMR wave %RBP within subject group (unit: %)

Group	Cz β-SMR wave %RBP			post-hoc″
	Pre	4 week	8 week	
	M ± SD	M ± SD	M ± SD	
Group I (n=10)	9.31 ± 1.71	12.56 ± 1.55	15.74 ± 2.04**	0,4<8
Group II (n=10)	9.45 ± 1.38	11.78 ± 1.66	14.04 ± 1.69*	0,4<8
Group III (n=10)	9.63 ± 1.88	11.48 ± 1.43	13.59 ± 1.84*	0,4<8

RBP: relative band power.
Group I: WBV+CPCT, Group II: AS+CPCT, Group III: CPCT.
″Tukey.
*$p<0.05$, **$p<0.001$.

Table 5. Comparison of Czβ-SMR wave %RBP between subject group

	Source	SS	df	MS	post-hoc″
C3 β-SMR wave %RBP	Within-subject factor				
	Time	286.861	2	128.451*	
	Time* group	16.964	4	4.083*	
	error	7.741	54	0.386	
	Between-subject factor				
	group	23.114	2	12.764*	G_{III},G_{II} < G_I
	error	8.997	27	0.379	

RBP: relative band power.
″Tukey.
SS: Sum of squares, df: Degress of freedom, MS: Mean squares.
*$p<0.05$.

study also showed significant improvement in leg muscle activity in all groups combined with the biofeedback, but showed a greater improvement in the group with whole body vibration. This supports the fact that the effect of biofeedback postural control training is greater combined with whole body vibration. In addition, compared to the previous study, the duration of intervention in this study was longer, which may have had a greater impact on the improvement of muscle activity. Sterman and Egner[8] showed that when the neurofeedback training is mediated using β-SMR, the time where β-SMR reached the maximum was shorter and the β-SMR showed a significant improvement. Keller[9] compared the experimental group that underwent neurofeedback training with computerized cognitive rehabilitation training in a group of 12 subjects with traumatic brain injury who had a concentration disorder, for 2 weeks, 10 times, 30 minutes a day. As a result, the experimental group with neurofeedback training showed significant improvement in the beta wave and was consistent with this study. Beta waves are brain waves with a frequency range of between 12 and 35 Hz and are highly active in situations requiring the performance and concentration of physical activities such as movement (Egner et al.[10]) and it is increased when paying attention while exercise (Kyung-ok Hwang[11]).

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Conflict of interest

None.

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