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Original Article

Effects of repeated vibratory stimulation of wrist and elbow flexors on hand dexterity, strength, and sensory function in patients with chronic stroke: a pilot study

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Abstract. [Purpose] The aim of this study was to investigate the effects of repeated vibratory stimulation to muscles related to hand functions on dexterity, strength, and sensory function in patients with chronic stroke. [Subjects and Methods] A total of 10 stroke patients with hemiplegia participated in this study. They were divided into two groups: a) Experimental and b) Control, with five randomly selected subjects for each group. The experimental group received vibratory stimulation, while the control group received the traditional physical therapy. Both interventions were performed for 30 minutes each session, three times a week for four weeks. [Results] There was a significant within-group improvement in the box and block test results in both groups for dexterity. Grip strength improved in both groups but the improvement was not statistically significant. [Conclusion] The vibratory stimulation activated the biceps brachii and flexor carpi radialis, which increased dexterity to grasp and lift the box and block from the surface. Therefore, repeated vibratory stimulation to muscles related to hand functions improved hand dexterity equality to the traditional physical therapy in patients with chronic stroke.
Key words: Chronic stroke, Dexterity, Vibratory stimulation

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INTRODUCTION

In previous literatures, approximately 65% reduction in sensory function including tactile and proprioceptions has been reported among stroke patients[1)]. Because post-stroke patients usually have sensory impairments and mobility disorders, restricting their performance of functional tasks, the intervention to increase both sensory and motor functions is crucial in their rehabilitation[2)]. Various interventions for the improvement of upper limb functions were performed for patients with hemiplegia. Further, related study was actively and widely conducted to find ways to enhance sensory stimulation[3)]. Among these, a sensory stimulation intervention was found to diminish spasticity and co-contraction of hemiplegic upper limb, resulting in gentle movement[4)]. In previous study, the sensory stimulation to a muscle affected the primary motor cortex and somatosensory area by Ia afferent fiber from muscle spindle, improving both sensory and physical functions[5)]. In the recent study, vibratory stimulation applied at the palm of the affected hand improved grasp and shoulder functions[6)]. In addition, vibratory stimulation of pectoralis minor, elbow flexors, and wrist flexors influenced the upper limb functions of patients with hemiplegia[3)]. Vibratory stimulation applied to elbow flexors and flexor carpi radialis also improved the reaching function of the affected upper limb[4)] and proprioception of elbow joint in able-bodied individuals, influencing upper limb movement and sensory function[7, 8)]. Although many studies have reported that this intervention improves upper limb and sensory functions in patients with hemiplegia, they did not reveal its effect on the strength and sensation of the hand. Therefore, the purpose

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Table 1. General characteristics of patients (N=10)

		EG (n=5)	CG (n=5)
Age, yrs ± SD		62 ± 9.0	59 ± 10.1
Weight, kg ± SD		62.4 ± 10.9	66.6 ± 5.3
Gender, n (%)	Male	2 (40)	4 (80)
	Female	3 (60)	1 (20)
Hemiplegia side, n (%)	Right side	2 (40)	3 (60)
	Left side	3 (60)	2 (40)
Stroke type, n (%)	Hemorrhagic	4 (80)	4 (80)
	Infarction	1 (20)	1 (20)
Stroke onset period, months ± SD		11.0 ± 4.3	9.2 ± 1.9
MMSE ± SD		28.6 ± 1.6	27.6 ± 2.8

EG: experimental group; CG: control group

of this study was to investigate the effects of repeated vibratory stimulation to muscles related to hand function on dexterity, strength, and sensory function in patients with chronic stroke.

SUBJECTS AND METHODS

This study was performed at B hospital in South Korea from April 1 to May 2, 2016 following the ethical principles of the Declaration of Helsinki. Written informed consents were obtained at the start of this study. The general characteristics of the subjects are shown in Table 1.

A total of 10 stroke patients were included in this study. The inclusion criteria were: 1) diagnosis of stroke from a physician, 2) no pain from vibration, 3) above 24 points in Mini Mental State Examination, 4) ability to grasp, and 5) sensory below 6.65 mm of mono-filament. Patients having other neurologic disorders were excluded in the study. The 10 subjects were divided into two groups: a) Experimental Group (EG) and b) Control Group (CG), with five randomly-selected subjects for each group. The EG received vibratory stimulation while the CG received the traditional physical therapy. Both interventions were done for 30 minutes each session, three times a week for four weeks. Thrive MD-01 (Thrive Co., Ltd., Osaka, Japan) was used for vibratory stimulation and applied by 2 testers with a frequency of 91 Hz and an amplitude of 1.0 mm for 20 minutes a session to the biceps brachii and flexor carpi radialis in the EG while sitting on a chair. Forearm and hand were placed comfortably and the hand grasped a dynamometer with 20% of maximal grip power. The procedure of applying the vibratory stimulator was that the biceps brachii and flexor carpi radialis in the affected side were placed on the heads of the vibratory stimulators and tied together by straps. Two kg of weights were put on the neck portion of the vibratory stimulators to fix the location of stimulation during the operation[9)]. Box and block test (BBT) was used for hand dexterity. It was originally used for assessing a patient with physical disorder by converting the number of block size of 1 inch carried from a box to another box for 1 minute. The intra-rater reliability of left hand and right hand were r=0.99 and r=1.00 respectively[10)], grip strength (GS) was used for hand strength and assessed from non-dominant hand to dominant hand. To assess for grip strength of the hand, the patient's shoulder should be adducted with the elbow joint in 90 degrees flexion and the forearm in neutral position. The test was performed three times and yielded the mean[11)]. And Weinstein monofilament (Baseline, USA) was used for sensory test in the affected hand. The test was performed with from 2.83 mm of the filament to gradually thicken filaments for 1.5 second each until the filament applied was bent and respond was elicited a total of three times and yielded the mean. The inter-rater and intra-rater reliability were r=0.78–0.89 and r=0.96 respectively[12)].

All data were analyzed using Statistical Package for the Social Science (SPSS) version 18. Wilcoxon signed ranked test and Mann Whitney test were used to determine variations within each group and between the two groups, respectively. All data were presented as mean with standard deviation (SD). An $\alpha=0.05$ level of significance was used for all statistical tests.

RESULTS

There were significant differences in BBT results within the EG and CG. In addition, GS in EG and CG was improved but not significant and Sensory after the intervention in both groups was same as before. The variations of upper limb functions within a group and between the two groups are shown in Table 2

DISCUSSION

Patients with hemiplegia after a stroke suffer in general from awkward and clumsy mobility of the affected hand and upper limb and weakness is a representative positive symptom from the upper motor neuron lesion. Therefore, basic and

Table 2. Variations of upper limb function within a group and between two groups (N=10)

	BBT		GS		Sensory (mm)	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
EG (n=5)	18.6 ± 9.3	22.2 ± 9.2[a]	11.9 ± 6.1	12.6 ± 6.5	3.6 ± 0.6	3.6 ± 0.6
CG (n=5)	20.4 ± 9.3	21.8 ± 9.0[a]	11.8 ± 5.0	11.9 ± 5.3	3.9 ± 0.5	3.9 ± 0.5

[a] $p<0.05$, within a group
EG: experimental group; CG: control group; BBT: Box and block test; GS: grip strength

instrumental activities of daily living are a huge challenge to them. Every movement is initiated from stimuli and the stimuli are delivered by ascending tracts from the skin, joint and muscle etc. to primary somatosenory area. After the integration of the sensations coming from the each sensory receptor, cerebral cortex gives a command to the spinal cord for movement. When human beings conduct some movements in bearing the body weight especially, more information is transmitted to the cerebral cortex and it can adjust and refine the movements more efficiently. Like this, movement like dexterity and strength develops sensation and vice versa. In this study, dexterity, strength and sensation were assessed altogether pre- and post-intervention. Low amplitude vibratory stimulation or transcranial magnetic stimulation to a muscle in a previous study proved to induce variations in motor excitability. In addition, applying vibratory stimulation to a muscle continuously for 90 minutes for three days induced longstanding variations in motor activity in both patients and able-bodied individuals[13]. In this study, BBT for hand dexterity significantly improved in both groups while GS for hand strength improved in both groups but the improvement was not statistically significant. Although the current study results did not show superior effect of the vibratory stimulation over conventional therapy for dexterity, it demonstrated that both interventions were effective for dexterity. One possible reason for the effectiveness of vibratory stimulation is that the vibratory stimulation affected the proprioceptors in the muscles. In turn, related muscles were reorganized in the brain, resulting in more accurate and powerful movements. Moreover, the stimulation activated the flexor muscles such as the biceps brachii and flexor carpi radialis, which increased the muscle power to grasp and lift the box and block from the surface. It has been shown in previous study that a reduction in muscle tonus and an increase in motor function coupled with a reduction in motor thresholds and an increase in motor map size of both flexors[5]. In addition, in the previous study, the use of functional vibratory stimulation (FVS) applying to the arm improved flexion of the hemiparetic shoulder. FVS carried to the palm made the patient repeat flexing his hemiparetic shoulder to operate objects with his hand. This study tried to verify if FVS giving to the hemiplegic upper extremity could influence voluntary movements of the extremity by growing the excitability of the motor cortex or motor neurons in the spinal cord via somatosensory-evoked potentials[6]. In this study, vibration stimulation giving to the biceps brachii and flexor carpi radialis influenced grasping the block and transferring it to the other place. In conclusion, interventions using vibratory stimulation and traditional PT are equally effective for improving dexterity in the subjects with chronic stroke. The limitation of the present study was a short duration of the intervention to elicit treatment outcomes in grip strength and sensation in patients with chronic stoke. In addition, activations of the target muscles were not objectively measured during activities and the sample size was small. In future follow-up studies, it is suggested to increase the duration and sample size and also use electromyography to verify the muscle activations during activities.

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