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Original Article

The effects of vibratory stimulation employed to forearm and arm flexor muscles on upper limb function in patients with chronic stroke

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Abstract. [Purpose] The purpose of this study was to investigate not only the effects of stimulatory vibration but also the retained effects 2 weeks after the last session of the intervention. [Subjects and Methods] Ten subjects with post-stroke hemiplegia were recruited in this study. The experimental group (EG) received vibratory stimulation for 30 minutes in each session, three times a week for 2 weeks. Grip strength (GS), box-and-block test (BBT), and Weinstein monofilament were used to assess hand strength, dexterity, and sensory in the affected hand, respectively. [Results] A significant difference was found between the pre- and post-follow-up BBT. Significant differences were found among the pre-posttest, post-follow-up test, and pre-follow-up test results for GS and BBT. [Conclusion] This study was conducted with 10 subjects, without a control group, to verify the pure effect of the intervention. As a result, significant positive effects were observed in the post-test and follow-up test of GS and BBT. Therefore, repeated vibratory stimulation influenced GS and BBT after the 2-week intervention and retained the effect for 2 more weeks.

Key words: Stroke, Upper limb function, Vibratory stimulation

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INTRODUCTION

Decreased muscle strength is one of the significant negative impairments in patients with hemiplegia after stroke. Muscle weakness is induced after stroke, and limited movement follows[1)]. A maximum of 65% patients with hemiplegia show reduced touch and proprioceptive sensations. Moreover, a sense of pain, temperature, and touch are diminished. Considering that the ability to detect these sensory features is impaired, it can be difficult to recognize items by touch and exploring the environment. In addition, it is noted that senses are vital, and influence the re-recognition of skilled movements. An impairment has negative effects on safety, natural use of hands, capability to maintain a proper level of force during grasping with no vision, object management difficulties, and sexual and leisure activities[2)]. In this manner, recovery of motor control is a compound and complicated process. Two mechanisms used by the brain to reorganize itself are increases in the unmasking of neural hidden connections and the numbers of synapses on dendrites. It is noted that functionally relevant adaptive changes take place in the brain after an injury[3)]. Segmental muscle vibration (SMV) is a method that applies a vibratory stimulus to a particular tendon using a mechanical apparatus. SMV brings about the creation of Ia inputs as a result of the facilitation of muscle spindle primary endings. The Ia sensory inputs facilitated by SMV can change the activation of the corticospinal pathway by managing intracortical inhibiting and activating sensory inputs to the primary motor cortex. A previous study used Transcranial magnetic stimulation, after applying low amplitude SMV to the flexor carpi radialis muscle and intrinsic hand muscles and excitability in the primary motor cortex was increased[4)]. Even though systematic data on the improvement of human somatosensation is lacking, the potential for progress has been noted on many accounts. Moreover, previous

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

		EG (n=10)
Age, yrs ± SD		62.6 ± 8.6
Weight, kg ± SD		67 ± 12.6
Height, n (cm)		165.1 ± 9.7
Gender, n (%)	Male	7 (70)
	Female	3 (30)
Hemiplegia side, n (%)	Right side	5 (50)
	Left side	5 (50)
Stroke type, n (%)	Hemorrhagic	5 (50)
	Infarction	5 (50)
Stroke onset period, months ± SD		21.6 ± 18.6
MMSE ± SD		28.4 ± 2.1

EG: experimental group

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

	EG (n=10)		
	Pre-test	Post-test	Followup test
GS	11.4 ± 5.4	13.4 ± 6.9[b]	12.6 ± 6.3[c, d]
BBT	13.3 ± 8.2	17.1 ± 8.5[b]	15.1 ± 8.3[a, c, d]
Sensory (mm)	3.9 ± 0.8	3.6 ± 0.7	3.8 ± 0.8

[a]$p<0.05$ in Repeated Measure ANOVA, [b]$p<0.05$ in pre and post test, [c]$p<0.05$ in post and followup test, [d]$p<0.05$ in pre and follow-up test
EG: experimental group; GS: grip strength; BBT: Box and Block Test

experimental research on primates with lesions revealed that a wide-ranging training of touch, proprioception, and vibration turned out to improve even the most sophisticated discriminatory abilities. It also helped recognize the somatosensory cortex[2]. Therefore, this study focused on understanding the pure effect of the repeated vibratory stimulation, and the retaining effects in 2 weeks after the last session of intervention compared in the experimental group or control group.

SUBJECTS AND METHODS

This study was conducted at a hospital in South Korea from March 6 to 31, 2017. Written informed consent was obtained at the beginning of the study and ethical approval for this study was granted by the Ethics Committee of Gacheon University (1044396-201701-HR-011-01).

Table 1 shows the general characteristics of the subjects.

Ten subjects presenting with hemiplegia after stroke were recruited to this study. The inclusion criteria were as follows: 1) no complaints of pain from the induced vibration, 2) >24 points on the Mini Mental State Examination, 3) possibility to grasp, and 4) can detect sensations below 6.65 mm of monofilament. Subjects who have other neurologic problems were excluded from this study. The experimental group (EG) received vibratory stimulation for 30 minutes during each session, three times a week for two weeks. The biceps brachii and flexor carpi radialis in the EG were chosen to receive vibratory stimulation by Thrive MD-01 (Thrive Co., Ltd., Osaka, Japan) in a sitting position on a chair. The affected arm was fixed. And then placed not let the stimulators move. After that, it was applied to the biceps brachii and flexor carpi radialis in the affected side[5]. Grip strength (GS) was used for hand strength and assessed affected hand[6]. The Box and Block Test (BBT) was used for dexterity[7]. And Weinstein monofilament (Baseline, USA) was used for sensory test in the affected hand[8]. A Statistical Package for the Social Science (SPSS) version 18 was used to analyze all data. Repeated measures such as analysis of variance (ANOVA) and Wilcoxon signed ranked test were used to determine variations within a group. All data were presented as a mean with standard deviation (SD). $\alpha=0.05$ level of significance was used for all statistical tests.

RESULTS

There was a significant difference in pre and post-follow-up tests of BBT. There were significant differences in pre to post test, post-follow-up test and pre-follow-up test of GS and BBT. The variations of upper limb functions in EG are shown in Table 2.

DISCUSSION

A 70 Hz tendon vibration was recently applied to 10 patients with hemiplegia after stroke in the forearm wrist musculature, and revealed that the stimulation on the muscles around distal wrist brought about stability on the proximal arm. This study concludes that tendon vibration was effective at increasing the reflex threshold, so that consequently co-contraction was decreased, while reflex excitability of the movement was normal[9]. Moreover, a regular arm positioning in hand strength tests might manipulate measurements, therefore, the American Society of Hand Therapists (ASHT) suggested that the subject should be in a sitting position with the shoulder adducted and neutrally rotated, elbow flexed at 90° and a neutral position of the forearm and wrist[6]. In this study, there were significant differences in the pre and posttest, post-follow up test and pre-follow up test of GS, respectively. This means the intervention using repeated vibratory stimulation and its consistent application taken from the previous study[6] was effective on GS, which was revealed in the post-test. Moreover, the effects have been retained for two weeks as observed in the follow up test. The result in the follow up test was slightly reduced, but still higher than the results of the pretest. This is because the stimulation applied on the biceps brachii and flexor carpi radialis facilitated a flexor pattern of movement, which may induce increased muscle tone of the flexors in the fingers, wrist, and elbow. As a result, the total grip power was increased and maintained. Improvement of motor function in patients with hemiplegia after stroke appears a foremost target in any rehabilitative treatment. In the previous study, subjects in the EG received 30 minutes of SMV therapy with low-amplitude at a set frequency of 120 Hz at the target muscles, which was employed at the end of each general physical therapy. As a result, the mean linear velocity in the EG notably improved at the post-treatment test and mean angular velocity at the shoulder was considerably higher at post-treatment test in comparison to the data at the baseline[4]. In this study, there was a significant difference in pre-post-follow-up test of BBT. The effect of the intervention was influenced by time. There were significant differences in pre- and post-test as well as post-follow-up test and pre-follow-up test of BBT, even though there was a time-dependent change in the result, this is more important. This is because this study was aimed not to compare the result in between the EG and control group but to prove the effect of the intervention in EG. Therefore, this is more meaningful in that the result in pre-follow up test still had a significant difference. The reason why BBT was improved was that the intervention brought about positive effects on reaching, grasping, and transferring objects. To be specific, the stimulation may activate the proprioceptors in these muscles and induced a better sense of position and control ability. Moreover, the two muscles employed in this study would affect the other muscles around in the wrist and shoulder joint so that subjects could hold the objects better. This is explained in the previous study. The study said that it seems to affect the central nervous network in terms of motor control; vibration amplitude of 10 m, which is adequate amplitude to drive Ia spindle afferents as sub-threshold of the tonic vibratory reflex remained and muscle fiber injury was avoided. The extensive stimulation duration (i.e. 30 min/day for 10 days) was chosen because means of constant vibratory stimulation causes long-term effects on cortical excitability, telling that the effects of SMV might be connected to the extent of proprioceptive stimulation[4]. Sensory features were not affected greatly and there were some increases after the administration of the intervention. In addition, the effects of the intervention were maintained in the follow-up test even though the varied extent was reduced from the post-test. Since the purpose of this study was only to verify the effect of the intervention, there was no control group. In this manner, this study was conducted with 10 subjects without a control group to verify the pure effect of the intervention. As a result, there were significant positive effects in posttest and follow-up test of GS and BBT. Therefore, repeated vibratory stimulation positively influences GS and BBT after the 2-week intervention and retained this effect for 2 additional weeks. Future studies can explore the use of electromyography to verify authentic muscle contraction of the employed muscles.

REFERENCES

1) Flansbjer UB, Downham D, Lexell J: Knee muscle strength, gait performance, and perceived participation after stroke. Arch Phys Med Rehabil, 2006, 87: 974–980. [Medline] [CrossRef]
2) Carey LM, Matyas TA, Oke LE: Sensory loss in stroke patients: effective training of tactile and proprioceptive discrimination. Arch Phys Med Rehabil, 1993, 74: 602–611. [Medline] [CrossRef]
3) Caliandro P, Celletti C, Padua L, et al.: Focal muscle vibration in the treatment of upper limb spasticity: a pilot randomized controlled trial in patients with chronic stroke. Arch Phys Med Rehabil, 2012, 93: 1656–1661. [Medline] [CrossRef]
4) Tavernese E, Paoloni M, Mangone M, et al.: Segmental muscle vibration improves reaching movement in patients with chronic stroke. A randomized controlled trial. NeuroRehabilitation, 2013, 32: 591–599. [Medline]
5) Noma T, Matsumoto S, Shimodozono M, et al.: Anti-spastic effects of the direct application of vibratory stimuli to the spastic muscles of hemiplegic limbs in post-stroke patients: a proof-of-principle study. J Rehabil Med, 2012, 44: 325–330. [Medline] [CrossRef]
6) Mathiowetz V, Kashman N, Volland G, et al.: Grip and pinch strength: normative data for adults. Arch Phys Med Rehabil, 1985, 66: 69–74. [Medline]
7) Mathiowetz V, Volland G, Kashman N, et al.: Adult norms for the Box and Block Test of manual dexterity. Am J Occup Ther, 1985, 39: 386–391. [Medline] [CrossRef]
8) Shaffer S, Harrison A, Brown K, et al.: Reliability and validity of semmes-weinstein monofilament testing in older community-dwelling adults. J Geriatr Phys Ther, 2005, 28: 112–113. [CrossRef]
9) Conrad MO, Scheidt RA, Schmit BD: Effects of wrist tendon vibration on targeted upper-arm movements in poststroke hemiparesis. Neurorehabil Neural Repair, 2011, 25: 61–70. [Medline] [CrossRef]