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Original Article

Effect of whole-body vibration exercise in a sitting position prior to therapy on muscle tone and upper extremity function in stroke patients

Jung-A Boo, PT, MD[1)], Sang-Hyun Moon, PT, MD[2)], Sun-Min Lee, PT, MD[1)], Jung-Hyun Choi, PT, PhD[3)], Si-Eun Park, PT, PhD[4)*]

[1)] *Department of Occupational Therapy, Dream Hospital, Republic of Korea*
[2)] *Department of Physical Therapy, Dream Hospital, Republic of Korea*
[3)] *Department of Physical Therapy, Institute for Elderly Health and Welfare, Namseoul University, Republic of Korea*
[4)] *Department of Physical Therapy, Yongin University: 470 Samga-dong, Cheoin-gu, Yongin, Republic of Korea*

Abstract. [Purpose] The purpose of this study was to determine the effect of whole-body vibration exercise in a sitting position prior to therapy in stroke patients. [Subjects and Methods] Fourteen chronic stroke patients were included in this study. Prior to occupational therapy, whole-body exercise was performed for 10 minutes, 5 times per week, for a total of 8 weeks. Muscle tone and upper extremity function were measured. The Modified Ashworth Scale (MAS) was used to measure muscle tone, and the Manual Function Test (MFT) and Fugl-Meyer Assessment scale (FugM) were used to measure upper extremity function. [Results] MAS score was significantly decreased, and MFT and FugM were significantly increased. [Conclusion] These results indicate that whole-body vibration exercise in a sitting position prior to therapy had a positive effect on muscle tone, and upper extremity function in stroke patients.

Key words: Whole-body vibration, Muscle tone, Upper extremity function

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INTRODUCTION

Stroke is a disease that has various after effects such as disturbance in sensory, motor, and cognitive function, and causes difficulty in motor control, degradation in balance and walking ability, and difficulty in leading an independent daily life[1, 2)]. Degradation of extremity function after stroke is one of the most common symptoms and functional movement disorders affecting the arms are observed in 85% of stroke patients[3)]. Normal extremity functions are generally based on fine motor skills for activities such as eating, wearing clothes, washing, and writing, and also play an important role in gross motor skills like crawling, walking, and maintaining balance. The disturbance in extremity function causes limitations in performing movements in daily life[4)].

In occupational therapy, the focus is on upper extremity function directly related to daily life. Delicate functions like grasping and manipulating objects are important for recovery of extremity function. In addition, because patients use the nonparalytic side more during arm action, it is necessary to use the paralytic arm for therapy[5)].

Postural control and balance ability are important for performing extremity functions, hence, trunk and lower extremity strengthening is very important[6)]. Trunk muscle strengthening, in particular, makes arm movements freer, and improves activities of daily living[7, 8)]. Verheyden et al. reported that training in the sitting position is effective in improving postural

*Corresponding author. Si-Eun Park (E-mail: si-yaa@hanmail.net)

Table 1. General characteristics of subjects

	Subjects (n=14)
Gender (male/female)	4/10
Affected side (right/left)	8/6
Age (years)	50.4±12.4
Weight (kg)	60.8±9.9
Height (cm)	162.4±9.9
Stroke type (infarction/hemorrhage)	6/8

Mean±SE

control ability[9]. Performance of various rehabilitation training exercises is suggested in a sitting position on an unstable surface or on a moving object to improve balance[10, 11].

Vibration exercise is a somatosensory stimulation method for the rehabilitation of stroke patients[12]. In particular, whole-body vibration exercise is a method for improving muscle function and balance through muscle stimulation[13, 14]. Han et al. reported that vibration improved postural balance in patients with neurological injury[15]. Recently, many studies have used whole-body vibration exercise in stroke patients. Torvinen et al. reported that it improves balance ability in stroke patients due to somatosensory stimulation, and Tihanyi et al. reported that vibration exercise significant improves knee extensor muscle strength in stroke patients[16, 17]. Verschueren et al. reported that body sway is decreased after the short-term application of whole-body vibration exercise in chronic stroke patients[18]. In reported that whole-body vibration exercise has a positive effect on muscle strength, balance, and walking in chronic stroke patients, and Baik reported its effectivensee as a warm-up exercise[19, 20].

However, previous studies used whole-body vibration in a standing position. Therefore, this study investigated the effects of whole-body vibration exercise in a sitting position prior to therapy in stroke patients.

SUBJECTS AND METHODS

This study was conducted on 14 subjects who were diagnosed with chronic stroke at Dream hospital (Seoul, South Korea). The subjects were selected from among patients who were able to independently maintain a sitting position and who had a score of at least 25 points on the Korean Mini-Mental State Examination (K-MMSE). This study complied with the ethical principles of the Declaration of Helsinki. All subjects agreed to participate in the study after receiving explanations regarding the purpose and procedures of the experiment, and they signed an informed consent statement before participation. The protocol for this study was approved by the local ethics committee of the Namseoul University of Cheonan (1041479-201503-HR-010).

The 14 subjects included 4 males and 10 females; 8 patients had hemiparalysis on the right side and the other 6 patients had hemiparalysis on the left. The average age was 50.4 ± 12.4 years, the average weight was 60.8 ± 9.9 kg, and the average height was 162.6 ± 9.5 cm. Six patients suffered an ischemic stroke and 8 patients suffered cerebral hemorrhage (Table 1).

Whole-body vibration exercise was applied for 10 minutes prior to general occupational therapy, and was performed 5 times per week, for a total 8 weeks. Vibro wedge (NEXT, Korea) was used as the equipment (Fig. 1); it has an up and down vibration mode and can control upto 10–40 Hz pulsation.

Whole-body vibration exercise was performed in a sitting position. The hip and knee joints were maintained at 90° of flexion (Fig. 2). A step-board adjusted for leg length was used to maintain a sitting position, and an arm rest adjusted for the arm length was also used.

General occupational therapy was performed for 20 minutes. The frequency was applied based on sensory conditions within a range less than 30 Hz so that the subjects did not develop muscle fatigue.

Muscle tone and upper extremity function were measured. The Modified Ashworth Scale (MAS) was used to measure muscle tone. The MAS test was performed in a sitting position, and the investigator performed the test by holding the subject's affected arm. The Manual Function Test (MFT) and Fugl-Meyer Assessment scale (FugM) were used to measure upper extremity function. The MFT assesses upper extremity function in stroke patients, and can be divided into three parts: shoulder function, hand function (grasping), and finger manipulation. The FugM is used to evaluate performance in daily life and has high reliability[21]. All subjects were evaluated prior to the intervention, and 8 weeks after starting intervention.

Data were analyzed using SPSS version 20.0 for statical abalysis. Wilcoxon matched pair signed-rank tests were used to evaluate the change in muscle tone, and paired t-tests were used to evaluate the change in upper extremity function. In all analyses, $p<0.05$ was considered statistically significant.

Fig. 1. Whole-body vibration exercise instrument (Vibro Wedge)

Table 2. Comparison of pre-test and post-test MAS

	pre-test	post-test
MAS (grade)	G2	G1+
	G1+	G1
	G1	G1
	G1	G1
	G1	G1
	G1	G1
	G1	G1
	G1	G1
	G1+	G1
	G1+	G1
	G1	G1
	G1+	G1+
	G1+	G1
	G1+	G1
Z		−2.449
P		0.014

MAS: Modified Ashworth Scale

Fig. 2. Whole-body vibration position

Table 3. Comparison of pre-test and post-test MFT and FugM

	pre-test	post-test
MFT (score)	14.1±8.6	15.4±8.6*
FugM (score)	40.7±17.6	44.2±17.6*

*p<0.05
MFT: Manual Function Test, FugM: Fugl-Meyer Assessment scale

RESULTS

This study incorporated whole-body vibration exercise in a sitting position prior to occupational therapy in 14 chronic stroke patients. The muscle tone and upper extremity function were measured.

Table 2 shows the muscle tone in the arm on the affected side. Eight of 14 subjects did not show a change in muscle tone. However, 6 subjects showed a significant difference in muscle tone ($p<0.05$). The scores for upper extremity function are shown in Table 3. The MFT score increased from 14.1 ± 8.6 points to 15.4 ± 8.6 points ($p<0.05$). The FugM score also increased from 40.7 ± 17.6 points to 44.2 ± 17.6 points ($p<0.05$).

DISCUSSION

This study investigated the effects of whole-body vibration exercise in a sitting position prior to therapy in 14 chronic stroke patients. The summary of these results is as follows.

Whole-body vibration exercise in a sitting position caused a decrease in muscle tone. Six of 14 patients showed a significant decrease in muscle tone between pre- and post-intervention ($p<0.05$). These 6 patients had increased muscle tone before the exercise compared with the other subjects, and hand function, in particular, was reduced. Therefore whole-body vibration exercise had a positive effect on muscle tone.

Upper extremity function was assessed using the MFT and FugM. After intervention, the MFT score had increased from 14.1 ± 8.6 points to 15.4 ± 8.6 points ($p<0.05$). Ten of the 14 subjects showed a significant difference in upper extremity function between pre- and post-intervention, but the other 4 patients did not show a significant difference. This was surmised to be because they had muscle weakness in the lower trunks while maintaining a sitting position. The FugM score increased from 40.7 ± 17.6 points to 44.2 ± 17.6 points ($p<0.05$). Therefore, whole-body vibration exercise in a sitting position prior to therapy had a positive effect on recovery of upper extremity function.

Whole-body vibration has a positive effect on trunk muscle stability[22]. According to Dickstein, trunk stabilization should precede contraction before moving the arms and legs to assist in performing exercise appropriately. Trunk stability is an essential element in daily life for stroke patients[23]. Trunk control ability in a sitting position is also closely related to long-term functional improvement, and is important to evaluate in determinig the severity and diagnosis of stroke disorders[24].

Prior studies examined the effect of whole-body vibration exercise in a standing position, and demonstrated an effective decrease in stiffness and an improvement in walking ability in patients with upper motor neuron lesions[15, 25]. Few studies have assessed the effect of whole-body vibration exercise in a sitting position, the present study demonstrated its effectiveness, its utility as a warm-up exercise prior to therapy was previously noted.

Stiffness (increased muscle tone) occurs in most stroke patients, and is the cause of pain, decline in motor function, and poor walking ability[26]. Macroni reported a decrease in stiffness after application of vibration exercise in chronic stroke patients[27]. And Bae and Kim reported that vibration stimulation can be used as effective therapy for the neurorehabilitation of patients with spasticity[28]. The results of previous studies are in agreement with this study, showing that vibration exercise reduces stiffness .

Whole-body vibration exercise was developed as an effective method for improving muscular strength rather than resistive movements, and is safe and effective[29, 30]. Torvinen et al. reported it as a new somatosensory stimulation method for the rehabilitation of stroke patients, and it is effective for improving balance ability[16]. In also noted that it is very effective for improving muscle strength, balance, and walking ability in chronic stroke patients[19]. Hence, in this study, whole-body vibration exercise had a positive effect on upper extremity function.

This study, included a limited number of subjects, and there was no control group. However, this study proved that whole-body vibration exercise in a sitting position prior to therapy improved muscle tone and upper extremity function in chronic stroke patients. Therefore, it can be assumed that the performance of whole-body vibration exercise before therapy can improve daily life performance ability in stroke patients.

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