

The Effect of Whole Body Vibration Treatment on Upper Extremity Functions Compromised by Stroke

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ABSTRACT

Introduction: In patients with neurological disorders Whole Body Vibration (WBV) has been reported to improve motor function. Our aim was to assess the effects of WBV on upper extremity function in adult stroke patients.

Methods: Forty-three post-stroke patients were randomly assigned to two groups: treatment group and control group. The demographic characteristics and Modified Ashworth Scale (MAS) were recorded in all patients. The plegic upper extremity range of motions (ROM) and motor functions were evaluated by goniometric measurement and Jebsen-Taylor Hand Function Test (JTHFT). All patients participated in a conventional rehabilitation program for three weeks while the treatment group also received WBV over the same period. All evaluations were performed before and after therapy.

Results: The median (range) age of all patients was 51.0±13.7 (18–66) years. The groups numbered 26 and 17 patients for the treatment and

control groups respectively. No significant differences were found between the two groups in the pre-treatment evaluation based on the JTHFT all scores ($p>0.05$). Significant improvement was found in the elbow extension ROM degree ($p=0.019$) for the treatment group. A statistically significant improvement was observed in all parameters of JTHFT in the treatment group after the intervention, whereas only page turning, removing small objects, removing large light objects and removing large heavy objects showed a statistically significant improvement in controls ($p<0.05$).

Conclusion: Statistically significant differences were observed between the treatment and control groups after intervention. WBV treatment is effective for the improvement of ROM and upper extremity functions in stroke patients.

Keywords: Stroke, upper extremity rehabilitation, occupational therapy, whole body vibration treatment

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INTRODUCTION

The perception, sense, muscle strength, motor control and balance loss in hemiplegic patients are the main causes of physical disability. According to the literature, 60% of stroke patients are not able to use the plegic upper extremity in activities of daily living (ADL). In particular, loss of function in the upper extremity leads a dependence on caregivers or family members during their daily life (1–3).

Whole body vibration therapy (WBVT) has been used in rehabilitation studies in recent years as there is evidence that somatosensory stimulation in stroke patients has beneficial effects, such as improvement in motor performance (4–6). Some studies have shown that the application of mechanical vibration increases the tonic vibration reflex, which results in an increase in the electrical activity of muscle (4, 7). Further studies have shown improvement in walking and balance in hemiplegic patients who have undergone WBVT (8–10). Although there are several studies showing the effects of vibration application on upper extremity functions and muscle tone (11, 12), there is no randomized, controlled study evaluating changes in the functional use of the upper extremity in stroke patients with WBVT.

The aim of this randomized controlled trial was to investigate the effect of WBVT on the functional use of the upper extremity of stroke patients.

METHODS

Forty-six post-stroke patients who were treated at the University Hospital Department of Physical and Rehabilitation Medicine were included in the study. The patients who had their first stroke attack were assigned to two groups using simple randomization technique: the treatment group ($n=26$) and the control group ($n=20$). The inclusion criteria included the following: age between 18 and 70 years, medically stable, a post-stroke interval of at least three months and balance impairments defined as a score of <40 on the Berg Balance Scale (BBS), an affected upper extremity of Brunnstrom stage ≥ 3 . Patients were excluded if they demonstrated severe spasticity, defined as a Modified Ashworth Scale (MAS) score of ≥ 3 in the upper extremity muscles (13); joint limitations (contractures); congestive heart failure; peripheral arterial disease; severe dementia; language problems; painful orthopedic conditions involving the shoulder, elbow or wrist; or were already undergoing vibration treatment. All



Figure 1. Upper extremity WBV application

patients provided informed, written consent agreeing to participate in the study. This study was approved by the University Ethical Committee (KAEK 2014/103).

The demographic characteristics were recorded for all patients. The plegic upper extremity range of motion (ROM) and motor functions were evaluated by goniometric measurement and Jebsen-Taylor Hand Function Test (JTHFT) (14). All evaluations were performed before treatment and following three weeks of intervention. ROM of shoulder flexion and abduction, elbow extension and flexion and wrist extension and flexion were evaluated.

Patients in the treatment group received WBVT using the Power Plate vibration platform (Performance Health Systems, Power Plate Pro5, North America 2009). The patient was seated on a stool placed next to the whole body vibration device, the elbow was positioned at 70–80 degrees flexion and wrist was positioned at dorsiflexion and WBVT was applied to the affected limb for two minutes (see Figure 1). The WBVT consisted of two sessions of 60 seconds of stimulation interrupted by a one-minute break between each session to prevent muscle fatigue. The amplitude of the vibration was 2 mm and the frequency was 35–40 Hz. An experienced physical therapist supervised the WBVT administration. The WBV treatment was performed 5 times a week for 3 weeks. The control group did not receive WBVT.

The rest of the rehabilitation program for both groups consisted of traditional therapy for the shoulder, elbow and wrist joints, including ROM exercises, stretching exercises, strengthening exercises and occupational therapy. All patients were treated at the rehabilitation center on each working day over a three-week period. All patients completed the intervention successfully and compliance was excellent. No adverse effects from WBVT were reported and training was well tolerated.

The data were assessed using the Mann-Whitney U test and Wilcoxon test using the Statistical Program for Social Sciences (SPSS), version 13.0, statistical software (IBM Inc., Chicago, IL., USA).

RESULTS

A total of 46 patients were included in the study. Three patients in the control group were excluded from our analysis because they have

Table 1. Comparison of patients' demographic data between the WBVT and control groups

	WBVT Group (n=26)	Control Group (n=17)	p
Mean age ± SD* (years)	46.8±15	51.6±10	0.451
Gender n (%)	14 (53.8%) F 12 (46.2%) M	9 (52.9%) F 8 (47.1%) M	0.409
Hemiplegic side n (%)	17 (65.4%) R 9 (34.6%) L	11 (64.7%) R 6 (35.3%) L	0.473
Dominant hand n (%)	22 (84.6%) R 4 (15.4%) L	14 (82.4%) R 3 (17.6%) L	0.576
Mean ± SD* duration since stroke (months)	34.5±25	35.5±20	0.520
Stroke etiology	21 ischemic 5 hemorrhagic	11 ischemic 6 hemorrhagic	0.401

*Standard Deviation

dropped-out from the study due to social reasons. A total of 43 patients (treatment group n=26, control group n=17) completed the study. There were no significant differences in sociodemographic variables between two groups (see Table 1).

No significant differences were found between the two groups in the pre-treatment evaluation, based on upper extremity shoulder flexion and abduction; elbow flexion and extension; and wrist extension ROM measurements (see Table 2). After treatment, statistically significant improvement was determined in the treatment group only for elbow extension ROM score when compared to the control group (p=0.019; Table 2).

Table 2. Comparison of ROM measurement in the plegic upper extremity

Range of Motion		Pre-treatment	Post-treatment	p**
Shoulder Flexion	WBV Group (Mean score ± SD)	63.2±8.3	70±8.8	<0.001
	Control Group (Mean score ± SD)	63.8±7.4	69.1±8.1	<0.001
	p*	0.879	0.723	
Shoulder Abduction	WBV Group (Mean score ± SD)	70.7±7.7	78.2±9.4	<0.001
	Control Group (Mean score ± SD)	69.1±6.9	76.1±7.6	<0.001
	p*	0.386	0.253	
Elbow Flexion	WBV Group (Mean score ± SD)	87.8±7.7	97.3±7.7	<0.001
	Control Group (Mean score ± SD)	86.4±8.9	93.2±8.2	<0.001
	p*	0.820	0.176	
Elbow Extension	WBV Group (Mean score ± SD)	60.5±8.5	42.3±7.9	<0.001
	Control Group (Mean score ± SD)	59.4±10.1	50.2±10.3	<0.001
	p*	0.810	0.019	
Wrist Extension	WBV Group (Mean score ± SD)	63.4±11.7	69.0±10.8	<0.001
	Control Group (Mean score ± SD)	57.3±14.3	62.6±13.7	<0.001
	p*	0.168	0.121	

*p value of between groups.

**p value of intragroup comparison before and after intervention.

Table 3. Comparison of vibration and control groups JTHFT performance time results

JTHFT Parameters (second)		Pre-treatment	Post-treatment	p**
Simulated page turning	Vibration Group	116.6±22.5	58.3±13.6	<0.001
	Control Group	138.4±34.7	118.5±29.2	0.003
	p*	0.549	0.320	
Lifting small objects	Vibration Group	178.5±29.2	114.2±21.5	<0.001
	Control Group	195.5±37.9	177.9±35.2	0.024
	p*	0.795	0.403	
Simulated feeding	Vibration Group	174.5±27.7	113.6±21.9	<0.001
	Control Group	197.9±37.3	194.3±38.0	0.091
	p*	0.990	0.158	
Stacking backgammon pieces	Vibration Group	104.0±21.4	60.6±15.4	<0.001
	Control Group	158.6±36.7	155.1±35.7	0.234
	p*	0.635	0.188	
Lifting large-lightweight objects	Vibration Group	89.0±22.2	49.7±13.6	<0.001
	Control Group	126.2±34.4	116.1±31.9	0.014
	p*	0.440	0.412	
Lifting large-heavy objects	Vibration Group	139.5±28.7	92.7±22.4	<0.001
	Control Group	127.4±35.4	121.4±34.1	0.025
	p*	0.228	0.649	

*p value of between groups.

**p value of intragroup comparison before and after intervention.

Table 4. Treatment response defined as the difference between JTHFT pre-and post-treatment mean values for the WBVT and control groups

JTEFT Parameters Treatment Response	Simulated Page Turning	Lifting Small Objects	Simulated Feeding	Stacking	Lifting Large Lightweight Objects	Lifting Large Heavy Objects
Vibration Group	39.3±9.2	64.2±13.7	60.8±12.7	43.3±8.3	39.3±9.2	46.7±8.3
Control Group	10.8±3.4	17.6±7.1	13.6±1.7	14.2±3.2	10.1±3.4	16.2±2.2
p	0.001	0.001	<0.001	<0.001	0.004	0.001

There were no significant difference in the pre-treatment evaluation of the JTHFT scores between the two groups ($p>0.05$). Post-treatment JTHFT categories did not show any significant difference, either (respectively page turning ($p=0.320$), removing small objects ($p=0.403$), feeding ($p=0.158$), stacking backgammon ($p=0.188$), removing large light objects ($p=0.412$) and removing large heavy objects ($p=0.649$) activities). The timed JTHFT performance results of the plegic hands of the treatment and control groups were shown in Table 3. However, in terms of the improvement in average performance (as treatment response) a significant improvement was observed in all the tasks of the JTHFT for the WBVT group (all $p=0.004$ or more significant; see Table 4).

DISCUSSION

Sufficient hand and upper extremity functions are required for independence in all ADLs, especially for nutrition, personal hygiene and dressing. It has been shown that the functional independence level following rehabilitation programmes in stroke patients, is largely associated with upper extremity and hand motor insufficiency improvement (15, 16).

In this randomized, controlled study, shoulder flexion-abduction, elbow flexion-extension and wrist extension-flexion movements of the upper extremity were evaluated. Conventional therapy, with or without WBVT, resulted in improvement in ROM for all joints measured in all patients.

Although there was no difference in ROM for the shoulder, wrist or elbow flexion measures, a significant improvement in elbow extension in the WBVT group was seen. There are some studies reporting the positive effects of vibration application on ROM in the literature (17, 18), however there are only a limited number studies showing the effect of WBVT on ROM in stroke patients (11, 19). The ROM of the stroke patients in this study was consistent with the literature. We believe that vibration application reinforces and enhances the effect of conventional therapies on ROM. The improvement in upper extremity ROM in the treatment group suggest that stroke patients who undergo additional WBVT therapy may have greater functionality in their upper extremity for ADLs.

In this study, upper extremity motor functions of the patients were evaluated with JTHFT (14, 20). While there was a significant improvement in all activities before and after the treatment in the WBVT group; in the control group a similar significant improvement was observed in all activities except for simulated feeding and stacking backgammon pieces activity. There was also a statistically significant difference in treatment response between the study and control groups. All parameters of JTHFT were found to be significant in favor of the study group. For each parameter of the JTHFT, the pre-treatment/post-treatment difference (response to treatment) was calculated with the percentage of the first evaluation data; it was found that the best recovery was in page turning (50%), then carrying light objects (43%) and laying backgammon (41%) activities.

There are few studies investigating the effect of WBV therapy on upper extremity functions in stroke patients in the literature (11, 21–23). In these studies, vibration has been shown to have positive effects on muscle activity and muscle strength, but no functional evaluations were performed. Our study was the first to evaluate the effect of vibration therapy on upper extremity functions. The small number of patients, the absence of the evaluation of muscle strength and tonus are the limitations of our study. However, the results of this small clinical trial have strengthened our belief in the benefit of WBV therapy, in addition to conventional treatments, on the functional use of plegic upper extremity in addition to active joint movement. Larger randomized, controlled studies demonstrating the efficacy of WBV therapy in stroke rehabilitation are needed to confirm and build upon our results.

Ethics Committee Approval: This study is approved by Kocaeli University Ethical Committee (KAEK 2014/103).

Informed Consent: All patients provided informed, written consent agreeing to participate in the study.

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