Aud Vestib Res (2020);29(1):54-59.
DOI: https://doi.org/10.18502/avr.v29i1.2371

**RESEARCH ARTICLE**

# The short term-effects of both feet plantar vibration in post stroke patients balance

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Received: 24 Nov 2019, Revised: 5 Dec 2019, Accepted: 8 Dec 2019, Published: 15 Jan 2020

## Abstract

**Background and Aim:** Balance disorder is a common problem in post stroke patients. Vibration therapy is one of the interventions that is used to treat this impairment in physiotherapy. There are several studies on the effects of more affected foot plantar vibration on balance, however according to the researchers this cerebral lesion causes bilateral side effects in the body. So the aim of this study was to investigate the short-term effects of both feet plantar vibration on the balance of post stroke patients.

**Methods:** This pretest-posttest clinical study included 12 post stroke patients (8 male and 4 female, mean age 52.41 ± 9.03 years). The participants received one session of 5-min vibration stimuli (frequency, 100 Hz) to the plantar region on both feet. Mini-Balance Evaluation Systems Test (Mini-BESTest) score and plantar cutaneous sensation by Semmes Weinstein monofilament examination (SWME) were assessed before and immediately after the intervention.

**Results:** Mini-BESTest mean total score improved significantly ($p \leq 0.001$) after both feet vibration and these results were supported by a large effect size (Cohen d = 2.83). Mean number of detected points by SWME decreased after vibration therapy ($p = 0.06$) but it was not statistically significant.

**Conclusion:** The findings suggest that local vibration applied directly to the plantar region of both feet in post-stroke patients could be an appropriate physiotherapy intervention to improve their balance.

**Keywords:** Vibration; balance; stroke

**Citation:** Sajedifar M, Fakhari Z, Naghdi S, Nakhostin Ansari N, Honarpisheh R. The short term-effects of both feet plantar vibration in post stroke patients balance. Aud Vestib Res. 2020;29(1):54-9.

## Introduction

Stroke is one of the most important causes of disability in adults which can happen at any time and to anyone. This brain disorder is the second commonest cause of death in the world [1]. A large number of survivors of stroke have a combination of sensory and motor impairments leading to a decrease in the quality of their daily living [2]. Impaired postural control which leads to a balance disorder has the greatest impact on individual independence. More than 90% of patients with chronic stroke suffer from balance

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dysfunction [3]. It can increase instability and fear of falling, and decrease the patient's confidence and social participation and make them more inactive [2-4]. Therefore, in stroke rehabilitation, it is necessary to improve the balance for efficient functional activity and reducing dependency.

Up to 41% of individuals, post-stroke experience sensory deficits and reduction in cutaneous sensation [5]. These deficits are caused by damage to primary somatosensory cortex which results in the inability to process and interpret sensory feedback. Following this inefficient processing and interpretation of sensory information, abnormal motor responses will be produced that lead to balance disorders [5,6].

Vibration stimulation is an effective modality which is used to improve poor balance in healthy and patient population. Given that the mechanical aspect of touch is transmitted from the environment by four different types of mechanical receptors and each one has its own particular characteristics, all of them are commonly involved in vibration therapy and transmit more efficient inputs to the central neural system to produce better neuromuscular responses for body posture maintenance [7,8]. According to a previous study, plantar vibration with 100 Hz frequency, can improve balance in older women [8]. Also, the results of a case study showed the positive effects of plantar region vibration therapy on balance of a 72-yaer old man with stroke [9]. A clinical study on post stroke patients reported that 100-Hz plantar vibration for 5 minutes results in balance and ankle dorsiflexion passive range of motion improvement and ankle plantar flexor spasticity reduction [10]. Another clinical study to investigate the effects of plantar vibration on more affected foot reported beneficial effects on ankle passive range of motion, spasticity and dynamic balance according to Timed Up and Go test results. Also, no effect on static balance has been shown in this study [11].

Most recent studies have investigated the effects of local vibration of more affected limbs on balance while according to researchers, after a unilateral stroke, the weakness and motor deficits appear on both sides of the patient [12], actually, when one side of the cerebral hemisphere is damaged by stroke, the patients' ipsilateral limb function and postural control might also be affected because of the existence of the uncrossed nerve fibers [13] and can contribute to poor stability and balance disorder. Therefore, the goal of this study was to evaluate the short-term effects of both feet plantar vibration on the balance of patients suffering from stroke. We postulated that the balance of these patients could be improved through the application of vibration to both feet.

## Methods

This pilot study was conducted in Physiotherapy Clinic for Stroke at School of Rehabilitation, Tehran University of Medical Science (TUMS). The review board and the Ethics Committee of Rehabilitation School of TUMS approved the study protocol (Code No: IR.TUMS.FNM.REC.1398.049). Inclusion criteria were: a) age, 18 years or older, b) duration since stroke, 6 months or more, c) balance disorder diagnosed by one leg stance (OLS) test; the patient is not able to stand on his affected leg for 30s with eyes open and d) ability to walk independently. Exclusion criteria were: a) receiving any balance treatment, b) any other disease that effects balance according to a neurologist, c) lower-limb surgery during last year, and d) unwillingness to participate in the study.

Twelve post stroke patients enrolled in this study. They were interviewed to collect information about age, sex, height and weight for body mass index (BMI [$kg/m^2$] = weight [kg]/height [$m^2$]) and duration since stroke onset. The outcome measures were balance and plantar cutaneous sensation which were assessed in order by Mini-BESTest [14] and Semmes Weinstein monofilament examination (SWME) before and immediately after intervention.

The Mini-BESTest is a clinical balance test [14] which consists of 14 items and assesses balance using four subsystems (anticipatory postural adjustments, postural responses, sensory orientation, and balance during gate). Each item scored from 0 (lowest level of function) to 2 (highest level of function), so the maximum score is 28 [15]. This test is a reliable and valid

**Fig. 1. Detected plantar points evaluation by Semmes Weinstein monofilament examination**

measurement tool for assessing balance in post stroke patients [16]. Monofilament testing was used to assess plantar cutaneous sensation. The 5.07/10 g monofilament has been recommended as the best indicator to determine peripheral neuropathy of the feet [17,18]. Participants were in supine position, with closed eyes and had rested for 5 minutes before the test. The assessor put a flexible nylon with perpendicular angle to one of the 10 points plantar surface in no specific order, including: nine plantar sites (distal great toe, third toe, and fifth toe; first, third, and fifth metatarsal heads; medial foot, lateral foot, and heal) and one dorsal site [19]. Then slight and steady pressure was applied until the monofilament began to bend. If the participant was able to detect the touch at this movement they said "Yes" (Fig. 1), the physiotherapist did this process for the other points and recorded the number of detected points [20]. This measurement tool is an easy-to-use, inexpensive, portable and reliable and valid tool to detect the peripheral neuropathy [21,22].

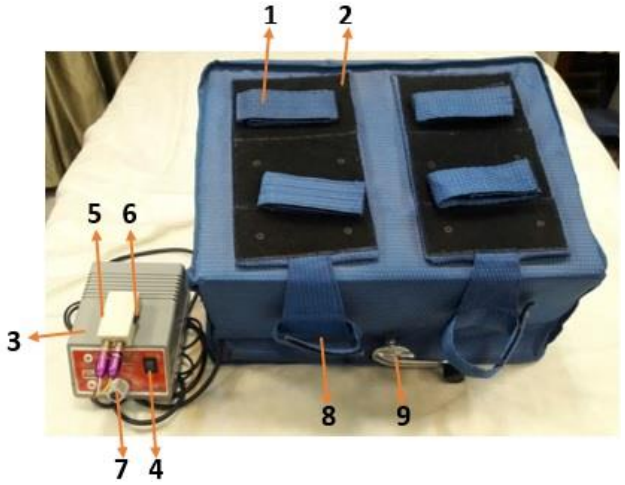


**Fig. 2. Custom-made vibratory device: 1) foot strap; 2) footplate; 3) adaptor; 4) on/off switch; 5) right on/off switch; 6) left on/off switch; 7) voltage control switch; 8) ankle strap; 9) plate inclination handle.**

A custom-made vibratory device (Erteashate Tebbie Iranian Co, Tehran, Iran) was used to apply plantar vibration to both feet. The subject was in supine position on a treatment bed with knees flexed by pillows under them and barefoot. This device has two vibrators located within a box (dimension [width × length × height, 30×45×20 cm]) and two plates for the feet have been placed at the top of the box to deliver the vibration stimuli to the entire plantar regions (Fig. 2), the physiotherapist positioned both feet on the plates and fixed them with its Velcro straps. Participants received plantar vibration with 100 Hz frequency for 5 minutes and immediately were assessed after intervention once again.

## Results

Twelve stroke patients (4 females, 8 males, mean age, 52.41 ± 9.03) participated in the present study (Table 1).

Kolmogorov-Smirnov (K-S) test showed all the data were normally distributed. The significance was set at $p \leq 0.05$. Paired t-test was employed to compare the pre/post data. Cohen d was calculated to determine treatment effect size [23]. Participants improved significantly not only on the Mini-BES Test mean total score ($p \leq 0.001$) but also on all mean scores of subscales after both feet vibration and this result was supported by a large effect size (Cohen d = 2.83). Mean number of detected points by SWME decreased from 8.5 to 7.5 after vibration therapy ($p = 0.06$) but it was not statistically significant (Table 2).

## Discussion

The results of this study showed significant improvement in balance after plantar vibration of

**Table 1. Demographic characteristics of patients with stroke (n = 12)**

| Characteristic | Mean (SD) | Range |
|---|---|---|
| **Age (year)** | 52.41 (9.03) | 33−69 |
| **Body mass index (kg/m$^2$)** | 25.34 (4.34) | 16.6−30.5 |
| **Duration of stroke (year)** | 5.29 (5.6) | 0.8−17 |

SD; standard deviation

both feet in patients after stroke. The balance improvement after one foot plantar vibration in post stroke patients was reported previously [9-11]. This is the first study, to our knowledge, which has investigated the short-term effects of both feet plantar vibration on the balance of these patients.

The mean of Mini-BES Test total score improved after both feet plantar vibration (on average 3.7 score) which was supported by a large effect size (Cohen d = 2.83). As Minimal Detectable Change (MDC) for Mini-BES Test was 3.5 score and Minimal Clinical Important Difference (MCID) was 4 score [24], therefore, after both feet plantar vibration the changes in the mean of Mini-BES Test total score were more than MDC and close to MCID. Whilst Karimi-Ahmad Abadi et al. reported the mean of Mini-BES Test total score after 5 minutes had affected foot plantar vibration more, with frequency100 Hz, and had a significant improvement (on average 3.5 score, Cohen d = 0.85). Also she reported that plantar vibration of the affected foot was effective for improving ankle plantar flexor spasticity, and ankle dorsiflexion passive range of motion in post stroke patients [10]. A case study reported the positive effects of another 5 minutes affected foot plantar vibration, frequency 100 Hz, on balance improvement in a patient after stroke [19]. Another study found that the plantar vibration, frequency100 Hz, had beneficial effects in improving balance of older women [8]. Recently a study on the immediate effects of one foot plantar vibration on balance dysfunction in patients with stroke showed that, 5 minutes vibration with frequency 100 Hz can improve the functional mobility and dynamic balance in patients with stroke [11].

The exact mechanism is unclear for balance improvement occurring after local vibration. The explanation for improvement in balance might be that the vibration, by stimulating cutaneous and proprioceptive receptors, has positive effects on the sensory system. Therefore, the sensory system provides more efficient information about the surroundings to the central nervous system and better neuromuscular responses will be produced for posture [8,25]. In addition, corticoreticular neurons originating from motor area descend ipsilaterally and bilaterally, and are involved in postural responses and can produce postural widespread effects [26,27]. Thus, balance improvement after both feet plantar vibration may be because of its effects on postural control.

In this study, the mean number of detected points in monofilament examination decreased after intervention, but it was not statistically significant. A randomized clinical trial recently reported that the acute response of the vibro-tactile threshold to one whole body vibration session increased but the 48 hour short-term response of this threshold decreased in healthy young adults [27]. It is highly likely that the load of vibration leads to adaptation of sensory receptors and immediate assessment of plantar cutaneous sensation did not allow them to return to their initial sensitivity and were in a fatigue phase. It is hoped that long term plantar vibration can improve postural control and consequently balance in post

**Table 2. Results of clinical tests**

| Variable | Pre-treatment | Post-treatment | p |
|---|---|---|---|
| **Mini-BESTest mean (SD) total score** | 20.08 (3.42) | 23.83 (2.08) | ≤ 0.001 |
| **Mean (SD) number of detected points (SWME)** | 8.5 (1.78) | 7.5 (2.11) | 0.06 |

SD; standard deviation, SWME; Semmes Weinstein monofilament examination

stroke patients.

## Conclusion

In conclusion, vibratory stimuli at a frequency of 100 Hz applied to both feet plantar region of patients after stroke could have beneficial effects on their balance disorders.

## Acknowledgments

This article has been extracted from M. Sajedifar MSc. thesis on Physiotherapy submitted to Tehran University of Medical Sciences. We would like to express our gratitude to all participants in this study.

## Conflict of interest

There are no conflicts of interests to be declared.

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