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Research Article

Effects of Whole Body Vibration on Processing Speed in Stroke Patients - A Pilot Study

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Abstract

Background: The motor consequences of a stroke are mainly treated with physiotherapy and blood thinning drugs. In exercise therapy with whole body vibration, studies with other patient groups show positive effects already after a single application. In stroke patients the effectiveness of whole body vibration is still quite inconsistent. Therefore, the present study aims to investigate the effectiveness of whole body vibration on processing speed in stroke patients.

Hypothesis: Whole body vibration has a positive effect on processing speed in stroke patients.

Methods: 13 stroke patients (age 68.23 ± 8.93 years, mean time past since stroke 10.82 ± 8.83 months) were randomized in two groups subjected to whole body vibration at 6 and 12 Hz, respectively. Before and after the treatment of 5 x 60 seconds with a break of 60 seconds between each set, the Digit Symbol Test was performed.

Results: Both groups improved their performance significantly from pre- to posttest ($F(1,11) = 15.85$; $p = 0.002$). There is no difference between groups and no interaction effect for factor time*group.

Conclusions: Even lower application frequencies (6 and 12 Hz) can have a positive effect on the processing speed of stroke patients. Nevertheless, further studies must try to develop an optimal training protocol for this patient group.

Keywords: Whole Body Vibration; Stroke; Cognition; Processing Speed; Rehabilitation

Introduction

Stroke ranks as the most common cerebrovascular disease. The World Health Organization (WHO) defines stroke as the rapid development of clinical signs of central or global disturbance of cerebral function over 24 hours or more for no apparent reason other than vascular origin [1]. Donaghy [2] describes stroke as a central neurological disorder with abrupt development due to a pathological process in the blood vessels. A stroke is usually not manifested by pain, consequently many affected persons do not consult a doctor and wait for the symptoms to disappear again. A "silent" stroke, triggered by a short-term circulatory disturbance, shows no symptoms and usually remains undetected. Another point is the variation of symptoms depending on which vessel is affected by the blockage at which site, or how the blood supply to the brain is organized in each person. This variation is not only found interindividually, but also intraindividually. In aphasia, the left hemisphere is usually affected, whereas in nonlinguistic disorders, the right hemisphere is usually affected [3].

Nakling et al. [4] describe cognitive deficits after stroke as a factor for long-term disability. These include visuoconstructive ability, visual and verbal memory, mental processing speed, executive functioning, and language production. They show that in the individual areas between 12% and 34% are affected by a cognitive deficit. Overall, 58% of the sample show cognitive deficits. In the area of processing speed, this is 20%.

Rehabilitation after stroke is a long process in which patients with disabilities resulting from their stroke have to relearn their activities of daily living. It is important that patients are guided in this process to recover their condition, manage their limitations and avoid further complications [5]. Typical post-stroke disorders include muscle weakness, abnormal muscle use or dystonia, which limit daily life [6].

WBV has been increasingly used as a gentle treatment method for stroke patients in recent years, as evidenced by several reviews and meta-analyses. They show that 40 studies deal with muscle strength, 19 with balance, 15 with gait function, 3 each with spasticity and cardiac function and 2 with bone metabolism. The effect sizes range from 0.09 (gait function) to 1.24 (spasticity). This shows that WBV has different effects on the different domains [7,8]. There are virtually no side effects, only contraindications are reported. Thus, WBV use should be avoided in pregnancy, acute thrombosis, severe cardiovascular disease, pacemakers, recent trauma or surgical wounds, hip and knee implants, acute hernia, discopathy, spondylolysis, severe diabetes, epilepsy, recent infections, severe migraine, tumors, recent intrauterine devices, metal pins or plates, kidney stones, and organ failure [9,10]. However, the situation regarding efficacy still seems to be rather mixed. It still does not seem clear what frequency of use is best, what training frequency per week, and over how many weeks WBV should be used. Lu et al. [8] suggest that WBV has no significant

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effect on strength, balance, and gait performance. Park et al. [7] state in their analysis that the effect of WBV on spasticity is most effective compared with all other areas studied. However, only two studies that examined a single application are included here. Training times also varied from 12 to 45 minutes per session. All studies were conducted with an application frequency of 20 or 30 Hz, and only weak to moderate effect sizes were found throughout. Nevertheless, these results are positive because they provide suggestions for the design of training protocols. For example, the effect is shown to be significantly higher for a single session than for multiple sessions; it is reasonable to assume that as the number of sessions and weeks of training increase, the effect decreases. Thus, it can be assumed that, for example, a single session per month is sufficient. Especially the results of Hanif et al. [11] showing a reduction of systolic blood pressure after WBV are encouraging: the reduction of blood pressure might prevent another stroke. Effects on cognitive functions are not addressed. Therefore, the present study aims to examine the effectiveness of WBV on cognition, especially on processing speed.

Hypothesis

A single application of WBV has a positive effect on processing speed in stroke patients.

Methodology

The study was approved by the ethics committee of Saarland University, application number 16-12. Trial registration was performed at Deutsches Register Klinischer Studien, registration number DRKS00012265. The recommendations of the reporting guidelines by Wuestefeld et al. [12] are followed.

Sample of persons

The test persons were recruited via medical practices, clinics, rehabilitation facilities and self-help groups in Saarland and Rhineland-Palatinate (Germany). Persons with the contraindications already described (e. g. fresh bone fracture/joint replacement, severe coronary heart disease, untreated hypertension etc.) were not included according to the recommendations [9,10]. The study was conducted in the gymnasiums of the respective facilities. The sample consists of 13 persons, of whom 5 female and 8 male persons. The average hip width is 31.86 ± 1.51 cm. The average age is 68.23 ± 8.93 years, the average time past since stroke is 10.82 ± 8.83 months. Table 1 shows the characteristics of the sample.

There is no significant difference between groups concerning the group characteristics.

Study design

Stroke patients were each randomized assigned to an application frequency (6 Hz or 12 Hz). The allocation to the different vibration frequencies was randomized by drawing lots.

Outcome measurement

Digit symbol test (subtest of WAIS-III or WAIS-IV). This test measures how quickly and correctly a patient can scan and sequence simple visual information. Short-term memory, attention, hand-eye coordination, or graphomotor problems could affect performance on the test. For example, stroke patients show a lower score than healthy individuals [13]. The test requires different cognitive abilities (visual scanning, attention, and psychomotor speed) [14]. A learning effect has not yet been established [15], thus the test can be administered a second time within a shorter period of time, i.e., immediately before and after an intervention. The test is demonstrated, then the patient has a mock trial (5 digits), then must complete as many items as possible within 120 seconds [16]. Here, the subject is instructed to work on the symbols in order and not to omit any. The test is administered with a pencil and eraser so that corrections can be made [17]. Test-retest reliability is r=0.83 (16 - 64 years, and r=0.81 (65 - 90 years, respectively). Internal consistency is α=0.85 (16 - 64 years), or α=0.86 (65 - 90 years) [18].

Intervention protocol

A side-alternating vibration platform (Galileo med Advanced) from Novotec Medical was used as treatment. Two different constant, immediately full vibration frequencies (6Hz for group 1 and 12 Hz for group 2) with an amplitude of 3 mm were used. The test persons were instructed to stand barefoot as upright and relaxed as possible with slightly bent knees (26 to 30°) on the markers on the platform (distance between feet 31.9cm) without holding on to the platform, as recommended [19-21]. The test persons were not informed which group they belonged to. For this reason, the display was covered. The examiner was also blinded. Five sets of 60 seconds each with a 60 second pause between the sets of static exercise (holding the stand position) with the corresponding frequency were applied, so there were 5 minutes of WBV in total for each participant. There was no muscle warmup before WBV. Figure 1 shows the course of the study.

Data analysis

SPSS Version 26 was used. To compare group characteristics (age, hip width, time past since stroke) and performance in the pretest, Levene test for homogeneity and t-test were calculated. Univariate ANOVA with measurement repetition was calculated for effects time (within, pre- to posttest), group (between, 6 Hz *vs.* 12 Hz) and interaction time*group. For this purpose, raw values from pre- and posttest were used (number of correct placed symbols). Significance level was set at $p < 0.05$.

Results

Levene test confirms pretest homogeneity of both groups (F=1.78ns, p=0.21), t-test shows no difference between the groups in the Digit Symbol pretest (T=0.58ns, p=0.57). Table 2 gives an overview of the results of the pre- and posttest for the Digit Symbol Test to compare the performance in the 6Hz and 12Hz group.

There is only an effect for factor time. Both groups show a significant difference from pre- to posttest (p=0.002). There is no difference between groups in pre- or posttest (p=0.68) and no interaction effect can be found (p=0.40).

Table 1: Group characteristics.

	Group 1	Group 2	Total
Male/Female	4/2	4/3	8/5
Age (years)	70.17 ± 8.86	66.57 ± 9.34	68.23 ± 8.93
Hip width (cm)	32.4 ± 1.67	31.42 ± 1.36	31.86 ± 1.51
Time past since stroke (months)	8.33 ± 8.24	12.96 ± 9.37	10.82 ± 8.83

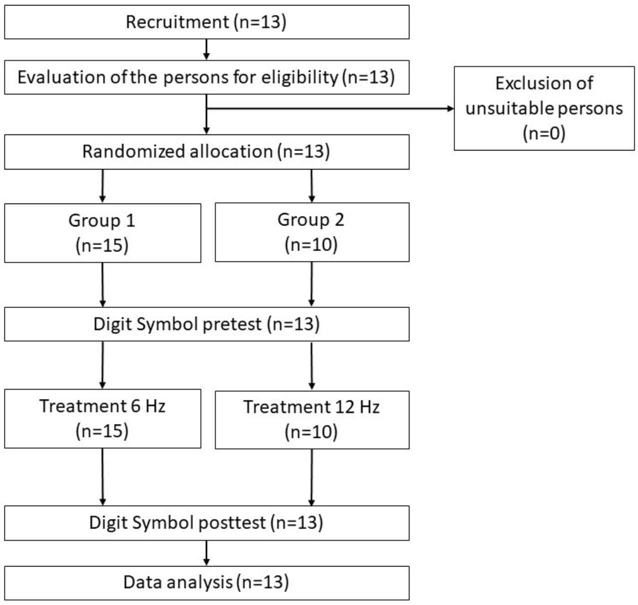

Figure 1: Flow diagram of the study process.

Table 2: ANOVA results for Digit Symbol Test for group 1 (6Hz) and group 2 (12Hz).

	Group 1: 6Hz (M±SD)	Group 2: 12Hz (M±SD)	Mean difference (±SE)	F(1,11) time	F(1,11) group	F(1,11) time*group
DST pretest	24.17 ± 13.60	20.43 ± 9.47	3.74 ± 6.42	15.85** (p=0.002)	0.18 ns (p=0.68)	0.78 ns (p=0.40)
DST posttest	27.17 ± 15.93	25.14 ± 9.82	2.02 ± 7.21			

Discussion

The aim of this study was to investigate the effect of a single application of whole body vibration on cognitive function in stroke patients. A significant change from pre- to posttest was found for both groups. At first, none of the participants showed a side effect or any other negative subjective experience like pain or dizziness.

The differences in the frequency of application do not seem to play a role here. Both frequencies were lower than 20Hz and still effective, which goes against the thesis that they are not effective because the internal organs vibrate themselves at this frequency and the surrounding tissue must constantly compensate for these vibrations [22-24].

Since WBV reduces spasticity [7], this could have had a positive effect on all participants. This could have been verified by a control group.

The groups did not differ significantly in their characteristics. Nevertheless, it can be assumed that the different age of the subjects and the time elapsed since the stroke might have played a role. Group 2 (12Hz) is younger on average and the stroke has occurred slightly longer ago compared to group 1 (6Hz). Group 2 improves by about 5 digits, group 1 by only 3 digits. Although no exercise effect has been reported so far [15], it would be possible that the participants improved since there were only about 15 minutes between the two tests.

However, there are no studies to date that have looked at the effect of WBV on processing speed in stroke patients.

Therefore, the study should be conducted with a larger sample and a control group. Further frequencies of application should also be tested.

Conclusions and Future Prospects

Both experimental groups improved their performance from pre- to posttest. WBV might have had a positive effect on the processing speed. Therefore, further studies with a larger sample, more application frequencies and a control group have to follow.

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