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Original article

Effect of whole body vibration on flexibility 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 flexibility in stroke patients. Hypothesis: Whole body vibration has a positive effect on flexibility 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 Sit and Reach test was performed (3 runs each, the respective mean value was evaluated). Results: Both groups improved their performance highly significantly from pre- to posttest ($F(1,11) = 9.05$; $p = 0.01$). 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 flexibility of stroke patients. Nevertheless, further studies must try to develop an optimal training protocol for this patient group.

Keywords: Whole body vibration (WBV); Stroke; Flexibility.

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Introduction

Rehabilitation after stroke is a long process in which patients with disabilities as a result of stroke have to relearn their activities of daily living. It is important that patients are accompanied in this process to regain their condition, cope with their disabilities and avoid further complications.[1] Typical disabilities after stroke include muscle weakness, abnormal muscle stress, or dystonia, which limit daily life.[2]

WBV has been increasingly used as a low-impact treatment method for stroke patients in recent years, which is evident from several reviews and meta-analyses.[3;4] There are virtually no side effects, only contraindications are reported. Thus, WBV application should be avoided in case of pregnancy, acute thrombosis, serious cardiovascular disease, pacemaker, recent wounds from an accident or surgery, hip and knee implants, acute hernia, discopathy, spondylolysis, severe diabetes, epilepsy, recent infections, severe migraine, tumors, recently placed intrauterine devices, metal pins or plates, kidney stones, organ failure.[5,6] However, the situation still seems to be quite inconsistent in terms of efficacy. It still does not seem to be clear, what frequency of application is best, what training frequency per week, and over how many weeks should WBV be applied. Lu et al[4] suggest that WBV does not significantly affect strength, balance, and gait performance. Park et al[3] state in their analysis that the effect of WBV on spasticity is most effective compared to all other areas investigated. However, only two studies are included here that reviewed a single application. Similarly, training times varied from 12 to 45 minutes per session. All studies were conducted with an application frequency of 20 or 30 Hz, whereby only weak to medium effect strengths were determined throughout. Nevertheless, these results should be considered positive, as they provide suggestions on how training protocols could be structured. For example, it can be seen that the effect is significantly higher for a single session than for multiple sessions; one can surmise that as the number of sessions increases and the number of training weeks increases, the effect decreases. Thus, it should be assumed that a single session per month, for example, is sufficient. Especially the results of Hanif et al[7] that show a reduction of systolic blood pressure after WBV are encouraging: Lowering blood pressure could prevent a further stroke. The results by Chan et al[8] are relevant too before the present study, because there it was shown that WBV can reduce spasticity, which should consequently have a positive effect on the patients' flexibility. The results by Tamini et al[9] show a positive effect on flexibility in obesity patients. Flexibility appears to be important in everyday life for maintaining independence. Only with sufficient flexibility the patient is able to put on and take off his clothes and shoes by himself, to take a shower or to comb his hair.

Therefore, the present study aims to find out whether lower application frequencies and a shorter application time can also produce a positive effect on flexibility with a single application.

Hypothesis

There is a difference in performance between the application of WBV of 6 Hz and 12 Hz in flexibility, measured by the Sit and Reach test 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.[10] 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.[5;6] 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.

Table 1. Characteristics of the sample of persons

	Group 1	Group 2
Sex	2 female / 4 male	3 female / 4 male
Age in years (M ± SD)	70.17 ± 8.86	66.57 ± 9.34
Hip width in cm (M ± SD)	32.40 ± 1.67	31.42 ± 1.36
Time past since stroke in months (M ± SD)	8.33 ± 8.24	12.96 ± 9.37

Source: The authors (2021).

There are no significant differences between the characteristics of group 1 and group 2.

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.

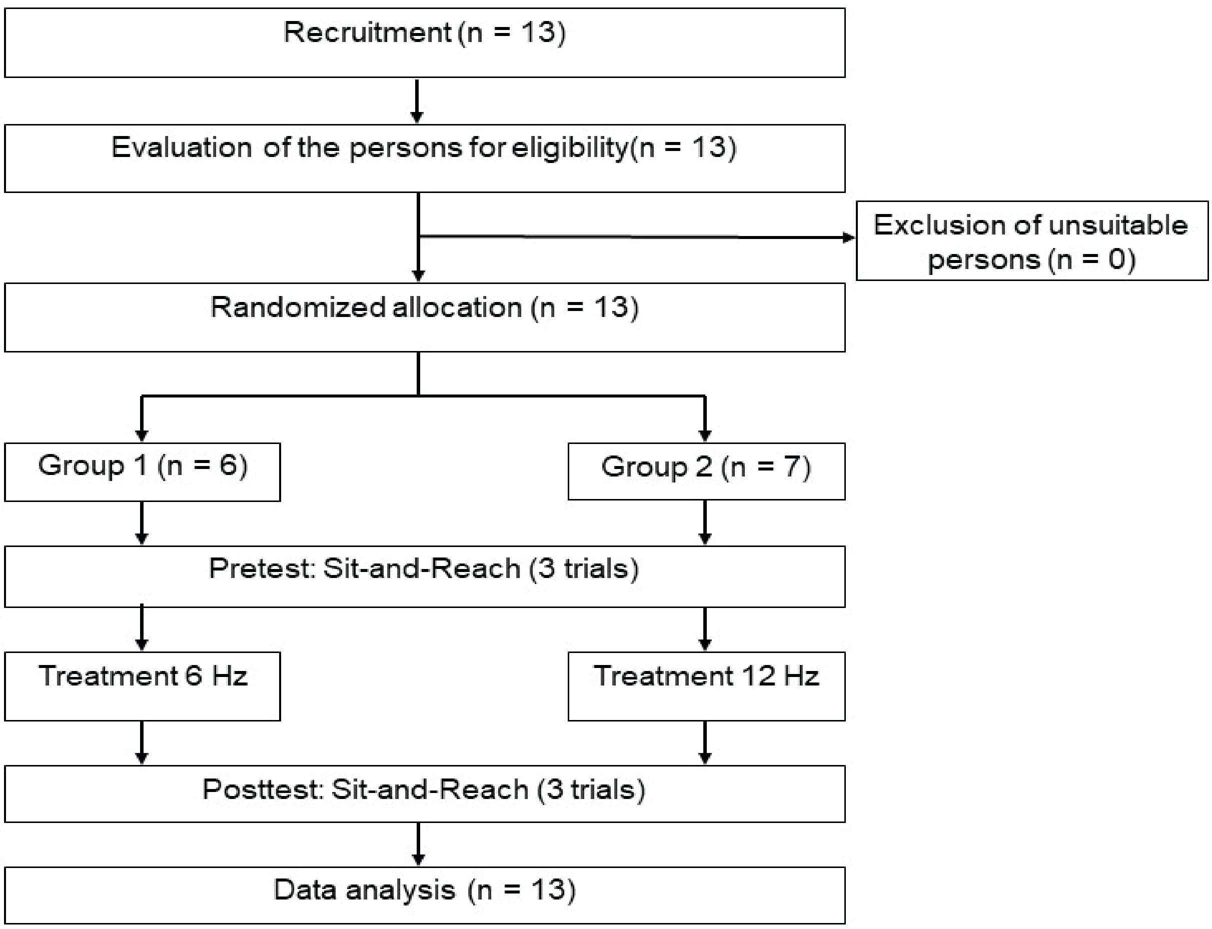
Outcome measurement

To measure the flexibility of the participants, the Sit and Reach test was performed. This procedure is an item of the Senior Fitness Test and is used to test the mobility of the hip joints and the stretching ability of the posterior thigh muscles. The test person sits with extended legs on a flat surface (floor, massage table or table) to which a measuring rod is attached. The person should push the hands towards the soles of the feet as far as possible with arms outstretched. The furthest reach of the fingertips is measured in centimeters, which can be held for two seconds without swaying.[11] The level of the sole of the foot corresponds to zero. Above the level of the sole of the foot the values are in the negative range (-1 to -30), below the level of the sole of the foot the values are in the positive range (1 to 30). As higher the value obtained, the better the flexibility. Both before and after the treatment, the person receives a trial test and then three further tests, the mean value of which is used for statistical analysis.

Intervention protocol

A side-alternating vibration platform (Galileo med Advanced) from Novotec Medical was used as treatment. Two different constant, immediately full vibration frequencies (6 Hz 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 31.9 cm) without holding on to the platform, as recommended.[12-14] 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.

Figure 1. Flow diagram of the study process



Source: The authors (2021).

Data analysis

SPSS Version 26 software was used. A t-test was used to compare group characteristics (age, hip width, time past since stroke) and flexibility in the pretest. Levene test was used to determine homogeneity in flexibility between groups. An ANOVA with measurement repetition was calculated. The effects time (within, pre- to posttest), group (between, 6 Hz vs. 12 Hz) and the interaction time*group were determined. For this purpose, the mean value from three test runs of the Sit & Reach was evaluated. The significance level was defined as $p < 0.05$.

Results

Levene test confirms in the pretest homogeneity of both groups in flexibility ($F = 0.50$, $p = 0.49$, n. s.)., the t-test shows no difference between the groups in the Sit & Reach pretest ($T = 0.71$, $p = 0.49$, n. s.).

Table 2 gives an overview of the results of the pre- and posttest for the Sit & Reach to compare the performance in the 6 Hz and 12 Hz group.

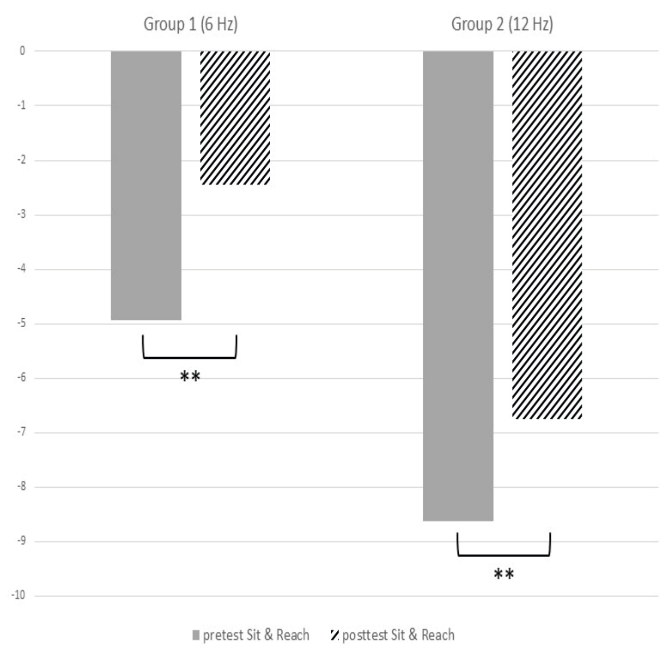
The following figure 2 shows the comparison of the results of both groups for pre-and posttest of the Sit & Reach and its significance for factor *time*.

Table 2. ANOVA Results for Sit & Reach for group 1 (6 Hz) and group 2 (12 Hz)

	Group 1 6 Hz (M ± SD)	Group 2 12 Hz (M ± SD)	Mean difference (± SE)	Time F(1,11)	Group F(1,11)	Time*group F(1,11)
Sit & Reach cm Pretest Posttest	-4.94 ± 10.43 -2.44 ± 8.43	-8.62 ± 8.31 -6.76 ± 7.89	3.67 ± 5.15 4.32 ± 4.53	9.05** (p = .01)	.69 n. s. (p = .43)	.20 n. s. (p = .67)

Source: The authors (2021).

Figure 2. Comparison between groups in Sit & Reach pre- and posttest (: p = .01)**



Source: The authors (2021).

A significant difference between pre- and posttest can be observed for both groups (p = 0.01). There is no difference between groups in pre- or posttest (p = 0.43), and no interaction effect can be found (p = 0.67).

Discussion

The aim of this present study was to investigate the effect of a single application of whole body vibration on flexibility in stroke patients. A significant change from pre- to posttest was found, but no effect for factor group and no interaction effect for factor group*time.

At first, none of the participants reported a side effect or any other negative subjective experience like dizziness or pain.

It can be assumed that the intervention may have had a positive effect on flexibility, as already shown in the study by Tamini et al.[9] although a higher vibration frequency was applied in their study. So it shows that even a lower frequency could be effective. In contrast to Chan et al,[8] a positive effect was achieved here with a lower application frequency and shorter training time. This also contradicts the assumption that low application frequencies below 20 Hz are not effective,[15] since the internal organs vibrate at a similar frequency.[16] and muscles and bones must constantly compensate for these vibrations.[17] There was no significant difference between the application frequencies so it seems that it plays no role if there are 6 Hz or 12 Hz applied.

A point that could have influenced the results is the short time past between pre- and posttest (15 min). Even if all subjects in the tests before and after each performed a test trial before the actual measurements, the muscles could have been stretched to such an extent that the effect was influenced by this as well. Vujnovich et al.[18] suggest that "the simplest explanation for the clinically observed benefits of muscle stretch is that mechanical elongation of muscle and intervening connective tissue has an effect on muscle or collagenous tissue" or that "stretching muscle tissue elicits a burst of proprioceptive activity, bombarding second- and third-order neurons located within the central nervous system". With increasing frequency of stretching, the muscle resistance decreases, i. e. the length-tension curve is shifted to the right.[19] All in all, it can be stated that a muscle reacts to a stretching stimulus in the short term with an exponential increase in torque or resistance, followed by a negatively accelerated decrease in resistance. Thus, the resistance that the muscle offers to the stretch stimulus ultimately decreases. According to findings by Scott,[20] it can be assumed that there is a short-term lengthening of the muscle and the sarcomeres.

In addition, the subject sample was very small, which may have affected the results and there was no control group. A control group could have been used to determine whether the improvement in flexibility was due to WBV alone or whether the pre-stretching in the pretest could have triggered the improvement. However, since this is only a pilot study, further investigations with larger samples should follow, also using a placebo condition.

Conclusion

It can be assumed that even lower application frequencies (6 and 12 Hz) could have a positive effect on the flexibility of stroke patients whereby the test performance of the Sit & Reach itself could have had an additional positive effect on the results. Nevertheless, further studies with larger samples and control/placebo condition must try to develop an optimal training protocol for this patient group with precise information about application frequency, number and duration of sets.

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Conflicts of interest

There are no conflicts.

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