# Alzheimer's Disease and Treatment

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# Effect of Whole Body Vibration on Balance in Parkinson's Disease-A Randomized Controlled Pilot Study

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**Keywords:** Whole Body Vibration (WBV); Parkinson; Balance.

**Key points**

- The effect of WBV is not completely clear on balance.
- Higher effects can be reached for PD patients compared to healthy elderly persons.
- Freezing, age and gender seem to affect the effectiveness of WBV.

## Abstract

**Background:** Parkinson's disease is the second most common neurodegenerative disease. The symptoms are treated with medication, physiotherapy, exercise and occupational therapy. The effect of Whole Body Vibration (WBV) as an alternative training method has already been investigated for several symptoms in Parkinson's patients. Since the effect on the balance does not seem to be clear, the effectiveness of different application frequencies should be tested in this pilot study.

**Hypothesis:** Different frequencies of WBV have different effects on balance parameters. *Study design:* RCT.

**Methods:** The 54 subjects (37 PD patients, 17 healthy age matched elderly persons) were randomly assigned to a frequency (6, 12 or 18 Hz) or to the control group (only for PD patients). Before and after the treatment of 5 x 60 seconds with a 60 second break each, the measurement on a force plate was performed.

**Results:** Significant differences only were found in 95% ellipse of sway for the condition best of 3 and in anterior-posterior center of pressure displacement. Only the PD 18 Hz group improves in the 95% ellipse of sway. Improvement in anterior-posterior displacement was found for all groups.

**Conclusions:** WBV can cause an increase of the sway area and an improvement anterior-posterior center displacement. Vibration frequency seems to play a subordinate role.

## Background

Parkinson's disease is the second most common neurodegenerative disease [1]. The main symptoms of this disease include bradykinesia (slowing of movement), hypokinesia (reduced amplitude and spontaneous movement) and akinesia (inhibition of movement initiation), rigor (muscle tone disorder, limited mobility), tremor and postural instability (disturbance of postural reflexes) [2,3]. Late motor symptoms include the on-off phenomenon after several years of treatment with dopamine preparations, propulsion (falling forward) and freezing (involuntary movement blockade) [4].

Symptoms are treated by medication, mainly to compensate for the dopaminergic deficit, with L-dopa preparations proving most effective in combination with decarboxylase inhibitors. Since the fluctuation in the effects increases with the duration of treatment, MAO-B inhibitors (monooxidase type B inhibitors) and COMT inhibitors (catechol-O-methyl transferase inhibitors) are prescribed as support. This results in a longer and more uniform duration of action of L-dopa [5]. Deep brain stimulation can be mentioned here as a surgical therapy [6]. Here, a pulse generator is implanted (usually below the collarbone),

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which causes an individually programmed electrical stimulation via the electrodes implanted in the subthalamic nucleus. In addition, physio-, ergo- and speech therapy is usually prescribed for Parkinson's patients [5], which becomes more and more important with increasing duration of the disease, since the drug-refractory symptoms such as freezing, gait and balance problems, speech and swallowing problems occur more frequently [2]. Whole Body Vibration (WBV) is an alternative treatment method in the field of physiotherapy. Here, mechanical vibrations are transmitted to the muscles via a platform on which the patient stands [7]. A distinction is made here between harmonic and stochastic whole-body vibration, whereby this can be induced on vertical or side-alternating plates [8]. The sinusoidal, harmonic whole-body vibration has the advantage that it can be used to test the effect of a certain frequency [9]. So far, only very few side effects are known, such as headaches or dizziness [10]. However, these can be reduced or avoided when standing on a vibration plate by adopting an upright, relaxed posture with slightly bent knees (approx. 26-30º) [9-11]. However, there are contraindications, such as acute thrombosis, inflammation, hernias, discopathy or rheumatoid arthritis, fresh bone fractures or joint prostheses [12], but also cardiac arrhythmia, untreated high blood pressure, pacemakers, deep brain stimulators, aortic aneurysm or migraine, which are also regarded as exclusion criteria for application frequencies above 15 Hz [13].

The effect of whole-body vibrations in Parkinson's patients has been researched in recent decades on many aspects of the symptoms. For example, there are many studies on mobility, gait and other motor symptoms such as tremor or bradykinesia, but the results are still inconsistent due to different examination methods (different application frequencies, frequencies, sentence numbers and lengths). The effect on balance still leaves many questions open [14]. In the present study we will investigate how different application frequencies of WBV affect different balance parameters in PD patients compared to healthy elderly persons.

## Methods

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.

### Sample of persons

The test persons were recruited via medical practices, clinics, rehabilitation facilities, self-help groups and residential homes in Saarland and Rhineland-Palatinate. Persons with the contraindications already described (e.g. fresh bone fracture/joint replacement, severe coronary heart disease, untreated high blood pressure, etc.) were not included according to the recommendations [12,13]. The sample consists of 54 persons, of whom 24 male and 30 female persons. The average age is 72.49 ± 11.85 years, the average stage of the PD disease according to Hoehn and Yahr is 2.11 ± 0.79, the PD patients have been ill for an average of 7·36 ± 4·63 years, the average hip width is 33.25 ± 1.53 cm. 11 of the PD patients suffer from freezing. (Table 1) shows the characteristics of the sample sorted by test groups. When comparing the groups, only a significant age difference for group 3 to groups 4, 5, and 7 can be observed.

**Table 1:** Characteristics of the sample, sorted by test groups, means ± standard deviations.

| | Group 1 PD 6 Hz | Group 2 PD 12 Hz | Group 3 PD 18 Hz | Group 4 PD control | Group 5 healthy 6 Hz | Group 6 healthy 12 Hz | Group 7 healthy 18 Hz |
|---|---|---|---|---|---|---|---|
| Total number of persons | 10 | 10 | 8 | 9 | 7 | 6 | 4 |
| Male | 5 | 5 | 4 | 5 | 3 | 1 | 1 |
| Female | 5 | 5 | 4 | 4 | 4 | 5 | 3 |
| Number of freezers | 2 | 5 | 1 | 3 | 0 | 0 | 0 |
| Age (years) | 70·36 ± 9·19 | 70·70 ± 10·68 | 57·13 ± 9·20 | 77·33 ± 10·37 | 83·00 ± 9·36 | 73·17 ± 7·08 | 83·25 ± 4·35 |
| Duration of illness years) | 5·63 ± 5·66 | 8·50 ± 5·32 | 6·00 ± 4·82 | 6·00 ± 2·65 | - | - | - |
| Disease stage (Hoehn & Yahr) | 2·19 ± ·70 | 2·11 ± ·70 | 2·33 ± ·90 | 2·11 ± ·74 | - | - | - |

### Variable sample

**Force plate:** The 95% ellipse of sway of the body's center of pressure, as well as the average center displacement deflection along anterior-posterior and medial-lateral axis are recorded. The 95% ellipse of sway in cm² provides information about the area in which the body's center of pressure fluctuates. This area should be as small as possible, which indicates good balance. The average center displacement deflection along the Anterior-Posterior axis (AP) in cm indicates how far the body's center of pressure is shifted forward or backward. Parkinson's patients tend to have a forward shift of the body's center of pressure, which is associated with an increased risk of falling. A further shift to the rear in the post-test can therefore be seen as an improvement. The average center displacement deflection along the medial-lateral axis in cm (ML) indicates how strongly the body's center of pressure is centred. A value of zero should be aimed for here, which means that the body's center of pressure is centred exactly between the feet [15,16].

There are three measurements of 20 seconds each with a 30 second break between each before and after the treatment. The best attempt (best of 3) and the mean value of the three runs (mean of 3) are evaluated. Examination was made by A.D.

### Treatment sample

A side-alternating vibration platform (Galileo med Advanced) from Novotec Medical was used as treatment. Three different vibration frequencies (6, 12, and 18 Hz) were used and a placebo condition (control group, standing on the switched off vibration plate) was created. The test persons were instructed to stand as upright and relaxed as possible with slightly bent knees (26 to 30º) without holding on to the platform, as recommended [9-11]. The test persons were not informed which group they belonged to. For this reason, the display was covered. The examiner (GW) was also blinded. Five sentences of 60 seconds each with a 60 seconds pause between the sentences with the corresponding frequency were applied. The allocation to the different vibration frequencies was randomized by drawing lots by A.D.

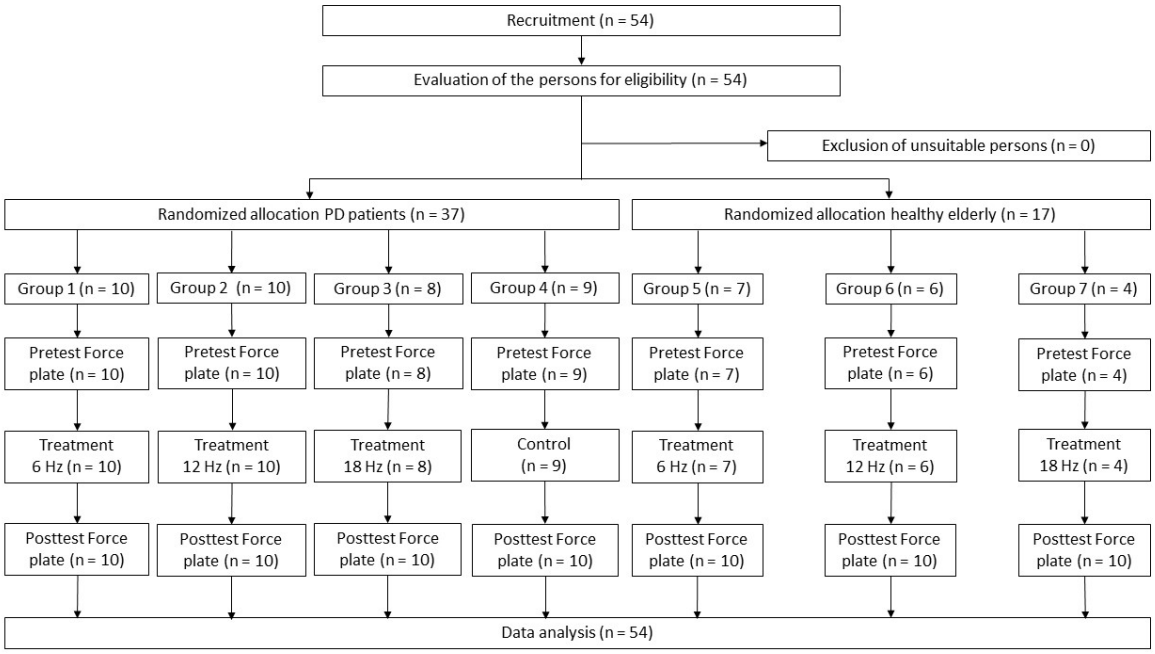


**Figure 1:** The course of the study.

**Table 2:** Results of pre- and posttests and ANOVA comparison: 95% ellipse of sway, Anterior-Posterior stability (AP) and Medio-Lateral stability (ML) for experimental and control groups.

| | 95% ellipse of sway | | AP | | ML | |
|---|---|---|---|---|---|---|
| | Best of 3 | Mean of 3 | Best of 3 | Mean of 3 | Best of 3 | Mean of 3 |
| **Group 1 (PD 6 Hz)** | | | | | | |
| **Pre** | 234·36 ± 109·47 | 451·64 ± 196·15 | -24·71 ± 16·67 | -18·66 ± 16·52 | -1·46 ± 5·14 | -6·05 ± 10·83 |
| **Post** | 327·36 ± 174·81 | 499·91 ± 202·77 | -28·94 ± 19·21 | -23·22 ± 17·31 | -·69 ± 5·57 | -2·06 ± 8·34 |
| **Group 2 (PD 12 Hz)** | | | | | | |
| **Pre** | 377·50 ± 412·79 | 554·97 ± 624·16 | -22·31 ± 14·42 | -16·44 ± 13·57 | -2·88 ± 7·49 | -4·54 ± 9·37 |
| **Post** | 430·90 ± 510·29 | 562·00 ± 602·17 | -25·22 ± 10·92 | -18·87 ± 12·54 | -4·01 ± 6·84 | -6·89 ± 7·97 |
| **Group 3 (PD 18 Hz)** | | | | | | |
| **Pre** | 229·63 ± 110·02 | 333·50 ± 138·30 | -25·25 ± 11·54 | -20·01 ± 12·44 | -2·36 ± 7·58 | -2·33 ± 9·79 |
| **Post** | 211·50 ± 143·04 | 322·42 ± 219·26 | -29·16 ± 9·10 | -23·46 ± 7·22 | -1·58 ± 8·31 | -3·61 ± 10·76 |
| **Group 4 (PD control)** | | | | | | |
| **Pre** | 291·56 ± 173·14 | 387·96 ± 188·21 | -22·01 ± 13·49 | -14·79 ± 11·20 | ·16 ± 5·56 | -1·33 ± 9·74 |
| **Post** | 391·22 ± 215·67 | 536·52 ± 264·75 | -22·87 ± 16·73 | -15·40 ± 14·09 | -3·18 ± 5·64 | -3·36 ± 8·56 |
| **Group 5 (healthy 6 Hz)** | | | | | | |
| **Pre** | 103·29 ± 30·79 | 200·67 ± 105·78 | -22·19 ± 11·86 | -15·31 ± 10·78 | -2·73 ± 18·87 | 3·67 ± 17·26 |
| **Post** | 168·57 ± 58·56 | 238·33 ± 108·01 | -21·33 ± 13·74 | -16·20 ± 13·90 | -2·60 ± 7·94 | -2·87 ± 11·84 |
| **Group 6 (healthy 12 Hz)** | | | | | | |
| **Pre** | 252·67 ± 159·23 | 313·72 ± 152·11 | -12·07 ± 18·00 | -5·82 ± 15·40 | -6·70 ± 10·48 | -8·20 ± 16·86 |
| **Post** | 321·83 ± 168·44 | 408·06 ± 148·62 | -15·10 ± 10·94 | -9·38 ± 10·97 | -4·75 ± 9·23 | -5·29 ± 11·76 |
| **Group 7 (healthy 18 Hz)** | | | | | | |
| **Pre** | 77·25 ± 10·87 | 127·75 ± 19·55 | -22·25 ± 8·71 | -15·64 ± 4·45 | -1·00 ± 4·77 | -·18 ± 9·51 |
| **Post** | 164·50 ± 43·52 | 194·42 ± 45·10 | -20·40 ± 5·81 | -17·23 ± 3·69 | 1·00 ± ·46 | -·86 ± 3·82 |
| **F(1,48), factor time** | 8·45** | 3·56 | 1·42 | 4·7* | ·03 | ·32 |
| **Part. Eta²** | ·15** | ·07 | ·03 | ·09* | ·00 | ·01 |
| **F(6,48), factor group** | 1·52 | 1·67 | ·83 | ·99 | ·38 | ·52 |
| **Part. Eta²** | ·16 | ·17 | ·09 | ·11 | ·05 | ·06 |
| **F(6,48), factor group*time** | ·54 | ·57 | ·35 | ·30 | ·62 | ·87 |
| **Part. Eta²** | ·06 | ·07 | ·04 | ·04 | ·07 | ·10 |

### Hypothesis

There is a difference in performance between pre- and post-test in balance parameters depending on the vibration frequency.

### Statistics

A K-S test was performed to verify a normal distribution of the data. An ANOVA with measurement repetition is calculated. The effects *time* (within, pre- to post-test), *frequency* (between, different application frequencies) and the interaction *time*frequency* are determined. The significance level is defined as $p<0{\cdot}05$.

## Results

A normal distribution of all variables is assumed. Table 2 gives an overview of the results of the pre- and post-tests of the individual variables to compare the application frequencies. In the average center displacement deflection along anterior-posterior axis, all groups shift further back in the post-test, and in medial-lateral axis only group 1 centres.

95% ellipse of sway: Only for factor *time* for condition best of 3, a highly significant change can be found. Anterior-Posterior center displacement (AP): Only for factor *time* for condition mean of 3, a significant change can be found. Medial-lateral center displacement (ML): No significant difference can be found.

## Discussion

The aim of the present study was to investigate the effect of a single application of whole body vibration on various balance parameters in PD patients compared to age matched healthy elderly persons.

Nearly all the results are not significant.

In the 95% ellipse of sway, only the PD 18 Hz group showed a reduction in sway area or an improvement, the other groups showed a worse result in the post-test than in the pre-test. This would support the thesis that low vibrations must be constantly compensated and the body no longer reacts to them [17]. It is possible that the vibration disturbs the organ of equilibrium in the inner ear, which means that the body needs more time to regain its balance.

In the average center displacement deflection along anterior-posterior axis, all PD experimental groups show a stronger improvement than the control group. Here it appears that in principle all application frequencies contribute to a weight shift to the rear. In healthy elderly persons the effect is not clear, there are both improvements and deteriorations in the anterior-posterior displacement of the body center of pressure. Therefore, one could assume that there are no consistent positive effects of WBV in healthy elderly people compared to patients with PD.

In the average center displacement deflection along medial-lateral axis, both 6 Hz groups, and the healthy 12 Hz group approach the target value in direction of zero, the PD 12 Hz, and both 18 Hz groups move away, as does the control group, in which a weight shift from one side to the other can also be observed. This would possibly also be due to fatigue of the lower leg muscles. In addition, a difference in leg length would also be possible as a cause, which is why no exact centring was performed in the post-test. Further cause could be the disturbance of the organ of equilibrium in higher application frequencies.

These results would be more or less in line with the statement of Cardinale and Pope [18] that frequencies below 20 Hz have no effect because the organs inside the body vibrate at a similar frequency [19] and these vibrations of muscles, bones and joints must be constantly balanced [17]. So, it would make sense to test another frequency above 20 Hz in comparison to those investigated here.

The non-significant differences in the test procedure may be due firstly to the unequal distribution of the freezers among the four PD groups. Secondly, the age of the test persons may also have played a role. Group 3 (PD 18 Hz) differs significantly from all groups. Thus, it can be assumed that younger people possibly benefit more from a WBV application than older people. Another problem could be the medication. All subjects were tested in the ON state, a phase in which the medication works well and the symptoms are suppressed [4].

Pre- and post-test were only about 10 to 15 minutes apart, so it can be assumed that an exercise effect could have occurred in all groups, since almost consistently a slight improvement was observed in all groups and variables, in part also in the control group. The sample was possibly too small for randomization, in which case it might have made more sense to match the PD patients on the basis of freezing, sex and age.

### Summary and prospects

The aim of the present study was to investigate the effect of a single application of WBV on various balance parameters in PD patients compared to healthy age matched elderly persons. It could be shown that the sway area deteriorates and the anterior-posterior center displacement increases independent from vibration frequency. Furthermore, it would be interesting at this point to apply an EMG to the lower extremities to record muscle activity during the balance tests. However, it is problematic here that higher frequencies are not suitable for everyone because of the described contraindications. The study should therefore be tested with a larger sample matched by age, gender and freezing in the OFF state using at least one additional frequency above 20 Hz.

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The authors confirm that each of the authors has read and approved the submission and concurs with the content in the final manuscript. The material within has not been and will not be submitted for publication elsewhere.

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