ORIGINAL ARTICLE

Whole Body Vibration Versus Conventional Physiotherapy to Improve Balance and Gait in Parkinson's Disease

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ABSTRACT. Ebersbach G, Edler D, Kaufhold O, Wissel J. Whole body vibration versus conventional physiotherapy to improve balance and gait in Parkinson's disease. Arch Phys Med Rehabil 2008;89:399-403.

Objective: To compare the effects of whole body vibration (WBV) and conventional physiotherapy (PT) on levodopa-resistant disturbances of balance and gait in idiopathic Parkinson's disease (PD).

Design: Randomized controlled rater-blinded trial comparing 2 active interventions, final follow-up assessment 4 weeks after termination of active intervention.

Setting: Specialized referral center, hospitalized care.

Participants: Patients with PD and dopa-resistant imbalance on stable dopamine replacement medication (N=27) were randomized (intent-to-treat population) to receive WBV (n=13) or conventional PT (controls, n=14). Twenty-one patients (per protocol population) completed follow-up (14 men, 7 women; mean age, 73.8y; age range, 62–84y; mean disease duration, 7.2y; mean dopa-equivalent dose, 768mg/d).

Intervention: Subjects were randomized to receive 30 sessions (two 15-min sessions a day, 5 days a week) of either WBV on an oscillating platform or conventional balance training including exercises on a tilt board. Twenty-one subjects (10 with WBV, 11 controls) were available for follow-up 4 weeks after treatment termination.

Main Outcome Measures: The primary measure was Tinetti Balance Scale score. Secondary clinical ratings included stand-walk-sit test, walking velocity, Unified Parkinson's Disease Rating Scale (section III motor examination) score, performance in the pull test, and dynamic posturography.

Results: The Tinetti score improved from 9.3 to 12.8 points in the WBV group and from 8.3 to 11.7 in the controls. All secondary measures, except posturography, likewise improved at follow-up compared with baseline in both groups. Quantitative dynamic posturography only improved in patients with WBV (1937–1467mm) whereas there was no significant change in controls (1832–2030mm).

Conclusions: Equilibrium and gait improved in patients with PD receiving conventional WBV or conventional PT in the setting of a comprehensive rehabilitation program. There was no conclusive evidence for superior efficacy of WBV compared with conventional balance training.

Key Words: Equilibrium; Parkinson disease; Rehabilitation; Vibration.

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REHABILITATIVE THERAPY in Parkinson's disease (PD) is widely recommended for the management of impairments that are not responsive to pharmacologic treatment. Whereas rigidity, tremor, and akinesia are often dramatically reversed by the use of drugs, other symptoms such as speech disorders or complex disturbances of gait and equilibrium are much less susceptible to medical treatment.[1,2] Lack of response to dopaminergic drugs predicts (with the exception of drug-resistant tremor) refractoriness to deep brain stimulation, leaving rehabilitative therapy as the sole putatively effective option. Dopa-resistant deficits become increasingly prominent in the late stage of PD[3] and significantly affect mobility, participation, and quality of life. Yet, few controlled clinical trials have actually tested the impact of rehabilitative interventions in PD.[4,5] The Quality Standards Subcommittee of the American Academy of Neurology[6] identified 8 studies with class II evidence suggesting that exercise modalities including music therapy, treadmill exercises, balance training, and cued training are "probably effective" in improving functional outcomes for patients with PD.

Technical devices are becoming increasingly important in rehabilitation but have only rarely been evaluated in PD. Technology applied to rehabilitative interventions in PD includes treadmills,[7] devices providing optical or acoustic cues, and different platform constructions for balance training. Treadmill training with[7,8] and without[9,10] body support was reported to have immediate and long-term effects on gait parameters. Ergometer exercises with eccentric high resistance not only increase muscle strength, but have also been shown to improve gait[11] and postural stability[12] in PD. Because deficient proprioceptive perception and processing have been described in PD,[13] devices providing sensory stimulation are potential training tools to enhance sensorimotor processing. Whole body vibration (WBV) acts through repetitive sensorimotor stimulation and has been applied to patients with cerebral palsy,[14] multiple sclerosis,[15] and stroke.[16] Improvement of gait and balance with WBV has furthermore been shown in a population of nursing home residents.[17] Vibration stimuli for the treatment of PD were first recommended by Jean Martin Charcot, who also developed a vibration chair ("chaise trépidante"). Although the effect of vibration on voluntary movement was reported to be weaker in PD than in healthy subjects,[18,19] a recent study[20] has shown that motor symptoms of PD respond favorably to vibration stimuli.

The present study was undertaken in order to identify influences of WBV on balance and gait in patients with PD and to compare immediate and medium-term effects between WBV and conventional physiotherapy (PT).

METHODS

Participants

Twenty-seven patients with idiopathic PD diagnosed according to standard clinical criteria[21] were randomized to receive either WBV with the Galileo device (n=14) or conventional PT (n=13) (intent-to-treat-population). Patients were required to show clinical evidence for imbalance, for example, scoring at least 1 point on item 30 of the Unified Parkinson's Disease Rating Scale (UPDRS) while being on optimized and stable medical treatment. We assessed balance during the on phase in patients with response fluctuations. Exclusion criteria included severe response fluctuations or other conditions requiring modification of medication, dementia, balance impairment due to other disease, and severe dyskinesia interfering with posturographic assessments. Minor changes of medication (modification of schedule, variation of daily dopa-equivalent <100mg) occurred in 8 patients after inclusion and did not exclude patients from follow-up. Six patients were not included in the final evaluation: 4 patients had major changes of dopaminergic treatment (>100mg variation of daily dopa-equivalent) in the follow-up period, and 2 patients were unable to attend the follow-up visit due to transportation problems. Comparison of the data obtained after 3 weeks did not show significant differences between dropouts and patients with follow-up. Final assessment was thus obtained in 21 subjects (per protocol population), 10 with WBV and 11 controls (see table 1 for subject characteristics). The study was performed between January and October 2006, and was conducted according to institutional guidelines and the principles outlined in the Declaration of Helsinki. Informed consent was obtained from all patients.

Intervention

The interventional part of the study comprised 3 weeks of inpatient treatment. Patients were then dismissed and scheduled for outpatient follow-up after 4 weeks. During the intervention period all subjects attended a comprehensive inpatient rehabilitation program. In this setting all patients received standard therapy comprising three 40-minute sessions a day (5d/wk) including relaxation techniques (group exercises focusing on muscle-stretching, relaxation, and body perception), speech therapy, and occupational therapy (OT). Patients with freezing were instructed to use release maneuvers such as an inverted cane. In addition, patients were randomly assigned (alternating allocation) to receive either 2 sessions (15min each) a day (5d/wk) of WBV with the Galileo device[a] or standard balance training including exercises on a tilt board (controls). The regular daily schedule during the intervention thus included 150 minutes of exercise with 30 minutes being exclusively dedicated to balance. All participants were encouraged to continue exercising after being discharged and most subjects received conventional PT during the follow-up period.

The Galileo system (fig 1) has been developed for sensorimotor stimulation and is commercially available in various countries. It consists of a vibrating platform that thrusts the right and left leg upward alternately with a frequency of 25Hz and an amplitude of 7 to 14mm. Standard calibration, as set by the manufacturer, was used. There was no electronic recording of individual sessions. Subjects stand with slightly bended knees and hips while WBV is delivered. Participants were instructed not to hold onto the railing during WBV.

Fig 1. Galileo device for WBV. During WBV the right and left leg are thrust upward with a frequency of 25Hz and an amplitude of 7 to 14mm. Reprinted by permission of Novotec Medical Systems, Pforzheim, Germany.

Table 1: Subject Characteristics for WBV and Controls

Characteristics	WBV	Controls
Men/women	7/3	7/4
Age (y)	72.5±6.0	75.0±6.8
Duration (y)	7.0±3.3	7.5±2.7
Mean dopa dosage (mg/d)	532.0±226.0	600.0±207.0

NOTE. Values are n or mean ± standard deviation (SD).

Data Collection

The main criteria for improvement of balance was the Tinetti Balance Scale score.[22] Secondary criteria included walking speed (time to walk 10m), stand-walk-sit test (in seconds) and sum score of the UPDRS motor examination (section III). The primary measure and UPDRS were taken by an experienced neurologist blinded for type of treatment but not for condition. Walking speed and stand-walk-sit test were assessed by a physiotherapist (not blinded). The pull test, which is used to assess postural stability (item 30 of the UPDRS[23]), was re-

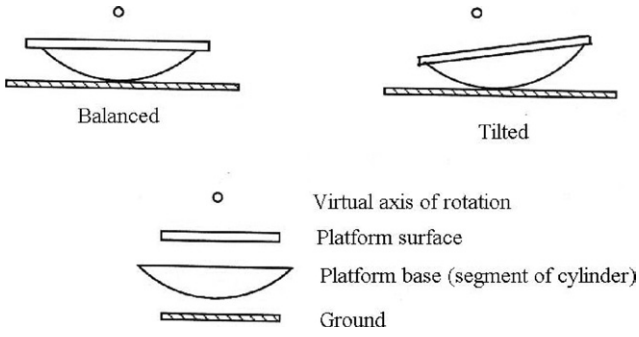

Fig 2. Tilt board used for dynamic posturography. The tilt board consists of a platform with a cylindrical curved base. The virtual axis of the tilt board is located outside the support surface and changes with every platform movement. The design of the tilt board makes the subject unable to stand still because there is continuous need for compensatory shifts of posture to keep balance. While the subject is standing on the tilt board, displacements of the base are registered as a measure of performance.

corded on video and rated by an experienced neurologist blinded for both condition and type of treatment. In addition to these clinical measures, dynamic posturography was performed on a tilt board (fig 2)[b] as previously reported in detail by Müller et al.[24] In brief, the tilt board is a seesaw consisting of a platform with a cylindrical curved base (radius, 55cm; height when level, 6cm). The virtual axis of the tilt board is located outside the support surface and changes with every platform movement. The design of the tilt board makes the subject unable to stand still because continuous compensatory shifts of posture are needed to keep balance. Tilts of the platform are continuously monitored and, as a measure of stability, the linear displacement of the pivot (pivot length) is recorded.

All measures were taken at baseline, at the end of each therapy cycle (week 3), and 4 weeks after termination of therapy (follow-up).

Analysis of variance (ANOVA) was used to assess effects of condition (baseline vs week 3 vs follow-up) and type of intervention (Galileo vs conventional therapy). The Student *t* test was used for post hoc analysis. Dose effects were presumed to decrease contrast between both treatments because experimental intervention was embedded into an intensive rehabilitative setting. So not to miss possible domain-specific differences in effectiveness, no correction for repeated measures was made, thus increasing probability of false-positive results.

RESULTS

Twenty-one patients were available for follow-up. Cases with completed follow-up included 10 patients randomized to receive WBV with the Galileo device and 11 subjects with conventional PT.

ANOVA showed a significant effect of condition (baseline vs end of treatment vs follow-up) for the Tinetti balance score ($F_{22,59}$, $P<.001$) and most secondary measures including gait velocity ($F_{8,163}$, $P<.003$), stand-walk-sit test ($F_{30,90}$, $P<.001$), UPDRS III ($F_{11,62}$, $P<.001$) but not for dynamic posturography. Post hoc testing disclosed improvement for all measures except dynamic posturography at the termination of treatment ($P<.001$) and showed no significant decline at the follow-up assessment, performed 4 weeks after termination of treatment (table 2). No significant effect of type of intervention (WBV vs conventional PT) was identified for the primary (Tinetti balance score) and most of the secondary measures used. Dynamic posturography was the only parameter that was differentially influenced by type of treatment with patients receiving WBV having a tendency ($F_{2,71}$, $P<.093$) for lower sway (better performance) at the end of treatment and follow-up. Although clinical ratings were consistently better after conventional PT, posturographic measures worsened compared with baseline in this group (see table 2).

DISCUSSION

WBV was found not to have greater effects on gait and equilibrium in patients with PD than conventional balance exercises. Both treatments were associated with improved performance in clinical assessments of mobility and postural stability in this group of patients receiving a comprehensive rehabilitative inpatient treatment. The observed difference in posturographic measures is not likely to indicate superior clinical efficacy of WBV because all clinical ratings, including the primary variable (Tinetti balance score), showed improvement of equilibrium in both treatment alternatives and did not differ between groups. Notably, improvements remained stable at follow-up 4 weeks after termination of treatment.

Postural instability and gait disorders are major determinants of disability in PD. Because response of these symptoms to dopaminergic medication is often unsatisfactory, PT is widely used to treat these "dopa-resistant" motor disturbances. Yet, due to the heterogeneity of methods applied in controlled studies and because many studies are characterized by small group size, absence of follow-up evaluation, and further methodologic flaws, the available evidence is still insufficient to prove or to refute effectiveness of PT to improve balance and gait in PD (see Keus,[25] Goetz,[5] Deane,[4] and colleagues for reviews).

Rehabilitative approaches to treat disturbances of gait and equilibrium in PD include training of compensatory steps,[26] high-resistance strength training,[12,27] use of visual[28] or acoustic[29] sensory cues, attentional strategies,[30] training of movement amplitude,[31] and other strategies. Devices used for bal-

Table 2: Treatment Results

Tests	Galileo			Controls		
	Baseline	3 Weeks	Follow-Up	Baseline	3 Weeks	Follow-Up
Tinetti balance score	9.3±3.1	12.8±1.9	12.8±2.3	8.3±2.9	11.5±2.4	11.7±3.1
Posturography (mm)	1937.0±1250	1306.0±331.0	1467.0±540.0	1832.0±746.0	2256.0±681.0	2030.0±878.0
Time to walk 10m (s)	17.6±5.0	15.1±3.5	14.5±3.5	18.4±4.2	16.5±2.5	16.8±3.4
Stand-walk-sit (s)	10.8±2.5	8.5±2.1	8.2±1.8	12.0±2.9	9.5±2.1	8.9±1.4
UPDRS III sum score	23.0±4.9	17.6±4.5	17.0±5.4	25.9±8.1	16.9±5.0	18.5±4.9
Pull test score	1.45±0.68	1.17±0.72	1.05±0.64	1.7±0.79	1.32±0.40	1.27±0.47

NOTE. Values are mean ± SD.

ance and gait training in PD include treadmills[7] and movable platforms.

Positive effects of WBV on postural control have been shown in athletes and orthopedic patients.[32] Furthermore, the effects of WBV on gait and balance were studied in a randomized study in 42 elderly nursing home residents.[17] Participants received 6 weeks (3 treatments a week) of WBV applied with the Galileo device in addition to standard PT. Compared with a control group receiving only standard PT subjects with WBV had better outcome in Tinetti global and balance score. In contrast to the present study, the total amount of therapy was higher in the WBV group and there was no follow-up. Using the Galileo device, Runge et al[33] found healthy elderly subjects to have improved performance in a chair raising task compared with controls not receiving WBV. Applications of WBV have recently been reported in different neurologic disorders. Ahlborg et al[14] compared WBV and resistance training in 14 patients with spastic diplegia and reported positive effect of WBV on measures of spasticity and strength but no improvement of mobility. Low-frequency WBV was compared with a placebo intervention in 12 patients with multiple sclerosis.[15] It was reported that only WBV improved performance in posturography and Timed Up & Go test. Daily sessions of WBV with Galileo during a 6-week trial were not more effective for measures of balance and mobility than the same amount of exercise therapy in a randomized study of 53 patients in the postacute phase of stroke.[16]

Turbanski et al[34] showed, for patients with PD, a short-term improvement in the ability to maintain postural stability on a movable platform after treatment with WBV. Haas et al[20] found better UPDRS scores in 63 patients with PD after WBV in a randomized rater-blinded study using a parallel crossover design. In contrast to the present study, these studies used irregular low-frequency vibratory stimuli for WBV. In both the above studies only immediate effects were measured and there was no active comparator intervention.

The mechanisms by which WBV acts on motor control are not completely understood. Vibration applied to the muscular-tendon system can elicit reflex muscle contractions and exerts effects on sensory processing. Further effects of vibration include modification of tracking movements, increased postural sway, and modification of gait. The parameters of vibration and predictability of stimuli can influence the physiologic effects.[20] In PD, it has been suggested that deficient proprioceptive processing contributes to the progressive worsening of postural responses.[13] Although the impact of vibration on motor performance was reported to be lower in PD than in healthy subjects,[18,19] enhancement of sensory processing through WBV would still be a possible mechanism.[20]

Study Limitations

Because treatments in the present study were embedded into a multidisciplinary inpatient setting and because there was no comparison with patients without treatment or with sham therapy the impact of nonspecific factors on treatment outcome cannot be determined. In addition to the experimental interventions, patients participated in many concomitant activities, including group exercises for stretching and relaxation, OT, and speech therapy. Although training of gait and balance was not emphasized in these concomitant interventions, dose effects may have obscured differences between WBV and conventional PT.

For patients with PD, maintenance of improvement after interventions is often critical[22] and this maintenance could be seen in the present study at 4-week follow-up. However, it was not possible to establish whether this stability of outcome resulted from the intervention alone or from compliance with regular outpatient therapy and home exercises.

CONCLUSIONS

WBV applied 5 times a week for 3 weeks was not more effective for improvement of equilibrium and gait in PD than conventional PT when applied as part of a comprehensive inpatient rehabilitation program.

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Suppliers

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b. T&T Medilogic, Medizintechnik GmbH, Saalmannstr 9, Berlin, Germany, 13403.