Clinical Rehabilitation 2005; **19:** 834–842

Effects of whole-body vibration in patients with multiple sclerosis: a pilot study

Othmar Schuhfried, **Christian Mittermaier**, **Tatjana Jovanovic**, **Karin Pieber** and **Tatjana Paternostro-Sluga**
Department of Physical Medicine and Rehabilitation, Medical University of Vienna, Austria

Received 6th April 2005; returned for revisions 16th May 2005; revised manuscript accepted 20th June 2005.

Objective: To examine whether a whole-body vibration (mechanical oscillations) in comparison to a placebo administration leads to better postural control, mobility and balance in patients with multiple sclerosis.
Design: Double-blind, randomized controlled trial.
Setting: Outpatient clinic of a university department of physical medicine and rehabilitation.
Subjects: Twelve multiple sclerosis patients with moderate disability (Kurtzke's Expanded Disability Status Scale 2.5–5) were allocated either to the intervention group or to the placebo group.
Interventions: In the intervention group a whole-body vibration at low frequency (2.0–4.4 Hz oscillations at 3-mm amplitude) in five series of 1 min each with a 1-min break between the series was applied. In the placebo group a Burst-transcutaneous electrical nerve stimulation (TENS) application on the nondominant forearm in five series of 1 min each with a 1-min break between the series was applied as well.
Main outcome measures: Posturographic assessment using the Sensory Organization Test, the Timed Get Up and Go Test and the Functional Reach Test immediately preceding the application, 15 min, one week and two weeks after the application. The statistical analysis was applied to the change score from preapplication values to values 15 min, one week and two weeks post intervention.
Results: Compared with the placebo group the intervention group showed advantages in terms of the Sensory Organization Test and the Timed Get Up and Go Test at each time point of measurement after the application. The effects were strongest one week after the intervention, where significant differences for the change score ($p = 0.041$) were found for the Timed Get Up and Go Test with the mean score reducing from 9.2 s (preapplication) to 8.2 s one week after whole-body vibration and increasing from 9.5 s (preapplication) to 10.2 s one week after placebo application. The mean values of the posturographic assessment increased from 70.5 points (preapplication) to 77.5 points one week after whole body vibration and increased only from 67.2 points (preapplication) to 67.5 points one week after the placebo application. No differences were found for the Functional Reach Test.
Conclusion: The results of this pilot study indicated that whole-body vibration may positively influence the postural control and mobility in multiple sclerosis patients.

Address for correspondence: Othmar Schuhfried, Department of Physical Medicine and Rehabilitation, Medical University of Vienna, Waehringer Guertel 18-20, A-1090 Vienna, Austria.
e-mail: othmar.schuhfried@meduniwien.ac.at

 10.1191/0269215505cr919oa

Introduction

Multiple sclerosis is the most common neurological illness leading to disability in the Western world.[1] The variable nature of the disease results in a broad spectrum of impairments such as disorders of balance, loss of co-ordination, muscle weakness, spasticity, altered sensation, impaired vision, cognitive impairment, fatigue and loss of bladder and bowel control.[1] Ataxia and balance disorders are the most incapacitating problems seen in patients with multiple sclerosis and the resulting disturbances of postural control are a common problem. The effects are walking impairment and reduction of mobility caused by worsening balance during ambulation. Patients typically describe a wide-base gait with worsening balance when initiating gait or changing directions. Physical intervention including balance training, strengthening of proximal muscles of the extremities and stabilizing muscles and compensatory techniques can be helpful. Unfortunately, balance disorders and ataxia are amongst the most resistant symptoms to therapeutic interventions and are often a major cause of disability.[2]

Whole-body vibration is based on the application of multidimensional whole-body vibrations (mechanical oscillations). The transmission of vibrations and oscillations to a biological system can lead to physiological changes on numerous levels. Stimulation of skin receptors, muscle spindles, vestibular system,[3–5] changes in cerebral activity, such as those in the thalamus and somatosensory cortex,[6,7] changes of neurotransmitter concentrations such as those in dopamine and serotonin,[8] and changes of hormone concentrations[9,10] have been described. It has been demonstrated that vibration is an effective method for improving postural control in elderly subjects.[11] Whole-body vibration resulted in improvement of gait parameters and co-ordination in patients with Parkinson's disease.[12–14] In these patients an improvement of gait and of postural control as well as an improvement in manual co-ordination could be achieved by means of multidimensional whole-body vibration in five series of 1 min each in 1-min intervals. This effect occurred about 10 min after the application and lasted up to 48 h.[12]

It appears to be reasonable to apply this method to patients with other progressive neurological diseases. Therefore the aim of this study was to test the effectiveness of whole-body vibration in improving postural control, balance and mobility in multiple sclerosis patients. This study was designed as a pilot study in order to get a first reference whether whole-body vibration could be effective in patients with multiple sclerosis.

Methods

Subjects

Twelve multiple sclerosis patients were included in the study. The participants were recruited from the outpatient clinic of the university department of physical medicine and rehabilitation in Vienna. Inclusion criteria were the existence of balance disorders, gait insecurities and/or ataxia and an impairment of ≤ 5 based on Kurtzke's Expanded Disability Status Scale (EDSS).[15] The subjects needed to stand independently, without assistive devices or external support.

Patients were excluded from the study in case of pregnancy (female patients in their reproductive age had to ensure reliable means of contraception), electronic implants such as pacemakers, conditions following artificial heart valves, epilepsy, malignant tumours, endoprothesis, conditions following recent fracture (less than six months), osteoporosis with vertebral body fracture, conditions following thrombosis, therapy with anticoagulant medication, relapse of multiple sclerosis in the last two months and refusal to participate.

After it had been determined that the patients met the inclusion criteria and that no exclusion criteria were present, they were informed in detail about the study and signed a written informed consent form to participate in the trial. This study was reviewed and approved by the ethics committee of the Medical University of Vienna.

The patients underwent a brief clinical examination following a standardized examination protocol. The Ataxia Clinical Rating Scale was determined.[16] In this scale the maximum score was equal to 78 and 0 = no signs of ataxia. To assess muscle tone of the lower extremity the Modified Ashworth Scale was used.[17] The Modified Ashworth Scale grades the level of resistance

encountered during manual passive stretching (0–5; 0 = no increase in muscle tone, 5 = joint fixed rigid in a position). The level of disability was determined by the EDSS.[15] The score ranges from 0 (no disability) to 10 (death due to multiple sclerosis). The baseline characteristics of the study population are presented in Table 1.

Treatment procedures

Six patients were allocated to the whole-body vibration group and six patients were allocated to the placebo group according to a randomization list. The examiner collecting the target parameters did not know which type of intervention was applied (placebo or whole-body vibration). The interventions were performed by a second staff member who was blinded to the examination results. During the examination period (two weeks) the patients' medications were not changed and no special pysiotherapy with gait training and balance training was performed. The interventions were a one-time term of nine minutes treatment or placebo application.

- *Group 1*: Application of a multidimensional whole-body vibration. Amplitude: 3 mm, frequency: beginning with 1 Hz slowly increasing until the patient no longer tolerated a further increase. With this frequency five series of 1 min each with breaks of 1 min each were performed. The construction of the device is designed to perform a nonharmonious generation of oscillating movements in vertical and horizontal planes in order to prevent habituation of receptors and occurrences of resonance. The Zeptor-Med system (Scisen GmbH, Germany) was used (Figure 1). While standing on the platform of the Zeptor system subjects were instructed to maintain a squat position with slight flexion at the hips, knees and ankle joints.
- *Group 2*: For the placebo treatment the patients stood on the Zeptor system's platform in the same position as for the verum application. The placebo application consisted of an application of Burst-transcutaneous electrical nerve stimulation (TENS) on the nondominant forearm in order to simulate a vibration. Just as with the verum application, TENS in five series of 1 min each with breaks of 1 min each were performed. The intensity of the TENS application was increased until a muscle contraction was just visible to simulate a vibration.

Outcome measures

The following target parameters were measured before, 15 min, one and two weeks after the application. The examinations were always done at the same time of the day.

Posturography (Sensory Organization Test) with a SMART Equitest System (NeuroCom International, Oregon, USA)

Dynamic posturography uses a computer-controlled, menu-driven, moveable platform and a moveable visual surround to isolate the effects of various sensory inputs to the brain and measures their effect on balance control. Platform and visual surround movements can be 'sway referenced' and move in direct response to the patient's sway. One type of posturography is the Sensory Organization Test.[18,19] This test consists of six subtests: (1) eyes open, fixed platform, fixed visual surround, (2) eyes closed, fixed platform, fixed visual surround, (3) eyes open, fixed platform, moving (sway referenced) visual surround, (4) eyes open, moving platform, fixed visual surround, (5) eyes closed, moving platform, fixed visual surround, (6) eyes open, moving platform, moving visual surround. The patients were carefully positioned on the platform with the lateral malleoli as marker along

Table 1 Subject characteristics

	Intervention ($n = 6$)	Placebo ($n = 6$)
Gender (male/female)	1/5	2/4
Age (years, mean; SD, range)	49.3 (13.3, 31–64)	46 (12.7, 34–62)
EDSS (mean; SD, range)	3.9 (0.8, 3–5)	3.7 (0.8, 2.5–4.5)
Ataxia Scale (mean; SD, range)	18.2 (9.4, 8–30)	16.8 (13.6, 5–43)
Modified Ashworth Scale (mean; SD, range)	1.5 (1.4, 0–3)	0.8 (0.9, 0–2)

EDSS, Expanded Disability Status Scale.

Figure 1 Multidimensional whole-body vibration device (with permission from Irschitz GmBH).

the rotation axis of the platform and the visual surround. The patients were instructed to stand upright and still with their arms hanging down laterally. Three repetitions of 20 s each were performed per subtest. From the obtained data a summary balance score was calculated. The values of the summary balance score were between 0 and 100, where values above 70 points were judged as 'normal' balance. This value represented the lower limit of a 95% confidence interval for healthy subjects (based on data from 112 healthy subjects).[20,21]

Timed Get Up and Go Test

By means of a stopwatch the time it took a patient to get up from an armchair (about 46 cm high), walk 3 m, turn around and sit down in the chair again, was measured. This test was used to evaluate functional mobility. The shorter the time needed to accomplish this task, the better the functional mobility of the patient was.[22]

Functional Reach Test

A yardstick was mounted at the height of the patient's acromion. The patient was asked to stretch their arm parallel to the yardstick with fist closed. Then the patient was asked to lean forward as far a possible without taking a step. The new position of the end of the metacarpal bone was marked and the difference to the starting position was calculated. The mean value of three tries was recorded. The Functional Reach Test is a simple measurement of standing balance. Additionally it yields information to what extent an everyday task of living – reaching for an object within reach – can be performed.[23]

Statistical analysis

The statistical analysis was applied to the change score from preapplication values to values 15 min, one week and two weeks post intervention. Due to the low sample size a nonparametric test (Mann–Whitney *U*-test) was performed to find significant differences between the therapeutic groups regarding the investigated parameters at 15 min, one week and two weeks post intervention. The α-level was 0.05.

Since no data with this patient group and this intervention were available and this study was conceived as a pilot study no power analysis to calculate the sample size was performed.

Results

All subjects completed the study without any side-effects except one who complained about increased fatigue. No subject dropped out (Figure 2). None of them showed clinical exacerbation at the time of the examination. During the follow-up period the patients were neurologically stable without an indication of a relapse. The average frequency (mean; SD; range) tolerated in whole-body vibration was 3; 0.7; 2–4.4 Hz.

There was a tendency for higher values in the posturographic assessment in the whole-body vibration group at all time points of measurement, where for the change score the statistical level of significance was just missed (Table 2). For the Timed Get Up and Go Test all measurements after the intervention tended to result in better (lower)

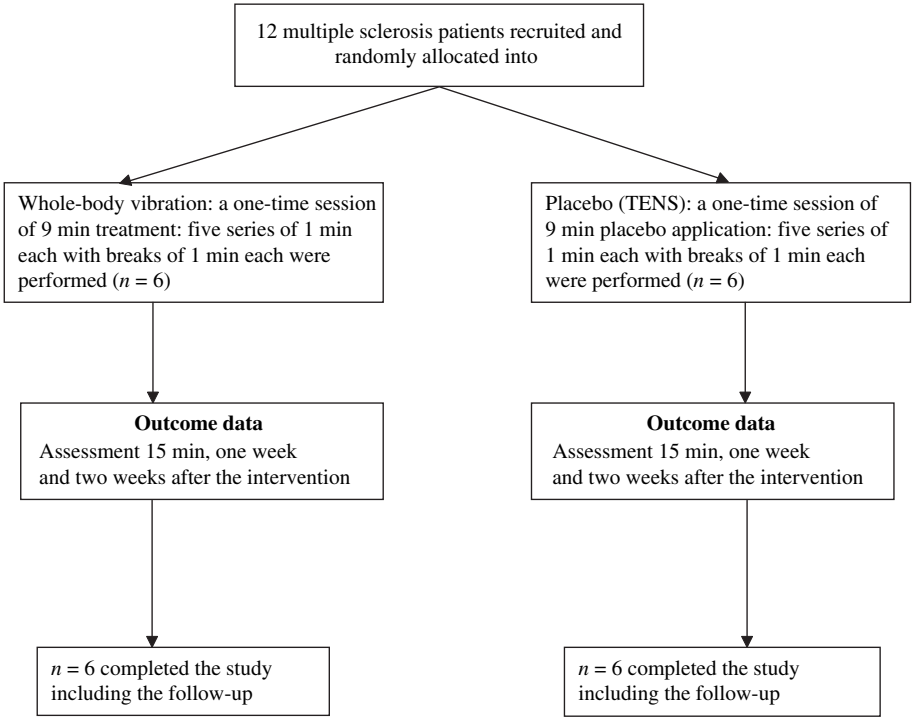

Figure 2 Flow diagram for the present study.

values for the whole-body vibration group compared with the placebo group. In the examination one week after the intervention a significant difference in the change score in favour of the whole-body vibration was found (Table 3). Two weeks after the intervention the values for posturography and Timed Get Up and Go Test in the whole-body vibration group were still higher than in the placebo-group, however without reaching statistical significance for the change score (Tables 2 and 3). In the Functional Reach Test no difference between the two groups was determined (Table 4).

Table 2 Sequential changes of the results of the posturographic assessment (SOT) after treatment with a whole-body vibration or placebo; data are given in absolute values at each time point of assessment and in changes from preapplication to 15 min, one week and two weeks post intervention

Dependent variable	WBV ($n = 6$)		Placebo ($n = 6$)		p-value[a]
SOT (points)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Preapplication	70.5 (5.2)	71 (61–76)	67.2 (14.4)	73.4 (44–81)	
15 min post	76.3 (6.1)	77.5 (65–83)	66.0 (18.6)	74.5 (41–83)	
Changes (15 min post)	5.8 (9.7)	6.0 (−11–18.0)	−1.2 (6.5)	−2.5 (−11–7.0)	0.180
1 week post	77.5 (2.2)	78.0 (74–80)	67.5 (19.1)	76.0 (37–84)	
Changes (1 week post)	7.0 (5.0)	7.5 (0–15.0)	0.3 (5.8)	−0.5 (−7–8.0)	0.065
2 weeks post	76.8 (7.0)	77.5 (64–83)	71.0 (15.2)	78.5 (48–84)	
Changes (2 weeks post)	6.3 (10.1)	5.0 (−7–22.0)	3.8 (2.5)	3.5 (1.0–8.0)	0.818

[a]Statistical analysis was applied to the change score; p-value revealed by Mann–Whitney U-test.
WBV, whole-body vibration; SOT, Sensory Organization Test.

Table 3 Sequential changes of the results of the Timed Get Up and Go Test after treatment with whole-body vibration or placebo; data are given in absolute values at each time point of assessment and in changes from preapplication to 15 min, one week and two weeks post intervention

Dependent variable	WBV ($n = 6$)		Placebo ($n = 6$)		p-value[a]
TUG (s)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Preapplication	9.2 (1.3)	9.4 (6.8–10.5)	9.5 (4.1)	8.6 (6.0–17.4)	
15 min post	8.7 (1.4)	9.0 (6.1–10.0)	9.6 (3.7)	9.0 (6.0–16.3)	
Changes (15 min post)	−0.6 (0.6)	−0.7 (−1.3–0.4)	0.1 (0.8)	0.0 (−1.1–1.3)	0.180
1 week post	8.2 (1.9)	9.1 (5.3–10.1)	10.2 (4.4)	10.1 (5.7–18.0)	
Changes (1 week post)	−1.0 (1.1)	−0.75 (−3–−0.1)	0.6 (0.8)	0.6 (−0.3–1.6)	0.041
2 weeks post	8.1 (1.8)	8.0 (5.2–10.5)	9.2 (4.1)	8.8 (5.5–16.9)	
Changes (2 weeks post)	−1.2 (1.1)	−1.1 (−2.9–0.1)	−0.3 (0.6)	−0.2 (−1.3–0.3)	0.093

[a]Statistical analysis was applied to the change score; p-value revealed by Mann–Whitney U-test.
WBV, whole-body vibration; TUG, Timed Get Up and Go Test.

Discussion

Compared with placebo, whole-body vibration showed advantages in terms of the Sensory Organization Test and the Timed Get Up and Go Test at each time point of measurement after the application. The effects of the whole-body vibration were already evident after 15 min and lasted for up to two weeks. The effects were strongest in the examination one week after the intervention, where significant differences ($p = 0.041$) were found for the Timed Get Up and Go Test and a tendency for improvement was found for the posturographic examination ($p = 0.065$). Including more patients in this study might lead to statistically significant differences in this parameter. A limitation of this study certainly is the sample size. Furthermore it must be considered that the patients had only mild to moderate disability. The follow-up period was relatively short (two weeks), and the whole-body vibration was only applied once for a short time of 9 min. A point of criticism could be that a TENS application is not the ideal placebo application, since TENS may enhance sensorimotor recovery in neurological patients.[24]

The maintenance of postural stability depends on a continuous information flow of the visual, vestibular and proprioceptive system, which is part of the sensory system, and on a continuous

Table 4 Sequential changes of the results of the Functional Reach Test after treatment with whole-body vibration or placebo; data are given in absolute values at each time point of assessment and in changes from preapplication to 15 min, one week and two weeks post intervention

Dependent variable	WBV ($n = 6$)		Placebo ($n = 6$)		p-value[a]
FRT (mm)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Preapplication	327.8 (61.9)	300 (286.7–446.7)	329.7 (72)	317.5 (226.7–430)	
15 min post	328.1 (33.2)	325.9 (290–380)	323.7 (92.6)	336.9 (183.3–436.7)	
Changes (15 min post)	0.3 (40.1)	−1.7 (−66.7–53.4)	−6.1 (33.1)	2.5 (−46.7–38.4)	1.000
1 week post	360.6 (47.2)	370 (295–418)	364.2 (83.7)	320 (300–498.3)	
Changes (1 week post)	32.8 (71.6)	37.5 (−63.4–111.6)	34.4 (42.0)	26.7 (−8.3–93.3)	0.818
2 weeks post	335.6 (48.2)	336.7 (276.7–396.7)	365 (83.8)	341.7 (276.7–520)	
Changes (2 weeks post)	7.8 (65.4)	18.4 (−66.7–90.0)	35.3 (64.5)	37.5 (−50–116.6)	0.394

[a]Statistical analysis was applied to the change score; p-value revealed by Mann–Whitney U-test.
WBV, whole-body vibration; FRT, Functional Reach Test.

Clinical messages

- Whole-body vibration may positively influence the postural control and mobility in multiple sclerosis patients with moderate disability.
- Further studies are needed to confirm the beneficial effects.

information flow from motoric centres to the muscular end organs. All this information is transmitted through myelinated connections. Multiple sclerosis is a demyelinating disease of the central nervous system and these systems are therefore frequently impaired in people with multiple sclerosis.[25] The effect on the visual system can lead to fuzzy vision and diplopia. If the vestibular system is affected it leads to vertigo and nystagmus. Lesions in the long ascending sensory tracts cause an impaired proprioception and reduced sensation for vibration.[26] Balance disorders are caused by a limited capacity to integrate visual, proprioceptive and vestibular stimuli for the determination of the body's position in space.

Balance disorders and ataxia are symptoms that are very resistant to therapy and restrict the outcome of the rehabilitation process significantly.[27] Balance disorders deteriorate the prognosis and negatively influence the transfer, the mobility and even the balance when sitting. Balance skill is one of the most important variables associated with fall risk in patients with multiple sclerosis.[28] Patients with multiple sclerosis have a higher risk of falling compared with other patient groups.[29] The management of the imbalance of equilibrium and ataxia is difficult and the medical and physical–therapeutic interventions known so far are of limited value.[2]

This is the first study examining the influence of whole-body vibration on postural stability, mobility and balance in patients with multiple sclerosis. It has been shown in several studies that various receptor types such as muscle spindles, skin and pressure receptors are sensitive to mechanical oscillating stimuli.[30,31] The oscillating vibration stimuli can lead to the following effects: (1) stimulation of the pressure receptors on the sole of foot (Merkel's receptor endings, Meissner's corpuscles, Ruffini nerve endings), (2) stimulation of proprioceptors, (3) generation of reflexes. The repetitive stimulation seems to be important as well. The consequence of this might be that a rearrangement of motor control strategies (balance control) takes place. This results in an improvement of postural stability. This could be shown in our study not only by experimental tests as posturograpy. This also was evident in a functional test, such as the Timed Get Up and Go Test.

The therapy scheme used in this study (five series of 1 min each with a break of 1 min each between the series) was adopted from a preliminary study with patients with Parkinson's disease.[12–14] The breaks between the individual series are designed to prevent rapid fatigue. In the preliminary study with Parkinson's disease patients, a positive effect on motor function appeared by using whole-body vibration 10 min after the intervention and for up to 48 h.[12] In another study short-term beneficial effects of whole-body vibration on postural control in chronic stroke patients were shown.[32] Stroke patients were subjected to one series of four consecutive repetitions of 45 s whole-body vibration with a 1-min break between the administrations. In contrast to this study where a vertical whole-body vibration was performed,[32] in our study a nonharmonious multidimensional whole-body vibration was applied in order to prevent habituation of receptors.[33] There seems to be great potential for the use of mechanical oscillating stimuli in the field of neuromuscular rehabilitation, especially because it circumvents the difficulties associated with the arbitrary initiation of movement. Even though the mechanisms of the effects are not fully clarified, this method could offer new approaches in the rehabilitation of neurological diseases und neuromuscular disturbances.

The posturographic parameters have been found to be able to detect generic failures of the postural control system. Posturography has gained wide acceptance as a method of measuring postural control and a good reproducibility has been determined.[18,29,34,35] The method can therefore be used to measure the effects of therapeutic interventions and rehabilitation methods.[18] The Timed Get Up and Go Test correlates with gait speed,

balance and movement of the lower extremities.[22] The Functional Reach Test is a simple measurement of standing balance and integrates an everyday task of living (reaching forward to grab something).[23]

This study was conceived as a pilot study. Future examinations should be carried out with a larger sample size, should test more frequent applications of whole-body vibration, and should investigate its mechanism in multiple sclerosis patients.

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