No effects of whole-body vibration training on muscle strength and gait performance in persons with late effects of polio: a pilot study

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Running head: Whole-Body Vibration in persons with post-polio

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ABSTRACT

Objective: To evaluate the feasibility and possible effects of whole-body vibration (WBV) training on muscle strength and gait performance in persons with late effects of polio.

Design: A case controlled pilot study with assessments pre- and post-training.

Setting: A university hospital rehabilitation department.

Participants: Five persons (3 men and 2 women; mean age 64 ± 6.7 years, range 55-71 years) with clinically and electrophysiologically verified late effects of polio.

Interventions: All persons underwent 10 sessions of supervised WBV training (standing with knees flexed 40-55 degrees, up to 60 seconds per repetition and 10 repetitions per session, twice weekly during five weeks).

Main Outcome Measures: Isokinetic and isometric knee muscle strength (Biodex dynamometer) and gait performance (Timed “Up & Go”, Comfortable Gait Speed, Fast Gait Speed and 6-Minute Walk tests).

Results: All persons completed the five weeks of WBV training, with no discernible discomfort. No significant changes in knee muscle strength or gait performance were found after the WBV training period.

Conclusion: This pilot study did not show any significant improvements in knee muscle strength and gait performance following a standard protocol of WBV training. Thus, the results do not lend support to WBV training for persons with late effects of polio.

Key-words: Gait; Muscle; Skeletal; Postpoliomyelitis Syndrome; Vibration; Walking

Abstract 191 words

LIST OF ABBREVIATIONS

CGS = Comfortable Gait Speed

FGS = Fast Gait Speed

ICC = Intraclass Correlation Coefficient

MVC = Maximal Voluntary Contraction

Nm = Newton Meter

SEM = Standard Error of Measurement

TUG = Timed “Up & Go” test

WBV = Whole-body Vibration

6MW = 6-Minute Walk

INTRODUCTION

Whole-body vibration (WBV) has become a popular form of training and is promoted as an efficient alternative to resistance training, especially for elderly people and persons with various impairments. WBV training is performed by standing on a vibrating platform in a static position or by doing dynamic movements at the same time. The vibrations are supposed to initiate muscle contractions by stimulating the muscle spindles and the alpha motor neurons and thereby have an effect similar to that of resistance training. Several studies have evaluated the effects of WBV training in healthy subjects, with a variety of results. Positive effects are reported in some studies, for example increased muscle strength in untrained females,[1] and improved balance, muscle strength or gait performance in the elderly,[2-4] whereas others have reported no or insufficient effects after several weeks of WBV training.[5-8] Few studies have investigated the effects of WBV in persons with neurological disorders. Increased voluntary muscle activation has been reported after just one session of WBV in patients with stroke.[9] Several weeks of WBV training improved muscle strength in adults with cerebral palsy[10] and balance in patients with stroke[11] and Parkinson's disease.[12] However, some studies did not find WBV training to be more efficient than traditional interventions.[10, 11] Moreover, very few studies have determined if an effect on muscle function following WBV training has any functional effect, such as improved gait performance, in persons with neurological disorders.

Despite the very limited evidence of its efficacy, many private gyms and public health care facilities use the equipment in their health promotion programs and rehabilitation interventions. As clinicians, we are frequently asked by patients with various neurological disabilities about the feasibility and effects of WBV training. However, the lack of evidence means that we cannot give any recommendations about this form of training. Studies of different populations with neurological disabilities are therefore urgently needed.

Persons who acquired polio in their childhood often experience new symptoms later in life, one very common being muscle weakness, which in turn is associated with ambulation difficulties. Studies have shown that resistance training can increase both their strength and endurance,[13, 14] indicating the capacity to improve muscular performance following training. Other interventions that can increase muscle strength and improve ambulation would therefore be of value. The aim of this study was to evaluate if WBV training is feasible for persons with late effects of polio, if it has any effect on muscle strength and if this can lead to improved gait performance.

METHODS

Participants

Five persons (3 men and 2 women; mean age 64 years SD 6.7, 55-71 years) were recruited from the Department of Rehabilitation Medicine, Skåne University Hospital, Sweden. All five met the criteria of postpoliomyelitis syndrome,[15] and based on the National Rehabilitation Hospital (NRH) Post-Polio Limb Classification,[16] all individuals had post-polio class III or IV (i.e., clinically stable or clinically unstable polio) in their lower limbs. For each individual, one lower limb was defined as the “more affected” and the other as the “less affected”. Inclusion criteria were: ability to walk at least 300 m with an assistive and/or orthotic device and not engaged in any heavy resistance training. Exclusion criteria were: epilepsy, cardiac disease or cardiac pace-maker, osteoarthritis in the lower limbs, knee or hip joint replacement or thrombosis in the lower limbs in the past six months. Prior to inclusion, information about the study was given and each participant gave their written informed consent to participate.

Whole-body vibration training

All participants underwent 10 sessions of WBV training (twice weekly during five weeks) on a vibrating platform (Xrsize[a], Sweden; vertical vibrations, frequency 25 Hz and amplitude 3.75 mm). The participants were standing on the platform in a static position with handhold support and the knees flexed 40-55 degrees. During the five weeks of WBV training, the time increased from 40 to 60 seconds per repetition and the number of repetitions from 4 to 10 (one minute rest between each repetition). Each session lasted no more than 30 minutes and was supervised by a physiotherapist.

Assessments

Isokinetic and isometric knee muscle strength, and gait performance were assessed before and after training. Muscle strength was measured with a Biodex Multi-Joint System 3 PRO dynamometer[b], following a standardized protocol.[17] Each participant performed three maximal isokinetic extensor and flexor contractions at 60°/s with the less affected lower limb, and the highest peak torques were recorded (Newton meter; Nm). After a 2-minutes rest, two maximal isometric knee extensor muscle contractions were performed with a knee flexion angle at 90°, and the highest maximal voluntary contraction (MVC) was recorded (Nm). The same procedure was thereafter repeated with the more affected lower limb.

Gait performance was assessed with the Timed “Up & Go” (TUG),[18] the Comfortable and Fast Gait Speed tests (CGS and FGS)[19] and the 6-Minute Walk test (6MW),

[20] following a standardized protocol.[21] The TUG was carried out twice, with one minute between each trial, and the CGS and FGS were performed three times with 30 sec between each trial. For the TUG, CGS and FGS, the mean values (sec) of the two or three trials were calculated. The 6MW was performed once and the distance (metres) was recorded.

In two studies, we have assessed the reliability of measurements of knee muscle strength[17] and gait performance[21] and concluded that they are reliable for persons with late effects of polio and can be used to detect changes following an intervention. The test-retest agreements for both measurements were high, ($ICC_{1,1}$ 0.87 to 0.99), measurement errors generally small and the percentage value of standard error of measurement (SEM%), representing the limit for the smallest change that indicates a real change for a group of individuals, was 4% to 14% for muscle strength, and 4% to 7% for gait performance.

Statistics

For each individual, we calculated the mean relative difference before and after WBV training: the difference between post- and pre-treatment values/the pre-treatment value x 100. To test for a significant difference before and after training, the raw data were analysed with the paired sample *t*-test. Exact significance levels are reported for values below 10%; significance levels less than 5% are considered to represent statistical significance. The SPSS[c] 16.0 was used throughout.

RESULTS

All participants completed the 10 sessions of WBV training, with no discernible discomfort. Two participants reported transient muscle soreness in the lower limb after a few of the sessions and one participant reported a positive feeling of increased short-term flexibility in the gastrocnemius muscles. There was no statistically significant difference in isokinetic or isometric knee muscle strength, or in gait performance after the five weeks of WBV training (Table 1).

DISCUSSION

This pilot-study is, to the best of our knowledge, the first that has evaluated the effects of WBV training in persons with late effects of polio. The five weeks of training was well tolerated but did not improve knee muscle strength and had no effect on gait performance.

Resistance training has been found to increase muscle strength in persons with late effects of polio, indicating that people with residual symptoms following polio can improve their muscle function with strength training.[13, 14] The five individuals in the present study were all moderately affected in their lower limbs and ambulatory, and not engaged in any resistance training, and could therefore have responded to conventional training. Thus, the lack of significant effect on muscle strength for these five persons, in agreement with studies on healthy subjects,[6, 7] may represent a genuine non-response to WBV training in this population.

Only one of the gait performance tests – CGS – improved to a degree that it nearly approached significance (cf. Table 1). Data from a recent reliability study suggest that the smallest change that indicates a real change (i.e., improvement) for a group of individuals with late effects of polio is over 7.2%.[21] Thus, it is possible that the improvement of 7.8% of CGS in the present study represents a real change and might have some functional benefit, even if it was not significant. Improved gait performance after WBV has been reported in elderly people.[4] However, in patients with Parkinson's disease, WBV training did not have a greater effect on gait performance than conventional physiotherapy.[12] Furthermore, in adults with cerebral palsy, no improvements in TUG and 6MW after eight weeks of WBV have been reported.[10] Thus, WBV training studies of populations with neurological disabilities have not shown any noticeable effects on gait performance. Whether this indicates that neurological disabilities do not respond to WBV training is too early to definitely conclude, but available data are not convincing with regard to improved ambulation.

Limitations

The duration and intensity of the WBV training in this study was similar to that in another WBV study.[7] It was decided after recommendations from a person with extensive experience of WBV training in the field of rehabilitation; training twice weekly is also a common frequency at private gyms and public health care facilities. However, it is not clear exactly how WBV training should be performed with regard to the number of sessions per week, duration of training session, number of repetitions, frequency and amplitude. It is therefore possible that the training in the present study was not intense or long enough to lead to significant improvements. However, this form of training is somewhat controversial with a general lack of effects, in particular in various neurological and neuromuscular disorders. A plausible explanation to the non-significant effect is that WBV training does not have any effect in individuals with late effects of polio. To provide more definitive guidelines about the clinical use of WBV training, further randomised controlled trials would be needed.

CONCLUSION

This pilot study did not show any improvements in knee muscle strength and gait performance following two sessions of WBV training per week over five weeks, and do not lend support to the use of WBV training for persons with late effects of polio.

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Suppliers

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[b]Biodex Medical Systems Inc, 20 Ramsey Rd, Shirley, NY 11967-0702.

[c]SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606

Table 1. Knee muscle strength and gait performance before and after whole-body vibration (WBV) training in the five participants with late effects of polio.

	Before WBV Mean (SD)	After WBV Mean (SD)	Mean relative difference (%)	Significance test
Muscle strength measurements				
Isokinetic knee extension (60º/s; Nm)				
Less affected lower limb	125 (43)	123 (46)	–1.6	NS
More affected lower limb	54 (35)	56 (39)	+3.7	NS
Isokinetic knee flexion (60º/s; Nm)				
Less affected lower limb	64 (32)	66 (37)	+3.1	NS
More affected lower limb	26 (21)	24 (20)	–7.7	NS
Isometric knee extension (MVC; Nm)				
Less affected lower limb	141 (55)	144 (59)	+2.1	NS
More affected lower limb	58 (40)	58 (42)	0	NS
Gait performance tests				
TUG (sec)	11.0 (2.0)	10.9 (1.9)	–0.9	NS
CGS (sec)	10.2 (2.6)	9.4 (2.1)	–7.8	0.07
FGS (sec)	7.2 (1.9)	7.1 (1.7)	–1.4	NS
6MW (m)	422 (105)	417 (92)	–1.2	NS

Nm=Newton metres; MVC=Maximal voluntary contraction; TUG=Timed "Up & Go"; CGS=Comfortable Gait Speed (10 m); FGS=Fast Gait Speed (10 m); 6MW=6-Minute Walk. NS= No statistical significance.
NB. A negative difference for TUG, CGS and FGS means improvement (i.e., a shorter time) whereas an improvement in 6MW is denoted by a positive difference (ie., a longer distance).