Vibration therapy

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CONFLICTS OF INTEREST

The author declares no conflicts of interest.

Whole-body vibration training is a method for muscle strengthening that is increasingly used in a variety of clinical situations. Key descriptors of vibration devices include the frequency, the amplitude, and the direction of the vibration movement. In a typical vibration session, the user stands on the device in a static position or performs dynamic movements. Most authors hypothesize that vibrations stimulate muscle spindles and alpha-motoneurons, which initiate a muscle contraction. An immediate effect of a non-exhausting vibration session is an increase in muscle power. Most studies of the longer term use of vibration treatment in various disorders have pursued three therapeutic aims: increasing muscle strength, improving balance, and increasing bone mass. In a small pilot trial in children we noted improvements in standing function, lumbar spine bone mineral density, tibial bone mass, and calf muscle cross-sectional area.

One factor contributing to impaired walking ability in cerebral palsy (CP) is muscle weakness.[1] Muscle weakness, in turn, is commonly associated with abnormal bone development, leading to increased susceptibility to fractures.[2] A recent task force of experts in the field of CP identified the prevention and treatment of secondary conditions such as muscle weakness and bone fragility as critical areas of future research on CP.[3] Muscle strengthening therefore might be useful for improving both motor function and bone development in CP. A method for muscle strengthening that is increasingly used in a variety of clinical situations is whole-body vibration (WBV) training. This article briefly summarizes what is currently known about the medical use of WBV.

VIBRATION: WHAT IS IT?

The recent years have seen a rising interest in the use of vibration platforms for achieving therapeutic or physical performance goals. Many devices are currently marketed for use in fitness or healthcare environments. Scientific data tend to be sparse on most of them, but many studies are under way.

There are large differences between the types of vibrations that these devices generate. Key descriptors of vibration devices include the frequency (measured in Hz; the number of Hz indicates the number of complete up-and-down movement cycles per second) and amplitude (measured in mm) of the vibration, as well as the direction of the vibration movement.[4] The frequency of vibration devices typically ranges from a few Hz to 50Hz, with amplitudes ranging from a few micrometers to several millimeters. The force produced by the vibrating plate, and thus the 'intensity' of the treatment, increases with the frequency and the amplitude of the vibration.

In most devices, the plate moves parallel to the ground. This means that both the patient's feet move up and down at the same time. On at least one device, the vibration platform oscillates around a pivot in the center of the platform. This exposes the patient to a side-alternating vibration pattern (i.e. the right foot is moving upward while the left foot is moving downward, and vice versa).

HOW IS THE VIBRATION DEVICE USED?

In a typical vibration session, the user stands on the device in a static position or performs dynamic movements. Studies about vibration treatment have used a wide range of protocols. In most cases, vibration sessions consist of several bouts of vibration exposure (each lasting from less than a minute to several minutes) that are separated by rest periods. The entire session thus takes from 5 to 20 minutes. The frequency of vibration sessions ranges from twice per day to once per week. The number of vibration sessions is probably dictated by the study setting (e.g. in-patient, outpatient, or home-based settings) rather than by

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considerations of treatment efficacy. In the various studies, the entire duration of the vibration treatment has ranged from a few weeks to 1 year. Given the wide range of devices, settings, and treatment protocols that are used under the banner of 'vibration treatment,' it is not surprising that published results on WBV are inconsistent among studies.

ACUTE EFFECTS OF VIBRATION THERAPY

The exact mode of action of vibration therapy is a matter of controversy.[5] Most authors hypothesize that vibrations stimulate muscle spindles and alpha-motoneurons, which initiate a muscle contraction.[6] Electromyographic activity increases during WBV.

Vibration therapy might be seen as a form of muscle training that is largely independent of the motivation of the patient.[7] Oxygen consumption increases during a vibration session; the higher the vibration, the greater the oxygen consumption. Muscle temperature[8] and skin blood flow[9] both increase during therapy. The latter effect sometimes becomes visible as an erythema in the lower extremities immediately following a vibration session, especially in new users.[7] An immediate effect of a non-exhausting vibration session is an increase in muscle power. In healthy participants this can result in an increase in jumping height. WBV also has endocrine effects. In elderly males and females, an acute increase in the circulating levels of insulin-like growth factor 1 and cortisol was observed.[10]

LONG-TERM EFFECTS

The acute effects of vibration treatment have been of interest mainly to physiologists and sport scientists; in the clinical context, by contrast, vibration therapy is usually given to achieve longer-term goals. Most studies of the therapeutic use of vibration treatment in various disorders have pursued three therapeutic aims: increasing muscle strength, improving balance, and increasing bone mass.

In young, immobilized volunteers, vibration treatment decreases the amount of muscle and bone atrophy that occurs during the immobilization period.[11] A number of randomized controlled trials have shown improved muscle performance and balance after vibration treatment in elderly but generally healthy people.[12–18] Probably as a result, the frequency of falls decreases.[18] In similar populations, WBV has been associated with an increase in hip bone mineral density.[13,15]

WBV studies on patients with specific neurological disorders have produced mixed results. In one study on the postacute phase of stroke, WBV was no more effective in the recovery of balance and activities of daily living than was the same amount of traditional exercise.[19] In patients with Parkinson's disease, WBV had much the same effect on balance and gait as conventional balance training does.[20] However, a positive effect was reported on postural control and mobility in multiple sclerosis patients.[21]

USE OF VIBRATION TREATMENT IN PATIENTS WITH CP

One randomized trial has been published that examined the effects of WBV in 20 children and adolescents (age 4–19y) suffering from immobilization (secondary mostly to CP and muscular dystrophy).[22] No side effects of the treatment were noted, and bone mineral density in the tibiae increased over the 6-month study interval.

In a small pilot trial, we treated four children with CP with WBV twice per week over a 6-month period. Improvements were noted in the Gross Motor Function Measure 88 D domain (which evaluates standing function) and in lumbar spine bone mineral density. There also was an increase in the bone mass of the tibial diaphysis and of the calf muscle cross-sectional area. A randomized study in 14 adults (age 21–41y) with spastic diplegia found that 8 weeks of WBV treatment increased muscle strength, improved gross motor function, and improved spasticity in knee extensors.[23]

POTENTIAL ADVANTAGES OF ADDING WBV THERAPY TO TRADITIONAL REHABILITATION

Better efficacy. Vibration treatment could result in a faster gain of muscle function, as many more stimulation cycles are applied to the muscles than during walking. A typical WBV session includes 9 minutes of vibration exposure at a frequency of 20Hz. This applies 10 800 stimulatory impulses to the lower extremities, which corresponds to the number of impulses received during 3 hours of walking at regular speed.

Increased Safety. Because the patient stands on the platform and does not actively move the limbs, there is less opportunity for slipping, tripping, or awkward movements than when the patient is using walking aids. This should reduce the risk of therapy-related accidents.

REFERENCES

1. Damiano DL. Activity, activity, activity: rethinking our physical therapy approach to cerebral palsy. *Phys Ther* 2006; **86:** 1534–40.
2. Stevenson RD, Conaway M, Barrington JW, et al. Fracture rate in children with cerebral palsy. *Pediatr Rehabil* 2006; **9:** 396–403.
3. Fowler EG, Kolobe TH, Damiano DL, et al. Promotion of physical fitness and prevention of secondary conditions for children with cerebral palsy: section on

pediatrics research summit proceedings. *Phys Ther* 2007; **87:** 1495–510.

4. Lorenzen C, Maschette W, Koh M, Wilson C. Inconsistent use of terminology in whole body vibration exercise research. *J Sci Med Sport* 2008; (Epub ahead of print).

5. Nordlund MM, Thorstensson A. Strength training effects of whole-body vibration? *Scand J Med Sci Sports* 2007; **17:** 12–17.

6. Cardinale M, Bosco C. The use of vibration as an exercise intervention. *Exerc Sport Sci Rev* 2003; **31:** 3–7.

7. Rittweger J, Beller G, Felsenberg D. Acute physiological effects of exhaustive whole-body vibration exercise in man. *Clin Physiol* 2000; **20:** 134–42.

8. Cochrane DJ, Stannard SR, Sargeant AJ, Rittweger J. The rate of muscle temperature increase during acute whole-body vibration exercise. *Eur J Appl Physiol* 2008; **103:** 441–8.

9. Lohman EB 3rd, Petrofsky JS, Maloney-Hinds C, Betts-Schwab H, Thorpe D. The effect of whole body vibration on lower extremity skin blood flow in normal subjects. *Med Sci Monit* 2007; **13:** CR71–6.

10. Cardinale M, Soiza RL, Leiper JB, Gibson A, Primrose WR. Hormonal responses to a single session of whole body vibration exercise in elderly individuals. *Br J Sports Med* 2008; (Epub ahead of print).

11. Belavy DL, Hides JA, Wilson SJ, et al. Resistive simulated weightbearing exercise with whole body vibration reduces lumbar spine deconditioning in bed-rest. *Spine* 2008; **33:** E121–31.

12. Runge M, Rehfeld G, Resnicek E. Balance training and exercise in geriatric patients. *J Musculoskelet Neuronal Interact* 2000; **1:** 61–5.

13. Verschueren SM, Roelants M, Delecluse C, et al. Effect of 6-month whole body vibration training on hip density, muscle strength, and postural control in postmenopausal women: a randomized controlled pilot study. *J Bone Miner Res* 2004; **19:** 352–59.

14. Bruyere O, Wuidart MA, Di Palma E, et al. Controlled whole body vibration to decrease fall risk and improve health-related quality of life of nursing home residents. *Arch Phys Med Rehabil* 2005; **86:** 303–07.

15. Gusi N, Raimundo A, Leal A. Low-frequency vibratory exercise reduces the risk of bone fracture more than walking: a randomized controlled trial. *BMC Musculoskelet Disord* 2006; **7:** 92.

16. Kawanabe K, Kawashima A, Sashimoto I, et al. Effect of whole-body vibration exercise and muscle strengthening, balance, and walking exercises on walking ability in the elderly. *Keio J Med* 2007; **56:** 28–33.

17. Rees SS, Murphy AJ, Watsford ML. Effects of whole body vibration on postural steadiness in an older population. *J Sci Med Sport* 2009; **12:** 440–44.

18. Bogaerts A, Verschueren S, Delecluse C, Claessens AL, Boonen S. Effects of whole body vibration training on postural control in older individuals: a 1 year randomized controlled trial. *Gait Posture* 2007; **26:** 309–16.

19. van Nes IJ, Latour H, Schils F, et al. Long-term effects of 6-week whole-body vibration on balance recovery and activities of daily living in the postacute phase of stroke: a randomized, controlled trial. *Stroke* 2006; **37:** 2331–35.

20. 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.

21. Schuhfried O, Mittermaier C, Jovanovic T, Pieber K, Paternostro-Sluga T. Effects of whole-body vibration in patients with multiple sclerosis: a pilot study. *Clin Rehabil* 2005; **19:** 834–42.

22. Ward K, Alsop C, Caulton J, et al. Low magnitude mechanical loading is osteogenic in children with disabling conditions. *J Bone Miner Res* 2004; **19:** 360–69.

23. Ahlborg L, Andersson C, Julin P. Whole-body vibration training compared with resistance training: effect on spasticity, muscle strength and motor performance in adults with cerebral palsy. *J Rehabil Med* 2006; **38:** 302–08.