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EDITORIAL

Shake it, baby: the two-edged aspects of vibration

Searching PubMed for "vibration therapy" and "whole-body vibration" currently yields about 5,300 and 1,200 publications, respectively, which are divided into those investigating the potential physiological problems associated with vibration (so-called "vibration sickness") and those addressing the potential benefits of vibration. The medical literature, although describing the whole clinical spectrum of manifestations of vibration-related issues, usually does not get into the fundamentals of this phenomenon. In the submicroscopic world, all molecules are made of atoms, which interact with each other and form chemical bonds that must vibrate. Mechanically, imagine that atoms in molecules are round balls that are attached by a spring that can stretch back and forth and create vibration. Even in a small molecule, there are incredibly large numbers of different vibrational states, which distribute heat. That is why temperature is a measure of the intensity of molecular vibrations in the body and in any inorganic material. When molecules are heated up, the temperature of the body is raised, and all atoms vibrate and move faster. Heating may break chemical bonds when vibrations become too intense for the atoms to keep together. Walking a bit further with this mechanism, the dominant chemical force at this level is electrostatic (negative electrons from two atoms are attracted to both positive nuclei), and this electrostatic attraction forms a chemical bond between the two atoms. Because electrons always move and their position fluctuates all over space, even uncharged neutral atoms exert some electrostatic attraction forces on each other. These are the dominant forces between uncharged molecules. Without these forces, there would be no liquids or solids, no life, and no planets. In human physiology, hydrogen bonds are the most important interaction between neutral atoms already engaged in a chemical bond. Hydrogen bonds, which vibrate just like any other chemical bond, albeit about 10 times slower, may be formed between a hydrogen atom and an electronegative atom such as oxygen or nitrogen atom, which may already be part of the same molecule or may belong to two different molecules. By the end of the day, hydrogen bonds are the chief three-dimensional structure makers of large biological macromolecules, such as the DNA, and the chief builders of the active sites of enzymes.

Now that the basic facts of vibration are understood, see how these project on human health. Vibration is usually perceived as a phenomenon that induces an unpleasant feeling. If one uses an electric toothbrush, it may lead to dizziness because its vibrations activate the inner-ear sensory pathways. If one sits in front of a music system and the speakers are turned on full volume, especially the bass wavelengths, then vibrations may shake one's entire inner organs and brain. Furthermore, occupational exposure to vibration is a common cause of acute and chronic musculoskeletal pain. Excessive exposure to vibrations (ie, working with a chain saw or pneumatic machinery) can result in various ill effects involving nerves, joints, muscles, blood vessels, or connective tissues. These most common adverse effects are usually categorized as hand-arm vibration syndrome or white finger syndrome.[1,2]

Vibration is a natural phenomenon that must be defined by strict parameters: (1) amplitude (mm or cm)—the extent of vertical displacement; (2) frequency (Hz)—the number of impulses delivered per second; (3) magnitude (G)—the acceleration power/force of the movement; and (4) duration (s or min)—the duration one spends in a vibrating environment. Once these definitions are set, it is possible to estimate whether the specific vibration may be harmful. Accordingly, there are international safety standards that define the thresholds for human tolerance of vibration.[3] The whole issue is nicely presented on the Web site of the Canadian Center for Occupational Health and Safety (http://www.ccohs.ca/oshanswers/phys_agents/vibration/vibration_measure.html).

Besides the damage that vibration may cause, certain types of vibration may be beneficial. Vibration plate/platform training is used for many clinical indications: strength and power training for athletes, ligamentous knee injuries/repairs, acute back problems, osteoporosis, neuromuscular disorders, obesity (via hormonal effects), peripheral vascular disease and diabetes (to improve circulation), incontinence (via muscle strengthening), and postural instability.[4-6] This therapeutic modality is called "whole-body vibration," and the procedure involves the transmission of low mechanical signals into the body, initiating some internal reactions that promote health.

In this edition of *Menopause*, Figueroa et al[7] showed that whole-body vibration training improved systemic and leg arterial stiffness, blood pressure, and leg muscle strength in obese postmenopausal women with prehypertension or hypertension. Thus, this study was characterized by a specific participant selection, specific endpoints, and a specific exercise and vibration protocol. Note the relative complexity of the protocol: "three supervised training sessions per week separated by at least 48 hours for 6 weeks." The whole-body vibration training included leg exercises while standing on a vibration platform (Power Plate pro5 AIRdaptive; Power Plate, Northbrook, IL). Exercises consisted of unloaded dynamic and static semisquats with a 120° knee angle (considering 180° as full knee extension), wide-stand semisquats, and calf raises. The dynamic exercises were performed with slow movements at a rate of 3 seconds for both concentric and eccentric phases. The vibration intensity progressed by increasing frequency (25-40 Hz) and amplitude (1-2 mm). The duration of the sets and rest periods progressively increased (30-60 s) and decreased (60-30 s), respectively. Thus, this study may be relevant only to very strict participant and method characteristics. However, other studies on the hemodynamic or muscular consequences of vibration therapy had a gamut of different protocols. As an example, the same investigators previously recorded the effects of whole-body vibration on arterial stiffness in young men.[8] In that study, vibration was characterized as "40 Hz, 1 mm, 5.37 G." In the study by Yarar-Fisher et al,[9] the intervention was described as "30, 40, and 50 Hz synchronous-vertical whole-body vibration with an amplitude of 2 mm on three separate days, at least 1 week apart." Rittweger et al[10] tested the frequencies of 18 to 34 Hz and the amplitudes of 2.5 to 7.5 mm. Furthermore, there are many types of vibration plates that are commercialized around the world. The Web sites of some of the major relevant companies provide data on the alleged best equipment for vibration therapy: Galileo's apparatus operates in the range of 25 to 27 Hz, which is believed to be optimal in increasing muscle power (www.galileo-training.com), whereas NEMES' platform vibrates at 30 to 50 Hz, which is said to be the best for muscle strengthening (www.nemes.com), similar to the features of the PowerPlate platform (www.powerplate.usa.com).

Questions on vibration therapy comprise of safety issues, on one hand, and efficacy of treatment, on the other hand. Vibration, in general, has the potential to be a two-edged sword. One must learn how to avoid its adverse effects and to master its clinical positive qualities. Unfortunately, there is still a lack of knowledge about the exact pathophysiological basis of the beneficial effects of vibration on specific clinical case scenarios. Furthermore, there are no widely accepted treatment protocols for whole-body vibration therapies. What is known is that even a small change in the intensity, frequency, or duration of vibration may lead to significant alterations in clinical outcomes. Because the National Aeronautics and Space Administration has been studying vibration as a possible tool for reducing muscle atrophy and bone loss during astronauts' long weightless trips in space, then the future of whole-body vibration as a nonmedicinal therapeutic alternative is probably bright.

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REFERENCES

1. Krajnak K, Riley DA, Wu J, et al. Frequency-dependent effects of vibration on physiological systems: experiments with animals and other human surrogates. *Ind Health* 2012;50:343-353.
2. Heaver C, Goonetilleke KS, Ferguson H, Shiralkar S. Hand-arm vibration syndrome: a common occupational hazard in industrialized countries. *J Hand Surg Eur Vol* 2011;36:354-363.
3. Griffin MJ. Minimum health and safety requirements for workers exposed to hand-transmitted vibration and whole-body vibration in the European Union; a review. *Occup Environ Med* 2004;61:387-397.
4. Gómez-Cabello A, Ara I, González-Agüero A, Casajús JA, Vicente-Rodríguez G. Effects of training on bone mass in older adults: a systematic review. *Sports Med* 2012;42:301-325.
5. Lam FM, Lau RW, Chung RC, Pang MY. The effect of whole body vibration on balance, mobility and falls in older adults: a systematic review and meta-analysis. *Maturitas* 2012;72:206-213.
6. Sitjà-Rabert M, Rigau D, Fort Vanmeerghaeghe A, et al. Efficacy of whole body vibration exercise in older people: a systematic review. *Disabil Rehabil* 2012;34:883-893.
7. Figueroa A, Kalfon R, Madzima TA, Wong A. Whole-body vibration exercise training reduces arterial stiffness in postmenopausal women with prehypertension and hypertension. *Menopause* 2014;21:131-136.
8. Figueroa A, Vicil F, Sanchez-Gonzalez MA. Acute exercise with whole-body vibration decreases wave reflection and leg arterial stiffness. *Am J Cardiovasc Dis* 2011;1:60-67.
9. Yarar-Fisher C, Pascoe DD, Gladden LB, Quindry JC, Hudson J, Sefton J. Acute physiological effects of whole body vibration (WBV) on central hemodynamics, muscle oxygenation and oxygen consumption in individuals with chronic spinal cord injury [epub ahead of print]. *Disabil Rehabil* 2013.
10. Rittweger J, Ehrig J, Just K, et al. Oxygen uptake in whole-body vibration exercise: influence of vibration frequency, amplitude, and external load. *Int J Sports Med* 2002;23:428-432.