IBMS BoneKEy. 2011 October;8(10):438-443
http://www.bonekey-ibms.org/cgi/content/full/ibmske;8/10/438
doi: 10.1138/20110536

COMMENTARIES

Can Whole Body Vibration Training and Vitamin D Supplementation Improve the Musculoskeletal System in Institutionalized Elderly Women?

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Commentary on: Verschueren SM, Bogaerts A, Delecluse C, Claessens AL, Haentjens P, Vanderschueren D, Boonen S. The effects of whole-body vibration training and vitamin D supplementation on muscle strength, muscle mass, and bone density in institutionalized elderly women: a 6-month randomized, controlled trial. *J Bone Miner Res*. 2011 Jan;26(1):42-9.

Osteoporosis and sarcopenia have a high prevalence in older adults and increase with age (1), often with sarcopenia preceding the loss of bone (2). For this reason, low muscle strength is a risk factor for hip fracture (3). It is estimated that 25% of people under the age of 70 are sarcopenic compared to 40% aged 80 years and older (1). Furthermore, more than 40% of women and 20% of men will sustain at least one fragility fracture after the age of 50 (4). The relationship between sarcopenia and osteoporosis with aging may be the result of common etiologic factors like mechanical factors, low levels of sex hormones and insulin-like growth factor-I (IGF-I), vitamin D deficiency and inflammation (high levels of IL-6 and TNF-α). These disorders are considered to be some of the most common risk factors for falls, frailty, disability, and loss of functional independence with age.

One of the main strategies to prevent falls is to improve balance and postural sway. Several factors can account for unsteady gait including low levels of physical activity, reduced vision, high pain scores, use of an assistive device, fear of falling, and dietary deficiencies. A multidisciplinary approach to the management of fallers including exercise and balance training incorporated in a comprehensive rehabilitation program is essential to improve functional disability. Epidemiological studies suggest that only intense physical activity (walking is not enough) and adequate dietary intakes can help to reduce fracture risk. In the elderly, gym or walking tailored programs do not induce bone gain although they provide many physiologic benefits, reduce risk of disease outcomes, and trigger important psychological gains (5). In older osteopenic or osteoporotic individuals, a sportive activity can be difficult, and even dangerous to practice. The attractiveness of whole body vibration (WBV) as a means to deliver mechanical accelerations lies in its ability to be applied in a low-impact manner, which is critical for individuals with impaired mobility and attenuated muscle strength. It is still a matter of debate whether vibrations may be sensed directly by transmittance of the signal through the skeleton or whether muscle activity modulates, and perhaps amplifies, the externally applied mechanical stimulus (6).

Improvements in hip bone mineral density (BMD), muscle strength, and postural control have been reported after 6 months of WBV in 25 women aged 58-74 years as compared to 23 controls and 22 volunteers practicing resistance training (7). Following one year of vibration at low frequency and acceleration (*i.e.*, 30 Hz and 0.2 g) in 70 postmenopausal women, no differences in BMD were observed between the vibrated and control groups (8). *Post hoc* observations revealed that women with lower body weight may benefit to a greater extent than those women with higher body weight. Also, high compliance with the vibration protocol is an important factor for a beneficial response (8). Eight months of WBV (3 sessions/week; 12.6 Hz; amplitude: 3 mm) improved hip BMD and postural balance above values observed in the walking group; however, no difference in lumbar spine BMD was observed (9). Furthermore, the combined treatment of WBV and alendronate for 12 months did not alter lumbar spine BMD nor markers of bone remodeling above those levels observed in postmenopausal women administered only alendronate. However, a reduction in chronic back pain was reported with combined treatments (10). In volunteers practicing conventional training consisting of dancing aerobics, balance training, functional gymnastics, and dynamic leg-strength training on vibration plates with or without vibration twice a week, a similar bone gain at the lumbar spine was reported after 18 months, and only the training including WBV affected the number of falls significantly (11). When participants performed the WBV protocol immediately preceding resistance exercises, in an attempt to “excite” the bone cell response to the mechanical loading of muscular contraction, no BMD benefit was found after 8 months, although WBV augmented the positive effects of resistance training on muscular strength in these old women (12). Another follow-up of 8 months of twice-weekly WBV was found to reduce bone loss at the hip and spine and improve lower limb muscle function (13). Hip BMD and serum markers of bone turnover during 24 weeks of alendronate or WBV therapy in postmenopausal osteoporotic women both showed improvement while osteocalcin increased in WBV women only (14). WBV (12 Hz, 0.3 g) was tested in two groups of postmenopausal women practicing either one or three times per week. Only the 3 times per week regimen was able to reduce a marker of bone resorption (N-telopeptide X normalized to creatinine) after 8 weeks (15).

From these studies regarding bone effects of WBV in postmenopausal women, some conclusions can be drawn:

- Although the WBV protocols (*i.e.*, frequency, amplitude, duration, and type of training on the platform) summarized herein vary considerably, they were well-tolerated by participants, and no adverse side effects were reported.
- WBV in the 12-50 Hz frequency range appears to be a safe and effective mode of enhancing muscular strength in postmenopausal women. Most muscles have both fast- and slow-twitch fibers with frequency ranges of excitation of 40 to 60 Hz and 15 to 30 Hz, respectively, and are thus compatible with WBV frequencies.
- In contrast, bone benefits (prevention of age-related bone loss or bone gain) were not always reported, suggesting that bone might need longer or stronger periods of stimulation and/or a very specific type of vibratory signal.

Along with the effectiveness of appropriate mechanical stimuli, several studies have also suggested that vitamin D is effective in reducing falls in the elderly (16). Several studies, including the current work of Verschueren *et al*. (17), have observed that more than half of women with osteopenia or osteoporosis have 25(OH)D levels less than 30 ng/ml (18;19). Yet the optimal replacement dose in this population is still unknown (20). In addition to its skeletal effect, vitamin D has been shown to ameliorate muscle strength (21), which may translate into an improvement in lower extremity function (22), better reaction time, and consequently a reduction in the risk of falling (23). Vitamin D might improve muscle function through a direct effect on myocytes, which express vitamin D receptors, leading to an increase in the cross-sectional area of type IIA muscle fibers (24).

The originality of Verschueren *et al*. (17) is to combine a mild load-bearing physical and balance rehabilitation training using WBV (vibration amplitude of < 2.2 g) with calcium/vitamin D supplementation. It is also the first long-term WBV intervention trial in institutionalized women over 70 years of age. This randomized, controlled trial investigated whether WBV training provides additional musculoskeletal benefits compared to a control group who received similar calcium (1 g) and conventional (880

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IU) or high (1600 IU) vitamin D supplementation but who did not follow training regimens. Overall, 6 months of treatment significantly improved dynamic muscle strength, hip BMD, and vitamin D serum levels in all groups (*i.e.*, WBV + conventional dose, WBV + high dose, control + conventional dose, control + high dose) whereas isometric strength and muscle mass did not change. The WBV training program does not provide additional musculoskeletal benefit over vitamin D supplementation. Compared with conventional doses of vitamin D, a higher dose of 1600 IU induced 20% higher levels of circulating vitamin D but was not more efficient in enhancing either muscle mass or strength or increasing hip BMD. This indicates that there is no need to go above 800 IU/day, which allows 25(OH)D blood levels to stay within the 50-75 nmol/L range. There is no indication suggesting that circulating 25(OH)D levels higher than a particular threshold will enhance BMD. Adequate levels of calcium and vitamin D decrease bone resorption activity and downregulate bone remodeling, thus reducing endocortical resorption and preserving cortical thickness (25). There is no evidence that additional calcium or vitamin D administration can promote periosteal apposition.

For ethical reasons, it was not possible in the Verschueren *et al*. study to include a group with WBV without any calcium/vitamin D supplementation since most of the volunteers were deficient (vitamin D level < 50 nmol/l), thus impeding efforts to unravel the unique contribution of both interventions to the improvements in musculoskeletal parameters. Results obtained with calcium/vitamin D supplementation lend further support to the well-established need for such supplementation in elderly populations (26), although the difference in muscle improvements found in the present trial are milder compared to others (27). The small but significant improvements in hip BMD are also consistent with previous studies (28), and might reflect the relatively fast response of bone to vitamin D in deficient individuals.

It is likely that if a load-bearing dynamic training-by-calcium/vitamin D interaction does exist, it may be limited to situations where the dynamic loading pattern reaches a certain level that might not be achieved in the Verschueren *et al*. study where calcium/vitamin D status was moved to adequacy. The training program is based on light squat exercises while standing on a platform that generates vertical sinusoidal vibrations. For safety reasons, the intensity, volume and length of the program were lower than in other studies (7;9;29;30) and may not have allowed the optimization of the bone and muscle responses in this context. Another possible reason for not observing a significant effect in WBV-trained groups might also be the small sample size.

If WBV is beneficial in restoring muscle strength, balance, and mobility in the elderly and may potentially reduce the risk of falls and fall-related injuries, the use of WBV for therapeutic purposes is far from being standardized. Optimal modalities are undetermined and it is unknown whether a threshold in terms of frequency, amplitude, signal pattern and training rate would be applicable to all tissues and organs of the body. Decrements in bone mass, muscle strength, tissue perfusion, systemic hormones, and articular cartilage are common ailments in elderly individuals. WBV training may be an efficient and cost-effective method to globally alleviate these deteriorations. Large randomized controlled trials are needed before recommendations can be made for clinical practice. In addition to examining the efficacy of WBV for BMD, future studies should also examine other bone quality parameters as measured by high-resolution peripheral quantitative computed tomography.

Conflict of Interest: None reported.

Peer Review: This article has been peer-reviewed.

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