24th COBEM - 2017

24th ABCM International Congress of Mechanical Engineering
December 3-8, 2017, Curitiba, PR, Brazil

COBEM-2017-2865
A REVIEW ON WHOLE BODY VIBRATION FOR BONE MINERAL DENSITY INCREASE: EFFECTIVENESS POTENTIALLY MASKED

Arthur Ferreira Rezende Delfim
Federal University of Minas Gerais – UFMG
Presidente Antonio Carlos Avenue, 6627, Pampulha, Belo Horizonte – MG, Brazil. ZIP: 31270-901
Department of Mechanical Engineering Post Graduation
arthurdelfim@me.com

Marina Vieira de Faria
University Oswaldo Aranha Foundation – UniFOA
Paulo Erlei Alves Abrantes Avenue, 1325, Três Poços, Volta Redonda – Rio de Janeiro, Brazil. ZIP: 27240-560
Medical Department
marinavieirafaria@gmail.com

Eduardo Bauzer Medeiros
Jefferson Ataide Oliveira
Guilherme Henrique Godoi
Federal University of Minas Gerais – UFMG
Presidente Antonio Carlos Avenue, 6627, Pampulha, Belo Horizonte – MG, Brazil. ZIP: 31270-901
bauzer@demec.ufmg.br; jefferson2z@hotmail.com; guilhermehg@outlook.com

Abstract. *Osteoporosis worldwide growth is concerning developed countries governors especially with the elder population increase rate prediction. This is because fractures tend to generate great expenses and is directly linked to elevated mortality rate. This paper aims to evaluate the correlation between WBV (whole body vibration) techniques and bone mineral density variation, taking into account factors like: nutrition dietary intake, blood pH regulation mechanism and fracture healing period oscillation. It revealed that most important studies related to the WBV role in raising bone mineral density excluded the indispensable bone nutrition and vibration application integrated analysis. Therefore, it indicates that vibration platform potential effectiveness could be frequently being masked on all of the previous experiments, what greatly justifies further studies as a new protocol approach on osteoporosis treatment can emerge from this, composing a public health contribution that could be able to avoid many severe fractures and, consequently, deaths, especially among the elderly.*

Keywords: Whole Body Vibration, Mechanical Vibration, Osteoporosis, Health.

1. INTRODUCTION

In recent decades, osteoporotic fractures have been recognized as one of the most common causes of disability and one of the main contributors to increased health care expenditures, being associated with increased mortality, especially for vertebral and hip fractures (Shi, 2010). While vibrating platforms are safe for most individuals and potentially used for bone mineral density increase in order to diminish the negative impacts of osteoporosis, including the elderly, the American Council on Exercise warns WBV treatment is contraindicated for those with electronic implants such as pacemakers, pregnant women, and those with a history of seizures, thrombosis and/or tumors.

Whole body vibration (WBV) is an exercise that uses high frequency mechanical stimulation generated by a platform, as shown by Figure 1, and transmitted through the body to the bones in order to stimulate the sensory receptors (Fratini, 2016). The platforms used in this type of treatment vibrates in all three dimensions: vertical, horizontal and sagittal (front to back). They can generate forces from 2 to 6Gs (gravity acceleration), depending on the frequency and amplitude settings used. This means that, even at the lowest setting, the body weight is nearly doubled in terms of the forces applied. Their manufacturing companies claim that when the body is subjected to this type of vibration, each muscle reacts in a continuous flow of micro adjustments, contracting reflexively, engaging up to 98 percent of your muscle fibers, including the fast and super-fast muscle fibers. The up-and-down movement, as shown

by Figure 2, aims to improve muscle tone and increase bone mineral density by acting on osteoblasts and osteoclasts activity form. The left-to-right, and front-to-back movements aim to improve balance and coordination.

Figure 1 – Whole Body Vibration Platform (Vibration Machines, 2017)

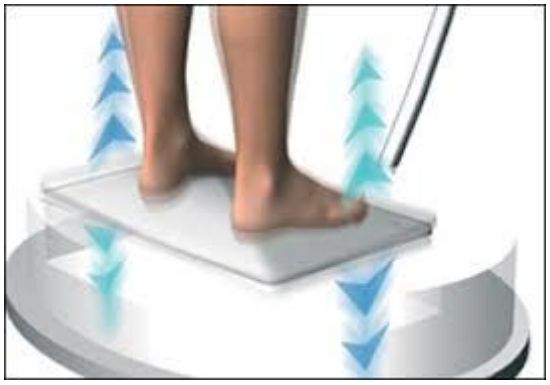

Figure 2 – Body Vibration Induction by the Platform (Science Based Medicine, 2017)

Studies have demonstrated that elderly can make significant gains in health and fitness areas using WBV, including improved physical function and quality of walking, equilibrium, pain reduction and vitality (Bruyere, 2005).

Despite the existence of many controversial studies further analyzed by this work, it can be found in literature (Fjeldstad, 2009; Frank, 2004; Lohman, 2007; Vissers, 2010) studies showing that many health benefits could be possibly acquired from whole body vibration treatments as show by Table 1.

Table 1. Healthy benefits from Whole Body Vibration Treatment found in literature (Fjeldstad, 2009; Frank, 2004; Lohman, 2007; Vissers, 2010)

Increase bone mass and mineral density, thereby decreasing risk of **osteoporosis**.	Improve in blood circulation, which can also stimulate tissue healing. Three minutes on a vibrating platform doubles mean circulation for at least 10 minutes
Increase muscle strength, especially explosive strength	Pain reduction (such as with fibromyalgia)
Increase hormone secretion: IGF-1, testosterone, and human growth hormone (HGH)	Counteract age-related muscle wasting
Increase fat loss; WBVT in conjunction with resistance training improved fat loss in menopausal women. WBVT can be 54 percent more effective than traditional aerobics and strength training in reducing visceral fat.	Reduce cellulite; 8 to 13 minutes of WBVT, two to three times per week for six months was shown to reduce cellulite by 26 percent. When combined with 24 to 48 minutes of cardio, cellulite was reduced by 32%.
Increase flexibility and mobility	Increase secretion of serotonin and norepinephrine
Improve proprioception and balance	Increase lymphatic drainage
Decrease cortisol levels	Speed up recovery from injury
Improve fitness in the elderly	Improve neurological conditions

Seniors compose a group of people who, due to physical limitations, may struggle to stay fit. The use of a vibrating platform can be quite helpful to allow strength development and mobility without engaging in more strenuous exercise routines (Cabello, 2013).

As people age, the existing bone is absorbed by the body while new bone is created to replace it. In the case of osteoporosis, the formation of new bone falls behind the rate of bone absorption, leading to thinner, more brittle bones. Weight-bearing exercises could prevent this, and help reverse the damage. Adding WBVT may further boost these results, as revealed by the bone density increase on mice due to 30 minutes of WBVT for 12 weeks (Wenger, 2016).

According to IOF (International Osteoporosis Foundation) one out of each three women worldwide over 50 years old will experience an osteoporotic fracture. The fast growth of the disease has been linked to dietary and vitamin D levels suggesting the existence of a close relationship between bone mineral density decrease and lifestyle factors such as diet and physical activity.

The negative effect of acidosis on the skeleton has been known for nearly a century, the acidifying properties of urine by food intake profile depend on its content of acids or precursors. The constituents may adversely affect calcium metabolism and accelerate bone reabsorption, thus representing an aggravating factor for osteoporosis (Buclin, 2001). Figure 3 shows the chart of pH spectrum for alkaline and acidic food distribution and reveals major acidosis on industrialized products.

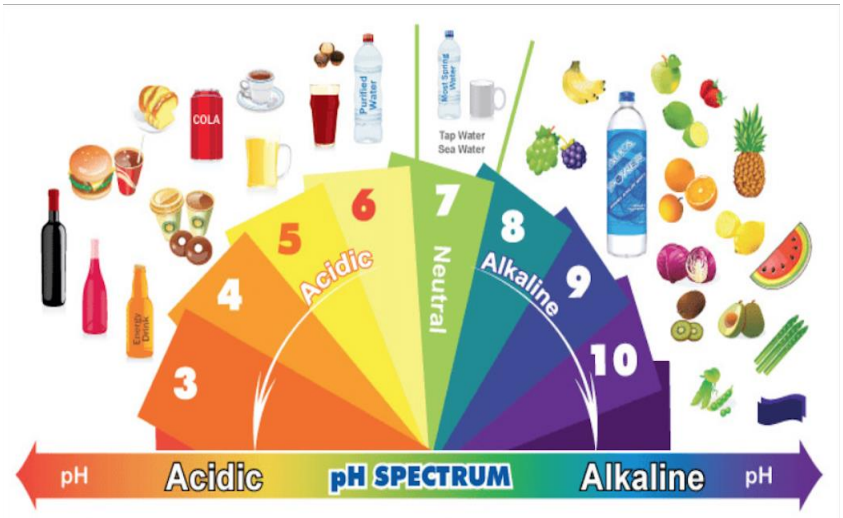

Figure 3 – Alkaline and Acidic Food Chart: the pH spectrum (MindBody, 2017)

Taken this point of view, this work aims to perform a critical analysis of previous studies related to the application of WBV to increase bone mineral density, verifying if diet and pH regulation mechanism were considered in the discussion of results, observing if high acid food intake would be able to mask the efficacy of the vibratory platforms and their statistical results.

2. METHODOLOGY

A broad bibliographic review of the vibration techniques applied to osteoporosis treatments will be carried out in detail, mainly evaluating the methodology used in each research in order to verify the existence of associations of bone mineral density increase by WBV induction on volunteers. Subjects related to the mechanism of regulation of blood pH will also be evaluated in order to corroborate the relevance of the proposed objective.

3. RESULTS AND DISCUSSION

Osteoporosis is known for its high risks of bone fractures increase, especially among the elderly, which can lead to long rest periods and promote even greater rates of bone loss due to muscle atrophy. However, recent studies (Rittweger *et al*., 2010; Cabello *et al*., 2013; Cabello *et al*., 2014; Lau, 2010; Yang *et al*., 2015; Sherk *et al*., 2013; Shi *et al*., 2010) tend to show good results in methods of resistive vibration exercise (RVE) that could prevent bone loss due to long period resting and the low-intensity high-frequency vibration (LMHFV) technique has been proving to promote bone healing acceleration.

Shi, *et al*., (2010) conducted a study to explore whether the application of Low Modulated High Frequency Vibration (LMHFV) - which consists of the application of low amplitude and high frequency vibration - was able to promote the healing of fractures in osteoporotic bone, increasing callus formation, remodeling and bone mineralization when compared to healthy bones of similar age. Rats with induced osteoporosis nine months old were distributed

between control group or subjected to vibration group. LMHFV (35 Hz, 0.3 g) was administered 20 min daily and 5 days per week to the treatment groups. Weekly radiographs with computed tomography and mechanical properties were evaluated 2, 4 and 8 weeks after treatment. The results confirmed that fracture healing in the control group was significantly lower than in the treated group. LMHFV showed to be effective in promoting fracture healing in all measured parameters, particularly in the early stages of healing, with results comparable to normal fracture healing at the corresponding age. Callus formation, mineralization and remodeling were increased by 25-30%, with a 70% increase in probability of failure for the control group.

In a Spanish study, seniors over the age of 65 performed 10 squats, held for 45 seconds on the vibrating platform, three times per week for 11 weeks. Compared to those who did the identical exercise on a stationary surface, the WBV group improved their fitness in a number of ways. After 11 weeks, they were able to perform two additional reps of upper and lower body strength exercises, had half an inch greater lower body flexibility, and improved their walking speed (Cabello, 2013).

Another six-month-long study found WBVT helped increase hip area bone density in postmenopausal women, while conventional training only slowed the rate of deterioration (Sabine, 2003). The women, aged 58 to 70 years old, did either static and dynamic exercises for the upper leg and hip area using WBV, up to 30 minutes a day, three times a week, or 60 minutes of conventional weight training, three times per week. According to the researchers, WBVT can be a helpful adjunct therapy to reverse bone loss and osteoporosis, increasing leg strength by as much as 16 percent, and bone density in the hip by 1.5 percent.

Rittweger, *et al*., (2010) examined twenty healthy male volunteers submitted to horizontal bed rest for 56 days and were randomly assigned to a group that performed RVE 11 times per week or to a group with only bed rest control. Bone mineral content was assessed by peripheral quantitative computed tomography in the tibia and by dual X-ray absorptiometry in the hip and lumbar spine at the beginning of the tests and at regular intervals during the 12-month follow-up. The results showed that RVE protected muscle size and function, in addition to preventing bone loss, which were larger in the distal epiphysis of the tibia, where bone mineral content decreased from 421.8mg/mm to 406.6mg/mm for the control group, but only from 411.1mg/mm to 409.6mg/mm in RVE. Therefore, it tends to behave as an effective measure to prevent bone loss, especially from the tibia.

In order to clarify whether a short-term whole-body vibration training has a beneficial effect on the mass and bone structure of elderly men and women, a total of 49 elderly (20 males and 29 females) were analyzed. Participants who met the inclusion criteria were randomly assigned to one of the study groups (whole body vibration or control). A total of 24 seniors trained squatting on a vibration pad 3 times a week for 11 weeks. The variables related to bone health were evaluated by dual energy X-ray absorptiometry and peripheral quantitative computed tomography. The conclusion of the study indicates that short-term whole-body vibratory therapy is not sufficient to cause any change in bone mineral content or bone mineral density and only produces a slight variation in the bone structure among the elderly (Cabello, *et al*., 2014). However, once again, the problem is that the ineffectiveness of the WBV exercise may be related to the variation of the food intake of the volunteers. No dietary control was performed and this relationship was not even mentioned in previous studies. This could explain why the WBV exercise program worked slightly for only a portion of the elderly group. They focused on the statistical analysis of covariance data, when the body of the volunteers could be compromised body pH regulation system, able to limit or prevent the increase in bone mineral density.

Sherk, *et al*., (2013) examined the responses of bone recovery markers to the exercise of high intensity acute resistance with WBV applied in young women taking oral contraceptives in a randomized crossover design. They were exposed to 5 one-minute vibration intervals (20 Hz, peak-peak shift of 3.38, separated by 1 min rest) before exercise. Fasting blood samples were obtained before and immediately after WBV. Variation of the menstrual phase, circadian rhythm, pre-exercise food intake and the evolution of physical activity were controlled in this study. The results demonstrate that the mechanical signal of WBV by its own is able to stimulate responses in the markers of bone reabsorption. Although control of pre-exercise food intake has been performed, it is assumed that they cannot guarantee food standardization or ensure the food energy balance of the volunteers, what severely hampers the establishment of the link between bone health and markers of acidosis in diets.

The mechanism responsible for the increase in markers of bone reabsorption may be related to the evidence that cells called osteocytes respond to low-magnitude and high-frequency vibration. This results in a significant reduction in the formation and activity of osteoclasts and kappa-B nuclear receptor, what begins to occur only 30 minutes after the vibration stimulus, stopping both activities that are harmful to bone health because they act decisively in the reabsorption processes that lead to a decrease in bone mass (Lau, 2010).

Yang, *et al*., (2015) examined the effects of an eight week controlled whole-body vibration training on reducing the risk of falls among adults in a community. Eighteen healthy older adults received vibration training through a vibrating platform alternately and intermittently: five repetitions of 1 minute of vibration followed by a rest of 1 minute. The frequency and amplitude of vibration were 20Hz and 3.0mm, respectively. The same training was repeated 3 times a week and lasted 8 weeks for a total of 24 training sessions, assessing the risk of falls among all participants in terms of body balance, functional mobility, muscle strength, bone density, range of motion in the joints of the lower limbs, level of cutaneous sensation of the foot and fear of falling. The results revealed that the training was able to decrease all fall risk factors and could significantly increase the range of motion of the ankle joints in the sagittal plane (6.4° at pre-

training evaluation versus 9.6° at post-training evaluation for dorsiflexion and 45.8° against 51.9° for plantar flexion); and reduced the overall fear of falls.

Marconi, *et al*., (2016) conducted a comprehensive literature review about the relevance of whole body vibration (WBV) in reducing the number of fractures in women with osteoporosis. There was a positive effect of this exercise in patients with risk factors, based on protocols generally performed two to three times a week, from 6 to 18 months, for frequencies in the range of 12.6Hz to 40Hz. The authors concluded that WBV could be a viable and effective way to modify risk factors for falls and fractures, with improvements in some aspects of neuromuscular function and balance. However, the criteria in the survey did not include any association between the dietary pattern and osteoporosis, or the possibility of the outcome being masked by many other factors that can promote the osteoporotic disease and diminish the treatment positive effects.

Many factors of health improvements have been found in the literature through the use of WBV exercises. These include: bone formation, prevention of sarcopenia and osteoporosis (Cardinali, 2003); increase in muscle strength and power that can lead to better neuromuscular and cognitive functions (Verschueren, 2004). In the case of patients with osteoporosis, the findings could reduce the risk of falls and fractures (Gusi, 2006). The WBV exercise proved to be of great importance in postmenopausal women in relation to fractures (Stengel, 2011).

Beck, *et al*., (2010) states that WBV exercise can be a viable and effective way to modify well-known risk factors for falls and fractures in older women and to improve the main determinants of bone fractures. In patients who already have fractures, it indicates a possible reduction in healing time, since by rats experiments positive effects of the genes at the cellular level as well as callus formation were demonstrated (Chow, 2016).

To test the relationship of acidosis to the blockage of bone formation, its effects were investigated on the cellular process of bone formation using cultures of primary bone-forming mineralized osteoblasts. The pH was manipulated by the addition of 5 to 30mmol/L of HCl (chloric acid) and monitored by a blood analyzer. Abundant matrix-containing mineralized nodules were formed in cultures of osteoblasts at pH 7.4, but acidification progressively reduced bone nodule mineralization, with complete abolition at pH 6.9. The alkaline phosphatase activity of osteoblasts, which reached a strongly close 7.4 pH peak, was reduced eight-fold at pH 6.9. Reducing pH to 6.9 also inhibited messenger ribonucleic acid (mRNA) for alkaline phosphatase, but stimulated the mRNA to matrix Gla protein, a mineralization inhibitor. The same pH reduction is associated with increases of two and four times in the solubility of Ca(+2) (ionized calcium) and PO4(-3) (phosphoric oxide), respectively. The results of the study confirmed that acidosis exerts a selective, inhibitory action on the bone mineralization matrix, which is reciprocal with the activation response of osteoclasts (Burch, *et al*., 2005).

Susan, *et al*., (1997) suggested that nutrient intake of potassium, magnesium, vitamin C, fiber and zinc was associated with increased bone mass and that a high fruit intake had a positive effect on adults. The results of this study indicate that high long-term intakes of these nutrients from fruits and vegetables may be important for bone health, possibly because of their beneficial effect on acid-base balance.

Calvo, *et al*., (2013) report that the excessive ingestion of phosphorus disrupts the hormonal regulation of phosphorus (P), calcium (Ca) and vitamin D, contributing to a decrease in bone mass, leading to worse capacity of bone reabsorption and greater risk of fracture. This work has shown that there is evidence that phosphorus added to food products may be contributing to the burden of osteoporosis in the population. It also showed the lack of information provided by large companies in the food supply chain, since the databases provided do not contain up-to-date and complete information on the extent of the added phosphorus compounds. Animal and human studies suggest that the ratio of calcium intake to phosphorus is important for the bone state, even when calcium intake is basically adequate relative to recommended values. A common and even more dangerous example for bone health and fracture occurrence is cola-based drinks because beside the fact of being sources of added phosphorus, they do not have any associated nutrients normally found in pure food sources, what categorizes them as "empty calories".

Gartland, *et al*., (2003) conducted a large observational study to examine the relationship between carbonated soft drinks (CSD) and bone mineral density (BMD) in a sample of 1335 teenagers from 36 different primary schools in Northern Ireland. Participants included 591 boys and 744 girls aged 12 to 15 years. BMD was measured and usual drink consumption was assessed by dietary history using an adjusted regression model to investigate the influence of CSD on BMD. The results showed a significant inverse relationship between total intake of CSD and BMD being dominant, mainly for girls' heels. However, there were no consistent relationships between CSD intake and BMD in boys.

Susan, *et al*., (2000) conducted a study on 62 healthy women aged 45 to 55 years. Bone mineral density (BMD) was measured by dual energy X-ray absorptiometry in the lumbar spine and femoral neck, and quantitative computed tomography in the root, trabecular and cortical regions were evaluated. Bone reabsorption was calculated by measuring the urinary excretion of pyridinoline and deoxypyridinoline and bone formation was calculated. Nutrient intake was assessed using a food frequency questionnaire, and the results showed that higher intakes of magnesium, potassium and alcohol were associated with higher total bone mass. BMD of the femoral neck was higher in women who consumed high amounts of fruit in childhood than in women who consumed medium or low amounts. In a regression analysis with age, weight, height, menstrual status and dietary intake in the model, magnesium intake represented approximately 12.0% of the variation in bone reabsorption. Intakes of alcohol and potassium accounted for 18.1% of the variation in

total bone mass of the forearm. Therefore, the highlighted findings associating bone reabsorption with dietary factors provide additional evidence of a positive link between fruit and vegetable consumption and bone health.

From a similar point of view, Buclin, *et al*., (2001) conducted a study to investigate whether a dietary intervention specifically focused on the acidic food charge could modify calcium metabolism in humans. Eight healthy volunteers underwent a four-day metabolic preparation with two types of diets, one rich in acid-forming nutrients and the other with base-formers (including bicarbonate-rich mineral water), both with similar calcium, phosphate, sodium, protein and calories. On the fourth day, a single oral dose of 1g of calcium, in the form of carbonate, was ministered. Samples of blood and urine revealed that the diet affected blood pH and urine pH in the expected direction, but had no influence on the absorption of calcium supplement. The acid-forming diet increased urinary calcium excretion by 74% when compared to the base-forming diet, both at the baseline and after oral calcium loading; additionally the C-telopeptide excretion was increased in 19%, suggesting the skeletal origin of the eliminated calcium. Therefore, it is confirmed that renal excreted acids derived from undue food patterns, influence calcium metabolism, and that alkaline nutrients inhibit bone reabsorption.

4. CONCLUSIONS

This article promoted a review to evaluate the correlation between WBV treatment and bone mineral density. It was found that all previous studies excluded an integrated analysis with a major cause of bone fragility: high acidity diet. The results suggests that WBV therapy can be even more effective than previously thought.

The analysis of 27 related articles revealed that none of them (Buclin, *et al*., 2001; Cabello, *et al*., 2014; Calvo, *et al*., 2013; Cardinale, *et al*., 2003; Gusi, *et al*., 2006; Lau, *et al*., 2010; Sherk, *et al*., 2013; Shi, *et al*., 2010; Susan, *et al*., 1997; Yang, *et al*., 2015) performed any type of dietary control and this relationship was not even mentioned in the vast majority of them. They focused on the statistical analysis of data covariance of bone mineral density specific increase, while the volunteers could have the pH regulation system of their bodies already compromised, what is able to limit or totally prevent the increase in bone mineral density. This fact explains why some studies have found it difficult to establish a trend between WBV treatment and bone fortification, since the volunteers were possibly submitted to completely controversial diets that acted in opposite directions not allowing the success by the use of the vibration platform.

5. REFERENCES

Beck, B. R.; Norling, T. L. The effect of twice-weekly low or higher intensity whole body vibration on risk factors for postmenopausal hip fracture. Am J Phys Med Rehabil 89:997, 2010.

Bruyere, O.; Wuidart, M. A.; Di Palma, E.; Gourlay, M.; Ethgen, O.; Richy, F.; Reginster, J. Y. Controlled whole body vibration to decrease fall risk and improve health-related quality of life of nursing home residents. Arch Phys Med Rehabil. Feb;86(2):303-7, 2005.

Buclin, T.; Cosma, M.; Appenzeller, M.; Jacquet, A.; Decosterd, L. A.; Biollaz, J.; Burckhardt, P. Diet Acids and Alkalis Influence Calcium Retention in Bone. Osteoporose International 493:499, 2001.

Burch, A. B.; Utting J. C.; Orriss I. R.; Arnett T. R. Acidosis Inhibits Bone Formation by Osteoblasts In Vitro by Preventing Mineralization. Calcified Tissue International 167:174, 2005.

Cabello, A. G.; Agüero, A. G.; Ara, I.; Casajús, J. A.; Rodríguez, G. V. Effects of a short-term whole body vibration intervention on physical fitness in elderly people. DOI: http://dx.doi.org/10.1016/j.maturitas.2012.12.008, 2013.

Cabello, A. G.; Aguero, A. G.; Morales, S.; Ara, I.; Casajus, J. A.; Rodriguez, G. V. Effects of a short-term whole body vibration intervention on bone mass and structure in elderly people. Journal of Science and Medicine in Sport 160:164, 2014.

Calvo, M. S.; Tucker, K. L. Is phosphorus intake that exceeds dietary requirements a risk factor in bone health? Annals of the New York Academy of Sciences 29:35, 2013.

Cardinale, M.; Pope, M. H. The effects of whole body vibration on humans: dangerous or advantageous? Acta Physiol Hung 90:195e206, 2003.

Chow, S. K.; Leung, K. S.; Qin, J.; Guo, A.; Sun, M.; Qin, L. Mechanical stimulation enhanced estrogen receptor expression and callus formation in diaphyseal long bone fracture healing in ovariectomy-induced osteoporotic rats. Osteoporos Int 137-141, 2016.

Fjeldstad, C.; Palmer, I. J.; Bemben, M. G.; Bemben, D. A. Whole-body vibration augments resistance training effects on body composition in postmenopausal women. Doi: 10.1016/j.2009.03.013. Maturitas, 20;63(1):79-83, 2009.

Frank, H.; Moos, B. Whole Body Vibration and Reduction of Cellulite. Sanaderm Professional Clinic for Skin Disease and Allergology, 2004.

Fratini, A.; Bonci, T.; Whole Body Vibration Treatments in Postmenopausal Women Can Improve Bone Mineral Density: Results of a Stimulus Focussed Meta-Analysis. Bull AMJ PLoS ONE 11(12): e0166774, 2016.

Gartland, C. M.; Robson, P.; Murray, L.; Cran, G.; Savage, M.; Watkins, D.; Rooney, M.; Boreham C. Carbonated Soft Drink Consumption and Bone Mineral Density in Adolescence: The Northern Ireland Young Hearts Project. Journal of Bone and Mineral Research 18;1563:1569, 2003.

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 Disorders 87:92, 2006.

Lau, E.; Al-Dujaili, S.; Guenther, A. Effect of low-magnitude, high-frequency vibration on osteocytes in the regulation of osteoclasts. Bone 46:1508:1515, 2010.

Lohman, E. B.; Petrofsky, J. S.; Maloney-Hinds, C.; Betts-Schwab, H.; Thorpe, D. The effect of whole body vibration on lower extremity skin blood flow in normal subjects. Medical Science Monitor: International Medical Journal of Experimental and Clinical Research. Indexed for MEDLINE, 2007.

Marconi, E. M.; Dionello, C. F.; Morel, D. S.; Caputo, D. C.; Goncalves, C. S.; Domingos, L. L.; Aguiar, E. O. G.; Beck, B. R.; Norling, T. L. Could whole body vibration exercises influence the risk factors for fractures in women with osteoporosis? Osteoporosis and Sarcopenia 1:7, 2016.

Mindbody; Alkaline & Acidic Foods Chart: The pH Spectrum. Acessed on 10/10/2017 at <https://www.mindbodygreen.com/0-5165/Alkaline-Acidic-Foods-Chart-The-pH-Spectrum.html>

Rittweger, J.; Beller, G.; Armbrecht, G.; Mulder, E.; Buehring, B.; Gast, U.; Dimeo, F.; Schubert, H.; Haan, A.; Stegeman, D. F.; Schiessl, H.; Felsenberg, D. Prevention of bone loss during 56 days of strict bed rest by side-alternating resistive vibration exercise. Bone 137:147, 2010.

Sabine, M. P.; Verschueren P., Machteld, R.; Christophe, D.; Stephan, S.; Dirk, V.; Steven, B. Effect of 6-Month Whole Body Vibration Training on Hip Density, Muscle Strength, and Postural Control in Postmenopausal Women: A Randomized Controlled Study. DOI: 10.1359/JBMR.0301245. Journal of Bone and Mineral Research, 2003.

Science Based Medicine, accessed <https://sciencebasedmedicine.org/whole-body-vibration-therapy/> October, 2017.

Sherk, V. D.; Chrisman, C.; Smith, J.; Young, K. C.; Singh, H.; Bemben, M. G.; Bemben, D. A. Acute Bone Marker Responses to Whole-Body Vibration and Resistance Exercise in Young Women. Journal of Clinical Densitometry: Assessment of Skeletal Health vol. 16;no.1;104:109, 2013.

Shi, H.; Cheung, W.; Qin, L.; Leung, A. H.; Leung, K. Low-magnitude high-frequency vibration treatment augments fracture healing in ovariectomy-induced osteoporotic bone. Bone 1299:1305, 2010.

Susan, A. N.; Robins, S. P.; Campbell, M. K.; Martin, J. C.; Garton, M. G.; Smith, C.; Grubb, D. A.; Lee, S. J.; Reid, D. M. Dietary influences on bone mass and bone metabolism: further evidence of a positive link between fruit and vegetable consumption and bone health? Am J Clin Nutr 71:142–51, 2000.

Susan, A. N.; Smith, C. B.; Grubb, D. A.; Reid, D. M. Nutritional Influences on Bone Mineral Density: a cross-sectional study in premenopausal women. Am J Clin Nutrition 65:1831-9, 1997.

Tajeu, G. S.; Delzell, E.; Smith, W.; Arora, T.; Curtis, J.; Saag, K. G.; Morrisey, M. A.; Yun, H.; Kilgore, M. Death, Debility, and Destitution Following Hip Fracture. Journal of Gerontology 346:353, 2013.

Verschueren, S. M.; Roelants, M.; Delecluse, C.; Swinnen, S.; Vanderschueren, D.; Boonen, S. Effect of 6-month whole body vibration training on hip density, muscle strength, and postural control in post- menopausal women: a randomized controlled pilot study. J Bone Min Res 19:352e9, 2004.

Vibration Machines, accessed by <http://vibrationmachines.org/vibrofit> on October, 2017.

Vissers, D.; Verrijken, A.; Mertens, I.; Van Gils, C.; Van de Sompel, A.; Truijen, S.; Van Gaal, L. Effect of long-term whole body vibration training on visceral adipose tissue: a preliminary report. doi: 10.1159/000301785. Obesity Facts, 2010.

Von Stengel, S.; Kemmler, W.; Engelke, K.; Kalender, W. A. Effects of whole body vibration on bone mineral density and falls: results of the randomized controlled study with postmenopausal women. Osteoporos Int 22:317e25, 2011.

Wenger, K. H.; Freeman, J. D.; Fulzele, S.; Immel, D. M.; Powell, B. D.; Molitor, P.; Chao, Y. J.; Gao, H. S.; Elsalanty, M.; Hamrick, M. W.; Isales, C. M.; Yu, J. C. Effect of whole-body vibration on bone properties in aging mice. DOI: 10.1016/j.bone.2010.07.014, Oct;47(4):746-55. Bone, 2010.

Yang, F.; King, G. A.; Fillon, L.; Su, X. Controlled whole-body vibration training reduces risk of falls among community-dwelling older adults. Journal of Biomechanics 3206:3212, 2015.

6. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.