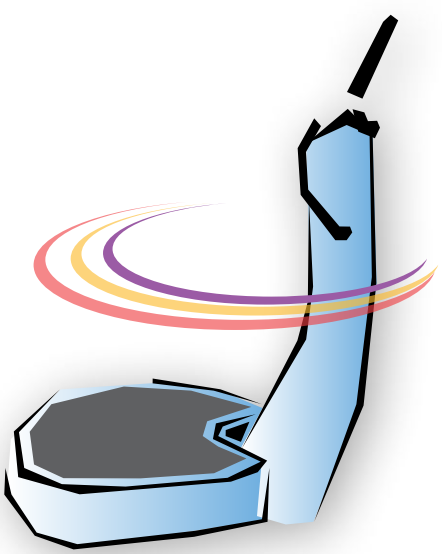
Whole body vibration,

part one: what's shakin' now?



How effective is whole body vibration as a training tool for older adults? Explore the evidence in this comprehensive review of the latest findings

by Joseph Signorile, PhD

This is the first installment of a 2-part article about whole body vibration in this year's Journal on Active Aging®. *In this issue, the author examines findings related to physical performance factors that affect successful aging. Part 2, which will be published in the November/December issue, reviews findings related to various protocols.*

Whole body vibration (WBV) has received considerable exposure as one of the new technical innovations in exercise. In my 2006 article "Whole body vibration training: a new wave in exercise intervention for older adults?" published in this journal, I reviewed the findings in the literature that examined the feasibility of using WBV as an intervention to address people's needs as they age. A good deal of research has been done since that review, and this paper is intended to bring you up to date on the latest findings. (For a more detailed explanation of whole body vibration itself, read the article mentioned above. See

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Illustration: Jacob Benaroch

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"Resources" on page 59 to learn how to access this article online.)

Perhaps one of the first questions that comes to mind when we look at this technology is why it has gained such attention. An article by Bautmans et al., who examined the feasibility of using WBV as a training intervention in institutionalized older adults, provides some insight into why we are all so interested. The researchers suggest that fatigue and lack of interest can affect the willingness of older residents in skilled nursing facilities to engage in high-intensity exercise to improve physical functioning.[1] To these obstacles, we should add other barriers that can reduce the likelihood of regular exercise among independently living older adults, such as levels of perceived exertion, time requirements, need to travel, exercise setting, and what I like to call "the environment of failure."

While perceived exertion, time requirements and the inconvenience of travel are commonly presented as impediments to activity, exercise setting and environment of failure may be less familiar to you. When considering exercise setting, many older people feel uncomfortable in surroundings filled with ominous machines and twentysomethings dressed in clingy fabrics, as an example. Environment of failure is based on the outdated and misleading attitude perpetrated by many fitness professionals that "you have to work as hard as you can every day, and if you miss a day, you'll lose everything." WBV is an exercise technique that has the potential to provide positive results while minimizing many of these obstacles (see Figure 1 below).

But just how effective is WBV as a training tool for older individuals? Before we take a look at what the research shows, let me make some things clear:

1. The topic of WBV is multidimensional. There are a number of different machines that provide vibrations in different ways. These include **vertical displacement machines** that move up and down; **triplanar machines** that provide vibrations up and down, forward and back, and side to side; and **centrally pivoting machines** that offer a seesaw, or teeter-totter, stimulus. Given the differences in these machines alone, you can expect the training protocols to vary considerably.
2. There is no miraculous remedy that can answer all the health and functionality questions as we age. The analogy I use in my book *Bending the Aging Curve* is that of a diamond (see Figure 2 on page 50). Just as the many facets of a diamond must be properly cut and polished to bring it "life," so independence and safety in our later years depend on many factors. This article will look at the impact of WBV on the many physical performance factors that affect successful aging.
3. Research offers no absolutes. I will present (to the best of my ability) an unbiased view of the results of controlled studies. For some factors, the conclusions may be clearer than for others. This may be due to conflicting results, different training or testing methods, or limited research in a particular area. In addition, some papers may be of greater or lesser importance due to study design, statistical methodology and other factors commonly considered when evaluating a research study.

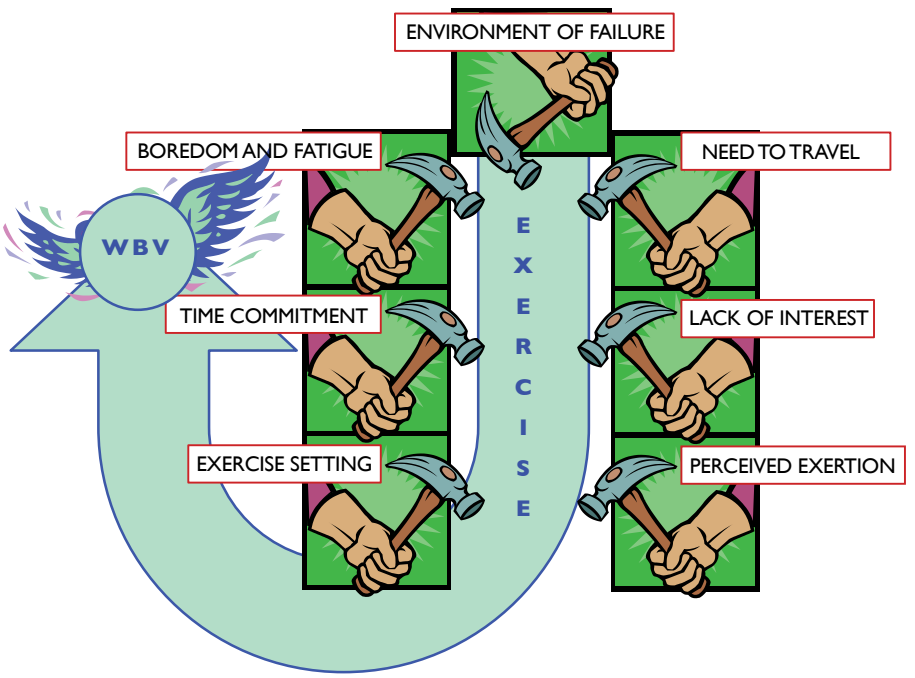

Figure 1. Obstacles to exercise: Is whole body vibration an answer?

I invite you to read this review with an inquisitive eye and critical mind and make your own decisions.

Strength and power

A number of recent studies have examined the effects of a single bout of WBV and WBV training programs on strength and power in older individuals. In an article examining the effects of combining triplanar WBV and high-intensity

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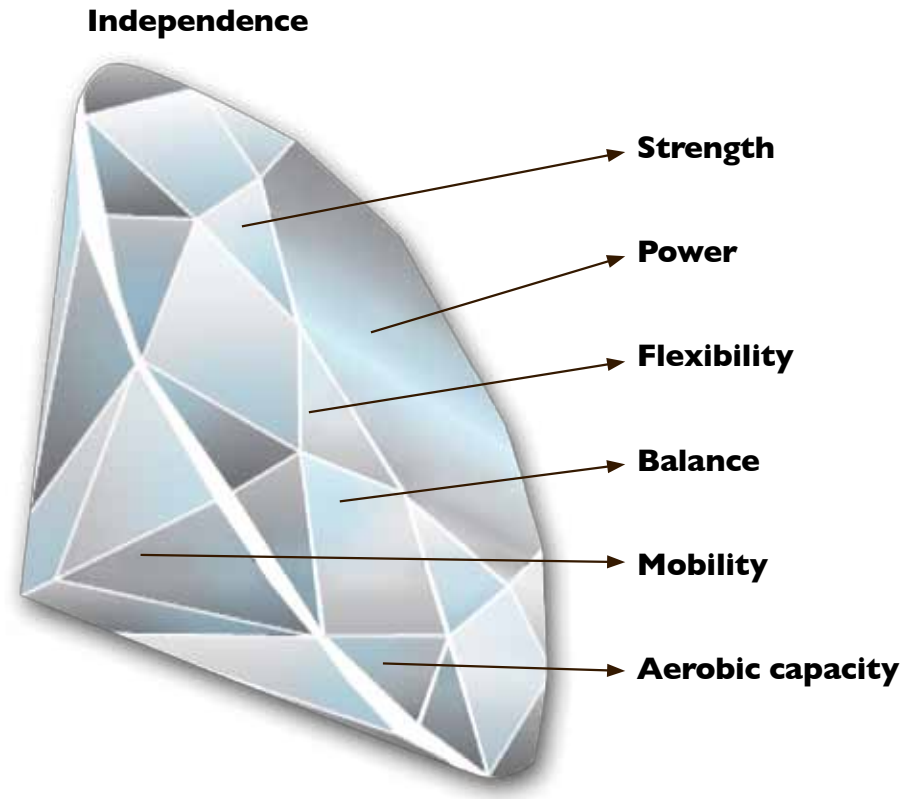

Figure 2. The diamond analogy for maximizing the benefits of exercise interventions. (After Signorile, J. F. *Bending the Aging Curve.* Human Kinetics Publishers, 2011.)

resistance training (approximately 80% 1RM [repetition maximum]), Bemben and colleagues[2] reported that their resistance-training group showed greater improvements than controls in 13 of 16 muscle groups tested, while their WBV-plus-resistance-training group showed better performances than controls for 15 of the muscle groups. Also, the improvements for the WBV-plus-resistance-training group exceeded those of the resistance-training group for 7 muscle groups. Bautmans and his team[1] reported that 6 weeks of static lower-body exercises with and without triplanar WBV produced similar increases in leg-extension strength and power (see Figure 3 on page 52). Similarly, a study by Bogaerts et al. at Katholieke Universiteit Leuven in Belgium found comparative increases in leg-extension strength and power between a standard exercise program (cardiovascular, strength and flexibility training) and a triplanar WBV exercise program targeting upper- and lower-body musculature.[3]

Indications of the ability of centrally pivoting WBV platforms to improve strength and power have come from the Centre of Physical Activity Across the Lifespan at the Australian Catholic University.[4] According to these researchers, significant increases were noted in both chair stand and timed up-and-go performance as the result of a 6-week WBV program, which consisted of 5 one-minute bouts of static squatting separated by one-minute recovery intervals. In a second study, Rees and his group reported that their progressive WBV protocol (6 sets; 45–80 seconds with equal recovery; 26 Hz; 5–8 mm) produced greater improvements in plantar flexion strength and power than a similar exercise program without WBV. Both protocols produced the same levels of strength and power improvement, however, in knee and hip flexion and extension.

Researchers from Spain's University of León Institute of Biomedicine[5] found a significant increase in muscle strength and thigh-muscle growth in women ages 65–90 years after 10 weeks of lower-limb vertical WBV training (unloaded static and dynamic squats: half-squats, knee angle 120–130°; deep squat, knee angle 90°; 20–40 Hz, 2–4 mm). There was no change in muscle power, however. Mikhael and colleagues from the University of Sydney, Australia, examined the capacity of a vertical displacement plate (12 Hz, one mm; 20 minutes per day, 3 days per week; one-minute 1:1 work:recovery duty cycle) to improve neuromuscular performance across a 3-month training period. This team looked at changes as they affected participants who stood with either locked or bent knees. Improvements were reported in upper- and lower-body strength for both WBV groups, with the locked-leg group having greater improvements in lower-body strength and upper-body movement speed than the control and flexed-leg groups, respectively.[6]

Overall, these studies support the positive effects of WBV on strength and, to some extent, power in older adults. They also indicate that this modality can produce results similar to standard high-intensity resistance-training programs. WBV appears to have limited benefit, though, when used as a supplement to high-intensity resistance training. In addition, the improvements seen in plantar flexion, and not in the upper thigh and hip muscles, may reflect a decline in the vibratory stimulus transmission across muscles and joints farther from the point of application. It has been sug-

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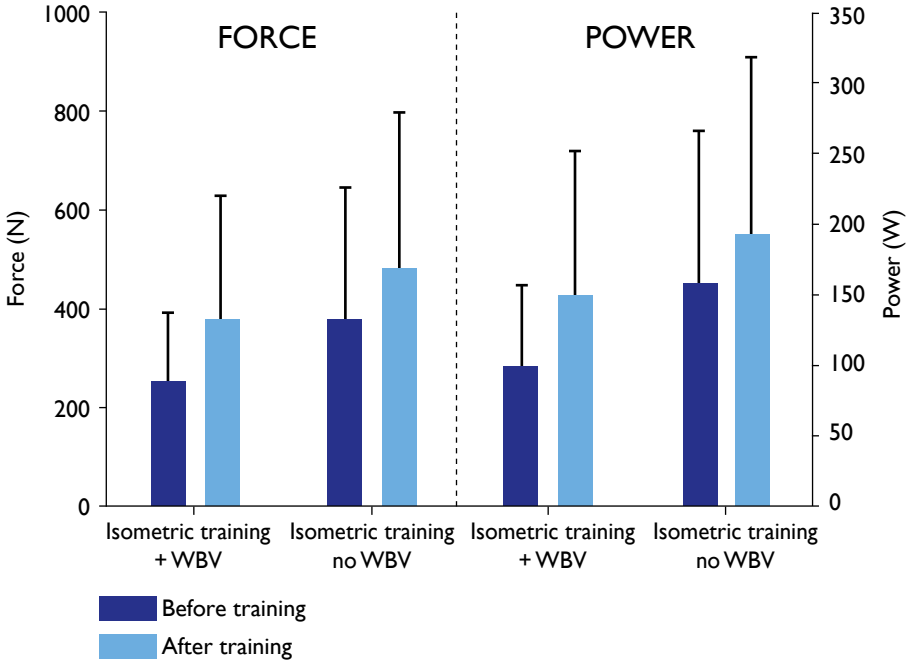

Figure 3. Similar increases in strength and power as a result of an isometric lower-body training program with (+WBV) and without (no WBV) whole body vibration. From data by Bautmans et al., The feasibility of whole body vibration in institutionalised elderly persons and its influence on muscle performance, balance and mobility: a randomised controlled trial [ISRCTN62535013]. *BMC Geriatrics, 5,* 17, 2005.

gested that this decline is due to damping (diminishing) of the stimulus by the tissues, especially when the joints are bent.[7,8]

Further research into the impact of WBV training on power in older adults is warranted for the following reasons:

- Power is well-documented as an important factor affecting independence and falls probability in this population.[9,10,11]
- A majority of studies examining the capacity of single bouts of WBV[12,13,14] and WBV training[15,16,17] to increase power in younger individuals have shown positive results.
- It remains to be determined if the frequency and amplitude settings shown to produce maximal results in younger adults are the same for older individuals, given changes in muscle structure, function and metabolism.

Finally, since WBV and standard high-intensity resistance-training protocols have similar positive impacts on strength and power, studies should compare perceived effort, exercise compliance, required exercise time and volume, and attitudes toward the exercise interventions to find out if WBV may be more acceptable, and therefore more effective.

Balance

As was the case with strength and power, controlled studies have looked at balance responses to acute bouts and training using WBV. Carlucci, Mazzà and Cappozzo[18] examined the impact of 6 one-minute bouts of dynamic and isometric squat exercise with 30-second recoveries during sessions with and without WBV. No significant changes were shown in postural control for either the WBV or non-WBV conditions. Rather than interpreting WBV as ineffective, the authors concluded that an acute bout of WBV did not induce a dangerous effect on older adults (average age about 72 years) and could safely be used as part of a long-term intervention.

In 2 separate training studies, Bautmans et al.[1] and Bruyere et al.[19] found that WBV training could significantly improve balance in older adults living in skilled nursing facilities and independently (see Figure 4 on page 54). Both studies looked at a 6-week training period. WBV training in the Bautmans study consisted of progressive training using 6 lower-body isometric exercises, with results compared to a control group doing the same exercises without WBV. The Bruyere study added WBV training to an existing physical therapy regimen practiced by the control group. Also, the machines used in these studies differed in the application of vibration: Bautmans' study used a triplanar WBV platform at frequencies of 35 and 40 Hz and amplitudes of 2 and 5 mm, while Bruyere's study used a centrally pivoting displacement platform with frequencies and amplitudes of 10 and 26 Hz and 3 and 7 mm.

Bogaerts and colleagues[20] looked at the combined impacts of vitamin D supplementation and triplanar WBV on measures of gait and balance. They found similar improvement in postural sway velocity with both high and low vitamin D supplementation (1600 IU and 880 IU per day, respectively), but no increase in balance due to WBV training. However, WBV training did produce superior improvements in 10-m preferred walking speed and for the timed up-and-go at both preferred and maximal performance speeds. A separate article examining the impact of this protocol on bone density and muscle strength reported no additional benefit from adding WBV to vitamin D supplementation.[21]

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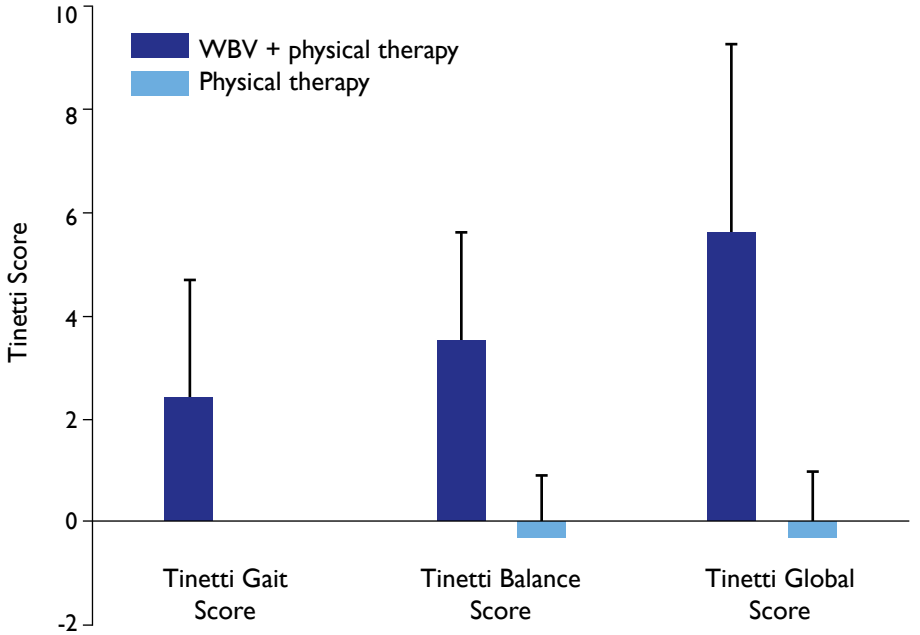

Figure 4. Increases in the Tinetti Gait, Balance, and Global (overall) scores as a result of Physical Therapy versus Physical Therapy plus WBV. Significantly greater improvements were seen by Physical Therapy plus WBV group over the Physical Therapy group for all scores. From data by Bruyere et al., Controlled whole body vibration to decrease fall risk and improve health-related quality of life of nursing home residents. *Archives of Physical Medicine and Rehabilitation, 86*(2), 303–307, 2005.

Using 6 weeks of centrally pivoting WBV training (26 Hz, 5–8 mm, 6 sets of 45–80 seconds), Sven Rees and colleagues found that WBV produced significantly better results for seconds 5–15 of a single-leg stand test than those produced by inactive controls or an exercise group performing the same lower-body training protocol without WBV.[22]

Overall, these results offer good support for WBV as a training modality that can improve balance in older adults. More research is needed to clarify the specific impact of different WBV platforms and protocols on dynamic and static balance in different planes of motion. Long-term studies on falls, injuries due to falls, and changes in falls efficacy are also needed to establish WBV as a viable training method to reduce falls and their potentially fatal consequences.

Bone density

Some studies have examined the potential for WBV to positively affect bone mineral density (BMD) and structure. Beck and Norling[23] looked at the impact of WBV on bone parameters using a vertical vibration platform (~2 mm; 0.3 g; 30 Hz) and a centrally pivoting platform (0–14 mm, 12.5 Hz). Their control group lost bone mineral content in the trochanter and lumbar spine (pelvis and lower back), while no significant decreases were seen in these parameters for either WBV group. The group that trained on the centrally pivoting WBV platform also showed an increase in the transfer of ultrasonic vibration at the ankle, an indicator of lower probability of fracture. Despite these positive effects, the participants who trained on the vertical WBV platform showed a loss in whole-body bone mineral content and proximal forearm BMD. In a second study of the impact of centrally pivoting WBV on BMD, Gusi et al.[24] reported that over an 8-month training period, a group that performed WBV static squatting (3 days/week, 60° knee flexion, 6 bouts, one-minute work/one-minute recovery, 12.6 Hz, 3 cm) had greater improvement in BMD in the femoral neck (which connects thigh to hip) and balance compared to a group that walked 55 minutes per day for the same period. Both groups showed no improvements in lumbar spine BMD.

Results were less impressive from an 8-month study of the impact of a high-intensity resistance-training program with and without triplanar WBV (30–40 Hz, 2–4 mm; 2–2.8 g).[2] The researchers found no change in whole body, trochanter or spinal bone density. In fact, they reported a significant decrease in bone density of the radius (forearm), hip and femoral neck for the control, resistance-training and WBV-plus-resistance-training groups (see Figure 5 on page 56).

Overall, these results, while generally positive, reflect the same need for further research that I noted for neuromuscular performance and balance. Let me quote Slatkovska et al.[25] at the conclusion of their systematic analysis of WBV and bone density:

> *"We found significant but small improvements in BMD in post-menopausal women and children and adolescents, but not in young adults. WBV is a promising new modality, but before recommendations can be made for clinical practice, large-scale long-term studies are needed to determine optimal magnitude, frequency and duration."*

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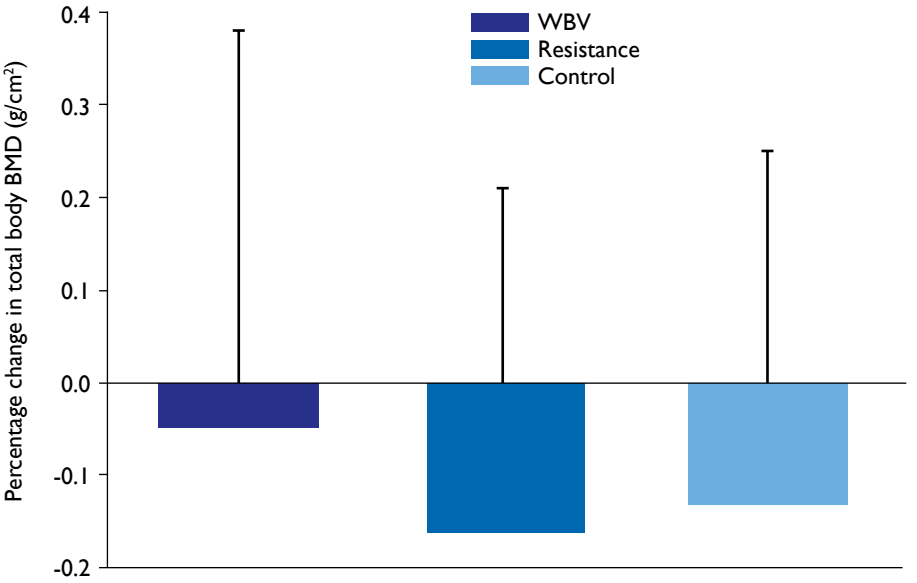

Figure 5. Similar percentage changes in bone mineral density (BMD) across 8 months for a whole body vibration (WBV), resistance training (Resistance) and control group. From data by Bemben et al., Effects of combined whole body vibration and resistance training on muscular strength and bone metabolism in postmenopausal women. *Bone, 47*(3), 650–656, 2010.

Cardiovascular fitness

While a number of studies have examined the impact of WBV on oxygen consumption, with an eye toward caloric output (see "Body composition" section below), few have looked at the impact of WBV on cardiovascular fitness. A study by Bogaerts and colleagues[3] mentioned earlier, which compared a standard exercise program to a WBV exercise program, indicated that both programs were equally effective in improving peak oxygen consumption ($VO_{2\,peak}$). However, the standard program produced a greater improvement in time to peak exercise, a measure of endurance performance, according to the researchers. Clearly, there is a need for controlled studies examining the potential for WBV training to improve not only oxygen consumption, but also other factors related to cardiovascular health.

Body composition

Given the studies that have shown WBV can increase oxygen consumption and caloric output when added to an existing exercise program,[26,27,28] it was logical to examine this modality's impact on body composition. To that end, our laboratory at the University of Miami and others have studied this impact.

The Bone Research Laboratory at the University of Oklahoma's Department of Health and Exercise Science[29] compared changes in body composition resulting from a standard progressive resistance-training protocol (8 exercises, 3 sets of 10 repetitions; 80% 1RM) to a triplanar WBV protocol consisting of static shoulder presses and wrist curls and dynamic body-weight squats (progressing from one set of 15 seconds at 30 Hz, 3 mm; to 2 sets of 30 seconds at 40 Hz, 3 mm; with 15-second recovery between sets). Both the resistance-training and WBV interventions increased bone-free lean body mass, but the WBV group alone showed a significant reduction in percent body fat (see Figure 6 on page 58).

Our laboratory compared the impact of 8 weeks of steady-state treadmill training, circuit resistance training or triplanar WBV on lean body mass and percent body fat, as well as maximum oxygen consumption, time to peak exercise, and upper- and lower-body strength. Our results showed no changes in body weight or percent body fat for any group. There was a trend, however, toward greater increases in lean body mass by the circuit training group.

Recovery from exercise

A few papers have investigated the feasibility of using WBV to aid recovery from exercise in an older population. A research group from New Zealand[30] questioned whether an acute bout of WBV could improve recovery from high-intensity interval training in a sample of well-trained runners whose average age was approximately 46 years. In addition to evaluating 3-km running performance, the researchers evaluated bloodborne markers of muscle damage and inflammation following a 3-km time trial and 8 400-m bouts of high-intensity interval training separated by 60-second recovery periods. Their results indicated that 2 bouts of 5 repetitions standing and sitting WBV (60-second bout, 30-second recovery) on a centrally pivoting plate (12 Hz, 6 mm) did not improve performance or reduce muscle damage or inflammation in these athletes.

Disease states

Several disease states are commonly seen in older individuals. Could WBV potentially affect declines associated with these disease states? Let's take a look at what the research shows.

Parkinson's disease. Pablo Arias et al. from the University of A Coruña in Spain examined the effects of WBV on Parkinson's disease.[31] In a double-blind, placebo study, they found that 12 sessions of WBV on a centrally pivoting

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Mark your calendar

Join Joe Signorile for a preconference workshop at the 2011 International Council on Active Aging Conference in Orlando, Florida. Sponsored by SPRI Products, "Bending the Aging Curve" will take place 9 a.m.–4:30 p.m. on Wednesday, November 30. For details or to register, visit the "Conference" section of the ICAA website, www.icaa.cc, or call ICAA toll-free at 866-335-9777.

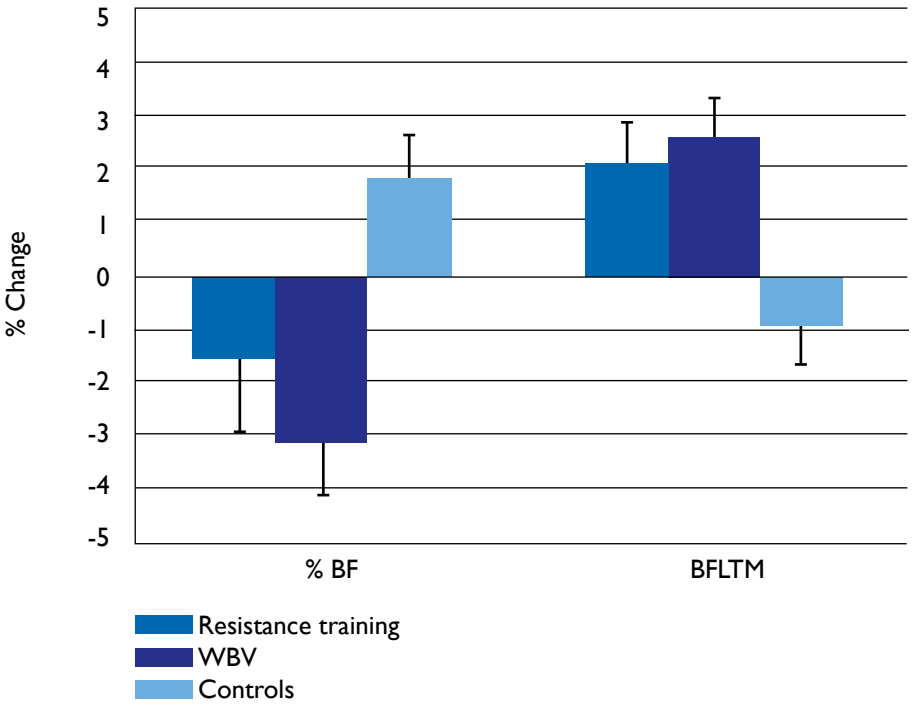

Figure 6. Significantly greater percentage increases in bone-free lean body tissue (BFLTM) in whole body vibration (WBV) and resistance training groups compared to controls. Significantly greater decreases in percent body fat (%BF) than controls only in the WBV training group. From: Fjeldstad et al., Whole body vibration augments resistance training effects on body composition in postmenopausal women. *Maturitas, 63*(1), 79–83, 2009.

platform had no effect on gait, the functional reach test, Purdue Pegboard test, Borg balance test, or the Unified Parkinson's Disease Rating Scale. The results support those reported earlier by this research group indicating no impact of centrally pivoting WBV at 3, 6 and 9 Hz on balance or gait. Somewhat different findings were reported by Georg Ebersbach and colleagues, who found similar improvements in gait and equilibrium as a result of WBV and standard physical therapy.[32] Additionally, 2 separate studies performed at Johann Wolfgang Goethe-Universität in Frankfurt, Germany,[33,34] demonstrated that WBV improved motor function in Parkinson's patients. Ricky Lau and associates summarize these findings as follows in their review of the topic: "There is insufficient evidence to prove or refute the effectiveness of WBV in enhancing sensorimotor performance in people with PD [Parkinson's disease]."[35] The positive effects reported in a number of these studies, however, indicate that further research is warranted.

Stroke. Jacqueline Merket and colleagues from the Forschungsgruppe Geriatrie, Charité Universitätsmedizin Berlin, examined whether adding a unique vibratory disc, which offered different levels of instability and vibration at 20–45 Hz, would improve trunk stability, muscle tone and postural control in older stroke patients to a greater degree than a standard rehabilitation program.[36] These researchers reported that although the improvements made by the 2 groups were not significantly different, the group that received the vibratory stimulus made larger gains in nearly every measure.

Multiple sclerosis. Broekmans et al.[37] studied the impact of a 20-week triplanar WBV lower-body training program (both dynamic and static exercises) on strength and functional performance in moderately impaired multiple sclerosis patients, average age 48 years. Neither strength nor functional performance was improved as a result of the program, which featured 5 training sessions per 2 weeks that progressed in duration from 2.5 to 16.5 minutes and from 20 to 45 Hz at an amplitude of 2.5 mm (2.32–2.71 g).

Polio. A pilot study from Skäne University in Sweden examined the impact of 10 vertical WBV (25 Hz, 3.75 mm) training sessions lasting 30 minutes or less on strength and gait parameters in patients ages 55–70 years with late-stage polio.[38] Neither strength nor gait performance showed any significant improvements due to this WBV training protocol.

Fibromyalgia. Narcis Gusi and his research group from Cáceres, Spain, investigated the potential for WBV to improve dynamic balance in 41 women with fibromyalgia, ages 41–65 years.[39] The researchers' intervention consisted of 3 sessions per week for 12 weeks, with each session employing 6 bouts of 45–60

seconds of centrally pivoting WBV at 12.5 Hz and 3 mm. They reported a significant increase in dynamic balance for the WBV group over controls.

So, based on all the evidence outlined above, what can we conclude about using WBV as a training tool for older adults?

Conclusions

I suggest that these recent study results support the conclusions of a number of researchers who have reviewed WBV as an intervention for addressing the structural and functional declines seen with aging.[40,6,25,41] These conclusions include the following:

1. Given the comparable results in many studies comparing WBV and standard training methods and the potential for declines in function across longer duration studies with older adults, new studies should include both a standard training and control group. Studies should also include measures of compliance and perceived exertion.

2. To truly evaluate the effectiveness of WBV as a training tool, future research should include larger sample sizes and longer interventions.

3. Since a number of studies have examined the use of WBV as a tool for warm-up and performance potentiation (a term used to indicate that an initial exercise bout has a positive effect on subsequent performance), studies should examine if WBV application prior to training can increase the benefits on functional performance.

4. Given the rapid declines in flexibility with age and the positive impact that improvements in flexibility can have on functionality in older adults, studies examining the impact of WBV on flexibility are imperative.

5. Finally, studies should continue to examine the mechanisms by which WBV can effect changes in specific fitness parameters.

Conclusions about the effectiveness of various protocols will be provided in the second part of this article. Watch for this installment in the next issue of the *Journal on Active Aging®*.

Joseph Signorile, PhD, is a professor of exercise physiology at the University of Miami, Florida, and a research specialist at the Miami Veterans Administration Medical Center Geriatrics Research Center. Signorile has been involved in research using exercise to address independence and falls prevention for over 15 years. He has more than 50 refereed manuscripts, and 175 national and international scientific and 200 industry presentations. Signorile is also the author of the recently published book Bending the Aging Curve: The Complete Exercise Guide for Older Adults, *available from Human Kinetics, www.humankinetics.com.*

A list of references is available online at www.icaa.cc/references.htm.

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Whole body vibration training: a new wave in exercise intervention for older adults?
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