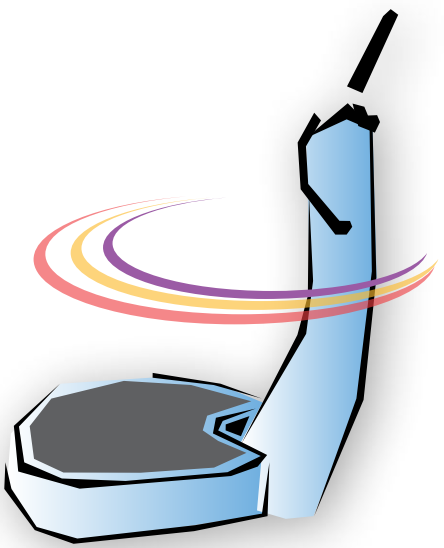
Whole body vibration, part two:

what's the most effective protocol?



Discover what the scientific literature shows about the effectiveness of different whole-body vibration platforms and protocols on specific physical performance measures for aging well

by Joseph Signorile, PhD

This is the second installment of a 2-part article about whole body vibration in this year's Journal on Active Aging®. *Part one, published in the September/October issue, examined findings related to physical performance factors that affect successful aging. In this issue, the author reviews findings related to various protocols.*

For any exercise device or intervention to be effective, it must be used correctly. This may seem a simple concept, but its application can be difficult. It may also take years to develop all the questions concerning the most effective protocols. Given the number of whole body vibration (WBV) devices, the available settings on each device, and the number of different exercises and patterns of training that you can use with WBV, the question should not be, What is the best protocol? Rather, we should be asking, What is the best protocol to improve a given parameter—strength, power, balance, etc.—in older adults and on what type of machine? (To learn more about whole body vibration itself and its impact on physical performance factors, see the articles noted in the "Resources" sidebar on page 71.)

In addition, traditional training techniques may be more effective in addressing some performance parameters, while WBV training may be more effective in improving others. An example is seen in the work of Raimundo, Gusi and

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Illustration: Jacob Benaroch

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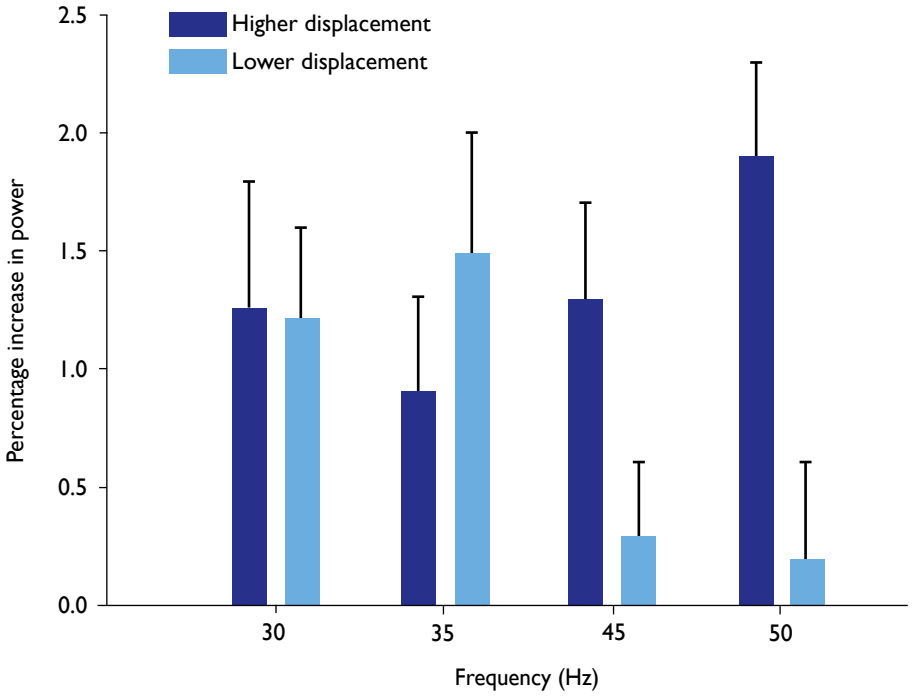

Figure 7. Improvements in power with a single bout of WBV showing the link between higher frequencies and higher displacements and lower frequencies and lower displacements. After data from Adams, J. B., Edwards, D., Serravite, D. H., et al. Optimal frequency, displacement, duration and recovery patterns to maximize power output following acute whole body vibration. *Journal of Strength and Conditioning Research, 23*(1), 237–245, 2009.

Tomas-Caru.[42] In 2009, these researchers reported greater improvements in 4-m maximum walking speed and chair rise testing among participants as a result of 60 minutes of walking at 70–75% HRmax (maximum heart rate), while centrally pivoting WBV (one-minute 1:1 work:recovery; 10–15 minutes) produced greater increases in power as measured by vertical jump. (Refer to the box on page 69 for a list of the three kinds of whole body vibration machines and the vibrations they provide.)

Trans and colleagues reported similar "split results" when examining the impact of a stable WBV platform and a uniquely designed platform (featuring a balance board with a built-in vibratory system) on knee strength and proprioception in women ages 60–70 years with knee osteoporosis. The same training protocols were used on both platforms, applying static lower-body exercise that progressed from six 30-second repetitions at 25 Hz to nine 70-second repetitions at 30 Hz. The work:recovery ratios for all training were 1:1. Training on the stable platform increased muscle strength, the researchers reported, while the balance board platform increased proprioception (the ability to sense the body's position in space).[43]

So let's look at what the scientific literature tells us so far about the effectiveness of different platforms and protocols on specific physical performance measures.

Strength and power

Power is not only one of the most important factors dictating success in most sports, but also arguably the most important neuromuscular determinant of independence and falls prevention in older adults. Two studies from our laboratory at the University of Miami have examined the most effective protocol for improving power after a single bout of isometric squatting.[12,13] Both studies used a triplanar WBV device. In the first, Bedient and her research group determined that a frequency of 30 Hz was most effective at improving power regardless of the amplitude setting. (Amplitude, within the WBV context, refers to how far the platform moves in a specific direction.) The results from Adams and her group supported the use of low frequencies (30–35 Hz) during low amplitude (2–4 mm) training, but suggested that 50 Hz may be more effective during high amplitude (4–6 mm) training (see Figure 7 on this page).

Lamont et al. produced study results that support those of Adams. These indicated that triplanar WBV applied intermittently using 50 Hz at a displacement of 4–6 mm produced higher vertical jump performance than any other frequency at this displacement level.[44] In contrast, a similar study performed recently by Armstrong, Grinnell and Warren found no significant differences in vertical jump performance across the entire spectrum of frequency/displacement combinations on the same triplanar WBV platform.[45]

An examination of the effects of eighteen 20-minute sessions of vertical WBV training over a 6-week period showed that high-frequency/high-displacement (50 Hz, 4 mm) training led to greater improvements in power and selected strength measures than low-frequency/low-displacement (30 Hz, 2 mm) or nonvibratory training.[46] Using isometric squats on a vertically oscillating platform, Turner and his colleagues[14] also found the greatest improvements in vertical jump with high-frequency/high-displacement (40 Hz, 8 mm) training.

Furness and Maschette[4] examined the impact of WBV training frequency

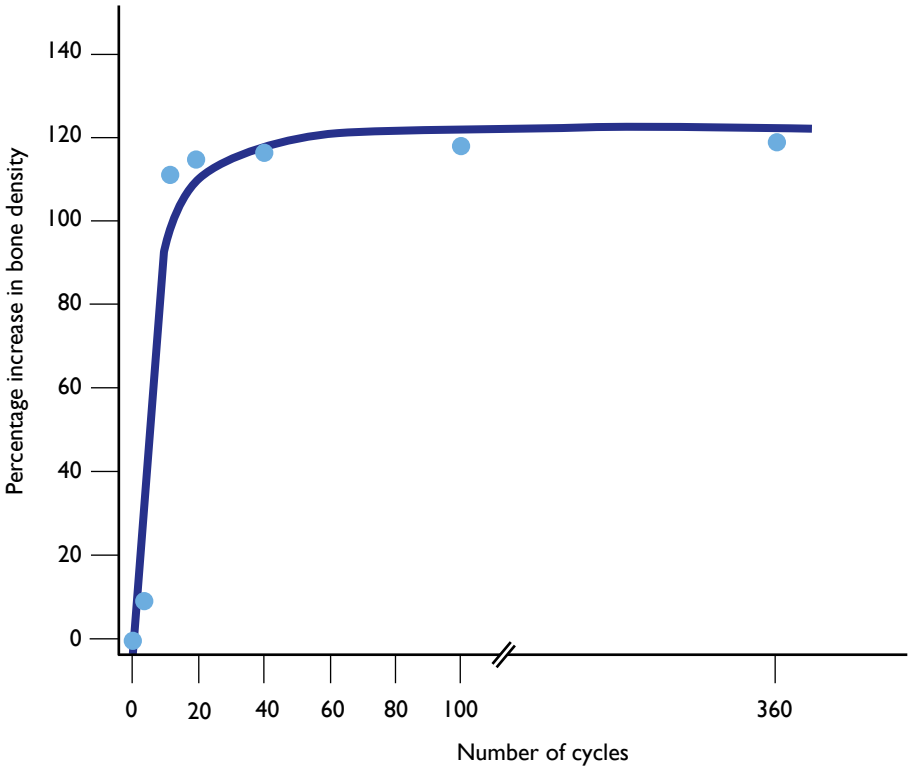

Figure 8. Changes in bone mass due to the number of loading cycles. Note the plateau in the rate of improvement when loading cycles exceed 40 cycles per day. After Burr, D. B., Robling, A. G., & Turner, C. H. Effects of biomechanical stress on bones in animals. *Bone, 30*(5), 781–786, 2002.

(number of sessions per week) on neuromuscular performance in a sample of community-dwelling older adults, average age approximately 72 years. The researchers found that during a 6-week training protocol on a centrally pivoting WBV device (progressing from 15 to 25 Hz at a reported displacement of 0.05 mm), 2–3 sessions per week were more effective than one. They also discovered that WBV training was more effective than the same training without WBV.

Overall, the results indicate that progressive protocols that eventually result in a high-frequency, high-displacement overload appear to be the most effective method of increasing strength and power. The effectiveness of low-frequency, low-displacement training, however, argues in favor of using a progressive protocol that gradually increases frequency and displacements across a training period, and incorporating these protocols into the recovery phase of periodized training programs. (Such programs alternate work and recovery periods in the training cycle.) Additionally, the most effective protocols appear to use work cycles that range between 30 and 60 seconds, have a similar recovery cycle length, and incorporate multiple sessions per week lasting 30 minutes to one hour including warm-up.

Balance

Controlled studies have found improvements in balance, another key performance factor, using vertical, centrally pivoting and triplanar plates. The studies producing positive results on vertical displacement plates typically incorporated frequencies between 12.5 and 26 Hz with a 5–8 mm displacement.[22,23]

Three types of whole body vibration machines

Vertical displacement machines: up and down movement

Triplanar machines: up and down, forward and back, and side-to-side movement

Centrally pivoting machines: see-saw, or teeter-totter, stimulus

These protocols also used 6 sets of 45–80 seconds with a 1:1 work:recovery ratio. When WBV was provided on a centrally pivoting plate, successful interventions used frequencies from 10 to 26 Hz with displacements ranging 2–3 mm.[47,48] The duration of exposure on the plates typically lasted 2–4 minutes and the training frequency was one to 3 days per week. Finally, those studies showing positive impacts with triplanar WBV used quite consistent protocols.[49,50,51] Frequencies ranged 30–40 Hz and amplitudes normally progressed from 2 to 5 mm. Protocols employed one to 3 repetitions of 8 lower-body exercises lasting 30–60 seconds with equivalent recovery periods, although recoveries were reduced in 2 of the studies as participants progressed. Training occurred 2–3 times per week.

Bone density

Part one of this article, published in the last *Journal on Active Aging®*, presented a good deal of research supporting the positive impact of WBV on bone mineral content and bone mineral density (BMD), but what is the most effective WBV intervention? Von Stengel and colleagues[52] examined the comparative effects over 12 months of three 15-minute WBV training sessions per week on BMD in postmenopausal women, average age approximately 68 years. The training consisted of 5 static and

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dynamic lower-body exercises, including squats, heel raise, leg abduction and hip flexion. Participants trained on a vertical plate that vibrated at 35 Hz with a 1.7 mm peak-to-peak displacement, as well as on a centrally pivoting plate that oscillated at 12.5 Hz with a 12 mm displacement at the most distant position from the axis of rotation. Both groups showed significant increases in BMD in the lumbar spine (lower back) and femoral neck (connecting thigh to hip), while a group that performed light exercise showed a loss and no change, respectively. For the femoral neck, the relative BMD gain was more pronounced for the vertical displacement versus the centrally pivoting platform. In addition, multiple shorter-duration sessions appeared more effective than longer sessions since bone desensitizes to overload by approximately 40 cycles (see Figure 8 on page 69).

Cardiovascular fitness

The impact of WBV on cardiovascular fitness is still largely unexplored, as shown in the first installment of this article. The only study to examine the effects of WBV on this performance factor produced positive results using a progressive training program. This program increased the duration of each exercise from 30 to 60 seconds, the frequency from 30 to 40 Hz, and the amplitude from 2–3 to 4–6 mm on a triplanar platform. Additionally, recovery times between exercises were progressively dropped from 60 through 15 seconds, while dynamic and static exercises were incorporated.[3]

Body composition

What about the impact of WBV on body composition? Although studies have shown that WBV can increase oxygen consumption and caloric output when added to an existing exercise program,[26,27,28] only one training study demonstrated declines in percent body fat.[29] For this study, Fjeldstad and colleagues used progressive triplanar WBV training, beginning at one set at 3 mm for 15 seconds (30 Hz) and increasing to 2 sets at 3 mm for 30 seconds (40 Hz). A 15-second recovery was provided between sets. Exercises included static shoulder presses, wrist curls and dynamic body-weight squats.

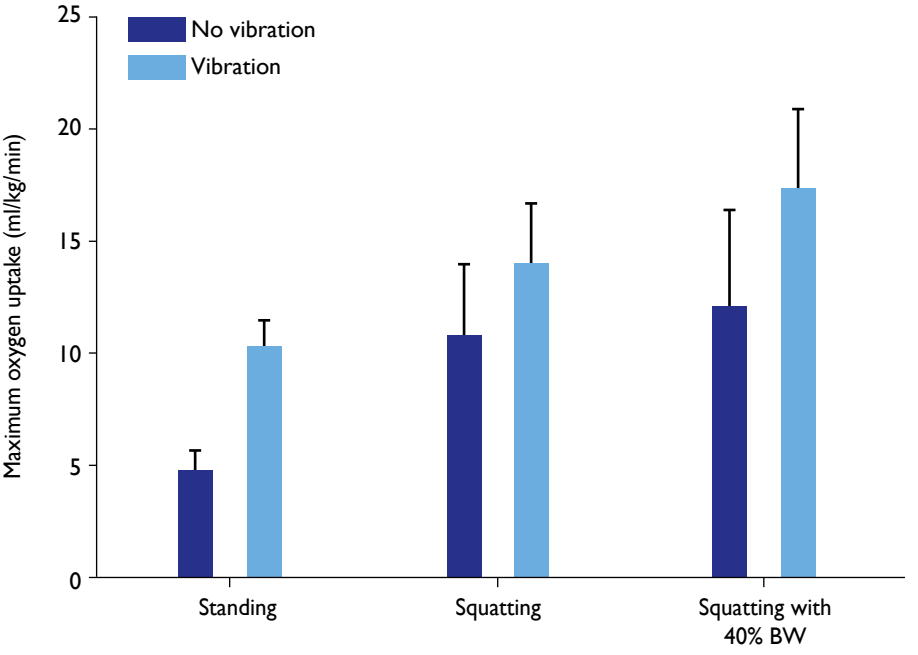

Figure 9. Oxygen uptake with and without WBV. Highest values were elicited during WBV squatting with 40% BW external loading. Data from Rittweger, J., Schiessl, H., & Felsenberg, D. Oxygen uptake during whole body vibration exercise: comparison with squatting as a slow voluntary movement. *European Journal of Applied Physiology, 86*(2), 169–173, 2001.

To maximize results, it appears that WBV can be coupled with added resistance to further increase caloric output. In 2 separate studies, Rittweger et al.[27,28] demonstrated that during active squatting on a centrally pivoting platform (26 Hz, 7.5 mm), loading the individual at 40% of lean body mass—or, alternatively, with 40% body weight for men and 35% for women—significantly increased the metabolic cost of WBV exercise over an unloaded condition (see Figure 9 on this page). Similar positive impacts of WBV on energy expenditure were reported during dynamic squatting using 5 sets at 10RM (approximately 77% 1RM, or repetition maximum) on a vertical force plate at 30 Hz and 4 mm displacement. [26] Increasing squatting speed from 4 or 6 seconds per cycle to 2 seconds per cycle also appears to significantly elevate energy expenditure during WBV on a vertical plate (30 Hz, 4 mm).[53] Finally, much greater increases in oxygen consumption are produced by applying the external loads at shoulder, rather than waist, level.[27,54]

Conclusions

As you can see by reading through this article, there are a number of factors to consider when you attempt to answer the question, What's the best WBV training protocol? Some general recommendations, however, do appear to be appropriate across all vibratory plates and goals. These include:

1. Multiple sets appear more effective than single sets.

Resources

Print

"Whole body vibration, part one: what's shakin' now?"
Author: Joseph Signorile
Publisher: *Journal on Active Aging, 10*(5), 46–59, September/October 2011

"Whole body vibration training: a new wave in exercise intervention for older adults?"
Author: Joseph F. Signorile
Publisher: *Journal on Active Aging, 5*(5), 30–37, September/October 2006

* Available to International Council on Active Aging® members in the "Articles archives" ("Research") in the members only section of the ICAA website, www.icaa.cc

2. Durations of 30–60 seconds appear most effective on vertical and triplanar plates, while somewhat longer durations (one to 4 minutes) are more frequently used on centrally pivoting plates.
3. A 1:1 work:recovery duty cycle appears most effective.
4. Multiple sessions (3–4 per week) are more effective than single sessions.
5. Just as with any training, intensity (frequency and displacement) and duration should gradually increase across the training period.

As to differences among protocols depending on machines and goals, I offer the following conclusions:

1. Centrally pivoting platforms, as would be expected by the nature of the mechanism, feature lower frequencies and higher displacements.
2. Balance training appears better addressed using lower frequencies than strength or power training.
3. Balance may also be better addressed using somewhat longer exposure times (45–80 seconds).
4. In contrast to balance, bone density appears better addressed using shorter, multiple cycles (15-minute sessions; approximately 40 cycles) to retain sensitivity to the vibratory stimulus.
5. Multidirectional stimuli should also be emphasized when training bone density.
6. For body composition, caloric output is increased most effectively by using external loading, progressing if possible to approximately 30–40% body weight at the shoulder area. In a pilot study from our laboratory, however, we found 20% of body weight equally effective and possibly safer for older clients.
7. Cardiovascular improvements are best addressed using intervals, which manipulate speed of movement, and work:recovery duty cycles.

While the recommendations and conclusions above represent our best information to date, scientists and clinicians should continue to explore the most effective methods to target specific goals using different machines. Remember, we have been incorporating modalities such as resistance training and cardiovascular training arguably for centuries, yet we continue to increase our knowledge on the most effective use of these training tools. Whole body vibration is one of the more recent tools added to our "training toolbox." Our understanding of its optimal utilization will also continue to increase for years to come.

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