

Balance, falls and whole body vibration training

Read on for an update on vibration exercise as a falls prevention intervention for older adults

by Larry Leigh, PhD, and Jonathan Scherer, MHK

Balance, stability and the prevalence of falls leading to injury are topics of great concern within the older-adult population. One-third of people ages 65 and over fall at least once each year, and falls are the leading cause of death from injury in this age group. Further, approximately 40% of falls that require hospitalization involve hip fractures, and half of these individuals never regain their previous level of functional ability.²¹

As we age, we are presented with a variety of contributing physiological challenges. Depending on *how* we have aged, muscles become weaker, the bones that they act to move become more fragile, balance becomes less predictable, and as a result, there is a tendency to compensate by restricting daily activities. Yet when we limit physical activity due to perceived ability, the nature of daily tasks becomes more challenging as we get older and falls become common.

A fall can be related to risk factors that affect balance—both intrinsic (inside the body) and extrinsic (outside the body)—whereas the outcome of a fall-related hip fracture largely depends on the relationship between a person's bone strength

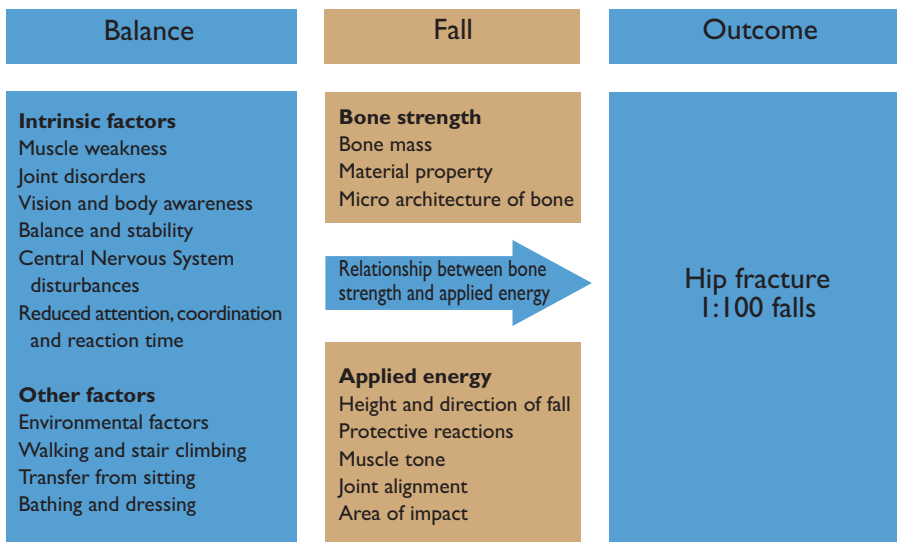


Figure 1. Factors associated with balance leading to the incidence of a fall and the potential for hip fracture. It has been documented that approximately 1:100 falls result in hip fracture for older adults.¹⁷

and the “applied energy” of a fall.¹⁷ Applied energy encompasses such things as the area of impact and the height and direction of a fall. (Figure 1 above provides an overview of balance and fall factors that influence the outcome of an event.)

Physical intervention can improve falls risk factors such as muscle weakness, poor coordination, reaction time and bone strength. A more common practice with older adults, however, is pharmacological treatment. Unfortunately, the use of prescription drugs is an additional falls risk factor, as a link exists between cumulative prescription use and the likelihood

of a falling incident. The risk of falling is compounded by a similar relationship with cumulative intrinsic factors, emphasizing the challenges faced by older adults (see Figure 2 below).

As well, there is no consensus for the reasons leading to falls in the aging population. In a study conducted by Blake et al.,³ 19.3% of men and women 65 years and over did not know the cause of their fall, limiting their ability to seek preventive measures. In light of the risks associated with osteoporosis, a condition affecting 44 million Americans of which 68% are female,¹² balance and falls prevention strategies become critical in

maintaining independence and quality of life with age.

Whole body vibration training: an introduction

The scientific literature would suggest the need for a nonpharmacological intervention to help intrinsic falls risk factors and bone strength. Increasingly, research points to whole body vibration (WBV) training as one possible alternative.

In a previous issue of the *Journal on Active Aging*,¹⁸ Joseph F. Signorile, PhD, presented an article reviewing WBV training and its possible implications for an older-adult population. Signorile, a professor of exercise physiology at the University of Miami and research specialist at the Miami VA Medical Center Geriatrics Research Center, detailed and discussed relevant studies according to the potential benefits for these individuals. Among the topics examined was the potential for WBV to positively impact balance and agility. According to Signorile, balance and agility are important to performing everyday activities efficiently and safely. With older adults and special populations, including individuals with various neuromuscular disorders such as multiple sclerosis, safely navigating daily activities can be attributed primarily to balance and postural ability. This article adds to the discussion with up-to-date research. To begin our exploration, let’s first examine what whole body vibration is and how it works.

How whole body vibration training works

There are three prominent types of WBV platforms on the market, each operating by a different means and having unique characteristics:

- Oscillating vibration platforms move vertically on either side in an alternating fashion.
- Linear platforms move vertically only.
- Tri-planar platforms move in all three axes.

(See Figure 3 on page 52 for a representation of these movements).

Continued on page 52

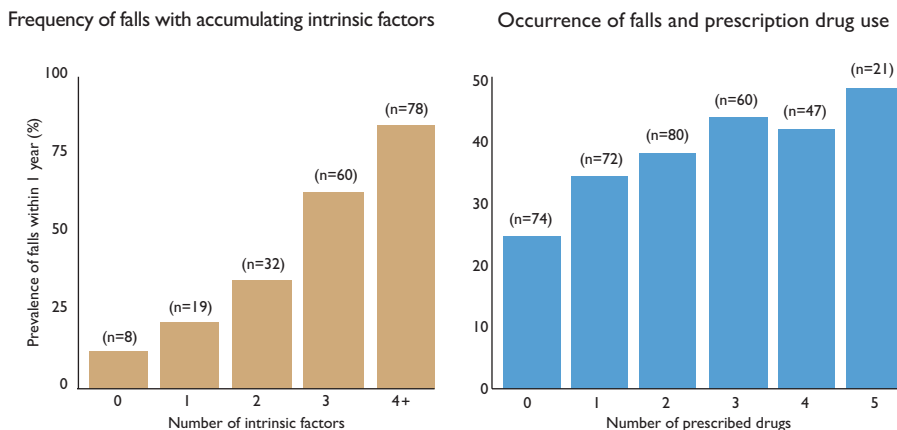


Figure 2. Prevalence of falls for older adults with cumulative intrinsic risk factors (left) and prescription drug use (right) expressed as a percent of the population. More than 75% of older adults characterized by four or more intrinsic risk factors were likely to fall within one year compared to nearly 50% of older adults using five prescription drugs; n = indicates the number of older adults studied.^{3,19}

Balance, falls and whole body vibration training

Continued from page 51

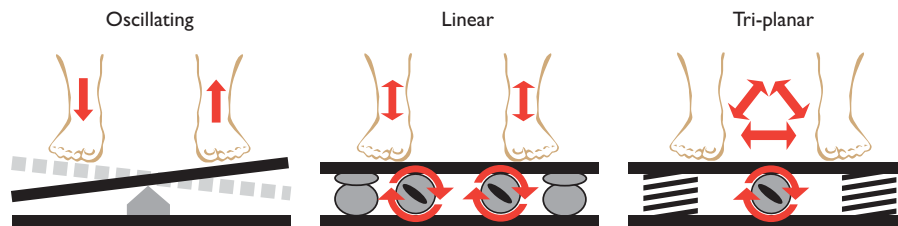


Figure 3. Three different types of whole body vibration technology, including oscillating, linear and tri-planar platforms.

These platforms share a common characteristic: They are effective in activating involuntary muscle contractions via a mechanism known as the stretch (tonic vibration) reflex.⁶ This response is similar to a health professional tapping the patellar tendon (knee) with a reflex hammer. As the hammer impacts the knee, the patellar tendon lengthens and a contraction occurs to counteract it and prevent overstretching of the muscle. The stretch receptors (muscle spindles and Golgi tendon organs) responsible for this reflex are located in the muscles and tendons, and are key factors in maintaining posture and balance for the human body.¹³

As a person stands on a vibration platform, the platform drops, lengthening the tendon, and an involuntary contraction occurs. The platform then moves back to its original position and the process repeats itself. Most linear and tri-planar WBV platforms have a frequency range from 20 to 60 hertz (Hz), and the oscillating platforms typically operate at frequencies below 30 Hz. Simply stated, a frequency of 35 Hz means that 35 muscle contractions are elicited every second. A typical WBV training session will last 15–20 minutes, including rest periods between exercises.

WBV training is best described as a form of resistance training without the use of weights and the joint stress often associated with them. The difference between conventional resistance training and WBV training can be found in Sir Isaac Newton's formula:

$$\text{Force} = \text{Mass} \times \text{Acceleration}$$

During conventional exercise or training, muscular strength (force) is typically enhanced through increasing the resistance (mass) lifted with weights. The acceleration (speed) of an exercise movement can vary; however, it is usually an afterthought and prerequisite to developing muscular power. With WBV training, the opposite holds true. The mass (body weight) typically remains constant during exercise, whereas the acceleration is varied through manipulating the frequency and amplitude of the vibration platform. (As defined by Signorile within the context of WBV,¹⁸ amplitude “refers to how far the platform moves in a specific direction.”)

It has been speculated through measurable outcomes that vibration training may present a strong stimulus for power development:⁷

$$\text{Power} = \text{Work} / \text{Time}$$

Muscular power is developed as a product of strength and speed. As older adults develop more power, they are able to develop more muscular strength (force) across a given distance in a shorter amount of time. In the context of balance and falls, it would seem that although related to strength, power is a separate attribute that may exert a greater influence on physical performance in older adults.²

Research relating to strength and balance

Research has shown that there is a relationship between strength and balance. For example, Jadelis et al.⁸ examined the association between strength and balance in a cohort of 480 adults ages 65 and over with knee pain (osteoarthritis). The study found that knee strength alone explained four percent of the variability in dynamic balance,²⁰ which is the ability to anticipate and respond to balance changes as the body moves.¹⁶ The authors concluded that strength was a significant determinant in maintaining balance among an older population with osteoarthritis.

Wolfson et al.²² studied the effects of lower extremity strength as well as gait and balance on the occurrence of falls in nursing home residents and community-dwelling subjects. The results indicated that as strength increased, the odds ratio for falls decreased significantly. The researchers concluded that within the population studied, a strong relationship existed between lower-body strength and balance and gait.

WBV devices—which may be capable of increasing strength, power and balance via the activation of muscle stretch receptors—therefore hold a great deal of promise for the prevention of falls in older adults.

WBV, strength, power and balance in older adults

In an early study conducted by Runge et al.,¹⁷ balance and power were measured through changes in the chair rising test, a measure that predicts falls and future locomotor status.¹⁹ The randomized, controlled trial had 34 participants, with a mean age of 67 years. The WBV group exhibited a mean performance gain of 18% in the chair rising test (five repetitions of rising from a chair as quickly as possible with arms crossed over the chest). The researchers interpreted the findings as improvements in muscle

power resulting from WBV's oscillative muscle stimulation.

Most hip fractures are caused by falls, and although exercise is considered a strong preventive measure, many older subjects are unable to exercise effectively to maintain muscle power. Miyamoto et al.¹¹ found that balance-function improved significantly after six months of WBV training (three times per week) in comparison to controls, and suggested that WBV may represent an alternative means to reduce the likelihood of falls and hip fractures in older adults.

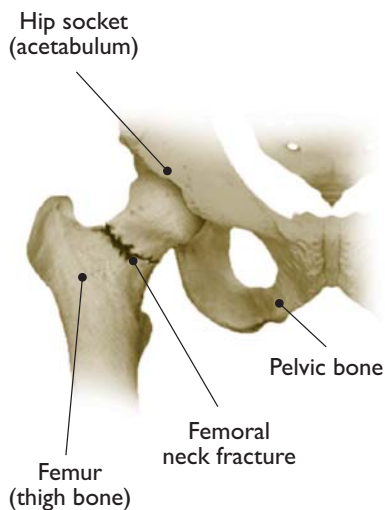


Figure 4. A femoral neck fracture of the hip.²⁰ This kind of fracture occurs below the ball in the ball-and-socket hip joint.

Bruyere et al.⁵ investigated the use of WBV as an intervention in a nursing home setting. Participants were randomly assigned to two groups: 22 took part in a WBV intervention plus standard physical therapy, and 20 were given physical therapy only. Tests were performed for balance, gait and motor capacity, along with a health-related quality of life questionnaire. After six weeks, the intervention group improved on the gait score, the balance score and a chair rising test, versus the control group. The researchers concluded that controlled WBV can improve elements of falls risk and quality of life in older-adult patients.

Investigators Roelants, Delecluse and Verschueren¹⁵ examined the effects of 24 weeks of WBV training on knee extension strength and speed of movement in

females ages 58–74 years. Thirty women were randomly assigned to a WBV group, 30 to a resistance-training group and 29 to a control group. The WBV and resistance-training protocols produced similar statistically significant increases in isometric and dynamic knee extensor strength within the first 12 weeks of training, according to the researchers. “Speed of movement in knee extension significantly increased at low resistance ... in the WBV group only,” they added, although “no significant differences in training effect” were found between the two groups. The authors concluded that WBV is as efficient as conventional resistance training in enhancing knee extension strength and speed of movement in older women.

[Ed. Knee extension is a movement that straightens the knee joint. Isometric (or static) strength involves muscle activation in which the muscle length does not change, while dynamic strength involves a shortening and lengthening of muscles to move the body.]

In another study, Bautmans et al.¹ stated that fatigue or lack of interest can reduce the feasibility of intensive physical exercise in nursing home residents. The researchers surmised that low-volume WBV interventions with similar training effects might be an alternative to conventional physical activity. They randomly assigned participants with a mean age of 77 years to a static WBV or control group (static floor exercise) for six weeks. The authors observed high compliance rates of 96% and 86% for the WBV group and control group, respectively, and concluded that WBV exercise is a feasible activity for older adults with respect to their physical capabilities.

Kawanabe et al.¹⁰ did not specifically examine balance, but they noted that within their study (a protocol incorporating WBV adjunct to muscle strengthening), balance and gait exercises had a positive impact on walking ability in older adults. The researchers also stated that WBV exercise was safe and well-tolerated.

Since WBV training is relatively new and not well understood at this time, the com-

ment about safety provides reassurance to individuals about to undertake a WBV training regimen.

In a randomized, controlled 12-month trial, Bogaerts et al.⁴ studied the effects of WBV on postural control in older adults. The authors stated that WBV training in this group resulted in a reduced frequency of falls among participants while standing on a moving platform with disturbed vision. The researchers concluded that WBV training may improve aspects of postural control in community-dwelling older adults.

Rees, Murphy and Watsford¹⁴ studied the effects of vibration exercise on postural steadiness performance in a healthy, older-adult population with a mean age of 63 years. The study was able to demonstrate that WBV exercise contributed to improved one-legged balance, and further substantiated vibration exercise as an intervention that appears to benefit older adults with diminished postural control.

Finally, Kaeding⁹ wrote an overview of sarcopenia (loss of muscle mass associated with aging) and WBV training. Kaeding reaffirmed that WBV has been shown to increase strength equivalent to that observed with resistance training, especially in older adults with deficits. The author concluded that WBV presents an interesting preventive intervention for older adults, due to its low injury-risk and rare side effects.

Since older adults tend to decrease activity levels and consequently develop sarcopenia, the loss of muscle strength and endurance may be a significant factor in loss of balance and increase in falls risk.

Summarizing the WBV research

In an older population, the research on WBV to date has indicated the following:

- WBV exercise may contribute to strength and power increases, especially in individuals with extreme deficits.

Continued on page 54

Balance, falls and whole body vibration training

Continued from page 53

- WBV appears to have a positive effect on balance and postural control, especially among those individuals who exhibit deficits as above.
- Vibration training appears to be safe, with few side effects.
- The reported compliance rates for WBV exercise are quite high.

Based on the evidence to date, WBV appears to offer benefits for older adults, particularly those with deficits in strength, power and balance. As a result, vibration exercise and WBV platforms are being integrated into facilities for fitness, wellness and medical rehabilitation.

Today, WBV training is increasingly accessible in private and public settings, such as medical and rehabilitative facilities, assisted living communities, fitness studios, weight loss centers and spas. Organizations involved with an older-adult population may want to consider offering this training in their centers or communities as an alternative falls prevention strategy. ☞

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