Research Report

Effects of Whole-Body Vibration Exercise on Lower-Extremity Muscle Strength and Power in an Older Population: A Randomized Clinical Trial

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Background and Purpose

Vibration training is a relatively new exercise intervention. This study investigated the effects of vibration exercise on strength (force-producing capacity) and power in older adults who are healthy.

Participants and Methods

Thirty participants (mean age=73.7 years, SD=4.6) were randomly assigned to a vibration exercise training (VIB) group or an exercise without vibration training (EX) group. The interventions consisted of 3 sessions per week for 8 weeks. Outcome measures included isokinetic flexor and extensor strength and power of the hip, knee, and ankle.

Results

The VIB group significantly improved ankle plantar flexor strength and power compared with the EX group. However, there were no significant differences between the VIB and EX groups for knee flexor or extensor strength.

Discussion and Conclusion

Vibration training contributed to an increase in plantar flexor strength and power. However, the strength gains for the knee and hip flexors and extensors for the VIB group and the EX group were comparable. Future vibration protocols should explore different body positions to target muscles higher up on the leg.

Age-related reductions in muscle mass and activity levels have significant implications for physical function in an older population, including reductions in strength (force-producing capacity), power, gait, and balance and increased susceptibility to falls.[1,2] These reductions can lead to a loss of functional independence, greatly affecting the quality of life for older adults. Fortunately, resistance training has been shown to offset many age-related declines in functional performance.[3–5] As sarcopenia contributes to decreased muscle function, exercise programs that can minimize or combat the loss of muscle mass, strength, and power can have significant implications on how older adults function.[6] Recently, whole-body vibration (WBV) has emerged as an alternative strength training intervention, with gains reported to be comparable to resistance training in young adults who were healthy.[7] There also have been reports that WBV training contributed to increased strength in older adults.[8,9] However, research on the effectiveness of WBV in increasing strength is still sparse. In particular, the effectiveness of WBV at improving muscle strength in older adults warrants further research.

Whole-body vibration involves exercising on a platform that oscillates up and down at a particular frequency and amplitude. Whole-body vibration has been promoted as a strength training intervention because it can increase motor unit activity of the lower limbs through reflex-induced muscle contractions.[10,11] Whole-body vibration as a training modality, however, cannot be performed without some sort of body-weight exercise. Typically, WBV involves static or dynamic squatting. Squatting exercises often are prescribed to older adults to improve strength and physical function.[12] Because squatting is a functional, multijoint exercise that can be performed at home without any specialized equipment, the facilitated effect of combining this training with WBV needs to be evaluated further.

Several studies[10,11,13] have shown that the application of vibration increases muscle electromyographic activity to a much greater degree than the same activity without vibration. It also has been reported that WBV activates muscles in the lower body to varying degrees; specifically, WBV induces greater activation in the gastrocnemius muscle compared with the rectus femoris muscle.[11] Despite this increase in gastrocnemius muscle activation with WBV, most studies have investigated the effect on the leg extensors, neglecting potential effects on the plantar flexors.[14] It appears that the vibration stimulus while squatting on a platform is attenuated by musculature in a distal to proximal manner.[15] Therefore, it is plausible to suggest that strength improvements in the lower limbs following WBV training may exhibit nonlinear adaptations in strength. However, to our knowledge, no study has examined strength and power adaptations following WBV training across the 3 lower-limb joints: hip, knee, and ankle. This study, therefore, investigated isokinetic flexor and extensor strength and power changes for the joints of the lower limbs in older adults who are healthy.

We hypothesized that WBV exercise will result in larger strength and power changes when compared with the same training program without vibration. We further hypothesized that potential strength and power gains of the ankle, knee, and hip flexors and extensors following WBV may be influenced by the proximity of the musculature to the platform. This study will provide insight into the use of WBV as a strength training intervention in an older population. The specific results may aid the prescription and design of future WBV training programs.

Method

Overview of the Study

The current study was designed to investigate the effects of vibration exercise on lower-limb strength in older adults who are healthy. The study involved 2 randomized groups in a pretest-posttest design. It examined lower-limb muscle strength and power following an 8-week training intervention with and without vibration.

Participants

Thirty older volunteers who were healthy (16 men and 14 women, 66–85 years of age) participated in the study. Exclusion criteria were: age less than 65 years; prosthesis; any neurological, musculoskeletal, or other chronic disease; participation in a resistance training program; a recent fracture or bone injury; and any medication that could affect strength adaptations and adversely affect the results of the study. Participants were stratified by sex, then allocated to 2 groups by simple randomization[16] using a computer-generated sequence: 15 participated in a vibration exercise training (VIB) group and 15 in an exercise without vibration training (EX) group. Two participants in the EX group withdrew 2 weeks into the study. The withdrawals from the study were not related to the exercise program; one participant left on a holiday, and the other participant took time out to care for an ill family member. Each participant gave informed written consent to participate.

The sample size for the current study was determined *a priori* using measures of effect size (ES) and based on a number of findings reported in relevant literature.[8,9] This estimated ES was based on strength improve-

Table 1.
Training Volume and Training Intensity of the Whole-Body Vibration (WBV) Program

	Sets	WBV Duration (s)	Rest (s)	Amplitude (mm)	Frequency (Hz)	Exercise[a]
Week 1	6	45	45	5	26	SWBK
Week 2	6	50	50	5	26	SWBK
Week 3	6	55	55	6	26	SWBK
Week 4	6	60	60	6	26	SWBK
Week 5	6	65	65	7	26	DLLE
Week 6	6	70	70	7	26	DLLE
Week 7	6	75	75	8	26	DLLE
Week 8	6	80	80	8	26	DLLE

[a] SWBK=standing with bent knees, DLLE=dynamic lower-limb exercises.

ments following WBV in an older population.[8,9] With a strong ES expected in the principal criterion measure—muscle strength—power analysis revealed that a sample size of 10 in the training groups was required to achieve a power of 0.8 and an alpha of .05.[17] To account for possible dropouts, we determined that 15 participants in each group represented a sufficient quantity for the results to be meaningful.

Training Program

To investigate flexor and extensor strength and power changes in the lower limbs for an older population, 8 weeks of WBV exercise (VIB group) was compared with the same program performed without vibration (EX group). Both the VIB and EX groups performed exercises on a platform (height=0.18 m, width=0.72 m, depth=0.51 m), with and without vibration respectively. Handlebars were available on these platforms if participants required their use; however, they were encouraged to perform the specified exercises without the assistance of handlebars. The exercise program for the VIB and EX group consisted of two 4-week blocks: (1) standing with bent knees (SWBK) (static squats), which were performed to a maximum depth of 100 degrees of knee flexion, and (2) dynamic lower-limb exercises (DLLE), which involved dynamic squatting (80% of the total time) and then calf raises (20% of the total time) (Tab.1). Initially, each participant was required to squat to the maximal depth (up to 100° of knee flexion) they could attain.

As the program continued, each participant was encouraged to progress deeper to a squat depth of 100 degrees of knee flexion. The rationale for this exercise program was to incorporate and evaluate previous protocols (static[13,18] and dynamic[9,19]). Resistance was provided by the vibration stimulus and through body weight exercises. Both treatment groups were required to use specific body positions: standing with the heel just off the ground (~1–2 cm) and never fully extending at the hips when squatting. Undertaking WBV training while standing with weight on the heels or the legs locked out increases the transfer of vibration to the upper body.[20,21] To avoid vibration transfer to the organs and eyes[22] and discomfort from the stimulus shaking the head,[20] the current study was limited 2 specific body positions to maximize dampening and minimize vibration transfer to the upper body.

Training frequency was 3 times per week, with at least 1 day of rest between sessions. The outcome measurements were made before randomization (pretest), following 4 weeks of training, and after 8 weeks of training (posttest). At the beginning of each testing and training session, a 5-minute walking warm-up was performed. All participants completed a familiarization session for each test before the study began.

Vibration Protocol

The participants in the VIB group were exposed to vertical sinusoidal WBV using a Galileo Sport platform.* The frequency used for this study was set at 26 Hz,[19,23] with peak-to-peak amplitude ranging from 5 to 8 mm. The training intensity and volume increased according to the overload principle. Training volume progressed by systematically increasing the duration of vibration sessions. Training intensity was increased by progressively raising the amplitude and incorporating dynamic lower-limb exercises. This progressive overload is displayed in Table 1.

Performance Tests

Bilateral strength and power of the hips, knees, and ankles was determined using a Cybex II isokinetic dynamometer.† Maximum isokinetic strength was measured as torque.

* Novotec Medical GmbH, Durlacher Str. 35, D-75172 Pforzheim, Germany.
† Lumex, PO Box 9003, Ronkonkoma, NY 11779-0903.

Maximum isokinetic power was calculated from the time required to produce the work (measured in watts). A standardized warm-up of 4 submaximal muscle contractions was performed prior to each isokinetic test velocity. The angular velocity for the hip and knee was 60°/s, with the ankle joint tested at 30°/s. Tests were performed in the following order: (1) knee, (2) ankle, and (3) hip. Isokinetic testing involved 4 cyclic (uninterrupted) maximal repetitions, performed twice. Maximum muscle strength and power were recorded for the 2 sets and then reported as an average. In between trials, a 1-minute rest period was imposed. Before each trial, participants were instructed to contract specific muscles as fast and as hard as possible. Verbal encouragement was given during the test.

Isokinetic testing of the hip, knee, and ankle flexors and extensors involved standardized body positioning. For all isokinetic tests, participants were strapped securely at the waist and chest. Each participant was instructed to fold their arms across the chest for each contraction to minimize any contribution of the upper body. Two stoppers were positioned to control the starting and end positions for each joint. For each participant, specific set-up measures at the pretest were recorded and used at the 4-week testing occasion as well as at the posttesting occasion.

To test hip strength, the participants lay in a supine position with the leg placed at 90 degrees of flexion and the opposite leg supported in an extended position. The dynamometer arm was secured 5 cm superior to the patella. Hip flexor and extensor strength was measured from a neutral 0-degree position to 90 degrees of flexion.

Knee strength was assessed in the Cybex chair with the back positioned at 100 degrees. The participants' knees hung over the edge of the chair, with the lateral femoral condyle of the tested leg aligned with the axis of rotation of the dynamometer. The dynamometer arm was secured 5 cm superior to the medial malleolus. Knee flexor and extensor strength was measured from 85 degrees to 10 degrees of flexion.

Table 2.
Subject Characteristics (Mean±SD) of the Vibration Exercise Training (VIB) Group and the Exercise Without Vibration Training (EX) Group

	VIB Group	EX Group
Age (y)	74.3±5.0	73.1±4.1
Height (cm)	167.5±10.9	168.7±10.6
Body mass (kg)	75.3±12.6	75.9±8.9

Ankle strength was measured with the participants lying prone. Their knees were fully extended and stabilized. The tested foot was fixed to the dynamometer footplate, with the ankle maintained at 10 degrees of dorsiflexion. The lateral malleolus was aligned with the dynamometer's axis of rotation. The tested leg was secured with a Velcro[‡] strap 5 cm inferior to the patella. Ankle flexor and extensor strength was measured from 10 degrees of dorsiflexion to 20 degrees of plantar flexion.

The Cybex dynamometer was calibrated prior to testing, using known masses placed on the lever arm. A gravity correction factor (additional torque created by the mass of limb) was determined by measuring the mass of the limb through its range of motion before each test. To enable comparisons between participants, isokinetic strength and power values were normalized relative to body weight (in newton-meters per kilogram and watts per kilogram, respectively). The procedures for isokinetic testing were based on a review of literature outlined in Perrin.[24]

Data Analysis

All data were examined using SPSS version 12.0.[§] Descriptive statistics are reported as means and standard deviations. Prior to training, a one-way analysis of variance (ANOVA) was used to determine whether differences existed between the groups. Upon completion of the training period, the data were examined for between-group and within-group effects using a 2 × 2 (group × time) ANOVA. To examine the vibration training effect between muscles of the lower limb, a treatment group × muscle group × time interaction was assessed with an ANOVA. For all procedures, significance was accepted at the alpha level of .05.

Results

Prior to the training period, no significant differences between the groups were observed for any variable (Tabs. 2, 3, 4, and 5). Because responses to the vibration exercise training and exercise without vibration training showed no sex differences, results for male and female participants were combined and analyzed together. Similarly, because there were no significant differences between right and left sides, the data were averaged for the purposes of clarity. Sphericity and homogeneity of variance were obtained for each variable. The results for isokinetic hip, knee, and ankle torque and power output at each testing occa-

‡ Velcro USA, Inc, 406 Brown Ave, Manchester, NH 03103.

§ SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606.

Table 3.
Hip Joint Results (Mean±SD) for the Vibration Exercise Training (VIB) Group and the Exercise Without Vibration Training (EX) Group

	VIB Group (n=15)	EX Group (n=13)
Hip flexor torque (N·m/kg)		
Pretest	141.1±30.8	137.4±47.9
Posttest	146.5±28.7	143.0±46.0
Hip flexor power (W/kg)		
Pretest	82.3±20.0	81.3±30.9
Posttest	85.5±17.0	82.5±28.1
Hip extensor torque (N·m/kg)		
Pretest	170.0±40.2	169.4±62.2
Posttest	177.4±44.0	176.2±58.6
Hip extensor power (W/kg)		
Pretest	104.7±23.8	100.6±44.8
Posttest	107.8±26.1	103.6±41.5

sions are displayed in Tables 3, 4, and 5, respectively.

Hip Joint

No significant changes were evident between or within groups for hip flexor and extensor strength and power output following the training period. The hip flexor and extensor strength and power results are displayed in Table 3.

Knee Joint

After the 8-week training intervention, there were no significant between-group changes for knee flexor (KF) and extensor (KE) variables. However, significant within-group effects for knee flexor and extensor torque and power output were evident for both the VIB group (KF torque: F=16.1, P<.01; KF power: F=14.3, P<.01; KE torque: F=15.7, P<.01; KE power: F=25.7, P<.01) and EX group (KF torque: F=10.2, P<.01; KF power: F=12.5, P<.01; KE torque: F=18.4, P<.01; KE power: F=14.2, P<.01). Knee flexor and extensor torque and power output results are displayed in Table 4.

Table 4.
Knee Joint Results (Mean±SD) for the Vibration Exercise Training (VIB) Group and the Exercise Without Vibration Training (EX) Group

	VIB Group (n=15)	EX Group (n=13)
Knee flexor torque (N·m/kg)		
Pretest	101.7±23.6	105.9±34.9
Posttest	111.6±26.5	112.4±36.1
Knee flexor power (W/kg)		
Pretest	67.6±17.3	69.8±24.7
Posttest	75.8±18.5	74.2±25.0
Knee extensor torque (N·m/kg)		
Pretest	162.2±32.6	165.3±44.2
Postttest	175.1±33.2	176.4±45.5
Knee extensor power (W/kg)		
Pretest	109.9±20.4	110.5±29.4
Posttest	121.6±21.0	119.2±30.0

Ankle Joint

Ankle dorsiflexor torque and power showed no significant changes between or within groups on any testing occasion. The VIB group had significant improvements in ankle plantar-flexor torque and power output compared with the EX group (torque: F=32.2, P<.01; power: F=30.4, P<.01). The average amount of change in ankle plantar flexor torque was 18% and 5% for the VIB and EX groups, respectively. Ankle plantar-flexor and dorsiflexor torque and power output results are displayed in Table 5.

Muscle Strength Interactions

At the completion of the 8-week vibration training intervention, a number of significant torque-dependent training effects were evident between muscles of the VIB group (F=29.0, P<.01). Ankle plantar-flexor torque change was significantly greater than the amount of change for the knee flexors (P<.01), knee extensors (P<.01), hip flexors (P<.01), and hip extensors (P<.01). There were no significant differences between knee flexor and extensor torque versus hip flexor and extensor torque within the VIB group. The changes in lower-limb torque following the training intervention are displayed in the Figure.

Similar to muscle torque responses, a number of power-dependent training effects were evident between muscles of the VIB group (F=19.6, P<.05). The change in ankle plantar-flexor power was significantly greater than the change in power for the knee flexors (P=.02), knee extensors (P<.01), hip flexors (P<.01), and hip extensors (P<.01). A significant difference between change in knee extensor power and change in hip flexor power was evident (P=.02). There were no signif-

Table 5.
Ankle Joint Results (Mean±SD) for the Vibration Exercise Training (VIB) Group and the Exercise Without Vibration Training (EX) Group

	VIB Group (n=15)	EX Group (n=13)
Ankle dorsiflexor torque (N·m/kg)		
Pretest	35.7±7.8	36.0±9.0
Posttest	36.2±7.4	35.8±8.7
Ankle dorsiflexor power (W/kg)		
Pretest	12.5±2.8	12.3±3.4
Posttest	12.5±2.7	12.3±3.0
Ankle plantar-flexor torque (N·m/kg)		
Pretest	103.2±21.7	102.1±28.1
Postttest	122.0±21.8[a]	107.2±27.3
Ankle plantar-flexor power (W/kg)		
Pretest	31.8±7.2	31.5±9.1
Posttest	38.3±7.2[a]	33.1±10.0

[a] Significantly greater change compared with pretest exercise without vibration ($P<.05$).

icant differences between knee flexor power versus hip flexor and extensor power or knee extensor power versus hip extensor power.

Discussion

The purpose of this study was to examine the effects of WBV on strength and power changes of the lower limbs in older adults who were healthy. Our results show that average strength gains following 8 weeks of WBV training were larger for ankle plantar flexors than for knee and hip flexors and extensors (Tabs. 3, 4, and 5; Figure). These strength measures illustrate that the WBV induced different increases in lower-limb strength, with significantly larger gains observed in plantar-flexor strength and power compared with the more proximal leg musculature. Our finding that WBV induced larger gains in ankle plantar-flexor strength than in knee or hip flexor and extensor strength is in accordance with previous research demonstrating that vibration applied at the foot predominantly recruits the calf musculature to dampen the stimulus.[25]

Whole-body variation can be separated into 2 training stimuli: the reflex muscle contraction induced by vibration and the body-weight exercise performed on the platform. Previous research has reported that strength gains following WBV were associated with the reflex muscle contractions it provokes and not the body-weight exercises.[7] In a 12-week study involving young female participants who were healthy, Delecluse et al[7] found a 9% increase in dynamic knee extensor strength following WBV training and a 7% increase for standard resistance train-

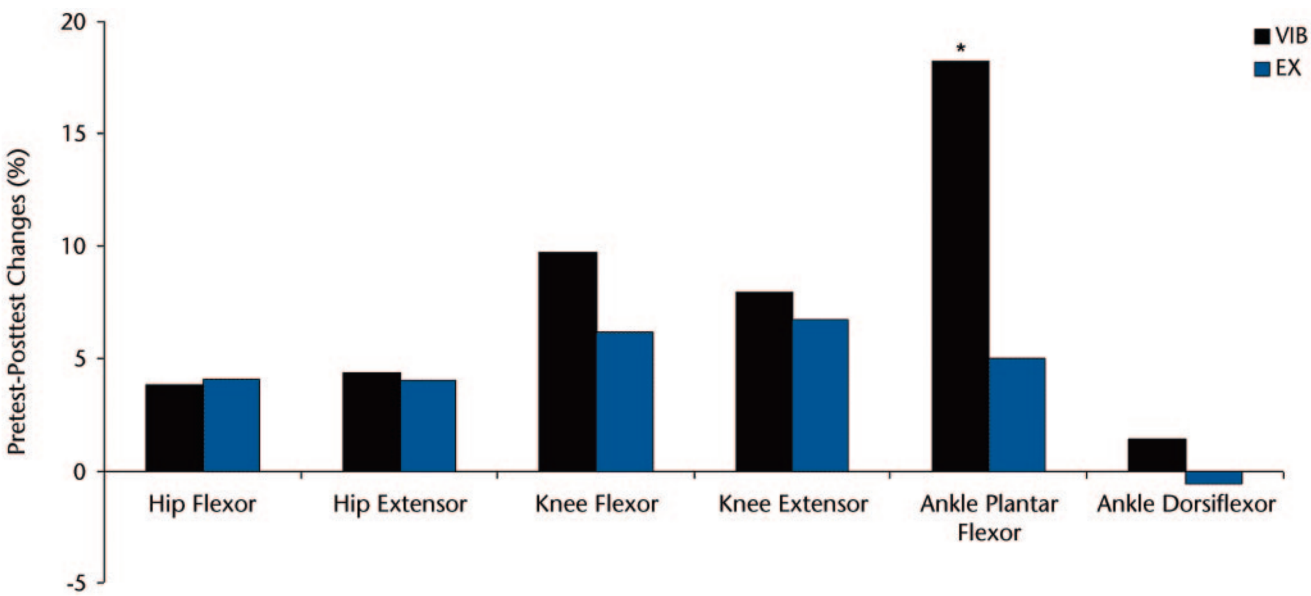

Figure.
Joint torque percentage change from pretest. VIB=vibration exercise training group, EX=exercise without vibration training group. Asterisk indicates significant difference compared with EX group.

ing. The vibration-induced knee extensor strength improvements found in the present study (Tab. 4) are comparable to the results of Delecluse et al.[7] However, the present study could not differentiate knee strength gains between the VIB and EX groups, suggesting that improvements were attributable to the body-weight exercises performed.

This is the first study to investigate the effects of WBV exercise on muscle strength and power of the 3 lower-limb joints in an older population. The results demonstrated that the effect of WBV on muscle properties is disproportional, with greater ankle plantar-flexor strength and power changes than those of the knee and hip (Tabs. 3, 4, and 5; Figure). The differences in changes in ankle plantar-flexor strength and power compared with changes in knee or hip flexor and extensor strength and power within the VIB group may be explained by WBV-induced reflex muscle contractions. Whole-body vibration can stimulate a number of muscle groups of the lower body at the same time. However, the muscle group closer to the vibration platform will attenuate more of the vibration stimulus than muscles higher up the leg,[11] thus eliciting a greater training response. It has been reported that WBV-induced reflex muscle activity of the ankle plantar flexors is higher than that of the knee extensors.[26] It, therefore, is reasonable to infer that the current differences in strength and power changes between lower-limb musculature in the VIB group may be the result of greater WBV-induced muscle activity.

The suggestion that WBV improved plantar-flexor strength to a greater degree than knee extensor strength because of its relative proximity to the vibration platform raises the question why there was not a corresponding change in dorsiflexor strength. The EX group displayed no changes in dorsiflexor strength following the training program. Therefore, it may be suggested that the training program did not stress this muscle group or that the measurement was not able to detect subtle changes in dorsiflexor strength. Because this phenomenon of different strength gains between opposing muscles of the ankle following WBV is the first to be reported, we suggest that future researchers examine the mechanisms of these differences.

A number of studies[7,8,27] have shown that WBV exercise resulted in improved knee extensor strength that was comparable to gains with moderate resistance training. In a placebo-controlled study,[7] knee extensor strength improvements following WBV were associated with reflex muscle activity and not the body-weight exercises. The current study also demonstrated improvements in knee extensor strength following WBV, yet these gains were not significantly larger than those for a group performing the same body-weight exercises without vibration. It is plausible that a much larger sample size may have been able to detect a statistically significant difference between the VIB and EX groups for knee flexor and extensor variables. Retrospectively, however, the results of the current study appear to suggest that any significant interaction for knee flexor or extensor torque between a VIB group and an EX group would be relatively small. Even with a much larger sample size, it is unlikely that knee flexor and extensor changes between the VIB and EX groups would be large enough to be considered a clinically significant difference between these training interventions. However, such an analysis was outside the scope of this study. More research is needed to examine knee flexor and extensor strength adaptations between a vibration and exercise-without vibration training intervention and its clinical significance.

In contrast to studies previously mentioned,[7,8,27] an 11-week WBV study involving young participants who were healthy showed no improvements in knee extensor strength.[28] Discrepancies among studies often are linked to differences in WBV protocols and methods. The discrepancies between the current study and those mentioned above also may be explained by differences in methods. Notwithstanding the participants' characteristics, Delecluse et al[7] included additional exercises, such as a deep squat, wide stance squat, one-legged squat, and lunge, that may have resulted in a greater exercise intensity in the WBV training group. These additional dynamic exercises also may have facilitated the delivery of vibration to musculature that would not have been stimulated to the same degree under traditional standing with bent knees or squatting. By incorporating activities that may be able to specifically target muscle groups higher up the leg, the potential for WBV training to improve performance would appear to be enhanced. This notion is in line with the emphasis on the specificity of training. In this respect, the terminology of "whole-body" vibration may need to be revised. Because the aging process is associated with deterioration in muscle strength, improvements in knee and hip muscle strength similar to those observed in the ankle plantar flexors with WBV could potentially benefit mobility and functional performance in an older population. Future studies need to examine WBV and the adaptation to different dynamic exercises.

The maximal plantar-flexor torques, expressed in absolute terms for the VIB group at the pretest occasion, were 90 N·m (SD=21) and 65 N·m (SD=18) for male and female participants, respectively. These results were similar to those previously reported for a matched group of older adults who were healthy (male participants: 94 N·m, SD=27; female participants: 60 N·m, SD=15).[29] The VIB group displayed an 18% improvement in plantar-flexor strength following the 8-week WBV training program (Tab. 5). This improvement in plantar-flexor strength in older adults who were healthy approached absolute torque values similar to those reported in younger adults who were healthy.[29] However, at the posttest assessment, the VIB group's plantar-flexor torque values were within 1 standard deviation of torque values obtained for younger men (124 N·m [SD=32] versus 107 N·m [SD=21] in our VIB group) and younger women (85 N·m [SD=27] versus 75 N·m [SD=17] in our VIB group). It must be acknowledged that there were differences in methods between these studies. Therefore, a direct comparison between the studies should be treated with caution. However, the current study's results do provide support for a clinically significant improvement in this measure. Because ankle plantar-flexor strength plays an important role in mobility and balance in the older population,[30–32] greater ankle plantar-flexor strength following WBV training can be considered to be an important adaptation for an older population. With plantar-flexor muscles displaying significant reductions in structure and strength with age,[33] WBV may serve as a supplement to other training methods in mediating functional decline in plantar-flexor strength.

Improvements in muscular performance following WBV are typically based on neuromuscular enhancement.[19,34] The potential for chronic neuromuscular enhancement with WBV training would provide a rationale for the increased plantar-flexor strength observed in the current study. However, specific neural adaptations were not measured in the current study. The specific contribution of mechanisms explaining increased strength following WBV in an older population awaits further investigation. Regardless of the mechanisms, it was clear that WBV contributed to the improved plantar-flexor strength in a group of older adults who were healthy. As the older population exhibits reduced plantar-flexor strength compared with their younger counterparts,[33] WBV may serve as a therapeutic intervention to combat or counteract reduced plantar-flexor strength.

Conclusion

The results of the current study demonstrated that 8 weeks of WBV training produced a significant improvement in plantar-flexor strength and power for a group of older adults who were healthy. Following the training period, improvements in knee joint torque and power showed no significant differences between the VIB and EX groups. Therefore, the observed improvements in knee extensor strength in both the VIB and EX groups can largely be attributed to the body-weight–specific exercises performed. The strength gains following vibration training appear to be dissipated distally by lower-limb muscle groups. Therefore, different WBV exercise protocols should be used in order to specially target muscles higher up the leg.

All authors provided concept/idea/research design. Mr Rees and Dr Murphy provided writing, data analysis, and project management. Mr Rees provided data collection. Dr Murphy and Dr Watsford provided fund procurement. Dr Watsford provided consultation (including review of manuscript before submission).

The study and its procedures were approved by the Human Research Ethics Committee of the University of Technology, Sydney.

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