Published in final edited form as:

PM R. 2013 March ; 5(3): . doi:10.1016/j.pmrj.2012.07.011.

Vibration Platform Training in Women at Risk for Symptomatic Knee Osteoarthritis

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Abstract

Objective—To determine whether a platform exercise program with vibration is more effective than the platform exercise alone for improving lower limb muscle strength and power in women age 45-60 with risk factors for knee osteoarthritis (OA).

Design—Randomized, controlled study

Setting—Academic center

Participants—48 women age 45-60 years old with risk factors for knee OA (history of knee injury or surgery or BMI $\geq 25\text{kg/m}^2$).

Interventions—Subjects were randomized to a twice weekly lower limb exercise program (quarter squat, posterolateral leg lifts, calf raises) on either a vertically vibrating (35Hz, 2mm), or a non-vibrating platform.

Main Outcome Measurements—The main outcome measures included change in isokinetic quadriceps strength, leg press power, and stair climb power by 12 weeks.

Results—39 out of 48 enrolled participants completed the study (26 vibration and 13 control exercise). Nine participants discontinued the study after randomization mainly due to lack of time. There were no intergroup differences in age, BMI, or activity level. Isokinetic knee extensor strength did not significantly improve in either group. Leg press power improved by 92.0 ± 69.7 W in the vibration group ($p < .0001$) and 58.2 ± 96.2 W in the control group ($p = 0.0499$), but did not differ between groups ($p = 0.2262$). Stair climb power improved by 53.4 ± 64.7 W in the vibration group ($p = 0.0004$) and 55.7 ± 83.3 W in the control group ($p = 0.0329$), but did not differ between groups ($p = 0.9272$).

Conclusions—Whole body vibration platforms have been marketed for increasing strength and power. In this group of asymptomatic middle-aged women with risk factors for knee OA, addition of vibration to a 12-week exercise program did not result in significantly greater improvement in lower limb strength or power than participation in the exercise program without vibration.

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Keywords

quadriceps; strength; power; vibration

INTRODUCTION

Symptomatic knee osteoarthritis (OA) affects 12-16% of older adults in the US,^{1, 2} making it one of the most common disabling diseases in older adults.³ Despite the high prevalence, there is little effective treatment.⁴⁻⁶ Therefore, prevention is paramount. Recent evidence suggests that older adults without knee OA who have greater quadriceps strength have approximately 60% decreased risk for developing incident symptomatic knee OA (the combination of knee OA with daily symptoms).⁷ This implies that quadriceps strength may be a modifiable factor for incident symptomatic knee OA. However, there is a need for exercise methods of sufficient intensity to result in quadriceps strengthening while remaining tolerable for older adults at elevated risk for knee OA.

Whole Body Vibration (WBV) exercise, exercise performed with the body in contact with a vibrating platform, may provide the benefits of strength training without adding potentially harmful loads to the knee joint through stimulating reflex muscle contractions and synchronizing motor unit activation.⁸ In one study that compared WBV to resistance training in older women, greater improvement in knee extensor strength and speed of movement was found with WBV exercises.⁹ Additionally, a 2-month WBV exercise program resulted in significantly improved walking speed, step length, and maximum unilateral standing time in adults between the ages of 59 to 86.¹⁰ WBV exercise has also been shown to be safe and well tolerated by older adults.¹⁰⁻¹²

There have also been indications that WBV on a stable platform may improve sensory function and balance in young,^{13, 14} but not older adults.^{15, 16} One study of women with knee OA demonstrated improvements in isokinetic knee extensor strength with exercise on a stable vibration platform compared with those who did not exercise, whereas improvement in strength was not found in those who exercised on an unstable platform.¹⁵ In that same study, proprioceptive function (threshold to detection of passive movement) improved in those who exercised on an unstable vibration platform in comparison with those who did not exercise; while a significant effect on proprioception was not detected in the group that exercised on a stable vibration platform. These findings suggest that exercise on a vibrating platform may be a well-tolerated and effective means of strengthening the quadriceps, and may contribute to improved sensory function.^{10-12, 14, 15} However, further study is needed in which WBV exercise is compared with the same exercise on a non-vibrating platform in order to determine the effects attributable to WBV in comparison with those attributable to the exercise program.

In order to extend these findings, the purpose of this randomized, controlled trial was to determine whether a stable vibration platform exercise program would be more effective than a non-vibrating platform exercise program for improving quadriceps muscle strength in women age 45-60 years with risk factors for symptomatic knee OA. Our primary hypothesis was that quadriceps strength would increase to a greater extent in the group randomized to receive 12 weeks of exercise augmented with WBV than in those randomized to complete the same exercises without WBV. Our secondary hypotheses were that lower limb muscle power (stair climb power) and vibration sense (vibration perception threshold) would improve to a greater extent in the WBV group.

METHODS

Participants

Fifty women between the ages of 45 and 60 years old at risk for developing knee OA based on a body mass index (BMI) greater than or equal to 25 kg/m² or a history of knee injury or surgery, were enrolled in the study. Recruitment methods included flyers, posters, website advertisement, and mass e-mails to institutional staff, faculty, and alumni. In addition, individuals who had previously requested to be contacted for research studies were contacted by phone. Potential participants were excluded if they had a history of joint replacement surgery, knee OA diagnosis, lower limb amputation, inability to walk without an assistive device or any contraindications to vibration platform exercise, including cardiovascular or neurological diseases, severe asthma, terminal illness, diabetes mellitus, or plan to become pregnant during the study period. Heart rate and blood pressure were collected at the baseline assessment as a general health screen and to confirm eligibility for involvement in the study. No participant had a blood pressure above 180/100 mmHg or a resting heart rate less than 40 or greater than 110 beats per minute.

The principal investigator used a random number generator to randomly assign participants in a 1:1 ratio to either the control exercise group or intervention exercise group (Figure 1) and randomized assignments were concealed in consecutively numbered, sealed envelopes which were opened by the study trainer following completion of baseline measurements. The study recruiters were unaware of the randomization and were not involved in the exercise interventions. The investigators' institutional review board (IRB) approved this study. All participants completed an IRB-approved consent process, culminating in signing a written informed consent document. This protocol was registered at clinicaltrials.gov as study NCT01239823. Enrollment took place between November 8, 2010 - December 20, 2010 and follow-up was completed March 3, 2011. This study was conducted at an academic center.

Assessments

1. Body Mass Index (BMI)—Height in centimeters (stadiometer, Seca, Germany) and mass in kilograms (Tanita digital scale: Arlington Heights, IL) were measured by trained staff and BMI (kg/m²) was calculated. Two height measurements without shoes were taken. If the measurements differed by more than 3mm, then 2 additional measurements were completed. All measurements were recorded and averaged. BMI was evaluated to confirm eligibility and to determine whether BMI levels significantly differed between the two exercise groups.

2. Physical Activity—In order to determine whether there was a significant difference in physical activity levels between the two exercise groups at baseline, participants completed the Physical Activity Scale for the Elderly (PASE: New England Research Institute, Watertown, MA) questionnaire, and activity scores were calculated.¹⁷

Primary Outcome

1. Isokinetic Knee Extensor Strength Measurements—Concentric knee extensor strength was assessed with a Biodex System 3 PRO computerized isokinetic dynamometer (Biodex Medical Systems, Inc.: Shirley, New York) at 60 degrees per second, through a range of motion of approximately 90 degrees, and a chair back of 85 degrees. Biodex medical system software version 3.30, System 3 PRO, Rev N Software Package was used for data acquisition. Participants were provided instructions using a standardized script. Participants were stabilized in the seat with a seatbelt over each shoulder, their lap and the thigh being tested. Participants with differing shank lengths were standardized by adjusting

the dynamometer arm length and seat height to accurately align the participant's lateral femoral condyle with the axis of rotation of the dynamometer. After trials of the range of motion to confirm comfort and proper form and one practice trial at 50% of perceived maximal exertion, four repetitions were completed with alternating knee extension and flexion while using a standardized script to verbally encourage participants' maximum effort. Knee extensor strength (Nm) was the maximum torque achieved over four trials.

Secondary Outcomes

1. Lower Limb Muscle Power—A certified research assistant measured leg press strength (N) and power (W), using a Keiser leg press (Air300 Keiser, Fresno, CA), at both the baseline and at the 12-week follow-up assessments. Participants were given instructions using a standard script. Double leg press strength was the maximum resistance the participant could push for one repetition (1RM). After each repetition, participants were asked to rate their perceived exertion on a standard 6-20 scale, with 20 indicating maximal exertion. Next, five double leg press repetitions were performed as fast as possible at 40% of the participant's 1RM to measure leg press power. Again, a standardized script was used to promote maximum effort. The participant's highest power output was recorded as their maximum leg press power (W).

2. Stair Climb Power—At both the baseline assessment and at the 12-week follow-up assessment, participants were asked to ascend a 1.441m flight of 8 stairs as quickly as possible.^{18, 19} Certified examiners timed two separate stair climb trials, and the results were averaged. The reliability for this test has been reported to be excellent (ICC = 0.97).¹⁹ Stair climb power (W) was calculated as the product of gravitational force (N) and vertical distance (m) divided by time (s).¹⁸

3. Vibration Perception Threshold—Vibration perception threshold (VPT) was measured at the baseline and follow-up visits to assess for changes in vibration perception as a result of WBV exercise training, as. Vibration perception threshold was assessed with a biothesiometer (Bio-Medical Instrument Co., Newbury, OH) using a validated protocol at two anatomical landmarks—the first metatarsophalangeal (MTP) joint and the tibial tuberosity, bilaterally.²⁰ Participants were instructed using a standardized script, and given an opportunity to become familiar with the testing apparatus. Two certified examiners administered the VPT exam. One examiner held the biothesiometer on the anatomical landmark, allowing the weight of the device to rest on the landmark, perpendicular to the skin, while the other examiner increased the voltage until the participant sensed vibration. Two trials were completed at each of the two anatomical landmarks and the mean value for each location was used for analyses. If the difference in voltage between the two trials was greater than 4V at the first MTP joint or 6V at the tibial tuberosity, then the test was repeated. The intraclass correlation coefficient (ICC) for this method has been reported previously and is 0.93 to 0.99 between initial and repeat testing on separate days.²⁰

Intervention

Participants were scheduled for two exercise sessions per week for 12 weeks (24 exercise sessions). Both of the exercise groups completed an identical exercise protocol on the WAVE Pro-elite vibration platform (WAVE Manufacturing Inc.: Concord, Ontario). However, the control group performed the exercises with the machine powered off and participants were not informed that the metal platform had any features other than use as a step. At the beginning and end of each exercise session, participants were asked to rate their level of knee pain on a verbal analogue scale. The exercise protocol included five leg-strengthening exercises with stretches and rest between repetitions (Figure 2).

The series of exercises were: 1) squats with the participant's feet placed shoulder-width apart in the center of the platform, with a maximum of 90 degrees of knee flexion; 2) standing posterolateral leg lifts with toes facing forwards; 3) plantar flexion "heel raises" from a flat footed position in the center of the platform; 4) single leg forward step-ups starting with one foot on the platform and the other off the platform; 5) lunges with the front foot on the platform and the back leg on the floor (maximum knee flexion of 90 degrees) and a balance bar available for support (mainly used during the single-leg lifts and single-leg step-ups). Three sets of each exercise were completed at 30-second intervals with a 30 second stretch between sets. The stretches included a standing hamstring stretch, a bent knee (soleus) and straight knee (gastrocnemius) calf stretch, and a standing hip abductor stretch with the feet crossed and the stretching limb posterior. Participants wore their usual shoes, which had flat rubber or polyurethane soles.

The timed exercises were performed at a rate of 60 beats per minute using a metronome, and each repetition lasted four beats (2 beats for the concentric phase and 2 beats for the eccentric phase). Heel raises were completed at 90 beats per minute to avoid muscle cramping. For both exercise groups the volume and intensity of work increased at exercise session 13 of 24. The timed exercise increased to 45 seconds of exercise for each set, and the rest between sets decreased to 15 seconds. The intervention group exercised on the WAVE Pro-elite platform vibrating with a vertical amplitude of 2 mm and a frequency of 35 Hz (theoretically providing an additional 3.5 g of peak acceleration given the synchronous vibration and lack of dampening with this platform). The vibration parameters remained constant throughout the 12-week exercise program.

Analytic Methods

Univariate distributions were analyzed for normality. Participant-based variables were assessed using paired t-tests for intra-group comparisons of baseline with follow-up measurements and Student's t-tests for intergroup comparisons of change scores (i.e. leg-press muscular strength and power and stair climb power). Mixed models were constructed to assess the change in limb-based variables, while controlling for the inclusion of 2 limbs per participant (i.e. knee extensor strength and vibratory perception threshold). Participant demographics were described using means $\pm$ SD for continuous variables and percentages for categorical variables. For comparison with other reports, percent change in outcomes was calculated as (final-initial)/initial measurement. Baseline demographics of the intervention and control groups were compared using t-tests for continuous variables. No baseline differences were detected, obviating the need for adjustment of outcome analyses. Analyses were based on "intention-to-treat."

A sample size calculation was conducted prior to initiation of the study, based upon prior data collected for the clinically significant difference in isokinetic quadriceps torque²¹ and appropriate standard deviations within and between groups. At a significance level of 0.025 (adjusted for two-sidedness), a standard deviation in the quadriceps strength response variable of 12.2 Nm, and a power of 0.80, to detect an inter-group difference in means of 11.4 Nm would require a minimum of 38 participants for this two-treatment parallel-design study. In addition, assuming that a clinically relevant difference in muscular power (the secondary outcome) would be 40 W with a standard deviation of = 45 W, at an alpha level of 0.05, 21 participants per group would provide 80% power. After considering a potential dropout rate of 10%, we aimed to recruit 46 participants.

RESULTS

A total of 48 women met eligibility criteria and were enrolled in the study (Figure 1). Out of this number, 39 participants completed the study and had complete data for analyses. Prior

to starting the intervention, three participants discontinued the study due to a lack of time and one discontinued due to personal issues. Following the first intervention visit, two participants dropped out due to lack of time, one dropped out due to excessive fuel expenses, another was lost to follow up, and one dropped out of the study due to a death in the family. Baseline characteristics including age, BMI, and physical activity level did not differ between participants randomized to the vibration intervention group compared with the control group (all $p < 0.05$, Table 1). As shown in Table 2, baseline outcome measures also did not significantly differ between groups (all $p < 0.05$).

Isokinetic knee extensor strength did not significantly improve in either group (Table 3). At follow-up, leg press power improved in both the WBV ($9.0 \pm 6.7\%$, $p < 0.0001$) and the control group ($6.8 \pm 11.5\%$, $p = 0.0499$), but improvement did not significantly differ between groups (changes and effect sizes presented in Table 3). Stair climb power also improved in the WBV ($14.1 \pm 16.9\%$, $p = 0.0004$) and the control group ($16.6 \pm 20.0\%$, $p = 0.0329$) but this improvement did not significantly differ between groups. Vibration perception thresholds did not change in a statistically significant manner in either group.

Compliance with exercise training attendance was 83% for the vibration group and 79% for the control group and did not differ between groups. No subjects discontinued participation due to the intervention. In addition, no subjects reported worsening of knee pain.

DISCUSSION

The results of this study indicate that completion of dynamic lower limb strengthening exercises on a vertically vibrating platform may not enhance improvement of muscle strength or power in comparison with completion on a stable platform. These results concur with the findings of several prior studies comparing static (isometric poses) and dynamic exercises completed with WBV to a variety of programs completed without vibration.²²⁻²⁴ Although there were no significant improvements in VPT observed, there also was no suggestion of worsening of vibratory perception with WBV exercise.

These results are consistent with those of prior studies. For example, in a study including women with knee OA, Trans *et al.* found that WBV exercise completed on a stable platform yielded increased muscle strength in comparison with a non-exercising control group¹⁵. The fact that our study included a control group that exercised may explain the improvement in both groups. This is supported by the consistency of our findings with those of Rees *et al.*²⁵ in an older population and Osawa *et al.*²² in a younger population. Both studies used a mixture of static and dynamic exercises on a WBV platform with the same number of exercise sessions as provided in our study, and found that improvement in isokinetic knee extensor strength did not significantly differ between those who exercised on a vibrating versus a non-vibrating platform.^{22, 25}

Our finding of increased strength in both exercise groups also is consistent with the findings reported for young men doing squat training either alone or on a vibrating platform^{26, 27} in a 6-week program. In an 8-week resistance training program with and without vertical WBV, isotonic strength improved in both groups of young adults, while isokinetic knee extensor strength improved in neither group.²⁸ Even in a longer duration program (8 months of twice weekly training), WBV was not found to lead to significantly greater wall squat, chair rise, or walk performance in comparison with a control group; although, similar to our study, there were intra-group improvements in the vibration exercise groups.²⁹ In aggregate, the results of these studies suggest that improvements in knee extensor strength may have been attributable to the exercises performed rather than to an effect of WBV.

Although the similar strength gains between the groups that performed dynamic exercises with and without WBV were consistent with the findings of some studies, they differed from those of others. For example, a recent study in men and women age 22-49 years old randomized to a 13-week exercise program with or without WBV found that WBV was associated with greater increases in isometric and isokinetic knee extensor strength compared with control.³⁰ Similarly, a comparison of WBV quadriceps exercise, non-vibrating quadriceps exercise, resistance training and non-exercise control group demonstrated that, in young untrained women, WBV increased quadriceps isometric and isokinetic torque to a similar degree as resistance training and that strength did not increase in the placebo vibration (a humming, but not macroscopically vibrating platform) or control groups.³¹ Based on the reported absence of effect of training on a non-vibrating platform in that 12-week, quadriceps-focused (i.e. squats and lunges) progressive exercise program, we selected a similar control group for our study. However, our findings differed in that improved muscle function was detected in our non-vibrating exercise control group.

There are several potential reasons that our findings differ with those of other studies, namely the timing of measurements, exercise intensity, measurement variability and stimulus parameters. Differing results may have been attributable to the duration between completion of exercise and assessment of the outcome measures. Our study aimed to assess whether WBV would enhance the effects of exercise on increasing quadriceps strength. However, some evidence suggests that the effects of WBV may persist less than 1 hour,³² potentially explaining the absence of a clinically-meaningful effect in this study in which we assessed strength 1-2 days after completing the final 12-week exercise session, rather than 5-10 minutes after WBV exposure as in a prior study.³³ Another potential reason for differing findings is that a relatively low intensity of exercise was selected for this study, as safety and comfort of women with risk factors for knee OA was a primary consideration. However, a higher intensity of training may have been necessary to elicit a greater training effect.

Another explanation for differing results in our study may relate to measurement variability. For example, the degree of increase in leg press power in our study (9%) was similar to that reported by others following WBV exercise (5-7%).³⁴⁻³⁶ However, the larger variability in the measure may have contributed to lack of statistical significance in our study. Although the women were approximately 10 years younger than those in prior studies, this difference is unlikely to account for the divergent findings.

Additional explanations for differing findings may relate to the intervention parameters. Platforms using vertical, horizontal, or pivot-based vibration have been shown to have varying effects.^{15, 37, 38} This possibility is supported by the presence of several WBV studies in which, in comparison with a control group, there were no significant effects on strength detected.^{25-27, 29, 32} To our knowledge, the Wave PROelite vibration platform WBV has not been tested in patients with risk factors for symptomatic knee OA prior to this study. We selected the duration of 12 weeks based on previous data, which indicated that the greatest gain in knee extensor strength and speed of the movement occurred at week 12 of a 24-week program.³⁶ It is possible that alternative vibration parameters (frequency, amplitude, duration, and direction) could produce different results. However, the parameters selected were comparable to those used by other investigators.

Each WBV platform has a different direction of vibration, even when amplitude and frequency are kept constant. The implications of these differences on neuromuscular stimulation are incompletely understood. In our study, a vibration frequency of 35 Hz was used for all WBV participants throughout the 12-week program, based on evidence that this is the optimal frequency for motor unit activation.^{33, 39, 40} Bedient and colleagues

researched the optimum displacement and frequency for maximizing power output resulting from a bout of WBV. The 30 Hz condition appeared to have a greater effect on normalized peak power output (at 1, 5 and 10 minutes) than either 35 Hz or 40 Hz, but not greater than 50 Hz.³³ Another study, which compared a 30 Hz frequency group with an individualized frequency group, derived from monitoring the participants' root mean square EMG activity, suggested that the use of an individualized vibration frequency may elicit a greater neuromuscular response than vibration at a fixed pre-selected frequency.⁴¹ Individualized optimum frequencies for each participant were not assessed in our study, although future studies could advance understanding of the potential effects of WBV exercise on muscle through individualizing the vibration frequency for each participant.

One novel measure in this study was vibration sense. Previous studies that have evaluated changes in sensory function with WBV used joint position sense or kinesthesia as their sensory outcome measure.^{13, 15} We used VPT as our outcome measure for sensory function because methods for evaluation of VPT appear to be more reliable and also because the vibration platform theoretically could have a greater direct effect on vibration sensation than on other components of proprioception. This study did not demonstrate improvements in vibration in either group, but did not demonstrate worsening either. Based on the low VPT values at baseline, indicating a high sensitivity to vibration (no impairment), it may not have been possible to improve VPT in the participants studied. Although this floor effect in the threshold is the most likely explanation for lack of improvement, it is also possible that this finding could indicate a lack of effect of WBV exercise on vibration perception. Alternatively, longer periods of training may be necessary to improve vibration sense than are necessary to improve joint position sense or kinesthesia. Also, this study may not have been adequately powered to detect very small changes in vibration with WBV. Ultimately, no significant worsening of vibratory sense was observed, supporting safety of the WBV intervention studied.^{42, 43}

CONCLUSIONS

This study expanded on prior findings by studying women at risk for symptomatic knee OA, increasing the duration of exercise, including dynamic exercises rather than static poses, and evaluating quadriceps exercises with and without WBV. The findings suggest that quadriceps strength and power improved after 12 weeks of training, but with the exercise intensity and vibration parameters studied, WBV exercise does not appear to improve lower limb strength, power, or stair climb power beyond that of exercise without WBV. Importantly, no participants discontinued due to the intervention. In addition, none reported worsening of knee pain and vibration perception threshold was unchanged, suggesting the safety of WBV.

Acknowledgments

The investigators appreciate the participation of the participants in this research study. This research was supported by a Beeson Career Development Award in Aging Research (NIH/NIA K23AG030945) and a Dennis W. Jahnigen Career Development Scholars Award through the American Geriatrics Society. WAVE Manufacturing Inc. (Concord, Ontario) lent the WBV platform that was used for this research. The study sponsors had no role in the study design, data collection, analyses and interpretation of data, writing of this manuscript, or submission of this manuscript for publication.

This study was supported by a 2006 Dennis W. Jahnigen Career Development Scholars Award through the American Geriatrics Society and a Beeson Career Development Award (Neil Segal, MD-K23AG030945).

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Figure 1.
Subject Flow Chart

Figure 2. Exercises (1) shoulder-width squats to 90° knee flexion; (2) standing posterolateral leg lifts; (3) plantar flexion; (4) step-ups starting with one foot on the platform; (5) lunges with front foot on the platform with 90° knee flexion

Table 1

Baseline Subject Characteristics (mean±SD)

Measure	WBV Exercise Group	Exercise Alone Group	p-value
Age (years)	52.8±4.9	52.8±4.7	1.0000
Body Mass Index (kg/m ²)	30.6±5.2	29.5±4.7	0.4484
Physical Activity Level (PASE)	187.5±83.6	171.1±87.6	0.5171

WBV: whole body vibration; PASE: physical activity scale for the elderly

Table 2
Baseline Measurements Comparing Groups (means $\pm$ SD)

Measure	WBV Exercise Group	Exercise Alone Group	p-value
Isokinetic Knee Extensor Strength (N·m)	120.9 $\pm$ 4.1	118.5 $\pm$ 4.9	0.7092
Double Leg Press 1RM (N)	391.5 $\pm$ 60.1	358.2 $\pm$ 61.5	0.0671
40% Leg Press Power (W)	1044.5 $\pm$ 156.3	1013.8 $\pm$ 195.3	0.5516
Stair climb power (W)	416.2 $\pm$ 84.5	378.2 $\pm$ 107.1	0.2386
VPT at Metatarsophalangeal Joint (V)	11.0 $\pm$ 1.2	12.5 $\pm$ 1.4	0.4271
VPT at Tibial Tuberosity (V)	21.8 $\pm$ 1.5	19.7 $\pm$ 1.7	0.3506

WBV: whole body vibration; 1RM: 1 repetition max; VPT: vibration perception threshold; Units are Newton-meters (N·m), Newtons (N), Watts (W) and Volts (V).

Table 3
Change in Outcomes Between Baseline and Follow up (mean±SD)

Measure	WBV Exercise Group	Exercise Alone Group	Effect Size (Cohen's D)	p-value
Isokinetic Knee Extensor Strength (N·m)	2.7±2.4	1.4±3.4	0.10794	0.7667
Double Leg Press 1RM (N)	6.1±7.7	21.8±11.3	-0.41284	0.2476
40% Leg Press Power (W)	92.0±69.7	58.2±96.2	0.43615	0.2262
Stair climb power (W)	53.4±64.7	55.7±83.3	-0.03231	0.9272
VPT at Metatarsophalangeal Joint (V)	-0.9±0.6	-1.1±0.9		0.8554
VPT at Tibial Tuberosity (V)	-3.0±1.1	-3.9±1.6		0.6403
Sessions Attended	19±3	20±2		0.0976

WBV: whole body vibration; 1RM: 1 repetition max; VPT: vibration perception threshold

* p-values indicate comparison of the WBV and exercise alone groups. Effect sizes are for the WBV exercise in comparison with the non-vibration exercise group.