THE EFFECT OF WHOLE BODY VIBRATION TRAINING ON BALANCE AND STRENGTH OF THE LOWER EXTREMITY MUSCLES IN OLDER INDIVIDUALS

An Independent Research Project

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This research project has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.
Abstract

The purpose of this study was to analyze the effects of whole body vibration training (WBVT) on lower extremity strength and balance in older adults. WBVT involves performance of an exercise on a vibrating platform. The current literature shows that WBVT can increase strength more than exercising on a static surface; however few studies have investigated WBVT and balance together. A total of 22 participants (mean age of 71) were randomly assigned to a WBVT group or a control group. Both groups performed the same exercise: a double leg squat to 30 degrees of knee flexion, 2 sets of 10 repetitions holding each squat for 10 seconds, 2 days per week on non-consecutive days for 8 weeks. The vibrating group performed the exercise a vibrating platform and the control group performed the exercise on a static surface. A baseline and final measurement of strength was assessed by the 10 RM on the leg press and balance was tested using the STAR Excursion Balance test (SEBT). The results did not show a statistically significant difference between the two interventions (F=0.905, df=9.0, p>0.05). There was a mean increase in strength for both the vibrating group and the control group, and the control group showed an increase in all eight directions of the SEBT. WBVT does not appear to be an efficient way to improve strength and balance when compared to a static surface in community dwelling older adults.
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Introduction

Physical therapists are continuously looking for new ways to improve strength and power in their patients. According to Marin and Rhea (2010), the conventional methods to improve strength and power are resistance training and plyometrics, respectively. Recent research shows a potential new way to improve muscle strength is whole body vibration training (WBVT). WBVT can be described as exercising on a platform with an oscillating motion (Cochrane & Stannard, 2005; Rees, Murphy, & Watsford, 2008). The purpose of this study is to investigate the effects of WBVT on balance and lower extremity strength of older individuals.

An individual can perform static or dynamic exercises while standing on the WBVT platform. The oscillating motion can be described by frequency and amplitude. Luo, McNamara, and Moran (2005) define frequency as the cycles per unit of time, and frequency is measured in Hertz (Hz). According to Lindberg and Carlsson (2012), the frequency of the platform should not be less than 20Hz. Marin and Rhea (2010) suggest that the optimal frequency for training is 35-40 Hz. Luo et al. define amplitude as the half difference between the maximum and minimum value of the periodic oscillation (p. 25). According to Adams et al. (2009), WBVT set at a low frequency (30-50 Hz) and amplitude (2-4mm) is a safe and effective way to exercise the neuromuscular system. These researchers also found that this low frequency combined with the low amplitude will result in increased power in the lower extremity muscles.

According to Roelants, Delecluse, & Verschueren (2004), involving a study with 89 post-menopausal women, WBVT training is a safe, low impact strength training method with a low starting threshold. One important finding of this study is that WBVT
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appeared to be as efficient as a traditional resistance strength training program. These
researchers also found in their literature review that muscle strength and power had
strong influence on the activities of daily living, such as walking and climbing stairs, in
older adults. Physical therapists may be able to use WBVT as a low impact exercise
modality to increase lower extremity muscle strength and balance in older adults.

The muscular and neuromuscular systems in the human body are theorized to be
the most affected by WBVT. Carlucci, Mazza, and Cappozzo (2010), Roelants,
Verschueren, Delecluse, Levin, and Stijen, (2006), and Simao et al. (2012) found that the
neuromuscular response to vibration, known as the tonic vibration reflex, causes a
temporary increase in muscular activity and proprioception. According to Eklund and
Hagbarth (1966), the tonic vibration reflex activates a sustained contraction in a muscle
subjected to vibration. This reflex is caused by applying vibration directly or indirectly
to the tendon of a muscle which in turn causes a vibratory activation of the muscle
spindles within the muscle itself. According to Roelants et al. (2004), WBVT elicits a
biological adaptation that is connected to the neural potentiation effect. In this effect the
proprioceptive pathways are strongly stimulated by the vibration which results in
reflexive muscle contractions. According to Jordan, Norris, Smith, & Herzog (2005),
WBVT excites the primary nerve endings of the muscle spindle which leads to a tonic
contraction of the muscle. This results in an increase in synchronization of the motor
unit. This motor unit synchronization leads to an activation of the afferent nerve fibers,
through the reflex arcs, which causes the efferent nerve fibers to contract the muscle.

Nordlund and Thorstensson (2007) concluded based on a systematic review, that
the firing of the muscle spindle is a result of the vibration of the muscle or tendon. This
not only excites alpha motor neurons, but also interneurons in the spinal cord. These interneurons inhibit the motor neurons of the antagonist muscles via reciprocal inhibition. According to Fernandez-Rio, Terrados, Fernandez-Garcia, and Suman (2010), WBVT has an impact on the motor neuron excitability and the recruitment of fast-twitch muscles. Roelants et al. also found that the muscle spindles in older women are still sensitive enough to the vibratory stimulus and evoke a muscle response. This shows that the muscle spindles can be affected by WBVT via the vibration reflex.

Older individuals commonly have a decline in cardiorespiratory fitness and a reduction in balance when compared to younger individuals. Kinzey and Armstrong (1998), mention that the visual, somatosensory, and vestibular systems contribute to balance and can be adversely affected by aging. According to a systematic review by Sitja-Rabert et al. (2012), falls are the leading cause of injury, death, nonfatal injuries, and hospitalization for older adults. Keysor and Jette (2011), note that strength deficits are generally associated with falls in the elderly. Roelants et al. (2004), note that muscle weakness and inability of lower extremity muscles to produce force rapidly are the most common risk factors for falls in older individuals. Based on this, it can be concluded that lack of muscle power can result in an increased risk of falling. Rittweger (2010) and Sitja-Rabert et al. (2012), each performed a systematic review of the research on WBVT, and concluded that WBVT can be used to decrease the risk of falling related to muscle weakness or balance disorders in the frail elderly. They also concluded that WBVT may increase the muscle power and strength in the elderly thus decreasing the risk of falling. According to Rittweger (2010), exercising on WBVT platforms have been shown to reduce postural sway which leads to increased balance and decreased risk of falling.
Rees et al. (2008) conducted a randomized clinical trial involving 30 participants with a mean age of 73.7 years. They found that a WBVT program showed the greatest increase in plantar flexion strength of the ankle when compared to the strength of the knee and hip flexor and extensor muscles. One reason Rees et al. (2008) believe plantar flexion strength improved the most is due to a direct result of the vibration causing the gastrocnemius to be recruited first, when the vibration is applied to the feet. Roelants et al. (2006) came to a similar conclusion: in their study measuring WBVT induced increase in leg muscle activity in male physical education students, the gastrocnemius is the closest muscle to the platform and thus the tonic vibration reflex is stronger and results in higher activation of the muscle. The increased power in the gastrocnemius can decrease the risk of falls by improving the reaction time of the individual.

According to Roelants et al. (2004), older individuals tend to overload the musculoskeletal system because of diminished ability to adapt to high levels of loading. WBVT does not cause a high level of loading so it is safe for older adults to perform. The researchers also found that WBVT can be used in physical therapy to enhance muscular performance in older adults who are not attracted to or unable to perform standard exercise programs. Merriman and Jackson (2009) suggested the home use of WBVT for the older population due to its ability to increase muscle power and strength without adverse side effects. Carlucci et al. (2010) and Roelants et al. (2004) found that older individuals became acquainted to the WBVT platform easily; and could complete a session of WBVT without adverse reactions or fatigue. According to Marin and Rhea (2010), WBVT is a safe exercise platform for individuals who may not have the desire to work out at high exertion levels. The concept of WBVT could be applied not only to
older individuals, but sedentary individuals of all ages because WBVT requires less technical ability, less space for equipment, and less time to complete an exercise session than traditional resistance training.

According to Bogaerts et al. (2009), WBVT training minimizes the need for conscious exertion and stress on the musculoskeletal, respiratory and cardiovascular systems, with a much shorter training program (30 minutes) in comparison with a traditional fitness program (±1.5 hours) (p.453). This is one reason older individuals may prefer a WBVT session over a resistance training program, since they may achieve similar strength results without spending a lot of time in the gym. Adams et al. (2009) found similar results: WBVT may take less time than traditional strength training to improve power in the lower extremities. According Merriman and Jackson (2009) and Roelants et al. (2004), many of the subjects in their studies enjoyed the workout. In a review by Lindberg and Carlsson (2012), individuals had a high compliance rate and low drop-out rates when using WBVT. This shows that patients can safely tolerate and may actually enjoy WBVT.

There are risks associated with WBVT for individuals of any age; however WBVT may affect an older population differently than younger individuals. According to Jordan et al. (2005), repeated exposure to 1-20Hz of vibration can produce blurred vision and excessive exposure to 20-70Hz can cause resonance of the eye. Jordan et al. (2005) also note the majority of negative effects of vibration are caused in the work force with long duration exposure to vibration, not from intermittent exercise on the WBVT platform. Other side effects mentioned by Sitja-Rabert et al. (2012) include erythema, edema, and headache. Risks of WBVT may be of special concern for the older
population because their vision and balance may be compromised which could lead to injury. In this study, these side effects were minimized by proper education, close supervision, and using a proper frequency, amplitude, and duration on the WBVT platform. Also, Merriman and Jackson (2009) found in their review of 13 studies that 70% of the studies found no adverse effects from WBVT. The remaining studies reported only minor side effects, such as transient itching and erythema, none of which were life threatening. According to Ritweger (2010), Sitja-Rabert et al (2012), Lindberg and Carlsson (2012), and Brooke-Wavell (2009) flexing the knees on the vibration platform reduces the vibration transmissibility to the spine and head. This study is using a squat exercise on the vibration platform to reduce the transient effects of vibration exposure.

There is limited evidence involving the effect of WBVT on balance, and leg strength in older individuals. According to Roelants et al. (2004), reports of the effects of WBVT in older adults are lacking. These authors recommended that future research studies should include a wider range of individuals to note the effects of WBVT on the general older population. Second, many of the studies researched muscle mass and power. More research is needed on the effects of WBVT that show improvement on strength, not just muscle mass and power. Also, more research is needed to show if there is a correlation between leg strength and power via WBVT and balance. Finally, the longest duration of the studies reviewed provided intervention over a 1-year period, with most of the studies lasting between 4-14 weeks. The use of WBVT is still a new training modality and there is much research to be done. The evidence suggests that the effect of WBVT can be used in conjunction with other
training modalities or as a modality on its own. The purpose of this study is to test the
difference between whole body vibration training and a static exercise programs on the
strength of the lower extremity muscles and balance in older individuals. Based on the
available literature, it can be hypothesized that lower extremity strength will increase in
with the use of WBVT. This strength improvement may result in an improvement in
balance in community dwelling older adults after eight weeks. It can also be
hypothesized that community dwelling older individuals will see both an improvement in
their balance and the lower extremity strength following an eight week training program
consisting of WBVT. Strength will be measured by the 10RM amount on a leg press and
balance will be measured by the Star Excursion Balance Test (SEBT).

This study was designed to answer the following research questions:
Is there a difference in strength as measured by 10 RM leg press weight amount in
community dwelling adults who participate in a WBVT training program versus those
who participate in a static exercise program?
Is there a difference in balance as measured by the Star Excursion Balance Test (SEBT)
in community dwelling adults who participate in a WBVT training program versus those
who participate in a static exercise program?

It was hypothesized that performing a static mini squat on a WBVT platform will
increase strength in the lower extremity muscles and the SEBT score, when compared to
a static surface squat results.
Methods

This was a quantitative research study with a quasi-experimental design including random assignment, manipulation of the independent variable, and a pretest and posttest. The independent variable in this study was the mode of exercise: Lower extremity strengthening using WBVT a static mini squat (double leg squat to 30 degrees of knee flexion). There were two levels to this variable: WBVT surface or a static surface. The experimental group performed the static mini squat on the iShape 8500 vibrating platform. The control group performed a static mini squat on a non-vibrating surface.

Sample

A non-probability convenience sampling strategy utilized was used. The participants were obtained by word of mouth and on a volunteer basis. The sample size was 22. Group 1 had 9 subjects, 6 males and 3 females, and performed a static mini squat on the i-Shape TVR-8500 vibration platform. Group 2 had 13 subjects, 6 males and 7 females, and performed a static mini squat on a regular, non-vibrating surface. The group assignment was completed by using the Microsoft Excel® (2010) random number generator. Subjects included 12 males and 10 females with an average age of 71, with the youngest subject aged 65 and the oldest aged 84.

Exclusion criteria for the participants included:

1. Currently participating in a strength training program
2. Diagnosed with a vestibular condition
3. Have had a joint replacement within the past year
4. Diagnosed with acute Rheumatoid Arthritis
5. Have post-operative wounds
Instrumentation

The *i-Shape TVR-8500* was the vibrating platform used for the intervention. The user’s manual suggests the use of a frequency of 20-50Hz to enhance body control and balance while avoiding possible resonance between the machine and the human body. The *iShape* user’s manual also suggests that the amplitude should be between 1-4mm.

The leg press was performed at a 10 repetition maximum in order to ensure the safety of the participants. According to Kisner & Colby (2002), a 10 RM is the amount of weight an individual can lift and lower exactly ten times. According to Avers and Brown (2009), the 10 RM involves the individual lifting 80% of their body weight through full range with good form. These researchers also mention that the 10 RM method can minimize the underestimation of the calculated 1 RM. This is recommended for the older adult in that they are not exerting a maximum effort. This weight amount was used to provide the researcher with a baseline measurement of lower extremity strength. According to Lambert, Armstrong, Jacks, Armstrong, and Flynn (2002) the ICC for 10 RM testing is .992 which shows the test is reliable.

The SEBT was used to test balance and functional performance of the subjects prior to beginning the program. The test is designed to challenge the patients’ postural control, strength, ROM, and proprioception. According to Plisky, Rauh, Kaminski, and Underwood (2006), the SEBT can also be used as a screening tool for sport participation and as a post-rehab test to ensure dynamic functional symmetry. According to Olmsted, Garcia, Hertel, and Shultz (2002), the goal of the SEBT is to reach as far as possible with one leg in eight directions while maintaining balance on the contralateral leg. The eight directions are anterior, anteromedial, medial, posteromedial, posterior, posterolateral,
lateral, and anterolateral. The distances in each direction are recorded and normalized by dividing each distance by the leg length of the patient and multiplying by 100 (Plisky et al. 2006). The test is scored by analyzing the normalized distance reached in each of the eight directions. This test varies per individual, however, the further a patient can reach with one leg while balancing on the other, the better functional performance they are deemed to have. According to Hertel, Braham, Hale, and Olmsted-Kramer (2006), the ability to reach farther with a limb requires a combination of increased balance, strength and motion on the contralateral stance limb. According to Stockert and Bacrakatt (2005), this instrument has a strong interrelater reliability (ICC = .91) for the geriatric population. According to Hertel et al. (2006) the SEBT also has strong intrarater reliability (ICC = .81-.93).

**Procedure**

A baseline measurement of 10RM strength and SEBT was obtained one week prior to implementing the intervention. Amount lifted on the *Cybex*® leg press machine was recorded as well as the distance reached with each leg in the eight directions of the SEBT.

Subjects from each group performed a static mini squat, holding the squat position for ten seconds. The subjects in both groups performed two sets of ten repetitions twice a week. This exercise was chosen for its ability to strengthen the lower extremity muscles by providing both concentric and eccentric contractions. Group A performed the squat on the WBVT platform while Group B performed the squat on a level surface. This study used a frequency of 35Hz and amplitude of 2mm based on current evidence, and to minimize the side effects that may be generated as a result of
using the platform. The researcher observed the subjects’ squat technique, and verbal cues were given to make sure each subject was correctly and safely performing the exercise. Careful attention was paid to the technique of the squat performed by all participants in order to ensure the safety of the subjects, and the accuracy of the results.

After the eight week intervention period each patient was re-evaluated for 10RM strength and the SEBT to obtain the post-test results. The time frame of eight weeks was based on the suggestion by Sitja-Rabert et al (2012) that a minimum of eight weeks is needed to observe strength gains. Interval level data was gathered from the pre-test and post-test data from the two dependent variables: seated leg press 10RM weight amount and SEBT score.

The Highland Woods community gym was used to perform all testing on the leg press and the SEBT. This gym was used for accessibility as well as continuity between subjects.

Approval from the Florida Gulf Coast University IRB was obtained before beginning this research project and careful consideration was given to legal and ethical issues. Each patient was given a full explanation of the study including its intentions, purpose as well as the treatment they received. Informed consent forms were given to all individuals interested in participating, and only those that provided signed forms were allowed to participate. Confidential information regarding the subjects was only discussed between the researcher and the physical therapist. The identity of the subjects remained undisclosed. Patient information was stored in a locked filing cabinet and names on a computer were numerically coded.
Results

This study investigated the following research questions:

1. Is there a difference in strength as measured by 10 RM leg press weight amount in community dwelling adults who participate in a WBVT training program versus those who participate in a static exercise program?

2. Is there a difference in balance as measured by the SEBT in community dwelling adults who participate in a WBVT training program versus those who participate in a static exercise program?

Change scores were calculated between the baseline test results and final test results for the 10RM weight lifted as well as each of the eight directions reached during the SEBT. The statistics were analyzed by IBM SPSS version 20. Descriptive statistics were used to describe the change scores from baseline to final test. In order to answer the research questions, a MANOVA was used to analyze differences in change scores between groups based on 10 RM and each direction of the SEBT. A MANOVA was also used to analyze differences in change scores for the co-variables, age and gender.

Descriptive statistics were calculated and displayed Table 1. Group 1 corresponds to the vibrating group, while group 2 corresponds to the control group. The vibrating group improved 10 RM weight by a mean weight of 26.67 ± 16.77 pounds, while the control group improved by a mean weight of 36.25 ± 17.34 pounds. SEBT change mean for the anterior direction was -1.63 ± 6.54 for the vibrating group and 3.63 ± 17.34 for the control group. SEBT mean change for the anterolateral direction was 0.84 ± 11.82 for the vibrating group and 2.62 ± 8.26 for the control group. SEBT mean change for the lateral direction was -0.71 ± 10.73 for the vibrating group and 1.92 ± 8.35 for the control group.
group. SEBT mean change for the posterolateral direction was $2.66 \pm 8.74$ for the vibrating group and $5.60 \pm 8.42$ for the control group. SEBT mean change for the posterior direction was $5.35 \pm 8.08$ for the vibrating group and $7.38 \pm 11.55$ for the control group. SEBT mean change for the posteromedial direction was $1.53 \pm 8.76$ for the vibrating group and $7.55 \pm 5.13$ for the control group. SEBT mean change for the medial direction was $-2.83 \pm 4.78$ for the vibrating group and $2.64 \pm 5.52$ for the control group. SEBT mean change for the anteromedial direction was $2.26 \pm 7.01$ for the vibrating group and $6.79 \pm 4.96$ for the control group.

Results of multivariate testing are displayed in Table 2. The MANOVA revealed that there was no statistically significant difference between groups ($F=0.905$, df=9.0, $p>0.05$).
Table 2: Multivariate Tests

<table>
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<th>Effect</th>
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<th>Hypothesis Df</th>
<th>Error Df</th>
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<tr>
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</table>

Co-variables, age and gender, were also analyzed. No statistically significant difference was noted between groups based on age (F=0.552, df=9.0, p>0.05) or gender (F=0.114, df=9.0, p>0.05).

Discussion

Of the 22 participants, no participants dropped out of the study due to injury or unwillingness to participate. No adverse side effects were reported in either of the training groups. A few of the participants in the vibrating group mentioned the vibration caused an itching sensation of the nose, but no serious side effects were noted. One participant was unable to complete the final SEBT due to recent shoulder surgery. All control group participants completed 16 sessions within the 8 week period. The average overall adherence to the vibrating group was 88.6%. The majority of the participants completed 13-16 sessions over an 8 week period; adherence was related to time constraints and travel.

Outcome Measures

Lower extremity strength of the participants improved over the 8 week period. Both groups demonstrated an increase in leg press weight compared to the baseline, with the control group having a greater increase in mean strength scores than the vibrating group. However, the differences between the groups were not statistically significant.
SEBT score results varied based on the direction. The control group showed an increase in all eight directions while the vibrating group actually showed a decrease in certain directions. Some of the change scores showed an increase in distance reached for both groups: posterolateral, posterior, and anteromedial. The vibrating group showed a decrease in distance reached for the following distances: anterior, lateral, and medial. Consistent with the leg press results, the control group shows a greater increase in distances when compared to the vibration group. The statistical analysis revealed no statistically significant difference in change scores for the SEBT between the two groups.

A learning effect may have occurred, resulting in an increase in final testing measurements. The learning effect can be described as the participant’s ability to improve their test results after a thorough explanation or test run of the specific task.

During the initial leg press measurement, the participants may have been intimidated by the machine or had never used the machine before. The participants were given 10 repetitions at a low weight to negate these effects. Even with the practice repetitions, some of the participants were reluctant to lift a heavy weight. During the final test, the participants had increased familiarity with the machine and had no trouble with increasing the weight.

During the SEBT baseline test, participants were asked to perform a practice trial of the SEBT to decrease the learning effect. Participants were asked to lightly touch the toe of reaching leg to the ground and maintain the body weight on the stance leg. Some participants were unable to perform the test this way, so the baseline data may have been skewed. On the final test of the SEBT, the participants were able to maintain their balance on the stance leg and demonstrated more consistent distances in each of the eight
directions. The final test represented trials 4 and 5 of the SEBT, so the participants had increased familiarity with the protocol of the test which may have resulted in more consistent results.

Despite trial runs for both tests, after analyzing the data it appeared that there was still a possibility of a learning effect. Most of the participants greatly increased the leg press weight and some of the SEBT directions showed a substantial increase in distance during the final test.

**Limitations**

The results of this study did not support the hypothesis that the vibrating group would have a greater increase in results. The control group showed greater improvement on both outcome measures than the vibrating group. There are a few possible explanations for these findings.

First, the vibrating platform may have provided the participant with a false sense of security due to its closed environment. The platform was placed in the corner of the Highland Woods fitness center and has a cage surrounding the front of the machine. The participants had the ability to focus on the corner of the room that could have decreased distractions. The control group performed their exercise in an open environment and may have utilized increased balance strategies to perform the exercise. The control group performed the exercise in the Highland Woods community room with many individuals walking outside that could have provided distractions causing increased use of balance strategies.

Another factor that could have resulted in the control groups increased performance is adherence. Every participant in the control group completed 2 sessions
per week for 8 weeks, while many of the vibrating group completed less than the necessary 16 sessions. Some of the participants in the study had travel plans already in place during the intervention period. The control group participants were instructed to continue their exercises while on vacation on a level surface 2 times per week. The vibrating group did not have this option because the platform could not be moved, so the participants had to miss treatment sessions.

The parameters of frequency and amplitude for the vibration platform used in this study were consistent with previous research, but the length of the intervention may need to be altered in the future to see a difference between groups. Eight weeks may not have been long enough to see a difference in the interventions. Also, the single exercise utilized in this study may have affected the results. A full lower body exercise program may have elicited a statistically significant difference for both strength and balance.

In order to obtain accurate and significant results, it was imperative that the subjects participate in each session for the entire duration. Two sessions per week for eight weeks presented an issue of adherence for some participants. The use of the Highland Woods fitness center increased adherence, however some subjects had travel plans and time constraints that prevented them from performing 2 sessions per week.

The number of individuals recruited to participate could have been an issue. The sample size could not have been large enough to show a statistically significant difference. The sample size was limited due to time constraints and reluctance about the study by potential subjects. Many individuals at the country club were informed of the study, but had travel plans already in place for a substantial amount of time during the intervention period. Word of mouth was utilized to obtain additional participants. Once
the vibrating platform was placed in the fitness center, many more people wanted to join the study, but had to be turned away due to the experimental design.

While no statistical significance between groups was found in this study, anecdotal differences were reported by the participants. Some of the participants in the vibrating group noticed changes in their balance during daily activities. One participant noted that riding his bike was easier because he felt “more balanced” and did not get the feeling that he was going to fall. Another participant noted that pain in her knee had improved since starting the intervention and climbing stairs had become easier and less painful. Another subject mentioned that her lower back pain had improved since beginning the program. Participants in both groups mentioned that other extracurricular activities had become easier; for example, participants noticed that it was easier to bend over to put a golf tee in the ground.

**Recommendations**

Future studies will need to examine the effect of an entire lower body strength training program using WBVT. Performing more than one exercise may have a greater impact on the strength of the lower extremity muscles as well as SEBT scores. Further research is also needed to investigate WBVT as a contributing factor to an increase in balance. This study used a complex balance test with a high margin of error. An alternate balance test may be warranted to show a statistical difference in balance.

**Conclusion**

Both the vibrating group and the control group showed an increase in change scores for the 10 RM, and most of the eight directions of the SEBT, but there was no statistically significant difference between the interventions. Further research needs to
investigate the benefits of WBVT and balance. WBVT in community dwelling older adults does not appear to be an efficient way to improve strength and balance when compared to a static surface.
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