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Research Paper Review

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The Effects of Whole Body Vibration Therapy on Bone Mineral Density and Leg Muscle Strength in Older Adults: A Systemic Review and Meta-analysis

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ABSTRACT

Objective

A systematic review and meta-analysis of randomized controlled trials was undertaken to determine whether whole body vibration improves bone mineral density and leg muscle strength in older adults.

Data Sources

Sources included MEDLINE, CINAHL, EMBASE, PEDro, PubMed, Science Citation Index and the reference list of each eligible article.

Review Methods

Article search and selection was performed independently by two researchers. The methodological quality of each selected article was rated by the PEDro scale.

Results

Thirteen randomized trials (18 articles) totalling 896 subjects fulfilled the selection criteria. Four were considered to have good or excellent methodological quality and the rest were rated as fair. Meta-analyses revealed that whole body vibration has no significant effect on hip or lumbar spine bone mineral density in older women when compared with no intervention or active exercise ($P > 0.05$). Whole body vibration, however, had a significant treatment effect on knee extension dynamic strength (standardized mean difference = 0.63, $P = 0.006$), leg extension isometric strength (standardized mean difference = 0.57, $P = 0.003$), and functional measures of leg muscle strength such as jumping height (standardized mean difference = 0.51, $P = 0.010$) and performance in sit-to-stand (standardized mean difference = 0.72, $P < 0.001$) among older adults compared with no intervention.

Conclusion
Whole body vibration is beneficial for enhancing leg muscle strength among older adults. However, the review suggests that whole body vibration has no overall treatment effect on bone mineral density in older women. No randomized trial has examined the effects of whole body vibration on bone mineral density in older men.

ANALYSIS

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Background Information
As we age, humans become increasingly more fragile and thus more susceptible to fracture. Two contributing factors to this phenomenon are a decrease in bone mineral density and an increase in the incidence of falls. Researchers are currently searching for effective strategies for enhancing bone mineral density and modifying the risk factors predisposing individuals to falling in an effort to quell the increase in morbidity, mortality, reduced quality of life and increased economic strain related to such fractures.

One surefire way of promoting bone mass and modifying fall risk is physical exercise. However, exercise, if not performed safely, could actually increase the risk of falling. Because of this, and many other factors not discussed in this particular article, therapists and researchers have sought new ways of providing this benefit to the frail elderly. Chief among these strategies is whole body vibration.

Whole body vibration is most often delivered to the body through a vibrating platform or chair. The neurophysiological theory behind this mode of exercise is that it activates muscle spindles (sensory receptors in muscles), which in turn, causes a reflexive firing of motor units, resulting in muscle contraction (1, 2). This lends credence to the idea that vibration therapy can potentially increase muscle strength.

Such dynamic loads have also been theorized to promote bone growth (3). This is mediated by the idea that muscle strength is highly related to bone mineral density; thus an increase in muscle strength realized through vibration training could lead to an increase in bone mineral density (4). It is the goal of this systematic review and meta-analysis to determine what the literature concludes on the relationship between vibration training and muscle strength, and bone mineral density.

PERTINENT RESULTS

Eighteen research articles that fit the inclusion criteria were selected to be part of this analysis. All of the studies selected used whole body vibration, save one, which used a vibrating chair. One problem with the entire collection of articles was the lack of homogeneity in the specific protocols used (i.e. session frequency and duration, trial duration, vibration frequency and vertical acceleration, to name a few).The most common exercises prescribed were forward lunges, high and deep squats, one-legged squats and heel raises.

Bone Mineral Density

- When compared to sham vibration, whole body vibration has no significant effect on femoral neck or trochanter bone mineral density. However, further analysis showed that a trend towards statistical significance if compliance was greater than or equal to 86%.
- Whole body vibration is not more efficacious than walking-based programs in improving bone mineral density of the femoral neck or trochanter.
- With regard to total hip bone mineral density, no significant difference is found when comparing whole body vibration to no intervention. The same result was found when analyzing the relationship between whole body vibration and active exercise.
- No significant treatment difference in lumbar spine bone mineral density was realized when comparing whole body vibration and no treatment. Similar results were found when comparing whole body vibration with active exercise, as well.
- The combination of whole body vibration and medication (alendronate) does not have an additive effect on bone mineral density of the lumbar spine in post-menopausal women with osteoporosis.
- Cortical and trabecular bone mineral density (measured by computed tomography) of the distal tibial epiphysis and the tibial midshaft were not influenced by whole body or physioacoustic chair mediated vibration.

Muscle Strength

- A meta-analysis was only possible when considering isometric knee extension strength, isometric leg extension, jump height and sit-to-stand performance.
- With consideration to isometric knee extension strength, no significant effect of whole body vibration was found when comparing it to no intervention, regardless of its method of introduction (i.e. physioacoustic chair or standing).
- With respect to the improvement of dynamic knee strength, whole body vibration is not superior to whole body active exercise.
- Whole body vibration training was significantly superior to no intervention when measuring isometric leg extension while performing a leg press.
- Whole body vibration therapy resulted in a significant increase in jumping height when compared to no intervention. However, no difference was found between whole body vibration and active exercise.
- Some studies utilized the Sit-to-Stand test to measure functional muscle strength changes. Whole body vibration was significantly superior to no intervention. However, vibration therapy is not better than an active exercise intervention in increasing functional performance.

The results of this study are in contradiction of a 2010 meta-analysis performed by Slatkovska et al. (5). Their analysis concluded that significant improvements in hip bone mineral density can be made with weight bearing vibration therapy, but not in the spine or tibia. They also concluded that in children and adolescents, vibration therapy can increase spine and tibia bone mineral density by small amounts. However, no significant changes were seen in any parameter in young adults in their review.

A similar contradiction was found in the randomized control trial performed by Zha et al. in 2011 (6) took 53 seniors and subjected them to vertical vibration with concomitant alternative tilting by 2° for

20 minutes per day, 3 days per week for 5 months. They tracked bone mineral density in the lumbar spine and femoral neck. This resulted in a respective 2.52% and 3.22% increase in bone mineral density in seniors with or without osteoporosis. A similar increase was seen in lumbar spine and femoral neck bone mineral density by1.63% and 2.05%, respectively. Along with the bone mineral density, ALP increased significantly as well.

Verschueren et al. (7) found similar results in their randomized control trial. Over their six month intervention, they found that bone mineral density of the hip significantly increased in the group performing vibration therapy. However, no changes in bone mineral density were observed in subjects performing resistance training (?).

CLINICAL APPLICATION & CONCLUSIONS

This meta-analysis showed that whole body vibration therapy, ranging anywhere to 6-18 months, has no overall effect on increasing the bone mineral density of the hip and lumbar spine in older women. However, this mode of therapy has a positive effect on enhancing certain aspects of muscle strength in older adults. The researchers conclude that the protocols designed in the studies included in their analysis may not be optimal for inducing bone formation in older adults.

The researchers also concluded that whole body vibration has a significant effect in increasing muscular strength in older adults – specifically, in dymamic knee extension strength, isometric leg extension and functional leg muscular strength (vertical jump and sit-to-stand). There is currently inadequate evidence to recommend a specific protocol (i.e. frequency, intensity, time and type – the FITT principle) for improving various leg muscle strength outcomes.

Because of the difference in its physical nature to standing vibration platforms, seated vibration platforms may produce different neurophysiological and therapeutic effects. This may be why seated vibration therapy may not have been as effective as standing whole body vibration at increasing isometric knee extension strength.

This amazing variability in the literature leads this reviewer to conclude that more studies need to be performed to understand the relationship between bone mineral density and vibration therapy. The heterogeneity among studies makes it incredibly difficult to find generalizable results and make broad conclusions regarding this mode of care. This should alert evidence-informed clinicians to critically analyze claims made by vibration device manufacturers, and consider carefully the issues of funding, peer-review and conflict of interest involved in the supporting 'research' these companies may provide.

STUDY METHODS

The authors utilized the following inclusion criteria for their meta-analysis:

- Randomized controlled trials investigating the effects of vibration therapy in older adults (qualified as 50 years or older)
- Articles including bone mineral density or leg muscle strength as an outcome measure
- Published in the English language

They used the following exclusion criteria:

- The subjects had a diagnosis of a pathological condition, such as stroke or arthritis
- Reports in books or other secondary sources
- Reports published as conference minutes or proceedings, which may have not been peer reviewed

The authors accessed a number of databases for their review, including Medline, CINAHL and EMBASE. All of the references for each source included in the study were then reviewed for additional articles. An 11-item PEDro scale was used to evaluate the methodological quality. Ratings ranged from < 4 (poor), 4-5 (fair), 6-8 (good) and 9-10 (excellent). Kappa values were then applied to assess agreement between the two raters on each article's PEDro ratings and inclusion. The degree of heterogeneity for the meta-analysis as assessed using the I2 test, which implies that the results of different tests were similar.

STUDY STRENGTHS / WEAKNESSES

Weaknesses

- The researchers did not access a sufficient number of databases to convincingly state that they combed literature adequately.
- A lack of homogeneity in the data questions whether the meta-analysis results are correct.

Strengths

- Despite of the lack of homogeneity in the data the researchers utilized kappa values to show inter-rater reliability and I2 scores to assess whether or not similar results occurred in different research articles, were used to mitigate this fact.

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