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Whole-body vibration augments resistance training effects on body composition in postmenopausal women

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ABSTRACT

Age-related changes in body composition are well-documented with a decrease in lean body mass and a redistribution of body fat generally observed. Resistance training alone has been shown to have positive effects on body composition, however, these benefits may be enhanced by the addition of a vibration stimulus.

Objective: The purpose of this study was to determine the effects of 8 months of resistance training with and without whole-body vibration (WBV) on body composition in sedentary postmenopausal women.

Methods: Fifty-five women were assigned to resistance only (RG, $n = 22$), vibration plus resistance (VR, $n = 21$) or non-exercising control (CG, $n = 12$) groups. Resistance training (3 sets 10 repetitions 80% strength) was performed using isotonic weight training equipment and whole-body vibration was done with the use of the power plate (Northbrooke, IL) vibration platform for three times per week for 8 months. Total and regional body composition was assessed from the total body DXA scans at baseline (pre) and after 8 months (post) of training.

Results: In the VR group, total % body fat decreased from pre- to post-time points ($p < 0.05$), whereas, the CG group had a significant increase in total % body fat ($p < 0.05$). Both training groups exhibited significant increases in bone free lean tissue mass for the total body, arm and trunk regions from pre to post ($p < 0.05$). CG did not show any changes in lean tissue.

Conclusion: In older women, resistance training alone and with whole-body vibration resulted in positive body composition changes by increasing lean tissue. However, only the combination of resistance training and whole-body vibration was effective for decreasing percent body fat.

1. Introduction

Age-related changes in body composition are well-documented with increases in fat mass, decreases in lean body mass, and a redistribution of body fat patterns generally observed [1–3]. In addition to the effects of aging, postmenopausal women experience hormone changes which are associated with an accumulation of central body fat, leading to the development of insulin resistance and the metabolic syndrome [4,5]. Sarcopenia, the age-related decrease in skeletal muscle mass, also negatively impacts health as it leads to reduced mobility and functional disability [3]. These body composition changes associated with aging and menopause have important implications for women's health as they contribute to increased risk for chronic diseases, such as type 2 diabetes and cardiovascular disease [6].

Resistance training has been shown to be an effective intervention for sarcopenia by increasing strength and muscle mass older men and women [7]. Several training studies [8–10] have found that high intensity resistance training increased lean tissue in postmenopausal women, whereas, decreased percent body with resistance training was documented in only one of those studies [8]. Since high intensity resistance training may not be feasible for certain clinical populations (i.e., osteoarthritis patients), alternative interventions are being developed for improving body composition and health-related outcomes.

Whole-body vibration (WBV) training has been receiving attention in recent years in the area of musculoskeletal research. The potential advantage of a vibration stimulus is that it may potentiate muscle activity while avoiding the safety and compliance issues associated with high intensity resistance training programs. Theoretically, a vibration stimulus also may have an osteogenic effect since a subject is exposed to a number of ground reaction forces in a very short time period while standing on a vibration platform moving at a high frequency (30–40 cycles per second) and displacing at a low amplitude (2–5 mm). Human research should take a conservative approach to ensure subject safety and to avoid side effects associated with chronic vibration exposure, such as dizziness, and low back pain [11]. However, the majority of vibration

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studies reported that this type of training was well-tolerated by older individuals with relatively minor side effects such as erthyma, edema, and itching of the legs [11]. For example, Verschueren et al. [12] demonstrated that postmenopausal women can safely handle up to 30 min of high amplitude, high frequency vibration training 3 days per week.

The beneficial effects of whole-body vibration in older populations include increases in muscle mass [13] and muscle strength [12–14], as well as improvements in balance [15]. The skeletal responses to WBV training are less clear as Rubin et al. [16] found that bone mineral density (BMD) did not increase after a 12-month WBV intervention, whereas Verschueren et al. [12] and Gusi et al. [17] reported that hip BMD improved significantly after WBV training programs in postmenopausal women. Body composition is another aspect of physiological function which may be affected by WBV training. In animal studies, brief exposure to high frequency, low magnitude whole-body vibration suppressed adipogenesis in young adult mice [18] and reduced fat accumulation in rats [19]. The effects of WBV on percent body fat and fat mass has not been well-documented in the literature, particularly in older women. Verschueren et al. [12] found that both WBV and resistance training treatments altered by body composition by decreasing fat mass assessed by dual energy X-ray absorptiometry (DXA). However, lean body mass did not change significantly for either treatment in this 6-month study [12].

Although previous studies have examined the influence of resistance training on body composition in older women [8–10] and the effects of WBV in older women [12,14–17], little is known about whether resistance training in combination with WBV has a greater affect on changes in body composition than resistance training alone. The purpose of this study was to determine the effects of a combined whole-body vibration and traditional high intensity resistance training intervention on body composition in sedentary, postmenopausal women. We hypothesized that women who underwent resistance training with whole-body vibration training would have greater improvements in total and regional bone free lean tissue mass and decreases in fat mass compared to the resistance training only group.

2. Methods

2.1. Subjects

Estrogen-deficient postmenopausal women between the ages of 60–75 years of age were the target population for this study. The inclusion criteria were: (1) subjects had to be normal healthy women volunteers, 60–75 years of age; (2) subjects had to provide information on menopausal status, menstrual history, and hormone replacement therapy (HRT) status obtained by a menstrual history questionnaire; (3) subjects had to be at least 5 years postmenopausal; (4) subjects who had a history of hormone use had to have been off HRT for at least 1 year; (5) subjects could not have participated in a weight training program for at least 1 year prior to the study; and (6) recruited subjects had to be medically stable, ambulatory, and capable of undergoing physical strength testing and training. The exclusion criteria were: (1) women diagnosed with osteoporosis; (2) any persons with physical disabilities preventing them from being strength tested and trained, including orthopedic or arthritic problems; (3) those with heart problems such as congestive heart failure and arrhythmias, or chronic high blood pressure; (4) subjects who were currently smoking or past smokers within the last 15 years; (5) women with a current diagnosis or a history of renal disease, chronic digestive or eating disorders, rheumatoid arthritis, or thyroid disease; and (6) those who were currently taking medications that affect body composition or bone, such as steroid hormones, calcitonin, or corticosteroids. All participants obtained medical clearance from their physician and signed a written informed consent form prior to testing. The Institutional Review Board at the University of Oklahoma approved all procedures in this study.

A total of 82 subjects responded to recruitment advertisements, however, 15 subjects were excluded due low BMD ($n = 3$), medical problems/illnesses or inability to obtain medical clearance ($n = 9$), steroid medication use ($n = 1$), inability to make time commit for the training program ($n = 2$), and five women did not show up for the first meeting. Sixty-two women began the study, however, 7 subjects were unable to continue for medical or personal reasons, thus, 55 subjects completed the entire 32 weeks of the study. The compliance for both training programs was excellent with an average attendance of 92% for the vibration plus resistance training group and 90% for the resistance training only group.

2.2. Research design

This study employed a mixed factorial research design with one between subjects factor (group) and one repeated measures factor (time). Women were non-randomly assigned to either a resistance training group (RG, $n = 22$), vibration plus resistance training group (VR, $n = 21$) or a non-exercising control group (CG, $n = 12$). During the first visit to the laboratory, subjects completed questionnaires to assess physical activity levels, menstrual history, calcium intake, and health status and performed a total body scan. A menstrual history questionnaire was used to determine menopausal status, and their physical activity levels were estimated by the physical activity scale for the elderly (PASE) questionnaire [20]. VR and RG subjects underwent a supervised 8 months progressive resistance training program in the Neuromuscular Laboratory. Total and regional body composition was assessed again immediately post-training.

2.3. Body composition

Total and regional body composition was measured by dual energy X-ray absorptiometry (DXA) (GE Lunar Prodigy, GE Medical Systems, Madison, WI). Height was measured with a wall stadiometer and body weight was measured using a Tanita BWB-800 digital scale (Tanita Corporation of America, Inc., Arlington Heights, IL). The subject removed any metal or plastic materials she was wearing, then she was positioned supine on the DXA table for the scan. The legs were secured in place using velcro straps and the arms were placed close to the sides. Scan modes for the total body scans were selected based on the subject's trunkal thickness as follows: thick > 25 cm; standard, 13–25 cm; and thin < 13 cm. One qualified technician performed all the scan analyses using the Prodigy enCORE 2002 software version 8.80. The total body scan analysis provides % fat, fat mass, bone free lean tissue mass (BFLTM) and bone mineral content (BMC) for the total body and for the arms, trunk, and leg regions. Quality assurance and spine phantom calibration procedures were performed daily prior to each scanning session to ensure no machine drift occurred during the intervention period. In our laboratory, the coefficients of variation (%) for the body composition variables are as follows: 2.5% for % fat; 2.74% for fat mass; and 1.39% for BFLTM. The least significant change at the 95% confidence level for the outcome variables was calculated as: LSC = 2.77 $\times$ precision error expressed as root mean square standard deviation.

2.4. Resistance training intervention

Resistance training and strength testing were performed by the use of Cybex® isotonic weight training equipment (Cybex International, Inc., Medway, MA). Prior to training, the subjects had an acclimation period of 2 weeks to get familiar with the equipment