Randomized controlled trial comparing weighted vest and whole-body vibration exercise: effects on bone and muscle health in older adults

Ensayo controlado aleatorizado que compara el ejercicio con chaleco lastrado y la vibración de cuerpo completo: efectos en la salud ósea y muscular en adultos mayores

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Abstract

Introduction: Bone and muscle loss is a problem particularly in sedentary older females. Resistance training is recognized as promoting bone and muscle health.
Objective: To investigate whether the incorporation of a weighted vest or whole-body vibration into exercise regimens could attenuate declines in bone mineral density and lean muscle mass among older adults.
Methods: Forty-nine participants were divided into three groups, a control group (CON) that performed brisk walk and various strengthening exercises, a weighted vest group (WV) that completed the same program with a weighted vest, and a whole-body vibration group (WBV) that exercised on a vibration platform.
Results: After 8-week training, the WV group showed significant improvement in bone T-score (0.06 ± 0.19), while the CON (-0.19 ± 0.11, p = 0.000) and WBV (-0.13 ± 0.19, p = 0.014) groups experienced decreases. Lumbar spine BMC increased in the WV group (2.82 ± 2.52 g) compared to CON (-1.92 ± 7.03 g, p = 0.023). WBV training led to lean mass gains (0.22 ± 0.71 kg) compared to CON (-0.98 ± 0.60 kg, p = 0.011) and WV (-0.60 ± 0.83 kg, p = 0.007).
Conclusion: The results indicate that weighted vest exercise may contribute to the prevention of bone loss, whereas whole-body vibration training appears to promote improvements in lean muscle mass.

Keywords

Osteopenia; sarcopenia; bone mineral content; t-score.

Resumen

Introducción: La pérdida ósea y muscular es un problema, especialmente en mujeres mayores sedentarias. El entrenamiento de resistencia es reconocido por promover la salud ósea y muscular.
Objetivo: Investigar si la incorporación de un chaleco lastrado o vibración de cuerpo entero en los regímenes de ejercicio podría atenuar la disminución de la densidad mineral ósea y la masa muscular magra en adultos mayores.
Métodos: Cuarenta y nueve participantes se dividieron en tres grupos: un grupo control (CON) que realizó una caminata rápida y diversos ejercicios de fortalecimiento; un grupo con chaleco lastrado (WV) que completó el mismo programa con chaleco lastrado; y un grupo con vibración de cuerpo entero (WBV) que se ejercitó en una plataforma vibratoria.
Resultados: Después de 8 semanas de entrenamiento, el grupo WV mostró una mejora significativa en la puntuación T ósea (0,06 ± 0,19), mientras que los grupos CON (-0,19 ± 0,11; p = 0,000) y WBV (-0,13 ± 0,19; p = 0,014) experimentaron disminuciones. El BMC de la columna lumbar aumentó en el grupo WV (2,82 ± 2,52 g) en comparación con el grupo CON (-1,92 ± 7,03 g, p = 0,023). El entrenamiento WBV produjo ganancias de masa muscular magra (0,22 ± 0,71 kg) en comparación con el grupo CON (-0,98 ± 0,60 kg, p = 0,011) y WV (-0,60 ± 0,83 kg, p = 0,007).
Conclusión: Los resultados indican que el ejercicio con chaleco lastrado puede contribuir a la prevención de la pérdida ósea, mientras que el entrenamiento vibratorio de cuerpo completo parece promover mejoras en la masa muscular magra.

Palabras clave

Osteopenia; sarcopenia; contenido mineral óseo; puntuación t.

Introduction

Aging is associated with a progressive decline in bone and muscle mass (Colón et al., 2018), which results in a progressive loss of muscle strength and function (Carina et al., 2020). Previous research has suggested a diet high in carbohydrate has a negative influence on bone density (Rivera-Paredez et al., 2023). It is thought that a high carbohydrate diet harms bone health because it negatively affects the proliferation and differentiation of osteoblasts and induces hyperinsulinemia, inhibiting calcium reabsorption in the kidney (Martiniakova et al., 2022). Thailand, rice remains the foundational dietary staple, accounting for 50% to 60% of total daily caloric intake (Rojroongwasinkul et al., 2013). Despite the increasing prevalence of energy-dense Western diets in urban centers, white rice continues to be the primary food group consumed across all demographics (Papier et al., 2017). This heavy reliance on a high-glycemic carbohydrate source may pose significant risks to skeletal integrity in the aging population, potentially compromising bone mineral density.

Short bouts of intense mechanical loading of bone with dynamic exercise provide a potential stimulus to maintain or increase bone mass (McArdle et al., 2010) such as weight lifting and running. However, older populations may not achieve the necessary changes required to improve clinical outcomes because they are unable to train at the desired intensity or duration due to existing health problems (Lachman et al., 2018). Therefore, more practical exercise programs that take into account these age-related problems should be developed. Previous attempts at this have combined exercise with other strategies such as wearing a weighted vest (Mierzwicki, 2019) or whole body vibration (WBV) with some success (Bemben et al., 2018).

The weight bearing by the weighted vest is thought to increase physiological stress on muscles (Gaffney et al., 2022) and thereby drive more adaptation. Some studies have reported on the effectiveness of wearing a vest containing additional weight (10% body weigh) at improving lower extremity muscle strength, muscle power, physical performance, and functional mobility in elderly (Normandin et al., 2018). Previous studies using weighted vests during training showed improved muscle mass and muscle function in older adults (Srisaphonphusitti et al., 2022); however, evidence remains limited and mixed. Nithisup et al. (2023) has demonstrated that weight bearing walking (by wearing a weighted vest) helps maintain and even increase bone mass (T-score and BMC at T-spine) after a relatively brief training period (8 weeks) in Asian older females adults (Nithisup et al., 2024). In a much longer training study, Waltman et al. (2022) revealed that after 12 months of bone-loading exercises using a weighted vest with jogging and resistance exercises, the BMD of total spine and total hip was significantly increased in postmenopausal women with low bone mass (Waltman et al., 2022). However, the effectiveness of weighted vest exercises on muscle mass and bone health in older adult Asian females who consume a high carbohydrate diet and have bone mass problems is not clear.

Whole-body vibration (WBV) on the other hand, is a form of non-invasive, passively induced mechanical stimulation that increases the mechanical load on bone tissues through the production of strain and modulating muscular force contractions (Judex & Rubin, 2010). Bemben and co-workers (2018) reported that WBV provides an effective option to deliver additional exercise training to older people, improving their muscle strength, balance, and reducing the incidence of falls (Bemben et al., 2018). Three months of exercise on vibration platform with frequencies up to 25.5 Hz improved trunk muscle strength and physical performance in elderly men with osteoporosis (Genest et al., 2021). Similar training on a vibration platform with frequency 20 Hz has been demonstrated to improve BMD in postmenopausal women (de Oliveira et al., 2019). On the other hand, other researchers have reported no significant impact on BMD after 18 weeks of low-frequency vibration training (12 Hz) in older female adults (Camacho-Cardenosa et al., 2019). Similarly, Santin-Medeiros and colleagues (2015) found that 8 months of WBV in elderly women did not produce osteogenic effects (Santin-Medeiros et al., 2015). The differences in the vibration frequency, duration of training, age and sex of participants and type of exercises performed on the vibrating platform may explain some of the variation in results between studies.

Currently, the benefit of WBV or weighted vest training at improving bone mineral content and lean body mass in older Asian females that consume a high carbohydrate diet is not fully understood. Consequently, we explored whether adding a weighted vest or whole-body vibration to regular exercise had a positive effect on bone mineral density and muscle mass in older females.

Method

Participants

This study was conducted in the Department of Rehabilitation Medicine, Srinagarindra Hospital, Faculty of Medicine, Khon Kaen University, Thailand, where 60 older female participants (60-77 years) were recruited. The inclusion criteria included; 1) Healthy elderly aged between 60 to 79 years old and, 2) Volunteers with congenital disease such as diabetes mellitus and hypertension had to be under optimal medication treatment for at least six months and had to be in clinically stable condition (e.g. volunteers must present with a fasting blood sugar level of 100-200 mg/dL or HbA1c 5-8 ("Addendum. 2. Classification and Diagnosis of Diabetes," 2021)), and systolic blood pressure between 140–159 mmHg, diastolic blood pressure 90–99 (Unger et al., 2020) which all must be diagnosed by a doctor prior to entry into the study. Exclusions to the study included any serious respiratory disorder, cardiovascular disease, neuromuscular and musculoskeletal disease, neurological disease, endocrine disorders, chronic kidney disease, or recent surgery. The participants included those with a normal bone density (n = 15), diagnosed with osteopenia (T-score -1.0 to -2.5, n = 23) or osteoporosis (T-score < -2.5, n = 11). Each of the participants were matched into the three exercise groups and all were clinically stable with no other health problems.

Procedure

A randomized controlled experiment was used to compare T-score, BMC, lean mass, physical performance, blood pressure, and heart rate before and after the 8-week intervention period. Randomization was accomplished using a computer-generated random number sequencing program, and allocation concealment was maintained using sealed envelopes prepared by an independent statistician. Sixty participants were randomly matched to three experimental groups by first ranking them by their bone density scores and then randomly selecting them into 1 of the 3 groups. After the 8-week training program, 49 participants completed the intervention: (i) control group (CON: n = 17), (ii) weight vest group (WV: n = 17), and (iii) whole-body vibration group (WBV: n = 15). All participants were asked to maintain their daily food intake, physical activity, and their normal lifestyle as well as to avoid other exercises during the experimental period. The study protocol was approved by the Khon Kaen University Ethics Committee for Human Research under the 1964 Declaration of Helsinki and the ICH Good Clinical Practice Guidelines HE651353.

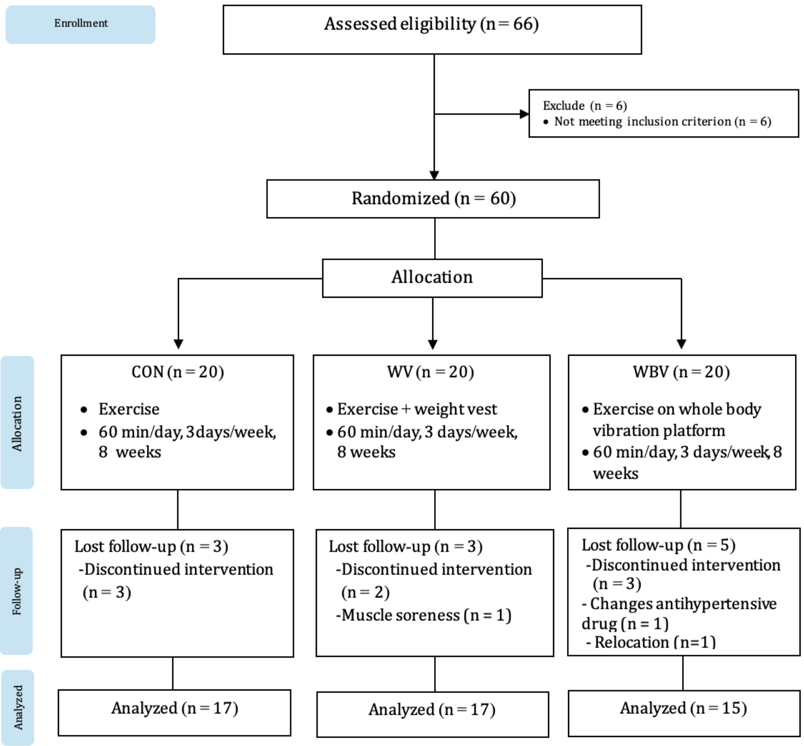
Experimental protocol

For the control group, the participants started with a 5-minute warm-up, followed by 10 minutes brisk walking and finally specific strengthening exercises, which included 5 postures, including squats, calf raises, wide-stance squats, left and right lunges without a weight vest. Participants performed 8 reps for 5 postures with a 30-sec rest and a 60-sec rest between postures, finishing with a 5-minute cool down. Training frequency was 3 days per week for 8 weeks. Before and after each training session, the researchers monitored the participants' blood pressure and resting heart rate.

Participants in the weighted vest group completed the same training as the control group except the participants also wore a weighted vest on the upper part of their body while completing the exercises. Small bags of sand were inserted into the pockets around the vest for an evenly distributed additional weight. The weight in the vests was progressively increased through 8 weeks as follows: the first two weeks the weight was an additional 5% of the individual's body weight then for the last six weeks the weight was increased to 10% of the individual's body weight. Participants completed 8 repetitions of each of 5 different postures, taking a 30-second break between repetitions and a 60-second rest between each posture. The session concluded with a 5-minute cool down (off the machine). This training routine was followed 3 times per week over an 8-week period.

The whole-body vibration participants completed the same warm-up, brisk walk and cool down as the control group then completed 5 postures of the strengthening exercises on a synchronized vibration platform (Power Plate Pro5, Performance Health Systems UK Ltd.) at a frequency of 30 Hz and amplitude of 2 mm (1.43 g in peak acceleration), sinusoidal waveform, vertical axis movement. Participants' exposure time on the vibration platform was 40 minutes. Overall exercise time including warm-up exercises and cool-down was 60 mins in all groups.

Figure 1. Consort diagram of this study.



Outcome measurements

The primary outcomes of this study were anthropometric and body composition measures including BMC, and lean mass. The secondary outcomes were single leg stand test (SLS), time up and go test (TUG), hand grip strength, 6-minute walk test (6-MWT).

Anthropometric and body composition. The participants underwent whole-body scanning for bone mineral content (BMC). A bone mineral content and bone mineral density (BMD: BMC divided by the bone area) are significant indicators for bone fractures, lean mass, and T-score measurements using a dual-energy x-ray absorptiometry (DXA version 13.5.4:3; Hologic, USA). BMC was calculated in grams (g). T-scores are calculated by using the difference between a patient's measured BMD and the mean BMD in healthy young adults, matched for gender and ethnic group, and expressing the difference relative to the young adult population standard deviation (SD). Data were presented as whole-body values and separately for the different body sub-regions (Trunk, arms, legs, pelvis, and total).

Physical performance. Dominant side handgrip strength was assessed using a handheld Smedley-type digital dynamometer (Takei, Japan) (Lee & Gong, 2020). Participants were asked to hold the instrument with an arm parallel to the body, elbow by the side, and were asked to squeeze the dynamometer maximally for 5 sec. The measurements were taken 3 times and the interval between measurements was 30 sec. The highest strength in kilograms from the three attempts was used for analysis.

Single leg stand test (SLS). Static postural control and balance were evaluated by single leg stand test (Blodgett et al., 2022). Before testing, the participants were instructed to stand on their preferred leg for as long as possible without any hand-held support. Standing time (in seconds) was recorded from when 1 foot was lifted off the floor and ended when the same foot touched the ground or the other leg.

Time-Up and Go test (TUG). The time (s) required to stand up from a chair, walk around a cone 3 m away, and return to the chair was measured. The test was performed twice for each participant with a 1-minute rest between trials and the best results were analyzed (Herman et al., 2011).

Six-Minute Walk Test (6MWT). Participants walked on a marked out 30-m track in a straight line with two cones for 6 minutes at their own pace, with rest allowed. At the end of 6 minutes, the participants were told to stop, and then the distances covered during the test were measured in meters (m) (Enright et al., 2003).

Data analysis

Sample size calculations were based on previous study (Sen et al., 2020) with 80% power and α = 0.05, two-sided tests. A sample size of 15 participants per group was selected with an estimated dropout rate of 20%. Data is presented as mean ± standard deviation (SD), of baseline and post-test data along with change scores. Data normality was evaluated by using the Shapiro-Wilk test. Baseline characteristics between groups were compared using one-way ANOVA. To determine within-time point differences, paired t-tests were applied for normal data. A one-way ANOVA was applied to determine significant differences in changes between groups. A post hoc test (Bonferroni test) was used for significant values. All statistical significance was accepted at p-value < 0.05. The data analysis was performed using SPSS software version 28.0 (SPSS Inc.; Chicago, IL, USA).

Results

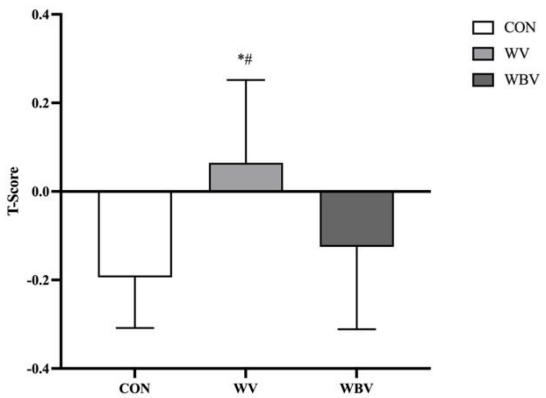
The characteristics of the participants in each group are presented in Table 1. There were no significant differences in clinical characteristics among the three groups at baseline.

Table 1. Clinical characteristics and physiological variables of participants at baseline.

parameters	CON (n = 17)	WV (n = 17)	WBV (n = 15)	p-value
Age (years)	66.82 ± 4.23	69.00 ± 5.35	66.07 ± 4.99	0.16
BMI (kg/m²)	25.23 ± 3.66	25.01 ± 3.44	24.83 ± 3.32	0.95
Resting heart rate (bpm)	76.18 ± 9.08	75.89 ± 7.08	72.93 ± 7.71	0.43
SBP (mmHg)	133.47 ± 13.57	134.26 ± 10.84	125.40 ± 9.47	0.06
DBP (mmHg)	75.47 ± 7.51	76.58 ± 6.23	73.33 ± 8.90	0.45
Normal bone density (n)	6	5	4	
Osteopenia (n)	8	8	7	
Osteoporosis (n)	3	4	4	

Data are presented as mean ± SD, CON: control group, WV: weight vest group, WBV: whole body vibration group, SBP: systolic blood pressure, DBP: diastolic blood pressure, bpm: beats per minute, mmHg: millimeters of mercury

Figure 2. Bone density T- score changes as a result from the 8-week training program in three groups.



CON; control group, WV; weight vest group, WBV; whole body vibration group, * Significant difference between CON and WV, # Significant difference between WV and WBV.

The changes of the T-score (Post T-score minus Pre T-score) of the bone density measurement are presented in Figure 2. After 8-week training, the WV group showed significant improvement in bone T-score (0.06 ± 0.19), while the CON (-0.19 ± 0.11, p = 0.000) and WBV (-0.13 ± 0.19, p = 0.014) groups experienced decreases. When compared to their baseline, the CON group and WBV group showed a significant decrease in T-score; CON group (pre = -1.31 ± 1.22 vs post -1.51 ± 1.21, p < 0.001), WBV group

(Pre = -1.30 ± 0.94 vs post -1.43 ± 0.95, p = 0.042) WV group (Pre = -1.75 ± 1.15 vs post = -1.68 ± 1.19, p = 0.173).

Table 2. Bone mineral content (BMC) measures in the three groups before and after 8-week training.

Parameters	CON (n = 17)			WV (n = 17)			WBV (n = 15)		
	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change
T- spine (g)	80.13 ± 15.46	77.78 ± 15.41	-2.34 ± 5.36	76.40 ± 18.74	73.47 ± 17.89	-2.93 ± 5.32	82.34 ± 19.39	83.62 ± 18.74	1.28 ± 5.20
L- spine (g)	39.36 ± 8.15	37.43 ± 7.38	-1.92 ± 7.03	32.03 ± 10.90	34.85 ± 11.93*	2.82 ± 2.52 [a]	39.99 ± 7.03	41.37 ± 7.43	1.38 ± 2.83
Pelvis (g)	139.72 ± 28.64	141.64 ± 31.49	1.92 ± 6.74	125.69 ± 29.52	130.04 ± 30.94*	4.34 ± 5.11	139.59 ± 29.81	142.73 ± 32.83	3.15 ± 5.92
Arms (g)	232.23 ± 39.53	228.81 ± 39.57*	-3.42 ± 4.43	211.63 ± 35.64	217.42 ± 38.47*	5.78 ± 5.97[a]	223.72 ± 28.36	227.89 ± 29.45*	4.16 ± 5.71
Legs (g)	581.57 ± 94.07	586.20 ± 95.08	4.62 ± 7.49	539.24 ± 82.81	544.17 ± 90.73	4.92 ± 16.14	593.81 ± 101.30	592.33 ± 108.20	-1.48 ± 19.97
Total (g)	1755.0 ± 241.39	1741.91 ± 246.39	-13.16 ± 14.44	1667.00 ± 213.22	1666.39 ± 121.29	-0.60 ± 19.60	1748.75 ± 237.81	1737.07 ± 245.02	-11.63 ± 35.22

Data are presented as mean ± SD, CON; control group, WV: weight vest group, WBV: whole body vibration group, BMC: bone mineral content, T- spine: bone mineral content at Thoracic spine, L- spine: bone mineral content at Lumbar spine, Arms: bone mineral content at arms, Legs: bone mineral content at legs, total: bone mineral content at total body, * Significant difference between pre and post, [a] Significant difference compared with CON.

The bone mineral content (BMC); T- spine, L- spine, pelvic, arms, legs, and total area are presented in Table 2. This study found BMC in WV group substantially increased (P < 0.05) in L-spine (pre = 32.03 ± 10.90 g vs post = 34.85 ± 11.93 g, p = 0.00)), pelvic (pre = 125.69 ± 29.52 g vs post = 130.04 ± 30.94 g, p = 0.004), and arms (pre = 211.63 ± 35.64 g vs post = 217.42 ± 38.47 g, p = 0.001), when compared to their baseline. The WV group showed significantly increased BMC in L-spine (2.82 ± 2.52 g, p = 0.023), and arms (5.78 ± 5.97 g, p = 0.001) compared to the CON group (L-spine = -1.92 ± 7.03 g, and arms = -3.42 ± 4.43). However, those participants on the WBV group showed significant increased BMC in only the arm area (pre = 223.72 ± 28.36 g vs post = 227.89 ± 29.45, p = 0.022).

Table 3. The lean mass measures in the three groups before and after 8-week training.

Parameters	CON (n = 17)			WV (n = 17)			WBV (n = 15)		
	Pre	Post	Changes	Pre	Post	Changes	Pre	Post	Changes
Lean mass (Kg)									
Head (Kg)	2.73 ± 0.22	2.76 ± 0.24	0.03 ± 0.08	2.72 ± 0.25	2.74 ± 0.28	0.01 ± 0.05	2.83 ± 0.28	2.83 ± 0.28	0.00 ± 0.06
Trunk (Kg)	19.11 ± 2.95	18.71 ± 3.11*	-0.39 ± 0.58	17.84 ± 1.65	17.49 ± 1.72*	-0.35 ± 0.47	18.06 ± 2.48	18.06 ± 2.51	0.00 ± 0.47
Arms (Kg)	4.11 ± 0.68	4.00 ± 0.75*	-0.11 ± 0.13	3.81 ± 0.37	3.81 ± 0.40	0.00 ± 0.21	3.78 ± 0.41	3.86 ± 0.40	0.08 ± 0.15
Legs (Kg)	11.45 ± 1.56	11.34 ± 1.76	-0.11 ± 0.35	11.07 ± 1.24	10.89 ± 1.25*	-0.19 ± 0.30	11.67 ± 2.06	11.77 ± 2.06	0.10 ± 0.36
Subtotal (Kg)	34.60 ± 4.96	33.90 ± 5.40*	-0.70 ± 0.82	34.14 ± 3.56	33.28 ± 3.53*	-0.54 ± 0.78	33.90 ± 4.80	34.04 ± 4.62	0.14 ± 0.81[a,b]
Total (Kg)	37.75 ± 4.94	36.26 ± 5.02*	-0.98 ± 0.60	36.50 ± 3.74	35.90 ± 3.76*	-0.60 ± 0.83	36.21 ± 4.85	36.43 ± 4.76	0.22 ± 0.71[a,b]

Data are presented as mean ± *SD*, CON: control group, WV: weight vest group, WBV: whole body vibration group, Head: lean mass at head, Trunk: lean mass at trunk, Arms: lean mass at arms, Legs: lean mass at legs, Subtotal: total lean mass exclude head region, Total: lean mass at total body, *Significant difference between pre and post, [a] Significant difference compared to CON, [b] Significant difference between WV and WBV.

The changes in lean mass in the head, trunk, arms, legs, subtotal, and total areas are shown in Table 3. This study showed that as a result of 8 weeks of training both CON and WV groups had significant decreases in lean mass (e.g. in trunk, arms, subtotal, and total lean mass) when compared to baseline values. Moreover, subtotal and total lean mass were significantly increased in WBV (0.14 ± 0.81, 0.22 ± 0.71 kg) compared to CON (-0.70 ± 0.82 kg, p = 0.036, -0.98 ± 0.60 kg, p = 0.011) and WV (-0.54 ± 0.78 kg, p = 0.019, -0.60 ± 0.83 kg, p = 0.00) as a result of the 8 weeks training.

Table 4. The physical performance measures in the three groups before and after 8-week training.

Parameters	CON (n = 17)			WV (n = 17)			WBV (n = 15)		
	Pre	Post	Changes	Pre	Post	Changes	Pre	Post	Changes
TUG (s)	13.28 ± 1.63	9.35 ± 1.15*	-3.94 ± 1.03	11.27 ± 2.29	6.36 ± 1.56*	-4.91 ± 2.72	9.91 ± 1.68	7.29 ± 0.78*	-2.62 ± 1.36
SLS (s)	12.97 ± 9.35	30.77 ± 17.47*	17.79 ± 15.64	14.45 ± 10.26	39.32 ± 27.52*	24.86 ± 25.46	17.29 ± 12.58	35.32 ± 19.64*	18.02 ± 23.50
Hand grip (kg)	17.29 ± 3.15	17.11 ± 3.88	-0.18 ± 2.14	19.29 ± 3.65	19.86 ± 3.79	0.57 ± 2.18	19.71 ± 3.41	19.88 ± 2.93	0.17 ± 2.48
6MWT (m)	334.06 ± 46.46	338.83 ± 48.58	4.77 ± 39.17	339.37 ± 20.18	417.08 ± 30.00*	77.71 ± 27.43 [a,b]	390.67 ± 39.43	399.25 ± 45.22	8.58 ± 47.88

Data are presented as mean ± *SD*, CON: control group, WV: weight vest group, WBV: whole body vibration group, TUG: time up and go, SLS: single leg stand test, 6MWT: 6-minute walk test, * Significant difference between pre and post, [a] Significant difference compared to CON, [b] Significant difference between WV and WBV.

All groups show similar improvement in the timed up and go and single leg stand tests, however, the WV group showed a significant increase in 6-MWT when compared to the baseline (p = 0.001). Additionally, after 8 weeks of training, the WV group showed significant improvement in 6-MWT when compared to the CON (4.77 ± 39.17 m, p = 0.001) and WBV (8.58 ± 47.88 m, p = 0.002). However, there was no significant difference in hand grip strength in all three groups.

Discussion

This research explored how physical activity either alone or combined with a weighted vest or whole-body vibration affects musculoskeletal health in older women who typically consume a high-carbohydrate diet. While we did not measure this directly, carbohydrates in the diets of Thai females primarily come from refined grains such as white rice and processed flour, which are staples in many Southeast Asian communities (Mohan et al., 2016; Sun et al., 2015). Resistance exercise is known to be highly beneficial for the preservation of bone and muscle mass (Hong & Kim, 2018). Typically, high-load resistance exercise (70% - 90% of 1 RM) is required to increase bone density and requires at least one year duration for changes to be noted in bone mass at the femoral neck and trochanter (Hong & Kim, 2018). Wearing a weighted vest during exercise is considered a form of resistance training, specifically, bodyweight resistance training with added load. This study explored the effectiveness of shorter, more practical exercise interventions for older females. The findings revealed that incorporating a weighted vest into a simple exercise program significantly enhanced bone density T-scores, a key clinical indicator of bone health. Additionally, bone mineral content in the lumbar spine, pelvis, and arms showed notable improvements after eight weeks of weighted vest training. These results highlight the beneficial impact of weighted vest exercise on maintaining bone health in older Asian female adults.

Our results aligned with previous studies highlighting the benefits of weighted vest training. Kelleher et al. (2017) found that a 22-week weighted vest program helped mitigate hip bone mineral density loss and promoted bone formation in older adults with obesity (Kelleher et al., 2017). Similarly, research has shown that six weeks of low-repetition, light-load power training with a weighted vest led to increased bone mineral density in the pelvic region of postmenopausal women with sarcopenia (Hamaguchi et al., 2017). Additionally, Klentrou et al. (2007) reported that a 12-week multimodal training regimen incorporating a weighted vest helped reduce bone resorption (Klentrou et al., 2007). However, Zehnacker et al. (2007) has reported that the duration of the exercise should be at least one year for changes to be noted in bone mineral density. Duration is important because the total time of bone formation at a bone multicellular unit is 4 to 6 months and some bone may be in the resorption phase when BMD is measured at 6 months (Zehnacker & Bemis-Dougherty, 2007).

These findings suggest that weighted vest training triggers osteocyte adaptation to mechanical stress, stimulating osteoblast activity and enhancing the extracellular matrix in the bone microenvironment. The mechanical signaling process promotes bone turnover and subsequent deposition(Chang et al., 2022). Our study further supports the effectiveness of weighted vest exercise as a strategy for slowing bone loss in older female adults, particularly those consuming a high-carbohydrate diet.

This study also observed a decline in lean mass in the trunk, legs, subtotal, and total body areas among participants in the CON and WV groups after eight weeks of training. This unexpected outcome of the weighted vest exercise warrants further investigation. It is hypothesized that the training frequency (three days per week for eight weeks) and intensity (10% of body weight) may not have been sufficient to stimulate muscle adaptation. Burton et al. (2017) suggested that weighted vest exercise might not effectively promote protein synthesis and fat oxidation in older females with osteopenia and osteoporosis (Burton et al., 2017), which could be linked to the low protein intake commonly seen in aging populations in Southeast Asia, where high carbohydrate consumption is prevalent (Pruksa Supannee, 2020). The WV group exhibited a significant reduction in lean body mass, raising the possibility that the added weight, combined with exercise, increased caloric expenditure to a level that led to muscle cell atrophy (Srisaphonphusitti et al., 2022; Nithisup et al., 2024). However, this hypothesis requires further exploration, particularly in relation to caloric expenditure and protein intake during exercise in older Asian females. Although the weighted vest (WV) program did not impact lean body mass, participants showed notable improvements in physical performance measures such as the timed up and go, single-leg stance, and six-minute walk test (Table 4). These improvements likely indicate increased muscular strength in the lower limbs and enhanced cardiopulmonary endurance, both of which contribute positively to the overall quality of life in older adults.

Whole-body vibration is recognized as a passive exercise modality that utilizes mechanical stimuli from a vibrating platform to disrupt neuromuscular structures. This study found a significant decrease in bone mineral content in both the control and WBV groups compared to their baseline measurements. WBV was ineffective in improving bone mineral content in the older female adult.

While WBV training did little to stop bone mineral loss, WBV training led to an increase in lean mass, both subtotal (excluding the head area) and total body mass, compared to the other groups. The mechanism behind this effect may be attributed to the tonic vibration reflex, where vibrations from the platform stimulate muscle spindles and α-motor neurons, triggering involuntary muscle contractions that enhance muscle mass (Alam et al., 2018; Rigoni et al., 2022). Previous studies have reported transient increases in electromyographic (EMG) activity in the upper and lower extremities following WBV treatment, indicating improved muscle control, potentially due to increased stress and adaptation (Fagnani et al., 2006; Lienhard et al., 2015).

The current study showed similar physical performance improvements with a significant increase in lower extremity muscle strength (time up and go test, single leg stand test) in all groups compared to baseline. While the two interventions had distinct effects, weighted vest training, benefiting bone health and whole-body vibration enhancing lean mass they both led to comparable improvements in physical performance. More specifically, this result conforms to the literature concerning exercise, the findings by Srisaphonphusitti et al. (2022) who found that 8 weeks of resistance training, WBV, and WV groups significantly improved physical performance in an elderly population (Srisaphonphusitti et al., 2022). Previous studies reported that weighted vests are used as an intervention to enhance muscle strength in older adults and improve physical performance (Mierzwicki, 2019; Swain et al., 2010).

Limitations

This study has some limitations, firstly all older adults were not asked to record daily food intake but maintained their regular eating routines throughout the study, therefore we are unsure whether diet influenced parameters such as bone mineral content. Secondly, lower-body muscle strength tests were not included in this study, and instead, we measured upper-body strength (handgrip strength), which did not directly correlate with the exercise training provided (mostly walking and lower-body exercise). Thirdly, we did not separate osteopenia and osteoporosis participants which may affect these results.

Practical implications

Exercise training programs incorporating weight vests in elderly populations appear effective in mitigating bone loss. Nonetheless, both interventions (weighted vest and WBV) exhibit substantial potential to improve physical functional capacity, a benefit that carries considerable importance for the daily health and overall quality of life of older adults.

Conclusions

Avoid presenting conclusions that are not a consequence of what is stated in the results or repeating those previously presented. The study's results indicate that weighted vest (WV) training has a beneficial effect on bone health, while whole-body vibration (WBV) training effectively increases lean muscle mass in older Asian women. WV exercises emerged as a promising strategy for reducing bone loss, whereas WBV notably improved muscular development. While the two interventions had distinct effects, weighted vest training benefiting bone health and whole-body vibration enhancing lean mass, they both led to comparable improvements in physical performance. Clinicians and fitness professionals need to thoughtfully assess these training methods to identify the most appropriate and effective approach for each client, taking into account various factors such as ethnicity, dietary habits, program duration, and the type of equipment used along with knowledge of the smallest clinically worthwhile change in these parameters.

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