Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 8, Issue, 11, pp. 21673-21682, November, 2017

ISSN: 0976-3031

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

THE EFFECTS OF WHOLE BODY VIBRATION TRAINING ON PHYSICAL PERFORMANCE, BODY COMPOSITION AND BONE MINERAL DENSITY IN OSTEOPOROSIS

Ramanli B[1]*., Toraman N.F[2]., Aktop A[3], Toktas N[3]., Basralı F[4] and Kacar G[5]

[1]Department of Coaching Education, Sports Science Faculty, Pamukkale University, Denizli, Turkey
[2]Physical Medicine and Rehabilitation Clinic, Antalya Training and Research Hospital, Health Sciences University, Antalya, Turkey
[3]Sports Science Faculty, Akdeniz University, Antalya, Turkey
[4]Department of Physiology, Faculty of Medicine, Akdeniz University, Antalya, Turkey
[5]Department of Nuclear Medicine, Antalya Training and Research Hospital, Health Sciences University, Antalya, Turkey

DOI: http://dx.doi.org/10.24327/ijrsr.2017.0811.1118

ARTICLE INFO

Article History:

Received 18th August, 2017
Received in revised form 10th September, 2017
Accepted 06th October, 2017
Published online 28th November, 2017

Key Words:

Postmenopausal Women, Osteoporosis, Whole Body Vibration Training, Strength Training, Bone Mineral Density.

ABSTRACT

The aim of this study is to determine the effect of a 24-week of vibration training and detraining in postmenopausal women with primary osteoporosis. Fourty volunteer women were randomised into vibration group (VG), strength group (SG) and control group (CON). Bone mineral density (BMD) as primary outcome measure was measured at baseline, at 24th week, and at 48th week. The secondary outcome measures as physical performance, muscle strength, and body composition were collected at baseline, at 4th week, 12th week, at 24th week, and also 48th week. After training, calve and lunge test performances increased significantly, and the lumbar BMD was lower in VG compared with CON. At 48th week lumbar BMD in VG increased compared to CON, while increase in femur BMD was higher in CON. In SG, femur BMD was lower than both VG and CON. This data suggested that vibration training effect differed for the lumbar and femur BMD.

INTRODUCTION

Osteoporosis is a skeletal disorder characterized by low bone mass and micro-architectural deterioration of bone tissue (Ruan *et al*, 2008; Shaw *et al*, 2001) and it is one of the most important health problems seen during menopause (Karadağ *et al*, 2007).

To reduce osteoporosis and fracture risk, not only bone mass should be increased, but muscle strengthening is also necessary. (Zehnacker and Bemis-Dougherty, 2007; Sirola and Rikkonen, 2005). Because muscle strength, which begins to fall in the perimenopausal years (Sirola and Rikkonen, 2005), has a determinative influence on bone mass and endurance, regardless of gender, age and body structure. During daily activities, the strongest loads on the bones are due to the muscles (Gökçe Kutsal, 2004), and exercise affects bone mass causing osteoblast activity (NAMS, 2006). Regular exercise helps prevent fractures by protecting the bone mass and / or reducing the frequency of injury-related falls (Kohrt *et al*, 2004; NAMS, 2006). And it helps reduce the risk of falls by increasing muscle mass, muscle strength and balance (NAMS, 2006).

Vibration training which is a new type of exercise, is a modification of the tonic vibration reflex caused by tendon vibration. (Jordan *et al*, 2005). Vibration is applied to human body in two ways during training: Local Vibration and Whole Body Vibration (WBV). Both isometric and dynamic exercises are used during WBV Training. The intensity of these exercises is ordered from submaximal contractions to maximal contractions. (Luo *et al*, 2005). It has been determined in the literature that increases in BMD (Verschueren *et al*, 2004; Kawanabe *et al*, 2007; Gusi *et al*, 2006), isometric and dynamic strength (Verschueren *et al*, 2004) and balance (Kawanabe *et al*, 2007; Gusi *et al*, 2006) are due to WBV training. It was observed that WBV training increased walking speed, step length, balance (Kawanabe *et al*, 2007; Bruyere,

Corresponding author:* **Ramanli B
Department of Coaching Education, Sports Science Faculty, Pamukkale University, Denizli, Turkey

2005) and agility (Bruyere, 2005; Bautmans, 2005) in elderly individuals. In the literature review, it has been determined that studies on the increase in chronic performance related to WBV training are inadequate (Jordan, 2005) and that the studies on WBV training are inconsistent with the results of the research. This inconsistency is thought to be due to the different VA protocols used in the studies and the lack of clarity of the training characteristics.

None of the studies on the performance impact of the TBVA have given a clear explanation of the superiority of a protocol used, and therefore it is necessary to conduct studies in this direction. Therefore the purposes of this study were to evaluate the effects of 24 weeks training (TBVA) and effects of detraining on the physical performance, the body composition and bone mineral density in postmenopausal women with osteoporosis.

MATERIALS AND METHODS

Subjects and study design

From March 2009 to January 2010, 341 consecutive women who diagnosed osteoporosis (lumbar 1-4 T score ≤-2.5) were evaluated according to the inclusion and exclusion criterias. Inclusion criterias were between 60-69 ages, postmenopausal age ≥5 years, who did not have health problems that prevent them from participating in exercise programs and tests, and sedentary. Exclusion criterias were secondary and severe osteoporosis with history of fracture, muscle, joint or bone operation, spinal deformity index ≥1, and using supportive devices. Although 101 patients who met the criterias participated in the informative meeting on the research program and 40 people gave their consent to participate in the program. Then participating patients were randomly assigned into three groups by a computer-derived protocol: Vibration Group (VG)=14, Strength Group (SG)=13, and Control Group (CON)=13 (Figure 1). Control group did not participate in any exercise program. The study protocol was approved by the Akdeniz University, Faculty of Medicine, Clinical Research Ethics Committee (142/26.02.2009/001925).

Baseline assesments included a thorough medical evaluation that covered a personal and family health history, a questionnaire on demographic characteristics, medicine use and health habits. The height, 6-minute walking test with the body composition (weight, body mass index, %fat, and fat free mass), and strength tests (squat, wall push up, front raise, calves, lunge) as the outcome measures was performed at the beginning, 4th week, 12th week, 24th week and 48th week. Lumbar spine (L1–L4) and proximal femur bone mineral density were measured using dual-energy X-ray absorptiometry (DEXA; QDR 4500, Hologic Inc., Waltham, MA, USA) at baseline, 24th week and 48th week. The device was calibrated daily with a spine phantom supplied by the manufacturer to provide measurement constancy. The precision (coefficient of variation) of the device for BMD measurements performed on spine phantom was less than 1 %.

The distance between the vertex point and the floor was measured with a stadiometer [Britain Holtain, Limited Crymych Dyfed], and height was recorded as cm.

A 6-min-walk test was used to assess aerobic endurance. The score was the total distance walked in 6 min along a 45.72-m rectangular course, which was marked every 4.57 m (Enright, 2003). The heart rate was measured at the beginning and at the end of the test and the intensity at the walking distance was calculated using the Karvonen method (Wilmore and Costill, 1994).

Body composition measurements were performed by bioelectric impedance analysis (TBF-300A, Tanita co., Tokyo, Japan), according to the manufacturer's instructions. Body weight, body mass index, fat free mass (kg), and percent fat mass (%) were measured.

Physical performance test was made using the short physical performance battery (SPPB) which was a group of measures that combines the results of the gait speed, chair stand and balance tests. For tests of standing balance, participants attempted to maintain the side-by-side, semitandem, and tandem positions for 10 seconds. For gait speed a usual pace, 8-ft walk was timed from a standing position. For chair stand test participants were asked to fold their arms across their chest, then stand up and sit down five times as quickly as possible. The test scores were calculated as suggested by Guralnik *et al* (Guralnik *et al*, 2000).

Strength tests were performed taking into account the exercise positions involved in the training program. For the *squat test*, the patient was asked to stop as much as possible in a static squat position on a flat plate (knee 30 degree flexion) and recorded as second. In the *static push-up* test, the patient's hands and feet were at the shoulder width, stopped at the arm's distance from the wall, and then with the command, the patient bended forward with elbow flexed, stopped on this position as far as possible. The time was recorded as second. In the *dynamic push-up* test, the patient began with the static push-up test position and the score was recorded the push-up repetition within 30 seconds. In the *static calves* test, the patient was asked to stand on the tip of the finger without support and to stop at this position and the time was recorded in second. In the *dynamic calves* test, the number of times the patient was able to rise at the tip of the finger within 30 seconds was recorded. In the *static lu*nge test, the patient was asked to step backward with one leg, lowering her hips until both knees are bent, stop at this position as much as possible and the time was recorded in second. In the *dynamic lunge* test, the patient was requested to step backward and bent both knees for 30 seconds, and the number of repetitions was recorded. In the *front raise* test, the patient was asked to lift the 2kg dumbbell shoulder up to 90^0, and the time on this position was recorded as second.

Training Program

A 24-week exercise program was supervised two times per week, with a 10-min warm-up and 10-min cool-down period. Slow, static stretching in the warm-up period followed a slow walk and low-impact calisthenics. Further stretching was performed in the cool-down period. In the main phase, the patients in the VG and SG performed static and dynamic exercises: squat, static push-up, dynamic push-up, static calves, dynamic calves, front raise, static lunge, and dynamic lunge. VG group trained on the vibration platform (Aspire 588, 95 Istanbul, Turkey) and SG group trained on a flat surface with the same time period as 30 minutes. During the vibration training, the amplitude was fixed at 2 mm and the frequency was set at 30 Hz. At the beginning of the training and every month, maximal test performance of each exercise was determined and the training intensity was changed. Training intensity was 50% at the beginning of training. After the second week, the training intensity was raised 5% for all participants in the VG and SG every week during the four weeks. The training intensity increase from week 4 to week 24 was 5% every 4 weeks. Motion rhythm had been applied slowly and smoothly, with regular breathing pattern. CON group did not participate in any physical activity program.

Statistical Analysis

Data analysis was performed using Statistical Package for the Social Sciences (SPSS, version 18.0). Descriptive statistics were expressed as median, minimum, and maximum and nonparametric statistical tests were used because of sample size. The absolute changes (24th week-baseline and 48th week-24th week) on the outcome measures for each subject were calculated. Chi-square test was used for paired group comparison of categorical variables.

Kruskal Wallis Analysis was used to compare the baseline values and absolute changes of the groups. Group differences was determined by using Mann Whitney U test, and the significance level was set at 0.05. Friedman test was used to compare the 1th, 4th, 12th, 24th week values of each group. The level of significance was set at 0.01 - that is, 0.05 divided by 4.

RESULTS

Three patients in the VG, five patients in the SG and six patients in the CON were excluded, because they did not participate to the test and exercise program on follow up, therefore the outcome measures of 26 patients were evaluated (Figure 1). None of the patients experienced angina, arrhythmias or pain during the tests and training program.

The groups did not differ in their baseline outcome measures, except for the 6 min walk test ($p<.05$). 6 min walk test performance was lower in the CON than VG ($p=.01$) (Table 1). 33% of patients in VG, 63% of patients in SG, 14% of patients in the CON group were using osteoporosis medication and there was no difference in the use of osteoporosis medication among the groups ($\chi2 = 4.609$, $p = 0.100$). 0.1% of patients in

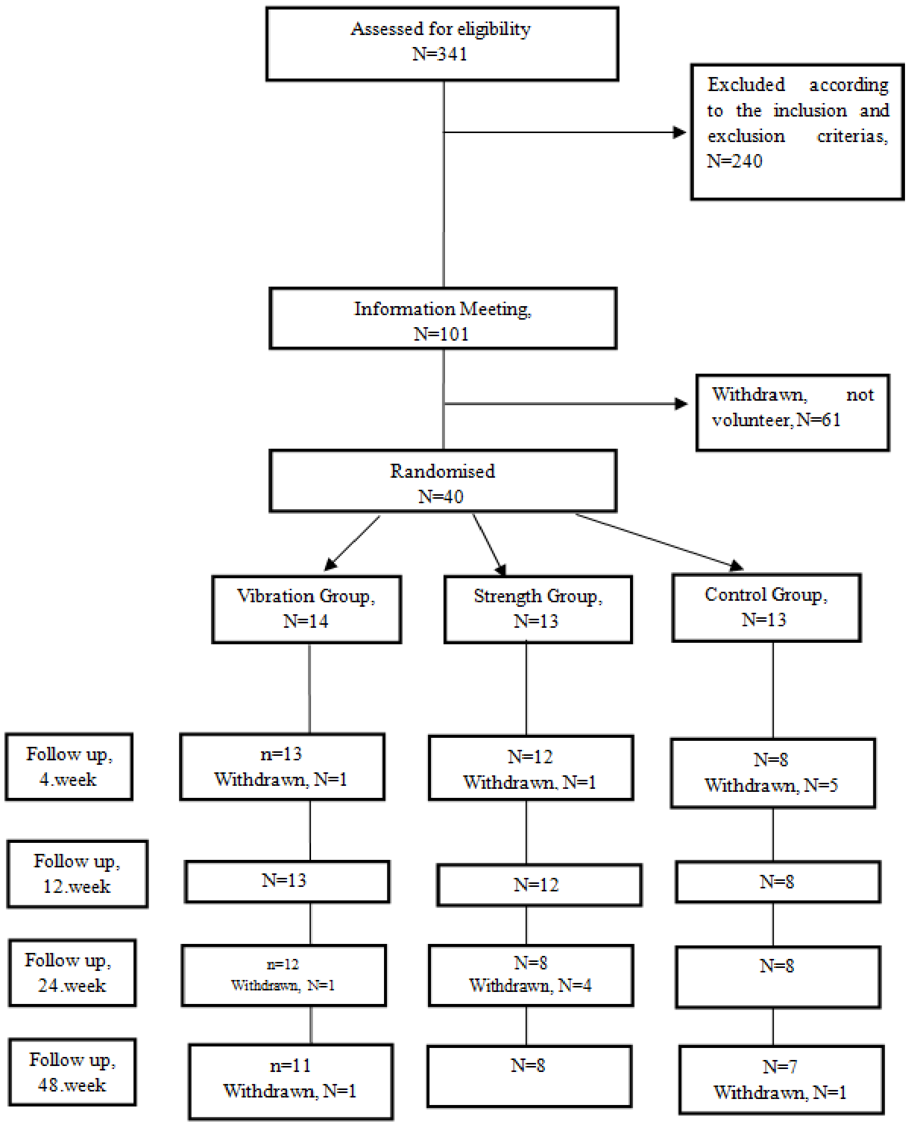

Figure 1 Consort statement

VG, 0.3% of patients in SG and 43% of patients in the CON group were using calcium and D vitamins and there was no difference between the groups due to the use of calcium and D vitamins ($\chi 2$=2.630, p = 0.268).

Lumbar BMD was lower in VG than in CON group (Z = -2.664, p = 0.005), but there was no significant difference between SG and CON group (p> 0.05).

Table 1 Baseline Characteristics of the Vibration Group (VG), Strength Group (SG), and Control Group (CON)

	VG (n=12)	SG (n=8)	CON (n=8)	χ2*	p
	Median (min/max)	Median (min/max)	Median (min/max)		
Age, year	62.5 (60/69)	62.5 (60/68)	62.5 (60/69)	0.054	.97
Postmenopausal period, year	10 (5/20)	13.5 (5/21)	13 (8/30)	1.699	.43
Height, cm	157.5 (148/167)	153 (148/160)	155.5 (144/162)	2.349	. 31
Weight, kg	68.6 (56.3/78.1)	66.7 (59/95.5)	65.3 (45.4/85.1)	0.779	.68
BMI, kg/m^2	27.4 (21.7/32.6)	28.30 (24.9/43)	26.1 (21.9/32.4)	2.444	.30
% Fat	38.8 (29.3/43.2)	40 (34/50.3)	38.3 (25.7/47.2)	0.664	. 72
FFM, kg	27.3 (16.5/33.3)	26.2 (20.7/48)	25 (11.7/40.2)	0.541	.76
L BMD, G/cm^2	0.76 (0.55-0.87)	0.75 (0.66-0.81)	0.74 (0.65-0.83)	0.170	.92
FN BMD, G/cm^2	0.66 (0.51-0.79)	0.68 (0.60-0.84)	0.66 (0.51-0.83)	0.171	.92
SPPB,s	9 (5/12)	8.5 (5/10)	8.5 (5/11)	1.277	.53
Squat,s	22.8 (7.2/300)	23.3 (13.9/42.6)	20.9 (11/47.4)	0.443	.80
SWPU, s	43 (21.3/300)	33.6 (11.7/141)	55.7 (19.1/106)	1.296	.52
DWPU, rep/30s	16.00 (11/24)	17.00 (11.00/20.00)	15.5 (11/20)	1.025	.60
FR, s	36.3 (13/144)	40.1 (17.5/74.9)	39.4 (0/63.1)	0.170	.92
SC,s	17.5 (5.6/109)	8.8 (3.7/58)	16.90 (0/170)	2.649	.27
DC, rep/30s	13.5 (2/43)	3 (1/19)	12 (0/29)	4.666	.10
SL, s	69.3 (4.1/175)	29.3 (10.5/67.2)	50.3 (15/144)	4.249	.12
DL, rep/30s	14.5 (8/30)	17 (8/24)	14 (3/23)	0.987	.61
6 min walk, m	520(447.5/680)	509.5 (426/683.5)	448.3 (373/560)	6.368	.04
WI, %	33.3 (6.9/71.4)	44.2 (25/88.9)	45.4 (26.32/74.3)	3.214	.20

Abbrreviatons: BMI: Body Mass Index, FFM: Fat Free Mass, L: Lumbar, BMD: Bone Mineral Density, FN: Femur Neck, SPPB: Short Physical Performance Battery, SWPU: Static Wall Push-Up, DWPU: Dynamic Wall Push-Up, FR: Front Raise, SC: Static Calves, DC: Dynamic Calves, SL: Static Lunge, DL: Dynamic Lunge, WI: Walking Intensity,.
*Kruskal Wallis test

Table 2 Changes of outcome measures in Vibration Group

	baseline median (min/max)	4.week median (min/max)	12.week median (min/max)	24.week median (min/max)	STS	48.week median (min/max)
Height, cm	157.5 (148/167)	156,5 (144/168)	157 (148/166)	157 (149/166)	*8.455; .04	158 (148/166)
Weight, kg	68.6 (56.3/78.1)	67,75 (57,3/77,7)	67,3 (55/76,9)	67,1 (55,1/77,3)	*10.600; .01	69,3 (57,4/82,4)
BMI, kg/m^2	27.4 (21.7/32.6)	28,15 (21,6/36)	26,9 (21,7/32,8)	26,7 (21,5/32)	*13.051; .01	26,7 (22,7/32,8)
% Fat	38,8 (29.3/43.2)	38,1 (29,7/45)	37,9 (28,9/42,9)	37,1 (28,8/41,6)	*24.076; <.001	39,1 (21,5/43,6)
FFM, kg	27,3 (16.5/33.3)	26,5 (17,1/35,3)	25,7 (16,3/33)	25,6 (15,9/30,8)	*28.200; <.001	27,5 (12,3/34,3)
L BMD, G/cm^2	0,76 (0,55/0,87)	-	-	0,75 (0,53/0,90)	†-0.785; .43	0,74 (0,63/0,89)
FN BMD, G/cm^2	0,66 (0,51/0,79)	-	-	0,66 (0,53/0,77)	†-0.196; .84	0,69 (0,55/0,80)
SPPB,s	9 (5/12)	9 (8/11)	9,5 (7/11)	9,5 (7/12)	*1.471; .69	10 (7/11)
Squat,s	22,8 (7,2/300)	27 (3,7/89,9)	26,3 (4,4/77,3)	45,9 (0/151)	*1.100; .78	35,6 (14,6/247)
SWPU, s	43 (21,3/300)	71,5 (15,4/303)	104,3 (25,5/210)	192,5 (42,7/342)	*21.500; <.001	113 (27,7/330)
DWPU, rep/30s	16 (11/24)	16,5 (10/21)	19,5 (10/29)	19,5 (13/28)	*11.917; .01	17 (13/23)
FR, s	36,3 (13/144)	44,8 (16,9/99,7)	61,8 (9/107)	72,10 (11,8/112)	*7.300; .06	38,2 (5,8/78,4)
SC,s	17,5 (5,6/109)	44,5 (17,3/146)	81,5 (24,2/323)	142 (24,1/411)	*22.900; <.001	80,7 (3,8/312)
DC, rep/30s	13,5 (2/43)	21 (9/49)	31,5 (17/58)	34 (6/56)	*18.078; <.001	32 (3/60)
SL, s	69,3 (4,1/175)	114,5 (41,5/451)	183,5 (17,8/351)	230,5 (49,90/503)	*14.500; .002	106 (27/500)
DL, rep/30s	14,5 (8/30)	14 (10/19)	15,5 (14/22)	18,5 (13/25)	*9.983; .02	16 (2/23)
6 min walk, m	520 (447,5/68)	489,5 (375/589,8)	488 (399/654)	490 (439/675)	*2.800; .42	488 (360/600)
WI, %	33,3 (6,9/71,4)	40 (18,4/73,6)	29 (10,8/71,4)	33,8 (20,3/66,7)	*3.410; .33	32,6 (14,3/64,7)

Abbrreviatons: BMI: Body Mass Index, FFM: Fat Free Mass, L: Lumbar, BMD: Bone Mineral Density, FN: Femur Neck, SPPB: Short Physical Performance Battery, SWPU: Static Wall Push-Up, DWPU: Dynamic Wall Push-Up, FR: Front Raise, SC: Static Calves, DC: Dynamic Calves, SL: Static Lunge, DL: Dynamic Lunge, WI: Walking Intensity,.*Friedman test, χ2; p=0.01; † Wilcoxon test, Z; p=0.01

Increase in static wall push-up, static and dynamic calves, and static lunge values were detected while% fat and FFM values were decreased in VG. (p <0.01). There was an increase in static wall push-up, front raise, dynamic calves and static lunge values in SG (p <0.01). CON group showed a decrease in % fat value (p <0.01). No significant changes were found in other outcome parameters (p> 0.01) (Table 2, 3, 4).

Static calves, static lunge, lumbar BMD values were statistically significant between groups in the comparison of the absolute difference between the 24-week training outcome and baseline outcome (p <0.05). There was no significant difference between VG and SG according to the lumbar BMD, static calve and lunge values (p> 0.05).

Static calve and lunge values were not different between SG and CON group (p> 0.05). The static calve and lunge values of VG were higher than CON group (Z = -3.049, p = 0.001 and Z = -2.546, p = 0.010, respectively) (Table 5).

There were significant group differences in terms of lumbar and femur BMD at 48th week (p <0.05). While there was no significant difference between VG and SG in lumbar BMD (p> 0.05), the femur BMD increased in VG (Z = -3.098, p = 0.001). The increase in femur BMD was higher in CON (Z=-2.084, p=0.035), while the lumbar BMD was higher in VG when compared the groups (Z=-2.943, p=0.002). There was no significant difference between SG and CON group in lumbar BMD (p> 0.05), however femur BMD decreased in SG and increased in CON group (Z = -3.240, p < 0.001) (Table 5).

Table 3 Changes of outcome measures in Strength Group

	baseline median (min/max)	4.week median (min/max)	12.week median (min/max)	24.week median (min/max)	STS	48.week median (min/max)
Height, cm	153 (148./160)	153.50 (143/159)	153 (147/159)	153,5 (147/159)	*6.344; .10	152.5 (147/159)
Weight, kg	66.7 (59/95.5)	67.6 (59.8/95.3)	67 (60.7/93.9)	66.1 (59.3/94.7)	*4.950; .18	67.5 (60.9/96.4)
BMI, kg/m^2	28.3 (24.9/43)	29.3 (26/40.7)	28.4 (25.3/40.1)	27.8 (24/40.5)	*9.234; .03	28.7 (24.7/42.3)
% Fat	40 (34/50.3)	39.5 (34.1/49)	38.3 (33.4/49.4)	37.2 (32.2/49.7)	*4.154; .25	39.15 (33.3/49.9)
FFM, kg	26.2 (20.7/48)	26 (21.4/46.7)	24.8 (21.1/46.4)	24.8 (19.2/47.1)	*6.797; .08	25.35 (20.6/48.1)
L BMD, G/cm^2	0.75 (0.66/0.81)	-	-	0.77 (0.71/0.82)	†-2.103; .04	0.73 (0.65/0.83)
FN BMD, G/cm^2	0.68 (0.60/0.84)	-	-	0.68 (0.60/0.82)	†-0.280; .78	0.67 (0.58/0.82)
SPPB,s	8.5 (5/10)	9.5 (8/11)	9 (6/11)	9 (6/11)	*3.250; .36	10 (8/11)
Squat,s	23.3 (13.9/42.6)	20.2 (10.4/44.9)	39.8 (12.5/55)	39.45 (27.9/103)	*7.050; .07	34.2 (17.2/60)
SWPU, s	33.6 (11.7/141)	50.7 (27.1/74)	130 (85.1/175)	117.5 (53.4/174)	*17.250; .001	99.3 (55.3/128)
DWPU, rep/30s	17 (11/20)	15.5 (110/20)	17 (15/24)	19 (16/21)	*6.120; .11	19 (15/22)
FR, s	40.1 (17.5/74.9)	37.4 (13.5/67.7)	82.3 (57.7/129)	78.15 (32.9/103)	*13.950; .003	49.4 (27.6/84.9)
SC,s	8.8 (3.7/58)	23.5 (0/82.6)	59.9 (3.8/130)	83.5 (0/339)	*9.228; .03	50.9 (21.3/138)
DC, rep/30s	3 (1/19)	13.5 (5/24)	26.5 (7/44)	30.5 (0/38)	*13.350; .004	19 (13/35)
SL, s	29.3 (10.5/67.2)	41.6 (17.3/87)	104 (54.4/193)	93.6 (41.5/520)	*15.450; .001	70.8 (23.2/159)
DL, rep/30s	17 (8/24)	14.5 (12/18)	15.5 (12/20)	15.5 (13/20)	*3.557; .31	16.5 (8/23)
6 min walk, m	509.5 (426/683.5)	459.1 (416.3/502)	486.5 (450/567.5)	476.5 (407/513)	*7.350; .06	476.5 (377/538)
WI, %	44.2 (250/88.9)	38.6 (12.5/60.9)	41.2 (27/50)	35.3 (15.8/47.1)	*4.753; .19	29.6 (21.9/40.7)

Abbrreviatons: BMI: Body Mass Index, FFM: Fat Free Mass, L: Lumbar, BMD: Bone Mineral Density, FN: Femur Neck, SPPB: Short Physical Performance Battery, SWPU: Static Wall Push-Up, DWPU: Dynamic Wall Push-Up, FR: Front Raise, SC: Static Calves, DC: Dynamic Calves, SL: Static Lunge, DL: Dynamic Lunge, WI: Walking Intensity,.
*Friedman test, $\chi 2$; p=0.01; † Wilcoxon test, Z; p=0.01

Table 4 Changes of outcome measures in Control Group

	Baseline median (min/max)	4.week median (min/max)	12.week median (min/max)	24.week median (min/max)	STS	48.week median (min/max)
Height, cm	155.5 (144/162)	154.5 (143/162)	154.5 (144/161)	154.5 (144/161)	*11.389; .01	156 (144/161)
Weight, kg	65.3 (45.4/85.1)	64.9 (45/85.8)	67.8 (44/86)	66.5 (44.4/84.5)	*0.450; .93	70.5 (46/84.4)
BMI, kg/m^2	26.1 (21.9/32.4)	27 (22/33.1)	27.1 (21.2/33.2)	27.3 (21.4/32.6)	*1.500; .68	27.6 (21.9/32.6)
% Fat	38.3 (25.7/47.2)	37.7 (26/47.1)	35.7 (25.6/47.1)	36.8 (23.9/46.2)	*14.544; .002	38.3 (27.3/48.3)
FFM, kg	25 (11.7/40.2)	24.2 (11.6/40.4)	24.2 (11.3/40.5)	24.8 (10.6/39)	*5.100; .17	27.7 (12.5/40.8)
L BMD, G/cm^2	0.74 (0.65/0.83)	-	-	0.77 (0.76/0.85)	†-2.521; .01	0.73 (0.69/0.81)
FN BMD, G/cm^2	0.66 (0.51/0.83)	-	-	0.66 (0.53/0.82)	†-0.560; .58	0.69 (0.57/0.85)
SPPB,s	8.5 (5/11)	9.5 (7/11)	9 (6/11)	8.5 (4/10)	*9.136; .03	9 (7/10)
Squat,s	20.9 (11/47.4)	21.7 (13.7/34.5)	26.8 (10.9/41)	18 (0/66.4)	*0.450; .93	16.9 (7.7/72.3)
SWPU, s	55.7 (19.1/106)	77.9 (31.3/107)	69.1 (39.4/135)	95 (65.2/129)	*7.500; .06	98.2 (62.7/115)
DWPU, rep/30s	15.5 (11/20)	18 (12/22)	17.5 (12/20)	14 (9/22)	*5.789; .12	17 (14/20)
FR, s	39.4 (0/63.1)	36.6 (0/134)	50.7 (0/98)	55.1 (0/103)	*5.783; .12	47.6 (0/73.3)
SC,s	16.9 (0/170)	41.7 (0/11)	50.2 (2.2/99.5)	40.4 (4/113)	*4.462; .22	25.5 (2.02/153)
DC, rep/30s	12 (0/29)	22.5 (0/38)	23.5 (1/33)	20.5 (0/30)	*2.959; .40	15 (0/23)
SL, s	50.3 (15/144)	57.7 (32.4/155)	55.4 (27.5/120)	88.2 (39.7/185)	*1.950; .58	58.9 (35.3/71.8)
DL, rep/30s	14 (3/23)	17 (0/19)	16.5 (11/20)	15 (0/17)	*3.154; .37	17 (5/21)
6 min walk, m	448.3 (373/560)	459 (375/547.5)	459.5 (378/555)	453.5 (301/512)	*1.177; .76	446 (319/538)
WI, %	45.4 (26.3/74.3)	43.1 (14/54.6)	29.9 (5.4/75.7)	39.7 (14.3/71.8)	*2.808; .42	36.9 (18.2/58)

Abbrreviatons: BMI: Body Mass Index, FFM: Fat Free Mass, L: Lumbar, BMD: Bone Mineral Density, FN: Femur Neck, SPPB: Short Physical Performance Battery, SWPU: Static Wall Push-Up, DWPU: Dynamic Wall Push-Up, FR: Front Raise, SC: Static Calves, DC: Dynamic Calves, SL: Static Lunge, DL: Dynamic Lunge, WI: Walking Intensity,. *Friedman test, $\chi 2$; p=0.01; † Wilcoxon test, Z; p=0.01

Table 5 Absolute changes in the groups

	Absolute change between 24.week and baseline				Absolute change between 48.week and 24.week			
	Vibration Group	Strength Group	Control Group	*$\chi 2$, p	Vibration Group	Strength Group	Control Group	*$\chi 2$, p
Height, cm	-1 (-2/4)	-1 (-1/4)	-1 (-1/0)	1.138; .57	0 (-1/1)	0 (-4/0)	0 (-2/0)	1.864, .39
Weight, kg	-1.4 (-3.9/3.3)	-0.8 (-2/0.3)	-0.1 (-4.2/4.2)	2.774; .25	1.5 (-1.4/7.5)	1.4 (-0.5/1.7)	1.6 (-5.1/4.7)	0.507, .78
BMI, kg/m^2	-0.6 (-1.8/1.6)	-0.1 (-2.5/0.5)	0.3 (-1.3/2)	3.324; .19	0.6 (-0.5/3)	0.7 (-0.2/1.8)	0.7 (-2.3/2)	0.200, .91
% Fat	-2.7 (-6/-0.3)	-1.1 (-5/0.5)	-2.2 (-3.6/1.7)	2.387; .30	2 (-7.3/4.3)	0.7 (-0.1/3.6)	2.1 (-1.3/3.7)	1.022, .60
FFM, kg	2.5 (-4.4/-0.3)	-0.9 (-4/-0.1)	-1.3 (-4.1/2.7)	2.627; .27	2 (-3.6/4.9)	0.9 (0/2.4)	1.8 (-2.2/3.2)	1.658, .44
L BMD, G/cm^2	-0.12 (-0.05/0.12)	0.01 (-0.01/0.06)	-0.05 (0.01/0.11)	9.645; .01	-0.00 (-0.05/0.02)	-0.01 (-0.11/0.01)	-0.04 (-0.08/-0.02)	7.945, .02
FN BMD, G/cm^2	0 (-0.05/0.06)	-0.002 (-0.03/0.03)	-0.01 (-0.1/0.1)	0.046; .98	0.03 (0/0.1)	-0.005 (-0.02/0.01)	0.06 (0.03/0.12)	15.856, .00
SPPB,s	1 (-3/2)	0.5 (-2/4)	-1 (-3/5)	1.066; .59	0 (-2/4)	0 (-1/4)	1 (-1/3)	2.500, .29
Squat,s	2.2 (-149/67.9)	18.9 (-7.6/85.7)	0.6 (-35.2/36.7)	1.555; .46	0.3 (-54.8/183.7)	-11.3 (-73.3/10.8)	-0.8 (-19.3/28.4)	2.090, .35
SWPU, s	104.5 (21.2/237.5)	76.2 (20.8/151.4)	42.4 (-13.3/79.5)	5.980; .05	-15 (-141.1/59)	-15.8 (-91.1/1.9)	-2 (-47.2/49.8)	2.643, .27
DWPU, rep/30s	1.5 (-1/9)	1 (-1/8)	-1 (-3/4)	5.933; .05	-2 (-8/3)	0.5 (-4/1)	2 (-3/6)	3.346, .19
FR, s	24.2 (-32/73.3)	38.1 (-30/56.5)	16.6 (-43/61.6)	1.693; .43	-28.3 (-65.8/-3.5)	-17.5 (-75.4/34.2)	-20.9 (-44.1/3.6)	1.540, .46
SC,s	109.7 (9.2/405.4)	72.8 (-15.5/327.5)	13.4 (-57/60.9)	8.762; .01	-57 (-300.7/103)	-22.7 (-299.5/80)	-15.2 (-30.8/40)	2.274, .32
DC, rep/30s	15.5 (-7/43)	23.5 (-10/37)	1 (-8/22)	5.090; 0.08	0 (-17/21)	-11.5 (-18/13)	0 (-24/9)	1.192, .55
SL, s	173.5 (0.7/445.9)	67.5 (-8/509.5)	16.6 (-102.9/149.5)	6.727; .04	-95 (-210/98)	-26.2 (-439.6/67.1)	-41.1 (-131.6/24.8)	0.748, .69
DL, rep/30s	3.5 (-9/16)	-0.5 (-4/6)	1.5 (-17/10)	2.044; .36	-1 (-14/2)	1 (-6/3)	0 (-8/5)	2.388, .30
6 min walk, m	12 (-203/117)	-33.8 (-217.5/10)	-8.8 (-72/50)	2.256; .32	-56 (114/137)	7.5 (-64/38)	0 (-68/26)	5.801, .06
WI, %	-2.7 (-32.7/39.3)	-19 (-41.8/8.3)	-8.3 (-12.1/7.5)	4.503; .11	2.6 (-32.8/35.1)	-5.9 (-24.6/16)	1.8 (-17.3/18)	0.716, .70

Abbrreviatons: BMI: Body Mass Index, FFM: Fat Free Mass, L: Lumbar, BMD: Bone Mineral Density, FN: Femur Neck, SPPB: Short Physical Performance Battery, SWPU: Static Wall Push-Up, DWPU: Dynamic Wall Push-Up, FR: Front Raise, SC: Static Calves, DC: Dynamic Calves, SL: Static Lunge, DL: Dynamic Lunge, WI: Walking Intensity.
* Kruskal Wallis test

DISCUSSION

The primary purpose of this study was to investigate the effect of strength training on the vibration platform on the bone mineral density, body composition and walking performance. The second aim was to determine how much gain could be sustained by training.

Exercise is crucial for osteoporosis in achieving peak bone mass, prevention of falls and fractures by providing bone mass protection, conditioning, flexibility and power gain. Especially exercise in the postmenopausal period; prevents prevents rapid bone loss caused by estrogen deficiency, reduces fall frequency and fracture risk by increasing muscle strength, mobility and flexibility and corrects the posture. (Karadağ *et al*, 2007; Ceceli *et al*, 2001).

Aerobic exercises, postural control exercises, strength exercises, stretching exercises, and balance exercises are recommended as well as various treatments and medication use in the prevention of osteoporosis. When patient-specific exercises are applied, physical performance, bone mass, muscle strength, and balance development are achieved, thereby reducing the risk of falls. The recommended exercises for postmenopausal women are brisk walking, jogging, going down/up the stairs, rowing, weight lifting and jump exercises. (Kohrt *et al*, 2004). Studies have shown that postmenopausal women have increased muscle performance (Swanenburg *et al*, 2007; Hongo *et al*, 2007; Young *et al*, 2007; Shirazi *et al*, 2007; Englund *et al*, 2005), balance (Young *et al*, 2007, Shirazi *et al*, 2007), and quickness (Young *et al*, 2007) as a result of endurance, coordination, and balance exercises. Studies have shown that strength training to increase or maintain bone mineral density and prevent osteoporosis is effective. There are studies to show that strength training is effective to increase (Zehnacker and Bemis-Dougherty, 2007; Englund *et al*, 2005) or maintain (Zehnacker and Bemis-Dougherty, 2007, Engelke *et al*, 2006; Cussler *et al*, 2003; Kell *et al*, 2001) bone mineral density and to prevent osteoporosis (Sirola and Rikkonen, 2005; Engelke *et al*, 2006; Cussler *et al*, 2003). Additionally in postmenopausal women, it has also been suggested that low muscle strength increases the risk of osteoporosis (Hongo *et al*, 2007; Iki *et al*, 2006) and reduction of muscle strength in bone mineral loss (Iki *et al*, 2006; Marcus, 1995) is effective.

Studies on the effects of strength training on muscle performance in women with osteoporosis have found an increase in strength (Hongo *et al*, 2007, Carter *et al*, 2001) and balance (Carter *et al*, 2001). WBV training is suggested to prevent bone fractures that may develop due to osteoporosis. (Ruan *et al*, 2008; Cardinale and Pope, 2003). Local increases in bone mass occur as a response to exercises that cause a significant stress in the bones. With active exercises involving weight training, bone mass can be increased if muscle mass and strength are increased. Applying passive stress tests to bone also shows promise, with the most positive results coming from use of high-frequency, whole-body vibration systems. (NAMS,2006).

Body Composition

One of the main marketing claims for the use of vibrating devices is that they can promote weight loss or decrease fat mass. In addition, BMD affects weight, body mass index, fat mass, fat-free mass, waist / hip ratio, and weekly physical activity level. (Bohannon, 2006). In this study, while there was a decrease in %fat and FFM values in VG at the end of training, there was no change in SG. CON group showed a decrease in %fat values. In this case, it can be said that vibration training is effective in reducing body fat percentage. But the FFM values are also low. So, it can be said that the desired muscle mass cannot be increased by the training programs. There was no definitive explanation for the decrease in the% fat value in the CON group. Because, the patients in the CON group did not participate in any training or exercise program during the study, but food consumption was not taken into account and there was no record of the number of daily steps or physical activity level.

As a result of metaanalysis on the efficacy of WBV treatment in women with postmenopausal osteoporosis; it has been found that WBV is not effective in improving muscle mass, fat mass, BMI or weight. However, the results of the meta-analysis indicated that the chronic application of WBV was insufficient to determine whether it altered the body composition. Elliott *et al*. also found that eight-week strength training did not significantly reduce body mass, body fat percentage, waist/hip ratio, or BMI. (Luo *et al*, 2016).

Tapp *et al*. examined the effects of 8-week WBV training on body composition, cardiovascular status and muscle strength in postmenopausal women aged 48-60 years. No significant main effect or interaction was seen for any body composition variable. They have indicated that WBV may not be an effective alternative to traditional training in relation to body composition. (Tapp and Signorile, 2014).

Bone Mineral Density

Low BMD and osteoporosis are health concerns in older adults with physical, neurological and mobility problems. Harmful changes in bone density and bone architecture may be partly due to mechanical strain on the bone and a decrease in physical activity in these individuals. (Luo *et al*, 2016). In our study, at the end of 24 weeks of training, the lumbar BMD was lower in the VG than in the CON group compared to the baseline, but there was no difference between SG and VG. When lumbar BMD values were evaluated at 24th week to 48th week, there was no difference between SG and VG, and between SG and CON group, but higher in VG than CON group. Femur BMD increased in VG and CON, and decreased in SG. Although there was no significant difference between groups in terms of osteoporosis, calcium and vitamin D use, 33% of patients in VG, 63% of patients in SG and 14% of patients in CON were using osteoporosis medication. However, 0.1% of patients in VG, 0.3% of patients in SG and 43% of patients in CON were using calcium and D vitamins. The variability in Lumbar and Femur BMD seen in the CON group is thought to be related to the osteoporosis drug, calcium and vitamin D. Because bone tissue is a cycle of formation and destruction of lifelong, and the most important factors that provide this cycle are vitamin C and vitamin D. (Sancak, 2017).

In a meta-analysis by Luo *et al*., Women with postmenopausal osteoporosis reported that WBV training had no effect on femur and lumbar BMD. (Luo *et al*, 2016). In addition, Rubin *et al*. reported that 70 postmenopausal women did not find any change in BMD in both the control group and the experimental group as a result of TBVA (30 Hz - 2 mm-exercise, standing alone) they had performed for 12 months / 10 days / day in the study they were doing. (Rubin *et al*, 2004).

Ruan *et al*. reported that WBV (6 months) was effective to improving two major determinants of bone fractures which are lumbar and femoral BMD in postmenopausal women with osteoporosis (age;61.23 years-63.73 years; menopause age:15.73 years-13.52 years), and even lumbar BMD can be improved by 3 months of vibration application. It is thought that this development is caused by the vibration training frequency (30 Hz, 5 mm, vertically stand on the vibration platform, five times per week, ten minutes each time) and the difference of vibration platform (up-down oscillation) in the research. In particular, it has been shown that the reason for the significant increase in lumbar BMD after vibration was the vertical standing of the subjects on the vibration platform and vibration was conducted upright along the longitudinal axis of the body. (Ruan *et al*,2008).

Similarly, Gusi *et al*. investigated whether WBV traning was more effective for the development of BMD in healthy porstermenopausal women than walking. While the WBV training (8 months-3 days/wk, exercise: 60º knees flexed) increased the femur neck BMD, lumbar BMD did not change in both groups. They were explained by the fact that the vibration device increases the femur neck BMD by the vibration to the left and right. (Gusi *et al*, 2006).

Verschueren *et al*. evaluated the effects of high frequency WBV training (35-40 Hz, 1.7-2.5 mm, exercise; squat, deep squat, wide stance squat, one-legged squat, and lunge) on musculoskeletal system in postmenopausal women. While total femur BMD showed a significant increase in the vibration group, there was no change in the strength group and the control group. Total BMD and lumbar BMD did not vary in any group, and no differences were found between the groups. (Verschueren *et al*, 2004).

Engelke *et al*. found that BMD is preserved in proximal femur and calcaneus while the lumbar BMD was increased as a result of exercises (aerobic, jumping, strength and flexibility) applied to women who were osteopenic in the early postmenopausal period (1-8 years) and who were using vitamin D with calcium together. However, the distal forearm BMD has also reduced. (Engelke *et al*, 2006).

Cussler *et al*. reported a significant relationship between total BMD and the amount of weight removed during 1-year strength training (3 days/week, 60-75 min, exercises;balance and weight lifting) in women with postmenopausal osteoporosis who received calcium and hormone therapy (age:40-65 years). (Cussler, 2003).

As a result of obtaining such different results, it can be said that the variability in the transmission of WBV signals may have different effects on different bone regions. The response to vibration depends on the intrasubject (the orientation of the subject, tbe body position and tbe body posture) and the intersubject (the size of the individual, body dynamics, age, gender, and the psychological preparedness of the individual) variability. (Jordan *et al*, 2005).

Balance, Walking, Power and Endurance

In this study, there was no significant change in SPPB test in all groups and there was no difference between the groups. Carter *et al*. observed an increase of 2.3% in static balance and 1.9% in dynamic balance with exercise in women with osteoporosis, but they concluded that the change was not significant. (Chubak *et al*, 2006).

Rees *et al* found that up & go test performance improved in VG (26 Hz, 5-8 mm) and in the exercise group (2 months, 3 reps/week, exercises: static squat, dynamic squat and calves both exercise group and VG) more than in the control group in male and female groups (age: 66-85 years). There was no significant difference between VG and exercise group. (Rees *et al*, 2007).

Bruyere *et al*. examined the effects of 6-week WBV training (10-26 Hz, 7 mm, 3 reps/week, on a vertical vibration platform, exercises; only vertically stand on the vibration platform) on health-related quality of life in elderly individuals. As a results, while the VG's balance scores improved, the control group had fallen. There was an increase in the control group, while the VG had a decrease in the up & go test results. (Bruyere *et al*, 2005).

Strength

At the end of the 24-week training session, there were static wall push-up, static ve dynamic calves, and static lunge values in VG and static wall push-up, front raise, dynamic calves ve static lunge values in SG. No change was found in the control group.

There are few studies (Hongo *et al*, 2007; Engelke *et al*, 2006; Cussler *et al*, 2003) in the literature that discuss the effects of strength training on BMD and muscle performance on postmenopausal osteoporosis or osteopenic women. It has been found in the literature that more focused on healthy postmenopausal women. In addition, it was determined that groups were different according to treatment forms (calcium, vitamin D or hormone treatment) in existing studies. (Engelke *et al*, 2006; Cussler *et al*, 2003). However, no study comparing the effects of vibration training on patients with osteoporosis who are regularly using calcium and vitamin D and patients who do not use calcium and vitamin D along with osteoporosis drug were found. Roelants *et al*. examined the effects of 24-week WBV Training on counter movement jump performance, knee extension strength and speed of movement in women (age 58-74 years). It was determined that isometric and dynamic knee extensor strength showed significant increases in both the resistance group and the WBV group, and the training effects between these two groups were not different. And they noted that WBV training is a feasible training method as well as traditional resistance training for development in knee extension strength, speed of movement and counter movement jump performance in elderly women. (Roelants *et al*, 2004). Verschueren *et al*. applied a similar training program used in our study. After 6 months of training, VG and KG found isometric and dynamic strength increases in knee extensors. (Verschueren *et al*, 2004). In the study of Carter *et al*., There was no significant increase in knee extensor strength of 13.9%. (Carter *et al*, 2001). Hongo *et al*. conducted a study to determine the efficacy of a 4-month low-intensity back extensor strengthening exercise on the back extensor strength, spinal mobility and quality of life. In this study, back muscle strength increased in both the exercise group (26%) and the control group (11%). They also found a positive correlation between back strength and quality of life. (Hongo *et al*, 2007). Delecluse *et al*. conducted a study to determine the effect of 12-week WBV training and strength training on knee extensor strength. In this study, isometric and dynamic knee extensor strength increased significantly in both the WBV group and the strength group, but the increase in the placebo and control groups was not significant. (Delecluse *et al*, 2003). Tapp *et al*. have examined the effects of 8-week WBV training on body composition, aerobic fitness, and muscular strength in postmenopausal women (age 48-60 years). As a result, they found that WBV could have a positive effect on low body strength. (Tapp and Signorile, 2014).

Aerobic Endurance

It was determined that the values of walking distance and walking intensity of patients did not change significantly during 24 week training program and detraining process.

Tapp *et al*. have examined the effects of 8-week WBV training on body composition, aerobic fitness, and muscular strength in postmenopausal women (age 48-60 years). As a result, they found that WBV may not be an effective alternative to traditional training with regard to aerobic capacity. (Tapp and Signorile, 2014).

Limitations

Interpretations of the present study must be made with caution for several reasons. First, the sample size was small. Second, baseline information on the participants' psychological factors was missing. To minimize the effects of this limitation, we selected only those who were free from obvious psychological problems that might have affected functional performance. The possibility remained, however, that some members of our cohort had previous psychological problems. Third, although there was no record of daily physical activity or number of steps recorded in the rationale that patients should not participate in any training or exercise program, and no food consumption was recorded. Forth, only 85% of the participant in the VG, 62% of them in the SG and 54% of the CON group completed the study. Therefore compliance to exercise especially for the SG was insufficient. Strengths of the study are that the detailed exercise program to be applied is repeatable, the response to the exercise program could be evaluated as the patients were under observation throughout the application and the testing and measurements were applied and repeated by the same individuals.

CONCLUSION

This study was conducted to determine the effect of 24-week TBV training on postmenopausal women with physical performance, body composition and BMD. Increase in static wall push-up, static and dynamic calves, and static lunge values were detected while% fat and FFM values decreased in VG. On the other hand SG'nda ise static wall push-up, front raise, dynamic calves ve static lunge değerlerinde artış saptandı. In the control group, only a decrease in% fat was observed. At the end of the 24-week training period, there was no difference between VG and SG due to the strength tests, while VG's static calve and lunge values were found to be higher than the CON group.

At 48th week lumbar BMD in VG increased compared to CON, while increase in femur BMD was higher in CON. In SG, femur BMD was lower than both VG and CON.

Acknowledgments

This study was supported by Akdeniz University Research Foundation (Project Number: 2009.03.0122.009), Health Sciences University Antalya Training and Research Hospital, which provided financial and equipment support. There is no professional relationship with companies or manufacturers who will benefit from the results of the present study. We would like to thank all the trainers for their help, and a very special thanks goes to all the participants who volunteered for this study.

References

1. Bruyere, O., Wuidart, M. A., Di Palma, E., Gourlay, M., Ethgen, O., Richy, F., & Reginster, J. Y. (2005). Controlled whole body vibration to decrease fall risk and improve health-related quality of life of nursing home residents. *Archives of physical medicine and rehabilitation*, 86(2), 303-307.
2. Bautmans, I., Van Hees, E., Lemper, J. C., & Mets, T. (2005). The feasibility of whole body vibration in institutionalised elderly persons and its influence on muscle performance, balance and mobility: a randomised controlled trial [ISRCTN62535013]. BMC geriatrics, 5(1), 17.
3. Bohannon, R. W. (2006). Reference values for the timed Up and Go test: a descriptive meta□analysis. *Journal of geriatric physical therapy,* 29(2), 64-68.
4. Cardinale, M., & Pope, M. H. (2003). The effects of whole body vibration on humans: dangerous or advantageous?. *Acta Physiologica Hungarica*, 90(3), 195-206.
5. Carter, N. D., Khan, K. M., Petit, M. A., Heinonen, A., Waterman, C., Donaldson, M. G., Prior, J. C. (2001). Results of a 10 week community based strength and balance training programme to reduce fall risk factors: a randomised controlled trial in 65-75 year old women with osteoporosis. *British journal of sports medicine*, 35(5), 348-351.
6. Ceceli, E., Kısaoğlu, S., Saraçoğlu, M., Kocaoğlu, S., & Yorgancıoğlu, Z. R. (2001). Postmenopozal Osteoporozda Egzersiz ve Kalsiyum Tedavisinin Etkinliği. *Romatizma*, 16, 90-5.
7. Chubak, J., Ulrich, C. M., Tworoger, S. S., Sorensen, B., Yasui, Y., Irwin, M. L., McTıernan, A. N. N. E. (2006). Effect of exercise on bone mineral density and lean mass in postmenopausal women. *Medicine & Science in Sports & Exercise,* 38(7), 1236-1244.
8. Cussler, E. C., Lohman, T. G., Going, S. B., Houtkooper, L. B., Metcalfe, L. L., Flint-Wagner, H. G., Teixeira, P. J. (2003). Weight lifted in strength training predicts bone change in postmenopausal women. *Medicine and science in sports and exercise,* 35(1), 10-17.

9. Guralnik, J. M., Ferrucci, L., Pieper, C. F., Leveille, S. G., Markides, K. S., Ostir, G. V., Wallace, R. B. (2000). Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 55(4), M221-M231.
10. Gusi, N., Raimundo, A., & Leal, A. (2006). Low-frequency vibratory exercise reduces the risk of bone fracture more than walking: a randomized controlled trial. *BMC musculoskeletal disorders*, 7(1), 92.
11. Engelke, K., Kemmler, W., Lauber, D., Beeskow, C., Pintag, R., & Kalender, W. A. (2006). Exercise maintains bone density at spine and hip EFOPS: a 3-year longitudinal study in early postmenopausal women. *Osteoporosis international*, 17(1), 133-142.
12. Englund, U., Littbrand, H., Sondell, A., Pettersson, U., & Bucht, G. (2005). A 1-year combined weight-bearing training program is beneficial for bone mineral density and neuromuscular function in older women. *Osteoporosis International*, 16(9), 1117-1123.
13. Enright, P. L. (2003). The six-minute walk test. Respiratory care, 48(8), 783-785.
14. Fukagawa, N. K., & Marcus, R. (1995). Relationship of age-related decreases in muscle mass and strength to skeletal status. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 50(Special Issue), 86-87.
15. Hongo, M., Itoi, E., Sinaki, M., Miyakoshi, N., Shimada, Y., Maekawa, S., Mizutani, Y. (2007). Effect of low-intensity back exercise on quality of life and back extensor strength in patients with osteoporosis: a randomized controlled trial. *Osteoporosis International*, 18(10), 1389-1395.
16. Iki, M., Saito, Y., Kajita, E., Nishino, H., & Kusaka, Y. (2006). Trunk muscle strength is a strong predictor of bone loss in postmenopausal women. *Clinical orthopaedics and related research,* 443, 66-72.
17. Jordan, M. J., Norris, S. R., Smith, D. J., & Herzog, W. (2005). Vibration training: an overview of the area, training consequences, and future considerations. *Journal of strength and conditioning research,* 19(2), 459.
18. Karadağ, G., Uçan, Ö., Ovayolu, N., Karadağ, E., & Torun, S. (2007). Ortopedi Polikliniğine Başvuran Menopoza Girmiş Kadınların Bazı Özellikleri ile Kemik Mineral Yoğunluğu Arasındaki ilişki. *Osteoporoz Dünyasından,* 13, 75-9.
19. Kawanabe, K., Kawashima, A., Sashimoto, I., Takeda, T., Sato, Y., & Iwamoto, J. (2007). Effect of whole-body vibration exercise and muscle strengthening, balance, and walking exercises on walking ability in the elderly. *The Keio journal of medicine*, 56(1), 28-33.
20. Kell, R. T., Bell, G., & Quinney, A. (2001). Musculoskeletal fitness, health outcomes and quality of life. *Sports Medicine*, 31(12), 863-873.
21. Kohrt, W. M., Bloomfield, S. A., Little, K. D., Nelson, M. E., & Yingling, V. R. (2004). Physical activity and bone health. *Medicine & Science in Sports & Exercise,* 36(11), 1985-1996.
22. Kutsal Y.G. Osteoporozda Kemik Kalitesi. Öncü Basımevi. (2004).
23. Luo, J., McNamara, B., & Moran, K. (2005). The use of vibration training to enhance muscle strength and power. *Sports Medicine*, 35(1), 23-41.
24. Luo, X., Zhang, J., Zhang, C., He, C., & Wang, P. (2017). The effect of whole-body vibration therapy on bone metabolism, motor function, and anthropometric parameters in women with postmenopausal osteoporosis. *Disability and rehabilitation*, 39(22), 2315-2323.
25. NAMS North American Menopause Society. (2006). Management of osteoporosis in postmenopausal women: 2006 position statement of The North American Menopause Society. *Menopause* (New York, NY), 13(3), 340.
26. Rees, S., Murphy, A., & Watsford, M. (2007). Effects of vibration exercise on muscle performance and mobility in an older population. *Journal of aging and physical activity*, 15(4), 367-381.
27. Roelants, M., Delecluse, C., & Verschueren, S. M. (2004). Whole□Body□Vibration Training Increases Knee□Extension Strength and Speed of Movement in Older Women. *Journal of the American Geriatrics Society*, 52(6), 901-908.
28. Ruan, X. Y., Jin, F. Y., Liu, Y. L., Peng, Z. L., & Sun, Y. G. (2008). Effects of vibration therapy on bone mineral density in postmenopausal women with osteoporosis. *Chinese Medical Journal* (English Edition), 121(13), 1155.
29. Rubin, C., Recker, R., Cullen, D., Ryaby, J., McCabe, J., & McLeod, K. (2004). Prevention of postmenopausal bone loss by a low□magnitude, high□frequency mechanical stimuli: a clinical trial assessing compliance, efficacy, and safety. *Journal of Bone and Mineral Research,* 19(3), 343-351.
30. Sancak, S. (2017). Kalsiyum ve D Vitamininin Kemik Metabolizması Üzerine Etkisi. *Turkiye Klinikleri Journal of Endocrinology Special Topics*, 10(2), 68-73.
31. Shaw J.M., Witzke K.A., Winters K.M. (2001). Exercise for skeletal health and Osteoporosis Prevention. In ACSM's Resource Manual for Guidelines for Exercise Testing and Prescription. Ed.M. Hauber. 4th ed. Baltimore: Lippincott Williams & Wilkins.
32. Shirazi, K. K., Wallace, L. M., Niknami, S., Hidarnia, A., Torkaman, G., Gilchrist, M., & Faghihzadeh, S. (2006). A home-based, transtheoretical change model designed strength training intervention to increase exercise to prevent osteoporosis in Iranian women aged 40–65 years: a randomized controlled trial. Health education research, 22(3), 305-317
33. Sirola, J., & Rikkonen, T. (2005). Muscle performance after the menopause. *British Menopause Society Journal*, 11(2), 45-50.
34. Swanenburg, J., de Bruin, E. D., Stauffacher, M., Mulder, T., & Uebelhart, D. (2007). Effects of exercise and nutrition on postural balance and risk of falling in elderly people with decreased bone mineral density: randomized controlled trial pilot study. *Clinical Rehabilitation*, 21(6), 523-534.

35. Tapp, L. R., & Signorile, J. F. (2014). Efficacy of WBV as a modality for inducing changes in body composition, aerobic fitness, and muscular strength: a pilot study. *Clinical interventions in aging*, 9, 63.
36. Verschueren, S. M., Roelants, M., Delecluse, C., Swinnen, S., Vanderschueren, D., & Boonen, S. (2004). Effect of 6Month whole body vibration training on hip density, muscle strength, and postural control in postmenopausal women: A randomized controlled pilot study. *Journal of bone and mineral research*, 19(3), 352-359.
37. Wilmore, J.H., Costill, D.L. Physiology of sport and exe rcise. Champaign, IL: Human Kinetics. Chicago. (1994).
38. Young, C. M., Weeks, B. K., & Beck, B. R. (2007). Simple, novel physical activity maintains proximal femur bone mineral density, and improves muscle strength and balance in sedentary, postmenopausal Caucasian women. *Osteoporosis International*, 18(10), 1379-1387.
39. Zehnacker, C. H., & Bemis-Dougherty, A. (2007). Effect of weighted exercises on bone mineral density in post menopausal women a systematic review. *Journal of Geriatric Physical Therapy*, 30(2), 79-88.

How to cite this article:

Ramanli B *et al*.2017, The Effects of Whole Body Vibration Training on Physical Performance, Body Composition And Bone Mineral Density in Osteoporosis. *Int J Recent Sci Res.* 8(11), pp. 21673-21682.
DOI: http://dx.doi.org/10.24327/ijrsr.2017.0811.1118

****