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Original Article

Effects of whole-body vibration in horizontal position on bone, quality of life, and balance in postmenopausal osteoporosis

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ABSTRACT

Objectives: The present study aimed to analyze the effect of high-frequency, low-magnitude whole-body vibration (WBV) therapy in horizontal position on bone, quality of life, pain, and balance in postmenopausal women.

Patients and methods: Sixty postmenopausal women were included in this prospective, randomized controlled study between May 2015 to September 2015. The patients were randomized into three groups, with 20 participants in each group: *(i)* WBV + infrared group, *(ii)* infrared group, and *(iii)* control group. Bone mineral density of the lumbar and femoral regions of all the patients was measured using dual-energy X-ray absorptiometry. In addition, osteocalcin and hydroxyproline values were measured. Quality of life was assessed using the Short Form-36, pain was assessed using the Visual Analog Scale, and balance was assessed based on the participants' performance in the Berg balance test.

Results: Seven patients (two from the vibration + infrared group and five from the infrared group) could not continue the study, and the analyses were conducted with the remaining 53 patients (mean age: 56.9±5.1 years; range, 45 to 65 years). At the end of a three-month treatment period, no statistically significant difference was found in bone mineral density, bone turnover markers, pain, and quality of life of the patients in all three groups compared to the pretreatment values. Berg balance test results showed a statistically significant increase after treatment in all three groups.

Conclusion: High-frequency, low-magnitude WBV performed under supervision in postmenopausal women was not found to be effective in improving bone, quality of life, pain, and balance. Future studies for determining effective vibration protocols having a longer duration and higher frequency of sessions are warranted.

Keywords: Bone density, osteoporosis, quality of life, vibration.

Osteoporosis is an important public health issue that may result in a high fracture risk in the elderly population. There is a general consensus that physical exercise decreases the risk of osteoporotic fractures by reducing the risk of falls and increasing bone strength. Although long-term high-intensity exercise programs have been shown to be successful in early postmenopausal women, a high-intensity exercise program appears to be less attractive to older postmenopausal women and may cause a lack of compliance in the long term and result in injury.[1] Some studies have described falls and fractures as side effects of exercise.[2]

Osteoporosis may cause chronic pain, decreased physical function, reduced participation in social activities, and health-related quality of life (QoL) impairments due to depression. In this context, improving the QoL of patients with osteoporosis has become an important goal. Although there is evidence suggesting that exercise can have positive effects on menopausal symptoms in women with low bone mineral density (BMD), there is limited data on

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the effects of different supervised exercise programs on QoL.[3]

Whole-body vibration (WBV) therapy is an easy-to-apply alternative for those who do not wish to initiate or continue pharmacological treatments and cannot perform high-impact exercises, and it has high patient compliance. Whole-body vibration therapy is among the promising new interventions for the prevention and treatment of osteoporosis[3] and is defined as mechanical vibration applied in a standing or supine position without any restrictions on frequency (Hz), amplitude (mm), magnitude (vibration acceleration due to gravity, g) and cumulative WBV dose.[4] The evidence obtained from animal studies has shown that WBV can be an effective method for increasing bone mass and improving bone structure and strength.[1] Some human studies have shown that WBV can positively affect BMD[5,6] and improve neuromuscular parameters associated with falls in postmenopausal women.[5,7]

Vibration parameters and exercise protocols vary among studies on WBV treatment in postmenopausal women. Moreover, different platforms have been used in studies.[2,4,8] Investigation of the effect of different devices or different vibration protocols to determine the most effective program is an important topic for future research.[1] Our device works based on the sinusoidal vibration principle as in other devices.[9] We used the findings in existing literature to decide on vibration parameters. Small changes in posture can have a significant effect on the extent to which a plantar-based mechanical stimulus is actually transmitted to the spine or hip; the stimulus is likely to be weakened by the inevitable changes in posture, which occur due to aging and osteoporosis.[10] Hence, this study aimed to examine the effect of high-frequency and low-magnitude WBV in horizontal position in postmenopausal women without being affected by posture.

PATIENTS AND METHODS

For this prospective, randomized controlled study, 185 postmenopausal women who were diagnosed with osteoporosis and followed in our outpatient clinic at the Şişli Hamidiye Etfal Training and Research Hospital based on the osteoporosis diagnostic criteria by the World Health Organization between May 2015 to September 2015 were assessed. According to the inclusion and exclusion criteria, 60 patients were included in the study. Inclusion criteria included postmenopausal patients aged 45 to 65 years with L2-L4 or femoral neck BMD T-scores of –2.5 to –3. Exclusion criteria included osteoporotic fractures, metabolic bone disease, hyperparathyroidism, presence of hyperthyroidism, previous or current use of corticosteroids, previous bisphosphonate use over the previous year, lumbar disk herniation, spondylolisthesis, and narrow spinal canal. Additionally, those with kidney stones, gallstones, pregnancy, epilepsy, cancer, a pacemaker, treatment of orthostatic hypotension, recent implants (joint, cochlear, or corneal), recent surgery, recent intrauterine device, acute thrombosis, acute rheumatoid arthritis, and serious cardiovascular events were excluded as WBV therapy is not recommended in individuals with these conditions. The patients included in the study were evaluated by a blinded researcher at the onset and end of the treatment.

The patients included in the study were randomized by the coresearcher into three groups of 20 patients each, according to the random numbers table. The first group received WBV and infrared therapy for 20 min per session, two days a week for three months. The second group received only infrared therapy for 20 min, two days a week for three months, in the same bed system. The third group did not receive any treatment. Patients in all three groups continued their treatment with 1000 mg calcium and 880 IU vitamin D (Figure 1). The patients were called every week by phone to check whether they were complying with the treatment.

Vibration therapy

The PowerAndullator (HHP-Andumedic 3 yellow edition, Karlsruhe, Germany) device was used as the vibration bed system for WBV therapy. The device was developed in 2007.[11] The patients were placed in the supine position with the whole body in contact with the bed during the treatment. The WBV therapy was increased in frequency from 25 Hz to 30 Hz in the first week, 40 Hz in the second week, 50 Hz in the third week, and 60 Hz in the fourth week. The therapy was then continued for a total of 20 min. Subsequent sessions continued with 60 Hz. The acceleration value administered by the device was 2.0 to 4.0 m/sec^2, and the amplitude of the applied vibration was 0.5 to 2.0 mm. A well-trained physical therapist was responsible for administering the therapy and monitoring the safety of the subjects.

Infrared therapy

Infrared therapy at a wavelength of 550 to 950 nm was applied to both groups of patients by means of infrared pads on the bed during the treatment.

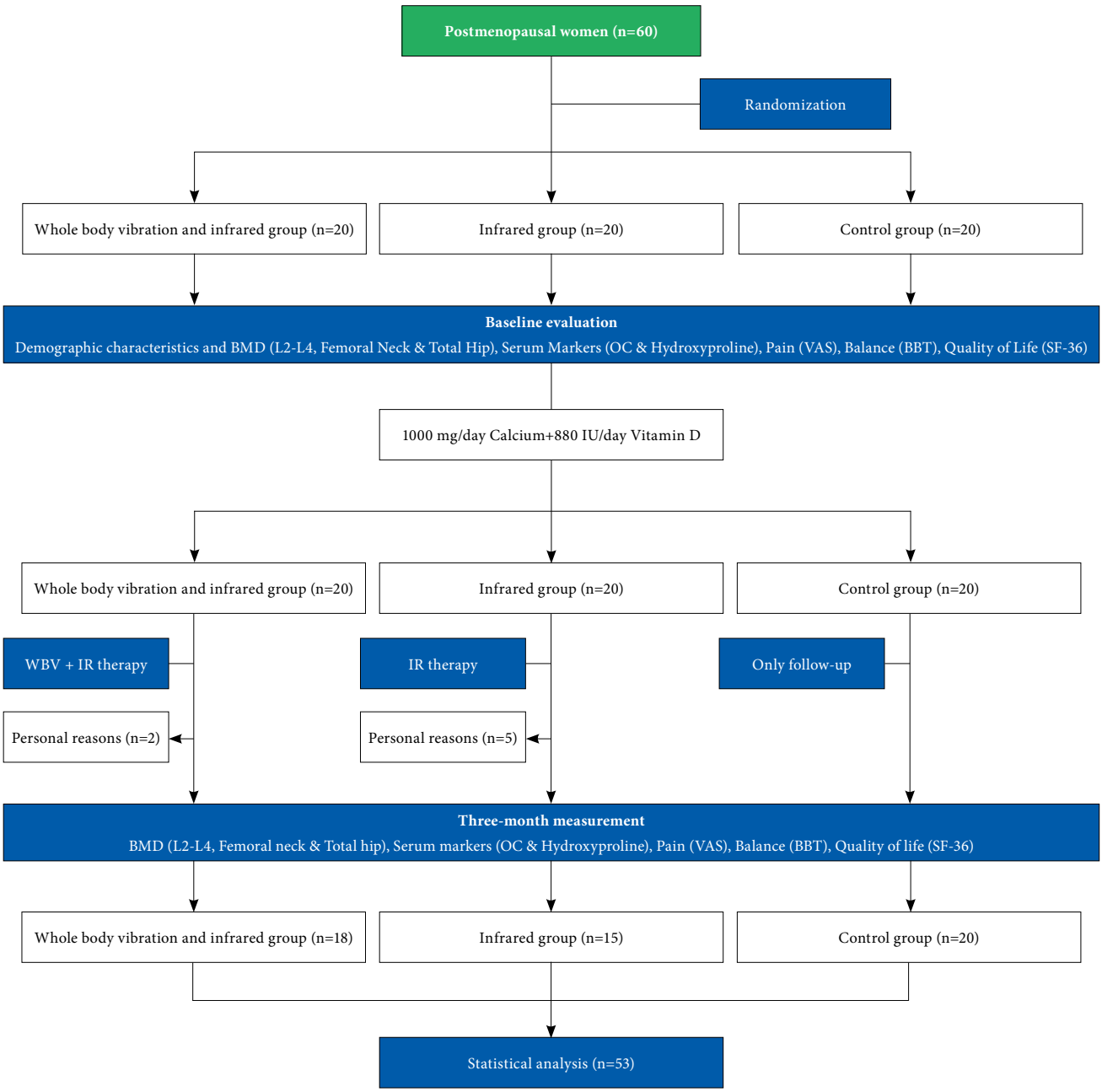

Figure 1. Exhibitor scheme.

WBV: Whole-body vibration; BMD: Bone Mineral density; OC: Osteocalcin; VAS: Visual Analog Scale; BBT: Berg Balance test; SF-36: Short Form-36.

Bone metabolism

Bone mineral density (g/cm^2) of the lumbar, femoral neck, and entire femoral regions of all patients was measured at the onset and end of the treatment using dual-energy X-ray absorptiometry (General Electric LUNAR Prodigy Advance; (GE Healthcare Lunar, Madison, WI, USA). In the precision studies for this device, the coefficients of variation were found to be 1.85% for the lumbar region and 1.38% for the entire femur region.

Bone turnover markers were assessed before and after treatment. Serum samples were taken from all patients between 08:00 and 10:00 in the morning after 12 h of fasting. Urine samples were analyzed in the first morning urine. In the present study, considering the laboratory conditions of our hospital, we checked

the values of osteocalcin (OC) as a bone formation marker and hydroxyproline/creatinine values as a bone resorption marker.

Quality of life

The Short Form-36 (SF-36) is a widely used health-related QoL scale. It is not specific to any age, disease, or treatment group. It includes general health concepts. It is a questionnaire containing 36 questions in eight subscales. The scale can be examined under two main sections: physical and mental health. Patients are scored out of 100 points in the SF-36, and the scores obtained vary between 0 and 100 points for each component. High scores on this scale indicate a better level of health, whereas low scores indicate deterioration of health.[12] The validity and reliability of the Turkish version of SF-36 have been analyzed.[13]

Pain

Pain was evaluated according to the Visual Analog Scale (VAS; 0=no pain, 10=very severe pain). They were asked to describe their back pain on the scale, choosing a number from 0 to 10 (10-cm VAS).

Balance

The Berg balance test (BBT) assesses whether people can maintain their balance during 14 different activities. The level of competence in the activity for each item is scored between 0 and 4, with 0 indicating the lowest score (incapable of performing the activity) and 4 indicating the highest score (independently and safely performing activities). The maximum score obtainable is 56. Higher scores indicate better balance.[14] The validity and reliability study of the Turkish version has been conducted by Şahin et al.[15]

Statistical analysis

As a result of the power analysis with PASS version 11.0 (NCSS, Kaysville, UT, USA) with reference to a similar study in the literature, the required sample size was determined as at least 51 individuals in total.[16] In this case, the power of the test was expected to be approximately 82.6%.

Data were analyzed using IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as mean ± standard deviation (SD) median (min-max), frequency, and percentage. Pearson's chi-square test was used to evaluate categorical variables. The conformity of the variables to the normal distribution was examined using visual (histogram and probability graphs) and analytical methods (Shapiro-Wilk tests). For the nonnormally distributed variables, the Wilcoxon signed-rank test was used to assess statistical significance between two dependent groups, whereas the Kruskal-Wallis test was used to assess statistical significance between three independent groups. The Mann-Whitney U test was used for pairwise comparisons with post hoc Bonferroni correction to determine the source of the difference in statistical significance between three independent groups. While calculating the percentage change in BMD, the posttreatment value was subtracted from the pretreatment value, divided by the pretreatment value, and multiplied by 100. In 15 patients whose descriptive features were similar to the patients included in the study, consecutive BMD measurements were performed at three different times on the same day. Using these measurements, coefficient of variation (CV) and least significant change (LSC) were calculated. In CV calculation, the following formula was used: standard deviation/mean BMD × 100. The following formula was used for LSC calculation: 2.77 × CV. A p-value <0.05 was considered statistically significant.

RESULTS

Seven out of the 60 patients in the study could not continue due to personal reasons (Figure 1). One

TABLE 1
Distribution of age, menarche and menopause age, menopause duration, and body mass index among study groups

	Vibration + infrared (n=18)			Infrared (n=15)			Control (n=20)			
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	p^*
Age (year)	56.33±4.49	55	49-65	54.07±5.76‡	53	45-65	59.40±3.75	60	50-65	**0.007**
Age of menarche (year)	13.33±1.53	13	11-17	14.13±1.51	14	12-18	14.05±2.16	14	11-20	0.237
Menopause age (year)	42.78±6.79	43.5	30-55	44.47±5.59	45	35-53	47.25±3.38	47	41-52	0.062
Menopause duration (year)	13.56±8.22	13.5	1-31	9.60±7.10	7	1-25	12.15±4.48	12	4-20	0.179
BMI (kg/m^2)	27.08±4.47	28.3	19.9-36.1	25.47±2.95	25	21.1-31.1	27.02±4.56	27.5	18.7-34.5	0.441

SD: Standard deviation; BMI: Body mass index; *Kruskal-Wallis Test (α=0.05); ‡ As a result of post-hoc pairwise comparisons, a significant differences was found with the "control" group.

TABLE 2
Distribution of BMD values between study groups and within each study group before and after treatment

BMD (g/cm²)		n	Before treatment			After treatment			Change percentage	
			Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	%	*p**
L2-L4	Vibration + infrared	18	0.880±0.021	0.882	0.838-0.911	0.892±0.038	0.891	0.805-0.964	1.36	0.122
	Infrared	15	0.896±0.068	0.865	0.837-1.111	0.899±0.067	0.880	0.830-1.116	0.33	0.955
	Control	20	0.893±0.065	0.885	0.841-1.145	0.889±0.069	0.884	0.785-1.137	−0.45	0.551
	*p***			0.902			0.691			
Femural neck	Vibration + infrared	18	0.772±0.088	0.763	0.644-0.995	0.787±0.080	0.764	0.683-0.956	1.94	0.538
	Infrared	15	0.749±0.077	0.742	0.671-0.904	0.768±0.087	0.737	0.662-0.921	2.54	0.182
	Control	20	0.756±0.096	0.737	0.652-1.021	0.770±0.094	0.775	0.625-1.021	1.85	0.173
	*p***			0.700			0.621			
Femural total	Vibration + infrared	18	0.835±0.082	0.830	0.695-1.015	0.844±0.078	0.829	0.725-1.005	1.08	0.811
	Infrared	15	0.820±0.060	0.826	0.738-0.914	0.821±0.063	0.818	0.717-0.928	0.12	0.851
	Control	20	0.838±0.094	0.840	0.706-1.049	0.846±0.088	0.827	0.717-1.049	0.95	0.345
	*p***			0.857			0.668			

BMD: Bone mineral density; SD: Standard deviation; Percentage of change=(After Treatment−Pre-treatment)/Pre-treatment×100; * Wilcoxon Signed-Ranks test; ** Kruskal–Walli's test (α=0.05).

TABLE 3
Distribution of osteocalcin, hydroxyproline values and BBT scores at baseline and after treatment between study groups and within each study group

			Before treatment			After treatment			
		n	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	*p**
Osteocalcin (ng/mL)	Vibration + infrared	18	23.64±9.90	22.2	9.8-53.8	24.40±12.01	22.5	8.4-61.6	0.602
	Infrared	15	24.33±7.10	23.3	13.9-42.6	27.62±10.74	23.6	16.4-57.2	0.084
	Control	20	21.79±5.83	22.1	11.5-32.5	23.31±6.87	23.4	11.6-36.9	0.266
	*p***			0.624			0.506		
Hydroxyproline/creatinine (mmol/mol) creatinine	Vibration + infrared	18	45.25±12.66	44.72	25.89-67.72	43.82±13.45	41.74	18.35-71.51	0.795
	Infrared	15	37.31±7.73	37.05	25.11-51.84	41.76±17.28	39.13	16.35-89.29	0.570
	Control	20	41.47±13.15	37.82	19.89-65.31	38.93±11.21	37.21	20.00-66.25	0.446
	*p***			0.187			0.251		
Berg Balance test	Vibration + infrared	18	51.06±2.86	52	44-55	52.72±4.09	54	41-56	**0.020**
	Infrared	15	52.80±1.97‡	53	48-55	54.00±2.17 c	55	50-56	**0.017**
	Control	20	48.80±5.44	50.5	36-56	50.55±4.36	52	42-56	**0.005**
	*p***			**0.018**			**0.021**		

BBT: Berg Balance test; SD: Standard deviation; ‡ Significant difference with "control" group was detected as a result of post-hoc comparisons; * Wilcoxon Signed-Ranks test; ** Kruskal-Walli's test (α=0.05).

TABLE 4
Distribution of Short Form-36 summary test and VAS scores at baseline and after treatment between study groups and within each study group

SF-36		n	Before treatment			After treatment			Change percentage	
			Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	%	p^*
Physical health	Vibration + infrared	18	53.54±27.75	42.5	15.63-95.00	57.84±22.72	60.94	18.75-93.75	8.0	0.449
	Infrared	15	65.50±20.62	67.5	25.63-98.75	56.08±23.99	49.37	18.13-97.50	–14.4	0.132
	Control	20	53.00±23.68	51.25	11.25-96.25	48.91±24.06	47.19	9.38-87.50	–7.7	0.125
	p^{**}			0.274			0.458			
Mental health	Vibration + infrared	18	47.14±13.57	48.6	12.38-67.54	49.81±13.88	51	13.38-74.42	5.7	0.177
	Infrared	15	56.24±15.98	57.71	25.08-82.50	51.95±14.37	49.13	22.71-77.67	–7.6	0.280
	Control	20	51.49±16.72	51	24.38-83.17	51.29±17.36	45.19	25.88-83.17	–0.4	0.554
	p^{**}			0.269			0.900			
VAS	Vibration + infrared	18	5.94±3.09	6	0-10	4.61±3.24	5	0-10	–22.4	0.077
	Infrared	15	4.67±2.84	5	0-10	3.87±2.97	5	0-7	–17.1	0.347
	Control	20	5.95±2.48	5	2-10	5.35±2.74	5	0-10	–10.1	0.245
	p^{**}			0.370			0.656			

VAS: Visual Analog Scale; SD: Standard deviation; Physical health: Physical Function, Physical Action Difficulty, Physical Pain, General Health State; Mental health: Vitality, Social Function, Emotional Role-Difficulty, Mental Well-Being; Percentage of change=(After Treatment−Pre-treatment)/Pre-treatment×100); * Wilcoxon Signed Ranks test; ** Kruskal-Wallis test (α=0.05).

patient in the group receiving WBV + infrared therapy developed vertigo. The patient continued the study after completing vertigo treatment. The other seven patients (two from the vibration + infrared group and five from the infrared group) who could not continue the study were excluded, and the statistical analysis was conducted with the remaining 53 patients (mean age: 56.9±5.1 years; range, 45 to 65 years). When the groups were compared in terms of demographic and clinical characteristics, the patients in the control group were older than the patients receiving infrared therapy (p=0.007). There was no statistically significant difference between the groups in terms of other parameters (p>0.005, Table 1). In addition, there was no difference between the groups in terms of dietary calcium intake, chronic disease status, previous osteoporosis treatment, and the history of osteoporosis in the family.

Before the intervention, there was no difference between the groups in terms of lumbar and femur BMD, OC, and hydroxyproline levels (p>0.05). There was no statistically significant difference in terms of L2-L4 vertebrae, femoral neck, and total femur BMD, OC, and hydroxyproline values in all three groups after treatment compared to the baseline (p>0.05; Tables 2, 3).

There was a difference between the groups in terms of BBT at baseline (p=0.018) and after treatment (p=0.021). It was observed that the difference was only between those who received infrared therapy and those who did not. A statistically significant difference was found in BBT values after the treatment compared to the baseline in all three groups (p<0.05, Table 3).

There was no difference between the groups in terms of SF-36 physical and mental health at baseline. After the treatment, there was no statistically significant difference in terms of both physical and mental health in all three groups compared to the baseline (p>0.05, Table 4).

When back pain was evaluated in the patients, no difference was found between the groups at the baseline. There was no statistically significant difference in VAS scores after the treatment in all three groups compared to the baseline (p>0.05, Table 4).

DISCUSSION

In this study, 30 to 60 Hz WBV therapy with 2 to 4 m/sec^2 magnitude was applied in horizontal position for 20 min two days a week for three months

to postmenopausal women with osteoporosis. No statistically significant difference was found in BMD, bone turnover markers, pain, and QoL of the patients in all three groups after treatment compared to the baseline. The BBT results showed a statistically significant increase after treatment in all three groups.

Since WBV treatment is considered relatively safe, its application does not depend on great motivation, and has few side effects, it can be used as an adjunctive therapy in BMD loss, particularly in patients with limitations in applying intense physical exercise.[2,8]

In the literature, study lengths vary between six months and 18 months, and the frequency of sessions varies between one to seven times a week.[2] There are studies showing that WBV therapy is effective on the lumbar vertebra,[2,16] on the hips,[5] and in both areas.[3,17] It has been stated that WBV treatment has the potential to contribute to an increase in BMD, particularly in the lumbar spine, which has been shown to be an area of osteogenesis in postmenopausal women. The developments in the femoral area, on the other hand, appear to be dependent on many factors, such as frequency, magnitude, and position.[2,18] In our study, we did not find that vibration therapy at 30 to 60 Hz and 2 to 4 m/sec^2 magnitude (high frequency, low amplitude) was effective on BMD. Similar to our study, there are studies in which vertical vibration therapy was applied for eight months or more, which had no effect on both the lumbar spine and hips.[1,6,19,20] Treatment frequencies vary between two to seven times a week. All were applied at high frequency and two at high magnitude.[6,19,20] While anabolic effects on bone were observed in animal studies at high frequency and low amplitude, this differs in clinical studies. Low-magnitude studies have not found any effect on BMD in postmenopausal women. In addition to the treatments showing that high-magnitude vibration therapy is effective, there are also studies showing that the BMD response is independent of the dose. The optimal vibration magnitude and frequency values in humans are still not clear.[3] In the study by Ruan et al.,[17] a significant increase was observed in the lumbar BMD values in the third and sixth months, while the femoral neck values only showed a significant improvement in the sixth month. This can be explained by the literature asserting that a significant response in BMD may be in the sixth month or in the longer run.[2,4]

In the light of this information, we can attribute the seemingly unsatisfactory results of our treatment to the short duration of the treatment and the horizontal application of vibration. However, looking at it from a different perspective, we did not view the results as insufficient, and as Verschueren et al.[5] stated, although bone morphology and structure were strengthened, no change could be detected with BMD measurements. There is a need for more comprehensive studies in which the optimum treatment parameters (frequency, magnitude, and session frequency) can be determined.

Bone remodeling continues in a certain balance with the simultaneous continuation of bone destruction and production processes.[21] With the onset of bone loss in the postmenopausal period, the existing balance in the bone turnover is disrupted.[22] The effects of medical treatment on bone turnover markers reflecting bone turnover have been comprehensively defined, and it has been stated that they can be used to monitor clinical efficacy and support patient compliance. In our results, we did not detect a significant difference after treatment in all three groups in bone turnover markers. Ruan et al.[17] applied WBV treatment once a week and three times a week for two months in postmenopausal women. While they found a decrease in N-terminal telopeptide fragment of type 1 (NTX) levels in the group that they applied three times a week in the two-month WBV treatment, they did not find a significant difference in the other group, and the bone formation marker bone-specific alkaline phosphatase (BALP) did not change in both groups.[23] Corrie et al.[24] found that WBV treatment, which they applied on older people three times a week for three months, was effective on bone formation. The frequency of sessions in the studies ranged from two to five.[3,5,7,19,20] We also planned our activity as two times a week due to transfer difficulty and device suitability. In addition, studies with postmenopausal and young women showed that WBV treatment applied for six months and eight months did not have a significant effect on bone turnover markers. Most of these studies did not include osteoporotic female patients, and some of them were performed on young healthy adults,[3,5,7,19,20] which may be the reason for the different bone turnover markers results. We believe that studies on the osteoporotic patient population with longer and more frequent sessions may be necessary to observe the changes in bone turnover markers.

It is known that osteoporosis adversely affects the QoL.[25] De Oliveira Ferreira et al.[26] found

that women with postmenopausal osteoporosis had deterioration in all aspects of their QoL and stated that their QoL was affected in physical, psychosocial, and social aspects. In a study conducted on women with postmenopausal osteoporosis with and without osteoporotic fracture, they found that osteoporosis causes deterioration in QoL due to chronic pain, decrease in physical functions, decrease in social activities, decrease in well-being, and depressive mood.[27] Therefore, increasing the QoL in patients with osteoporosis is of great importance. We aimed to use the infrared feature of the vibrating device (HHP-Andumedic 3 yellow edition, Karlsruhe, Germany) in our study, considering that it may have a significant effect on QoL which is an indirect indicator of pain. When the QoL was examined in our results, a significant difference was not found in all three groups. Since we did not include patients with fractures in the present study, the initial QoL scores of our patients were not very poor; thus, no significant change could be detected in the QoL scores.

In our study, no significant difference was found in all three groups in terms of VAS values. In other studies, WBV treatment was found to be effective on QoL[3,28-30] and back pain.[17] In the study of Furness and Maschette, they applied WBV treatment to four groups: once a week, twice a week, three days a week, and no treatment. They found a significant effect on the QoL in the group treated three days a week.[30] Perhaps there may be a chance of increased efficacy in more frequently applied WBV treatments. In our study, we attribute the unresponsiveness in VAS and SF-36 parameters to the low frequency of sessions and the shortness of their duration.

Whole-body vibration is a biophysical modality that increases BMD, bone strength, and proprioception, as well as provides strength and balance by stimulating muscle spindles and biogenic neurotransmitters. Therefore, it is reasonable to assume that WBV can improve balance by increasing muscle performance.[31] Whole-body vibration therapy may be a viable therapeutic approach to reduce the risk of falls among older adults by improving muscle strength, balance ability, and mobility.[32] In a WBV study in which balance was evaluated with BBT, a significant increase in balance was observed in both the WBV and exercise group and the exercise only group, and this increase was found to be significantly higher in the WBV and exercise group.[31] Its effect on the timed up and go test was found to be significant.[3,28-30,32] However, Torvinen et al.[19] did not find any effect of WBV treatment on balance. Furthermore, in a systemic review and meta-analysis by Orr,[33] no effect of WBV treatment on functional balance, including BBT, was found. When we evaluated the BBT scores in our study, there was heterogeneity between our groups at baseline and after treatment due to the infrared treatment and control groups. The mean BBT scores of our control group were significantly lower than those of the infrared group. We can attribute this to the fact that the patients in the control group were older. The BBT scores of each group increased significantly after the treatment, and the groups were not superior to each other in terms of increased BBT values. We can associate this well-being with the calcium and vitamin D treatment that they were taking since the increase in vitamin D values at the end of the treatment in each group was statistically significant in all groups. It has been found that calcium and vitamin D supplementation in postmenopausal women increases BMD and reduces the risk of falls and fractures in the elderly.[34]

This study had several limitations that should be considered when interpreting the results. First, the number of patients in the study group was low. We did not have sufficient time to get better results both in terms of BMD, QoL, and bone turnover markers. The frequency of sessions appears to be insufficient to elucidate the QoL. We did not perform vertebral radiography at the end of the treatment to determine whether there was a possible vertebral fracture, but no significant side effects, fracture due to falls, or newly developed vertebral pain were observed throughout the study. Another limitation of our study was that the mean age of the control group was higher than the other groups. This is an unpredictable result of randomization, which should be taken into account in future studies. In addition, our study continued with supervision, which is a factor that positively affects the effectiveness of treatment.

In conclusion, WBV treatment in horizontal position applied for two days a week for 20 min for three months at 30 to 60 Hz and 2 to 4 m/sec^2 magnitude under supervision in postmenopausal women was not found to be effective on BMD, bone structure, QoL, pain, and balance. There is a need for studies in which effective vibration protocols with longer duration and higher frequency of sessions are utilized.

Ethics Committee Approval: The study protocol was approved by the Şişli Hamidiye Etfal Training and Research Hospital Ethics Committee (date: 28.04.2015, no: 952). The trial was registered at ClinicalTrials.gov (NCT05182281 Date: 01.06.2022). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Research, data collection, methodology, resources: F.A.B.; Design, supervision, analysis, critical review: F.Y.; Supervision, analysis, critical review, design: J.Ö.A.; Supervision, critical review, resources: B.K., M.Ü.; Data collection, materials: H.E.

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