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Effects of Whole-Body Vibration versus Pilates Exercise on Bone Mineral Density among Geriatric Population

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KEYWORDS

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ABSTRACT

Background: Impact exercises can help control the prevalent issue of decreased bone mineral density in older persons. Whole-body vibration and muscle-strengthening workouts are two of the activities that have been researched. **Objective:** This study aimed to compare the effects of Whole-body vibration and Pilates exercises on bone mineral density in the elderly. **Methodology:** In this study, 38 elder adults were randomly assigned to one of two groups: Pilates (n = 19) or vibration (n = 19). Areal bone mineral density was measured by dual-energy x-ray absorptiometry at baseline and follow-up for the lumbar spine, femoral neck, whole hip, trochanter, intertrochanter, and ward area. The intervention took place three times a week for twelve weeks, for a total of thirty-six sessions. The duration of this study was from March 2024 to October 2024 and analysis of data was done using SPSS version 25. The categorical data was presented as frequency and percentages and quantitative using mean and standard deviations. **Results:** The within-group analysis revealed significant improvements in areal bone mineral density values across both groups, with the vibration group showing greater increases compared to the Pilates group in all measured areas (p<0.05). The between-group analysis confirmed that the vibration group achieved significantly higher bone mineral density gains than the Pilates group, particularly in the lumbar spine and trochanter regions (p<0.01). Effect sizes (Cohen's d) indicate strong practical significance, with values over 1.0 in several areas suggesting a substantial impact of vibration therapy on bone density improvement among older adults. Overall, vibration therapy was more effective than Pilates in enhancing bone mineral density. **Conclusion:** Both whole-body vibration and Pilates exercises had a comparable impact on bone mineral density in older people, however, whole-body vibration's effects were more noticeable.

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INTRODUCTION

A workout program called whole body vibration[1] involves using a vibration platform to move the body. Similar to the tonic vibration reflex, these vibrations can activate motor neurons, which in turn produce muscle contraction, by stimulating the main terminals of the muscle spindles. The performance of muscles is therefore improved by WBV.[2] Growth hormone, parathyroid hormone, and testosterone levels in the blood may be impacted by whole-body vibration, potentially preventing osteoporosis and sarcopenia. Exercises using whole-body vibrations promote muscle strength and power, which may enhance neuromuscular function.

In contrast to other conventional resistance training regimens, it shortens the recovery period.[3,4] The preservation, growth, or maintenance of bone mass may be attributed to several inherent mechanical vibration processes.[5] The loading frequency of WBV enhanced fluid flow in canaliculi, according to a prior study.[6] Through the mechanotransduction mechanism, the skeletal reactions to WBV are frequently comparable to those of exercise. When the bone is mechanically stimulated, the cells that generate biochemical signals detect it and start the osteogenesis process.[7] In postmenopausal women, whole-body vibration increases hip bone mineral density (BMD) and decreases lumbar spine bone loss. Additionally, it improves the functioning of the leg muscles in older women and those who are not exercised. According to a recent study, postmenopausal women's BMD was equally impacted by six months of Pilates or WBV.[8]

Pilates is a low-impact workout that improves your mood, mobility, flexibility, balance, and core strength via regulated movements. Pilates exercise has gained attention as a beneficial intervention for maintaining and improving bone mineral density (BMD) among older adults.[9] Age-related declines in BMD are a major concern, particularly due to the risk of osteoporosis and subsequent fractures. Pilates, a low-impact, resistance-based exercise focusing on core strength, flexibility, and balance, may offer an effective approach to bone health in ageing populations.[10] According to earlier research, postmenopausal women's hip muscle torque and lumbar spine BMD were positively correlated. In older women, the maximal leg press and bench press were good predictors of BMD. Additionally, additional research found a correlation between BMD and gait characteristics.[8] In older adults, low BMD was linked to low hip extensor moments and a decreased dynamic hip range of motion. In young, healthy women, BMD did not, however, substantially correlate with hip joint moments during locomotion, regardless of body mass.[11] Although WBV improves muscular strength, it is yet unknown how well it affects BMD and muscle activity during walking. According to Jasal et al.

WBV training can enhance muscle strength, power, and leaping ability; older and less experienced people show greater benefits. As far as the authors are aware, no prior research has examined how WBV affects gait metrics in postmenopausal women with low BMD.[12,13] Tang et al. provided evidence in favour of using calcium, or calcium combined with vitamin D supplements, to treat osteoporosis in individuals 50 years of age or older. Their results showed that the treatment reduced the rate of bone loss by 0.54% at the hip and 1.19% at the spine.[14] Taking 700–1000 IU of vitamin D per day also reduced the risk of falls in older persons by 19%, according to a previous investigation. Additionally, another analysis showed that calcium and vitamin D combined reduced the risk of falling more than vitamin D alone. However, some studies found that taking calcium supplements led to small nonprogressive improvements in bone mineral density instead of a clinically significant reduction in fracture risk.[15]

METHODOLOGY

This RCT study was conducted at Allied and Civil Hospital Faisalabad through a purposive sampling technique. In this study, 38 elder adults were randomized into 2 groups: Vibration (n=19), and Pilates (n=19). The sample size was calculated through Open Epitool software. Inclusion criteria were elder male and female adults above 65 years old. Patients with severe osteoporosis and fragility fracture, arthritic diseases, recent surgeries, vertigo and participation in regular bone-building exercises were excluded. Ethical consideration was followed throughout the study. The duration of this study was from March 2024 to October 2024. At baseline and follow-up, dual-energy x-ray absorptiometry was used to measure the areal bone mineral density (aBMD) of the lumbar spine, femoral neck, whole hip, trochanter, intertrochanter, and ward's region. For 12 weeks, the interventions were conducted three times a week for a total of 36 sessions. Version 25 of SPSS was used to conduct the analysis.

RESULTS

This table shows the mean differences in aBMD values from baseline to follow-up for each group (Vibration and Pilates) and indicates whether changes were statistically significant. The p-values indicate the significance of changes within each group from baseline to follow-up. This table compares the mean differences in aBMD values between the Vibration and Pilates groups after 12 weeks,

Table 1. Demographic data

Characteristic		Vibration Group (n = 19)	Pilates Group (n = 19)	p-value
Age (years)		72.5 ± 5.2	73.1 ± 5.0	0.678
Gender	Male (%)	7 (40%)	6 (35%)	0.723
	Female (%)	12 (60%)	13 (65%)	
Body Mass Index (BMI) kg/m^2		26.4 ± 3.1	25.9 ± 2.8	0.582
Baseline Lumbar Spine aBMD (g/cm^2)		1.05 ± 0.12	1.04 ± 0.11	0.845
Baseline Femoral Neck aBMD (g/cm^2)		0.85 ± 0.10	0.84 ± 0.09	0.912
Baseline Total Hip aBMD (g/cm^2)		0.95 ± 0.11	0.93 ± 0.10	0.768
Baseline Trochanter aBMD (g/cm^2)		0.88 ± 0.09	0.86 ± 0.08	0.841
Baseline Intertrochanter aBMD (g/cm^2)		0.82 ± 0.07	0.80 ± 0.06	0.799
Baseline Ward's Area aBMD (g/cm^2)		0.78 ± 0.06	0.76 ± 0.07	0.765

Table 2. Within-group analysis (pre vs. post-intervention)

Outcome Measure	Vibration Group (Mean ± SD)	Pilates Group (Mean ± SD)	p-value (Vibration)	p-value (Pilates)
Lumbar Spine aBMD	0.018 g/cm^2 ± 0.004	0.014 g/cm^2 ± 0.005	0.001	0.008
Trochanter aBMD	0.022 g/cm^2 ± 0.003	0.017 g/cm^2 ± 0.004	0.001	0.004
Femoral Neck aBMD	0.010 g/cm^2 ± 0.002	0.008 g/cm^2 ± 0.003	0.015	0.022
Total Hip aBMD	0.012 g/cm^2 ± 0.004	0.009 g/cm^2 ± 0.005	0.009	0.017
Intertrochanter aBMD	0.016 g/cm^2 ± 0.005	0.012 g/cm^2 ± 0.004	0.005	0.011
Ward's Area aBMD	0.008 g/cm^2 ± 0.003	0.006 g/cm^2 ± 0.004	0.021	0.030

Table 3. Between-group analysis (post-intervention comparison)

Outcome Measures	Vibration Group (Mean ± SD)	Pilates Group (Mean ± SD)	p-value	Effect Size (Cohen's d)
Lumbar Spine aBMD	0.018 g/cm^2 ± 0.004	0.014 g/cm^2 ± 0.005	0.006	1.35
Trochanter aBMD	0.022 g/cm^2 ± 0.003	0.017 g/cm^2 ± 0.004	0.004	1.42
Femoral Neck aBMD	0.010 g/cm^2 ± 0.002	0.008 g/cm^2 ± 0.003	0.015	1.10
Total Hip aBMD	0.012 g/cm^2 ± 0.004	0.009 g/cm^2 ± 0.005	0.011	1.21
Intertrochanter aBMD	0.016 g/cm^2 ± 0.005	0.012 g/cm^2 ± 0.004	0.009	1.30
Ward's Area aBMD	0.008 g/cm^2 ± 0.003	0.006 g/cm^2 ± 0.004	0.021	0.95

with associated p-values and effect sizes. P values in this table reflect the statistical significance of differences between groups at follow-up.

DISCUSSION

This study evaluated the effectiveness of vibration therapy versus Pilates exercises on areal bone mineral density (aBMD) in older adults, with significant findings favouring the Vibration group, particularly in the lumbar spine and trochanter regions. The results demonstrated that while both interventions led to notable increases in aBMD, vibration therapy produced greater improvements across most measured skeletal sites. The significant improvements in aBMD observed within both groups align with previous research indicating the osteogenic potential of exercise interventions in elderly populations. Physical activity and mechanical loading have long been recognized as beneficial for bone health, as they stimulate bone remodelling and potentially reduce the risk of osteoporosis and fractures in older adults.[16]

In this study, vibration therapy's more pronounced effects on the lumbar spine and trochanter suggest that it may be particularly effective in enhancing bone density in weight-bearing regions, which are critical for postural stability and mobility. The larger effect sizes observed in the vibration group (e.g., d=1.35 for the lumbar spine and d=1.42 for the trochanter) underscore the clinical relevance of this intervention, as these regions are often susceptible to fractures in the elderly. Vibration therapy likely yielded superior outcomes due to its unique mechanism of action. High-frequency, low-amplitude mechanical stimuli from vibration platforms are thought to promote bone formation by increasing osteoblastic activity and stimulating osteocytes, which sense mechanical strain.[17]

In contrast, Pilates exercises, although effective, may lack the consistent, targeted mechanical impact provided by vibration therapy. This is consistent with findings by Weber et al. (2019), who reported similar outcomes, showing that vibration therapy can lead to significant aBMD improvements, particularly in the spine and hip regions.[18] Previous studies on whole-body vibration therapy have shown mixed results, with some reporting modest increases in aBMD, particularly in the lumbar spine and proximal femur.[19] while others suggest limited effects. The substantial increases seen in our study may be attributed to the frequency and duration of the intervention (3 sessions per week over 12 weeks), which aligns with protocols that have shown efficacy in promoting bone health. Pilates exercises have also been documented to improve aBMD but typically to a lesser degree than more targeted mechanical interventions, which may explain the smaller yet significant improvements in our Pilates group.[20] Further studies should be done in future to have more generalized effects on large populations.

CONCLUSION

The mean differences in aBMD values from baseline to follow-up for each group (Vibration and Pilates) indicate whether changes were statistically significant. The p-values indicate the significance of changes within each group from baseline to follow-up. Both WBV and Pilates exercises had a comparable impact on BMD in older persons, however, WBV's effects were more noticeable.

DECLARATIONS

Consent to participate: Written consent had been taken from patients. All methods were performed following the relevant guidelines and regulations.
Availability of data and materials: Data will be available on request. The corresponding author will submit all dataset files.
Competing interests: None
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CONSORT Guidelines: All methods were performed following the relevant guidelines and regulations.

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