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High versus Low-Intensity Resistance Training on Bone Mineral Density and Content Acquisition by Postmenopausal Women with Osteopenia: A Randomized Controlled Trial

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Abstract

Background: The menopause stage in women reduces estrogen levels and bone indicators. This study compared the effects of high-intensity resistance training (HIRT) and low-intensity resistance training (LIRT) on bone mineral density (BMD) and bone mineral content (BMC), T-score, and Z-score in postmenopausal women with osteopenia.

Methods: A randomized controlled trial was conducted among 45 postmenopausal women, aged 50 to 60, who were randomly assigned into 3 parallel groups (n = 15 in each). The exercise program was performed by the interventional groups—the HIRT and LIRT groups—at 4 different intensities, 3 times a week for 24 weeks: 8 repetitions at 80% of 1 repetition maximum and 16 repetitions at 40% of 1 repetition maximum. The evaluated areas (BMD, BMC, T-score, and Z-score) included the lumbar spine (LS) and the femur neck (FN) using a DEXA machine. One-way analysis of covariance and Bonferroni's post hoc tests were used for data analysis.

Results: The results indicated significant differences in BMD, BMC, T-scores, and Z-scores between the means of the LS and the FN in all groups. In addition, significant differences were revealed in the BMC of the LS, the BMD, T-scores ($P < 0.001$), Z-scores ($P = 0.001$), and in the BMC of the FN ($P < 0.001$), the BMD ($P = 0.001$), T-scores, and Z-scores ($P < 0.001$), respectively. In addition, the HIRT group's bone indices were considerably greater than those of the LIRT group ($P < 0.00$). Nonetheless, LIRT was significantly greater than that of the control group ($P > 0.00$).

Conclusion: According to the current findings, HIRT seems to be the most effective training program compared with LIRT for bone indicators improvement in the femur neck and the lumbar spine among postmenopausal women with osteopenia.

Keywords: Bone Mineral Content, Bone Mineral Density, Bone Rehabilitation, Osteoporosis, Postmenopausal

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Introduction

Bony conditions in osteopenia among healthy adults are defined as a standard deviation of a T-score greater than −2.5 and lower than −1.0 and bone mineral density (BMD) between 1 and 2.5 (1). Lower values than the average in the femur neck (FN), the lumbar spine (LS), and the radius of the forearm can be considered a risk factor for osteoporosis (2, 3). Osteoporosis is a significant health problem worldwide that affects patients' health physically, mentally, and emotionally (4). According to epidemiological studies, 8.9 million fractures occur due to osteoporo-

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↑What is "already known" in this topic:
Physical exercise can effectively stimulate osteopenia and prevent osteoporosis. However, effective intensity and amount of physical activity are unclear for bone acquisition in menopausal women.

→What this article adds:
Improving bone density in 6 months with high-intensity resistance training improves bone indicators. However, low-intensity resistance training can stabilize bone density for women with physical limitations such as osteoarthritis.

sis during a year globally, which is about 1000 fractures per hour (5). The disease is prevalent in both sexes; however, it is more common in women because estrogen levels decrease after menopause (6). A previous study reported that women and men over 50 years suffer from bone loss fractures of about 50% and 20%, respectively (7). Pharmacological and nonpharmacological options are applied to prevent and treat osteoporosis. Nowadays, pharmacological treatment is known as the first line of treatment, and the use of drugs such as bisphosphonates, to some extent, has increased BMD and bone mineral content (BMC) (8).

Considering the side effects of such treatment, exercises have been recommended to increase BMD by stretching muscles through contractions and shocks (gravity), which might transfer the force to the bone. Although the gravitational force might play a more significant role in BMD, according to Wolff's law, it could also be concluded that the bone adapts to the pressure exerted on it, which results in its improvement (9). Increasing bone density through exercise is the secretion of estrogen, which can partially compensate for the hormone deficiency after menopause (10). Exercise intensity plays a vital role in effective exercise prescription for bone; however, the definition of intensity is not straightforward but is mainly effective for improving BMD and BMC (11).

While most previous research was designed as cross-sectional, focusing mainly on BMD, this study was conducted as a randomized controlled trial concerning a 24-week follow-up to find the effects of 2 types of resisting training on bone indicators among postmenopausal women with osteopenia (12). According to recent research, resistance exercise has been reported to have the optimal pressure required to improve bone indices. Such pressure is necessary to be increased gradually to gain the progressive condition. In addition, by expediting the secretion of estrogen hormone, exercise can moderately compensate for the hormone deficiency after menopause. Based on previous research findings, the load on the bone is more important than the exercise duration; therefore, very low-intensity exercise programs (such as walking) displayed no improvement in osteoporosis prevention. However, resistance training causes osteogenic stimulation and reaction of the bone in terms of load resistance, which is recognized as one of the most effective bone health issues for hypertrophy and muscle strength (13, 14).

Several studies reported that high-intensity resistance training (HIRT) >70%, 1-rep max (1RM) is more effective compared with low-intensity resistance training (LIRT) for optimal bone adaptation (15-17). Consequently, high-intensity exercise may have a positive effect on bone formation; however, it may have harmful side effects for those with low BMD and physical function or chronic disorders such as osteoarthritis (18). Thus, LRIT may be the best option for this population.

Stuart et al stated that in HIRT, more equipment and accurate monitoring are required, which may be inappropriate for those with weaknesses and disabilities (19). On the other hand, Yalcabe et al reported that resistance training improves BMD and hypertrophy without using high weights (20). Comparable effects of HIRT (1RM, >70%) and LIRT (regarding 1RM<70%) on increasing bone density in the FN and LS were investigated by Souza et al. The intensity threshold for the best adaptation to BMD began at 40% of a maximum repetition (21). The optimal intensity and amount of the exercises are unknown for bone acquisition among menopausal women. It is expected that the 2 training methods used in this study over 24 weeks will efficiently induce osteopenia, which will be beneficial for preventing osteoporosis and stabilizing bone density in women with physical restrictions.

Given the benefits of exercise for BMD and BMC, a practical training program with minimal expense and risk is necessary to identify an effective, secure, and attractive resistance-training paradigm for women with osteopenia. Appropriate approaches are essential to decrease the damage and fragility and increase the functional capacity to achieve the desired osteopenia level. In light of this, the present study assessed the effects on BMD and BMC, T-score, and Z-score in postmenopausal women with osteopenia of a 24-week high-intensity—low repetition and a low-intensity—high repetition resistance training routine 3 times a week.

Methods

Study Design and Participants

A total of 45 postmenopausal women with osteopenia, ages 50 to 60 years, were recruited from 59 volunteers and were assigned to 3 groups for a parallel-group randomized control study. Two interventional groups— including the HIRT and LIRT groups—implemented the exercise program 3 times a week for 24 weeks concerning 80% 1RM, low repetition, and 40% 1 RM, high repetition, respectively, at the Red Crescent Physical Rehabilitation Center, training department, Tehran, Iran (22). The control group continued their daily activities. The participants exposed to osteopenia were eligible with a T-score between −1 and −2.5.

The inclusion criteria contained no regular exercise, hormone therapy, and a history of any fractures or surgery on the lower limbs and spine during the last 6 months or taking medications that affect BMD (eg, bisphosphonates) in the study period (23). The participant was excluded if they missed the follow-up or were missing from 3 consecutive training sessions or if they suffered a bone fracture or other lower extremity injury during the study (23). The participants were allowed to leave at any stage of the study process. The Ethics Research Committee at Shahid Beheshti University (SBU), Tehran, Iran (IR.SBU.REC.1399.037 dated 2020/06/20) and the Iran Clinical Trial Registration Center (IRCT20200829048554N1 dated 2020/10/04) approved the trial. The patients were referred for musculoskeletal illnesses from Iran University of Medical Sciences and the Red Crescent Physical Rehabilitation Center. At the baseline and after the 24-week follow-up, demographic data, including age, height, body mass index, and monopolizing age, were completed. The study outcomes were measured using Dual-energy X-ray absorptiometry (DXA). These outcomes included BMD as the primary and BMC, the T-

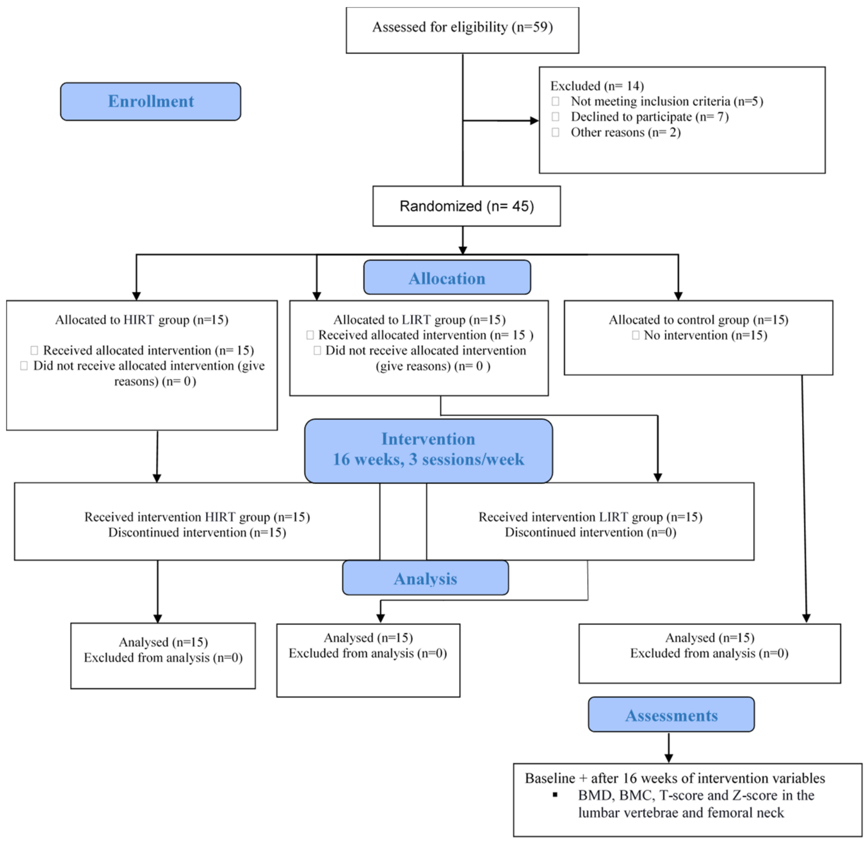

Figure 1. Study flowchart

score, and the Z-score in the LS and the FN as the secondary outcomes, respectively. Before the study commencement, all participants signed written informed consent according to the format of the Ethics Research Committee at SBU. The lead researcher coordinated and implemented the abovementioned affairs. The study flowchart is displayed in Figure 1 based on the Consolidated Standards of Reporting Trials (CONSORT) guidelines for standard reporting and procedure transparency (24).

Assessments and Outcomes

All primary (BMD) and secondary outcomes (BMC, T-score, and Z-score) were completed by Hologic QDR 4500 elite USA, Dual Energy X-Ray Absorptiometry as a gold standard for measuring bone density, a DXA bone densitometer for the LS (L1-L4) and the FN at the baseline and after 24 weeks of intervention (25). A radiography specialist took the scans for the LS in the straight position when the patient's back was entirely in contact with the scanning bed, along with a cube under the knee and palms facing down. The body was positioned completely straight for scanning the FN with straight hands and legs (26, 27). To ensure the test reliability, the patients were instructed to be unmoved upon the scanning procedure; otherwise, the scan was repeated. After that, the results were provided to the patient in color print.

Randomization

The leading researcher enrolled and generated the random allocation sequence using the computer-generated block randomization retrievable (https://www.sealedenvelope.com) with a 1 to 1 to 1 random block size of 3 (28). Participants were randomly assigned through concealed, sequentially numbered, sealed, and opaque envelopes and put a card inside them indicating the allocated group (HIRT, LIRT, and control groups), respectively. The participants were fully blinded to interventions after the assignment, as no patient was aware of the assigned intervention. To ensure the unpredictability of the assignment schedule, a university assistant professor supervised all procedures.

Intervention

A 24-week training program based on the Frequency, Intensity, Time, and Type (FIIT) principle was conducted in both interventional groups considering 1RM per person. Thus, frequency, intensity, duration, and type of exercises progressed during 24 weeks, gradually considering patients' characteristics and their process of acquiring functional ability. Both interventional groups implemented their training program 3 times a week in 3 sets. The HIRT group started the program at 70% in the first 4 weeks in a low repetition (8 reps) and reached 85% 1RM. The LIRT group implemented 40% 1RM at the beginning of the program with a high repetition (16 reps) of 40% and reached 60% 1RM (Figure 2). Meanwhile, the duration of exercise performance lasted from 20 to 60 minutes. A 20-second break between each set and 7 to 10 minutes. Warm-up and cool-down exercises were considered before and after each session, respectively (22, 29). To fulfill the single

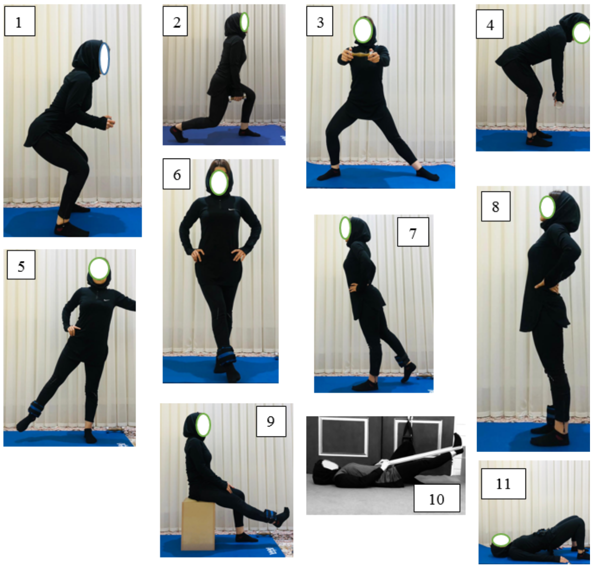

Figure 2. The exercise program

blinding procedure, the interventional groups were unaware of the details of their exercise program as each participant was trained at different times on odd and even days individually; thus, they could not distinguish the type of training (high or low intensity). The leading researcher thoroughly supervised the program implementation in the given period. In addition, all participants in the 3 groups were advised to follow their previous diet during the study, while the control group continued their routine life without exercise.

1. Squat. Standing position in a split stance with foot approximately 2 to 3 feet, lowering the hips and then standing back up. The core is engaged, and hands are in front of the chest.

*2. **Lunge.*** Standing in a split stance with approximately 2 to 3 feet in front of the other, with a straight trunk, the shoulders are back and down, the abs, and the hands resting on the hips. Bending the knees and lowering the body until the back knee is a few inches from the floor. Body weight is evenly distributed between both legs. Push back up to the starting position, and keep the weight on the heel of the front foot. Repeat on the other side.

3. Side Lunge. Standing position with the feet hip-width apart. Hands in front of the chest. Widening step with one leg to the side of the body and bending the one side knee as stepping outward and keeping the hips back. Repeat on the other side.

4. Deadlift. Standing with the feet shoulder-width apart, grasping the dumbbell in hands just outside the legs and lifting the bar by driving the hips forward, keeping a flat back, and lowering the bar under control.

5. Thigh Abduction. Standing position, lifting the leg away from the body with the weight. Repeat on the other side.

6. Thigh Adduction. Standing position, lifting the leg with the weight slightly in front of the other leg across your body. Repeat on the other side.

7. Thigh Extension. Standing position, lift legs almost straight with the weight. Do not lock your knees. No arching the back. Repeat on the other side.

8. Spine Extension. Standing position, beginning to back the upper body slowly while keeping your pelvis flat and creating an arch in the lower back without discomfort.

9. Knee Extension. Sitting position with about a 90° angle between the thighs and lower legs. Moving the lower legs with the weight slowly upward until the knees are nearly straight. Then, slowly return to the starting position. Repeat on the other side**.**

10. Single-Leg Press. Stretch the band double while lying on your back. Then, take hold of the band with both hands and wrap it around one foot. Stretch the leg out to its maximum length. Return to the starting position gradually. Continue on the opposite side.

11. Bridge. The lying position is on the back with the hand's palms down and the arms at the sides. A 90-degree angle is formed by bending the knees and putting your feet flat on the floor, hip-width apart. Flex gluteus, tighten lower back and abs, and push hips upward. Hold the bridge by pressing your heels into the ground.

Sample Size

The sample size calculation (G*Power software, Version 3.0.10), with an estimated effect size = 0.67, α = 0.5, and 1-β = 0.85, revealed a number of 45 participants (30). Then, 15 extra percentages of the samples were added to compensate for the undue dropouts. Unfortunately, only 45 patients were eventually enrolled in the trial and randomly assigned into 3 groups (n = 15) due to the COVID-19 pandemic during the study.

Statistical Analysis

The IBM SPSS Version 20 for Windows (SPSS Inc) was used for the data analysis, and the Shapiro-Wilk test was applied to assess the normality of data distribution ($P \geq 0.05$). One-way analysis of covariance (ANCOVA) and paired t tests were used to determine the differences between and within the groups considering mean ± standard deviation and significance level set at $P \leq 0.05$ (31).

Results

The study outcomes were measured and analyzed for all assigned patients (n = 45). The demographic data of postmenopausal women with osteopenia were compared between groups (Table 1).

The results of ANCOVA indicated a significant difference between the means of the LS BMC, BMD, and T-scores ($P < 0.001$) plus Z-scores ($P = 0.001$). In addition, the findings demonstrated BMC ($P < 0.001$), BMD ($P = 0.001$), T-scores, and Z-scores ($P < 0.001$) for the FN (Table 2).

Figure 3 displays the results of comparing the means of all groups by using the post-hoc test (Bonferroni test). The BMC for the LS is significantly higher in the HIRT group than the LIRT and control groups, receptively ($P = 0.004$), ($P < 0.001$) (Figure 3 A). The amount of BMC for the FN in HIRT is significantly higher than in LIRT and control groups, receptively ($P = 0.006$; $P < 0.001$), while it is significantly higher in the LIRT group than in the control groups ($P < 0.001$, Figure 3 B). BMD for the LS is signif-

Table 1. Descriptive statistics of postmenopausal females with osteopenia (n=45)

Demographic	Unit/Category	Control (n=15)	LIRT (n=15)	HIRT (n=15)	*P*-value
Age[a]	yrs	53.1 (3.1)	53.2 (3.6)	54.3 (3.5)	0.557
Height[a]	cm	159.6 (4.1)	160.4 (4.1)	159.7 (5.5)	0.878
Weight[a]	kg	68.5 (7.1)	66.3 (3.9)	65.4 (7.1)	0.371
BMI[a]	Kg/m^2	26.9 (2.4)	25.8 (1.9)	25.6 (2)	0.211
Menopause Age[a]	yrs	47.8 (3.2)	48.3 (3.1)	48.3 (2.8)	0.857

Data were [a]Mean (standard deviation), LIRT: low-intensity resistance training, HIRT: high-intensity resistance training, **P*-value (One-way ANOVA) < 0.05.

Table 2. Between groups' differences (One-way ANCOVA)

Variable	Group	Mean ±SD	F	*P* value	ES	95% Confidence Interval	
						Lower Bound	Upper Bound
BMC lumbar	Control	42.54±1.18	44.37	< 0.001	0.684	40.146	44.935
spine	LIRT	52.62±1.17				50.253	54.988
(g)	HIRT	58.46±1.20				56.034	60.881
BMD lumbar	Control	0.78±0.03	22.62	< 0.001	0.525	0.717	0.834
vertebrae	LIRT	0.95±0.03				0.895	1.006
(g/Cm^2)	HIRT	1.06±0.03				0.999	1.112
T-score lumbar	Control	-1.98±0.22	22.15	< 0.001	0.519	-2.432	-1.536
spine	LIRT	-1.00±0.22				-1.447	-0.554
	HIRT	0.11±0.22				-0.340	0.555
Z-score lumbar	Control	-0.88±0.26	8.49	0.001	0.293	-1.419	-0.350
spine	LIRT	0.24±0.25				-0.272	0.760
	HIRT	0.62±0.25				0.114	1.119
BMC femur neck	Control	3.14±0.09	31.44	< 0.001	0.605	2.957	3.314
(g)	LIRT	3.72±0.09				3.547	3.899
	HIRT	4.13±0.09				3.956	4.313
BMD femur neck	Control	0.69±0.02	8.04	0.001	0.282	0.636	0.733
(g/Cm^2)	LIRT	0.75±0.02				0.697	0.793
	HIRT	0.82±0.02				0.773	0.869
T-score femur	Control	-1.68±0.16	29.45	< 0.001	0.590	-2.010	-1.344
neck	LIRT	-1.17±0.16				-1.501	-0.835
	HIRT	0.07±0.16				-0.268	0.399
Z-score femur	Control	-0.60±0.19	13.49	< 0.001	0.397	-0.984	-0.210
neck	LIRT	-0.12±0.19				-0.510	0.261
	HIRT	0.78±0.19				0.394	1.156

One-way ANCOVA: analysis of covariance, F: Fisher distribution, Statistical significance: P ≤ 0.05, ES: Partial Eta Squared, LIRT: low-intensity resistance training, HIRT: high-intensity resistance training.

icantly higher in the HIRT group than in the LIRT and control groups (*P* < 0.001), while it is significantly higher in the LIRT group than in the control group (*P* < 0.001, Figure 3 C). The BMD of the LIRT group for the FN is significantly higher than that in the control group (*P* = 0.001, Figure 3 D).

As displayed in Figure 4, the T-score for the LS in the HIRT group is significantly higher than that in the LIRT and control groups, respectively (*P* = 0.003), (*P* < 0.001), while is significantly higher in the LIRT than the control groups (*P* = 0.009, Figure 4 A). The T-score for the FN in HIRT is significantly higher than that in the LIRT and control groups (*P* < 0.001), while it is significantly higher in the LIRT than in the control groups (*P* < 0.001, Figure 4 B). The Z-score for the LS is significantly lower in the control group than in the LIRT and HIRT groups, respectively (*P* = 0.016), (*P* = 0.001, Figure 4 C). The Z-score for the FN is significantly higher in the HIRT than in the LIRT groups and control groups, respectively (*P* = 0.005, *P* < 0.001) (Figure 4 D).

Discussion

The present study indicated the positive effects of 24-week HIRT and LIRT exercises in study outcomes, including BMD, BMC, T-score, and Z-score of the LS and the FN areas in the interventional groups.

Considering the effect of resistance training, duration, and intensity of the program on the BMD due to the principle of joint overloading, using very heavy weights can increase the risk of bone cartilage damage since bone formation is a slow cycle. The reconstruction of this cycle is completed by entirely replacing bone loss with a new osteoid (32). Beck et al reported the apparent benefits of targeted therapeutic exercises for chronic diseases (33). Because of the widespread sedentary lifestyles that exist today, exercise is acknowledged as an inevitable and endlessly effective means of treating a wide range of disorders. On the other hand, certain conditions—like osteoporosis—respond well to low-risk exercises like walking. In contrast, others call for higher-risk programs that must be carried out under the supervision of a professional (33). However, weightbearing exercises, in particular, cause mechanical stress on the bones, and act as a stimulus for osteoblast activity whose increase can enhance bone density (11). A recent review study including 14 articles reported that weightbearing exercises and calcium plus vitamin D effectively increase BMD and reduce the risk of fractures in postmenopausal women (34). Aquino et al represented that a 12-month resistance training improved the BMD and T-score score of the FN and the LS. |It also reduces the risk of falls in postmenopausal women, in line with the present study (35). Conceição et al similarly stated that 16 weeks of resistance training increased the Z-score in upper and lower limbs, causing an improvement

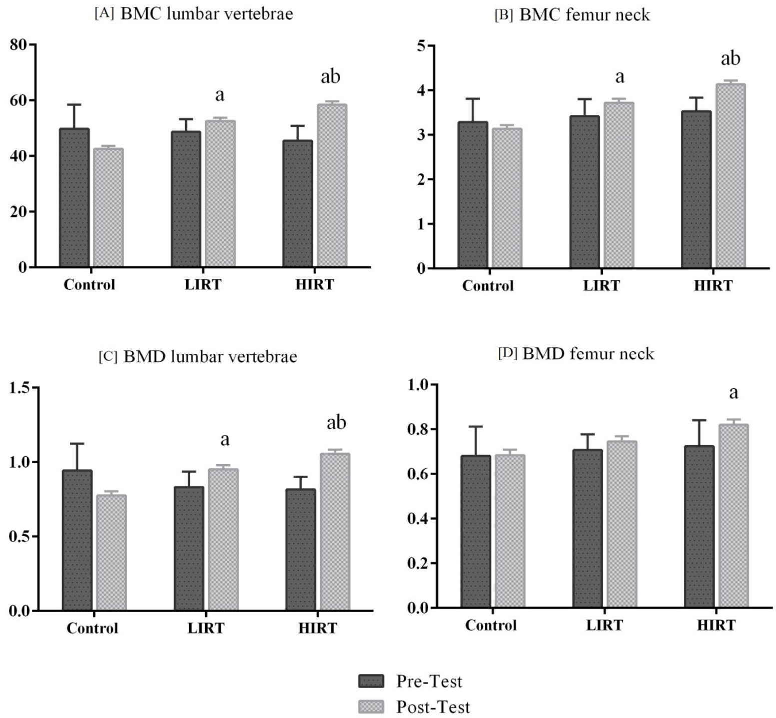

Figure 3. The results of the Bonferroni post-hoc test for BMC (Bone Mineral Content) lumbar vertebrae (A), femur neck (B), and BMD (Bone Mineral Density) lumbar vertebrae (C) and femur neck (D).
[a]$P \leq 0.05$ significant difference with the control group. [b]$P \leq 0.05$ significant difference with the LIRT group.

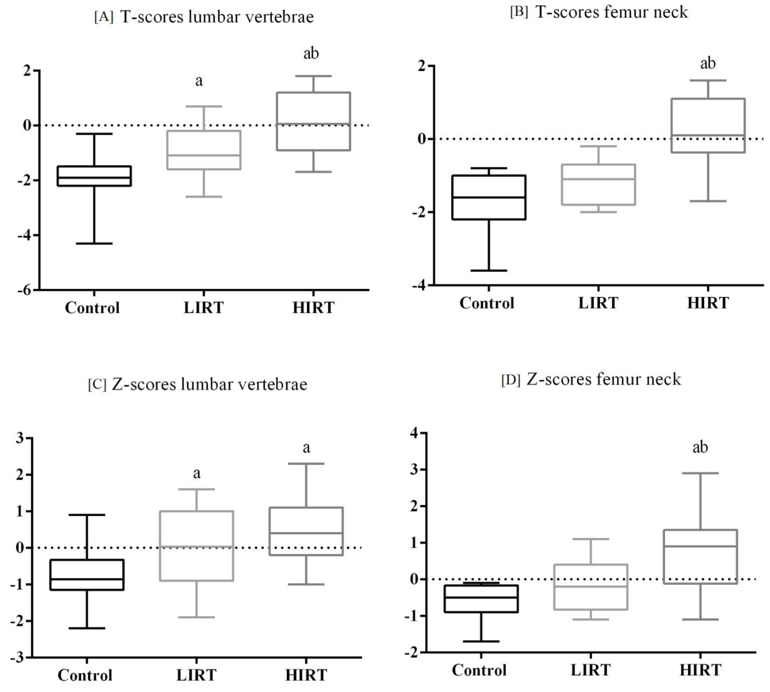

Figure 4. Bonferroni post-hoc test + Box plots (A, B, C, D).
Box plots of (A) Lumbar vertebrae T-scores, (B) Femur neck Z-scores, (C) Lumbar vertebrae T-scores, (D) Femur neck Z-scores,
[a]$P \leq 0.05$ significant difference with the control group. [b]$P \leq 0.05$ significant difference with the LIRT group.

in the health of postmenopausal women. Based on the literature, resistance training is the most effective type of exercise in bone health (12, 35, 36).

Resistance training, according to Ebid et al, regulates bone vessels through mechanical loading and angiogenic mediators, which are crucial for maintaining skeletal health by avoiding or postponing the loss of bone mass due to osteoporosis and the risk of falling (37). Then, the effects of resistance training on bone density depend on the duration of the program, the intensity, and the applied treatment.

Consistent with the current study, Cgalhoub et al found that the amount of bone mass in the FN, LS, and hip increased with exercise intensity (38). In addition, Kistler-Fischbacher et al reported that progressive resistance training is the best exercise prescription for improving BMD in postmenopausal women (39).

The present study findings are consistent with the experiment of Weston et al, indicating that an 8-month HIRT intensifies BMD and postmenopausal women's performance. In the meantime, it is evident that HIRT is remarkably an effective treatment option for osteoporosis management in postmenopausal women with low BMD. If the training is closely monitored, no fractures or harm can occur in the participants (40)

In the study of Hattchen et al, 1 group performed high-intensity exercises 3 times a week, and the other group implemented low-intensity exercises once a week for 13 months. BMD in the high-intensity group was maintained; however, it decreased significantly in the low-intensity group in the end. Contrary to our study, BMD improved in the HIRT group and remained stable in the LIRT group. The inconsistency was probably the presence of resistance in our exercises (36).

Based on the findings in the present study, 24 weeks of resistance training with an intensity of 70% to 85% 1RM implies that the applied type of training during such a period is probably an acceptable intensity, incurring sufficient mechanical stress to stimulate the improvement of bone indices in the anatomical parts, such as the FN and the LS (41). In addition, Frost et al reported that the mechanical load produced in the muscle increases the strength and density of bone minerals based on Wolff's Law (9). Furthermore, resistance training positively affects bone by applying mechanical pressure directly to the bone through muscle contractions and indirectly increasing the amount of obtainable muscle mass for loading (30). Accordingly, bone can be considered a dynamic tissue in which mechanical stimuli differences can change the processes of ossification and bone destruction by influencing its metabolism (42).

The mechanical loads applied to the bone create a slope in the lacunar-canalicular network filled with the necessary excitation threshold in the bony fluid. This phenomenon leads to a boost in intracellular calcium levels, the appearance of growth factors, the production of bone matrix, and eventually ossification (43). Based on a previous study, LIRT (1RM>70%) could significantly increase BMD after 27 weeks of training; nonetheless, the reported results were inconsistent with the present study. The possible reason may be due to the duration of the training compared with our study duration, which was 24 weeks (44). Furthermore, another finding among 29 women with osteoporosis was in line with the current study, indicating an increase in BMD in the experimental group compared with the control group. The exercise program was performed with the intensity of 50% to 70% of a maximum repetition twice a week for 6 months (32). Meanwhile, the consistent findings reported by Souza et al, underline similar effects of HIRT (1RM >70%) and LIRT (1RM<70%) on improving BMD in FN and LS areas. Then, repetition is recommended for the intensity threshold concerning optimal adaptation to BMD by 40% of a maximum (21). On the other hand, the present study's findings indicated that both types of resistance training improved bone indexes during 6 months; HIRT was more effective than LIRT. The differences in the previously reported results may be due to the duration, type, volume, intensity, and rest time in the exercise programs, as well as the age group and racial differences. However, according to Wolf's law, it could be concluded that bone adaptation and improvement occur with the pressure exerted on it. Consequently, compared with HIRT with LIRT, since more pressure and load are applied to the bone in HIRT, a greater effect can also be expected (45).

This study's findings specified that performing physical activities concerning the FIIT principle training can benefit postmenopausal women without arthritis and pain or osteoporosis in their daily living. In addition, future studies can be conducted on women of the same age and conditions with pain and osteoporosis to prescribe the appropriate exercise program implemented by these populations.

The main limitations of this study were the diet program, hormonal status, and the dose of vitamin D and calcium of the participants, who were out of the researcher's strict control. In addition, the level of their daily activity was not under control, considering their different lifestyles.

Conclusion

In conclusion, HIRT (85% 1RM) is considered the most effective training for the improvement of bone indices (BMD, BMC, T-scores, and Z-scores) in individuals without physical limitations, with more operative results in 24 weeks. Moreover, a 24-week LIRT (60% 1RM) could successfully counteract the loss of age-related bone indices in the FN and LS areas, particularly for those with osteoarthritis or joint pain or those with severe osteoporosis, limited from HIRT, and weak bones which may not be able to withstand HIRT. However, in both intervention groups, significant changes were observed in postmenopausal women with Osteopenia. This study contributes to understanding the importance of exercise intensity for BMD and content acquisition. Based on the findings, the exercise program can be applied by postmenopausal women with osteopenia. It can also be helpful for those without osteoporosis or arthritis pain, as well as for associated therapists and clinicians in their future work in this area.

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Authors' Contributions

Z.Y. helped draft the article and critically revise it for important intellectual content. M.GH. and F.E. proceeded with the conception, design, and data collection; F.H. carried out the analysis and interpretation of the data, and all authors agreed to the final approval of the version to be published.

Conflict of Interests

The authors declare that they have no competing interests.

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