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RESEARCH ARTICLE

WEIGHT-BEARING EXERCISES AND BONE MINERAL DENSITY IN POSTMENOPAUSAL OSTEOPENIA: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Background: Weight-bearing exercises provide an effective way to stress important sites of bones enhancing the improvement of bone mineral density. The purpose of this study was to investigate the effect of Weight-bearing Exercise for Better Balance program on bone mineral density in postmenopausal females with osteopenia.

Methods: Twenty-four postmenopausal females with osteopenia were randomly assigned into two equal groups; experimental and control. The Weight-bearing Exercise for Better Balance program was performed by the experimental group while the control group didn't receive any treatment. Bone mineral density T-scores were measured for all participants in both groups by the dual energy x-ray absorptiometry scan of spine. Measurements were done twice before and after six weeks of the program.

Results: There was no statistically significant difference in the post testing mean values of bone mineral density T-scores compared with the pre testing ones in the experimental group. Also, there was no statistically significant difference in the post testing mean values of bone mineral density T-scores between the two tested groups.

Conclusions: Six weeks of Weight-bearing Exercise for Better Balance program are not enough to produce significant effects on bone mineral density in postmenopausal females with osteopenia. Trial registeration: PACTR201602001478123.

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INTRODUCTION

Osteoporosis is a chronic progressive disease characterized by low bone mass leading to deterioration of bone tissue and increased risk of fracture. Primary osteoporosis results from age-related changes in which imbalance in the activity of osteoblasts and osteoclasts occurs producing bone loss (Parfitt, 2002; Mauck and Clarke, 2006). Secondary osteoporosis results from secondary causes including; chronic medical conditions, nutritional deficiencies, and medications (Mauck and Clarke, 2006). Osteopenia is a condition of decreased bone mineral density (BMD) and is analogous to prehypertension, so it is the precursor to osteoporosis (Chobanian *et al*., 2003). To prevent fracture related morbidity and mortality, osteopenia has to be managed (Cummings and Melton, 2002). Dual energy x-ray absorptiometry (DEXA) scans are used for BMD screening (Nordin, 2011). The world health organization (World Health Organization (WHO), 2003) categorizes BMD according to the number of standard deviations above or below the normal mean for young adults as follows; normal BMD: T-score equals -1 or higher, osteopenia: T-score is between -1 and -2.5, and osteoporosis: T-score equals -2.5 or less. Griffith and Genant (2008) illustrated that bone strength depends on a number of interrelated factors, including the amount of bone tissue size and mass and the intrinsic properties of the bone material; porosity, matrix mineralization, collagen traits, and micro-damage. Small changes in bone mass distribution either cortical or trabecular and bone geometry that contributes to a greater bone cross section lead to large increases in bone strength independent of increases in BMD (Jarvinen *et al*., 2005). It was proved that training is an effective method for preventing falls in elderly people, by improving BMD and bone health, especially when the strength and balance exercises are combined (Halvarsson *et al*., 2015). There is also evidence that aerobic exercise, load-lifting and resistance training have positive effects on both spine and hip BMD in postmenopausal elderly. Moreover, Madureira *et al*. (Madureira *et al*., 2010) observed that balance training program significantly improves quality of life, overall health and balance performance with

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reduced risks of falling. During physical activity, mechanical forces can be exerted on bones throughout the ground reaction forces and the contractile activity of the muscles, resulting in maintenance or gain of bone mass (Vieira, 2013; Moreira *et al*., 2014). Additionally, exercise program that aims at improving flexibility, body balance, muscle power of lower extremities, and walking ability reduces the incidence of falls in the elderly (Iwamoto *et al*., 2009). Therefore the main goal of the current randomized study was to examine the effect of six weeks of specific weight-bearing program called weight-bearing exercise for better balance (WEBB) program on BMD in postmenopausal females with osteopenia.

MATERIALS AND METHODS

Design

This was a randomized pre-test post-test controlled trial with concealed allocation. The principal investigators randomly assigned the eligible females to an experimental group or a control group, according to a computer-generated random assignment list and applied the WEBB program to the experimental group. A specialized radiologist who measured the BMD T-scores via DEXA scans was blinded to group allocations and was neither present during group allocation nor during performing the program. Also, the principal investigators were blinded from measuring BMD for all participants of both groups.

Participants

Twenty-four postmenopausal females with osteopenia volunteered to participate in this study. All participants were recruited from a group of females admitted to El-Haram Hospital, Giza, Egypt to assess their BMD through DEXA scans. They were randomly assigned into two equal groups of 12; experimental and control. The BMDT-scores were measured for all participants in both groups before and after six weeks of the WEBB program, which was only performed by the experimental group. The inclusion criteria included; Postmenopausal females aging from 50 to 60 years. The mean ± standard deviation (SD) of age, body mass, and height of the experimental and control groups were represented in table1. All participants were diagnosed with osteopenia; T-score value between -1 and -2.5 SD of the normal mean value of young persons of same sex. All participants didn't participate in sports or athletic activities.

Procedures

Before starting the study procedures, a pilot study was conducted to determine the appropriate sample size. Power analysis was done at a significance level of 5% and a test power of 80%. It revealed that a minimum of nine participants for each group were required and the total required sample size was 18. The total assessed number of participants was 78, while the 54 participants, who didn't meet the inclusion criteria or declined to participate or any other reason were excluded from the study. Only twenty-four participants met the inclusion criteria and were included in the study. This sample size achieved 93% power of significance. Once allocated to the groups, none of the patients dropped out of the study as represented in Figure 1. The participant's personal data were collected. The data included the participant's name, age, address, body mass, height, and phone number. The nature of the study, aims, and procedures were explained to the participants before starting measurement to be familiar with the study. To measure BMD, central DEXA scans of the lumbar spine (Lewiecki *et al*., 2008) were done for all participants before and after six weeks of the program by a specialized radiologist. After the pre-test, the WEBB program was performed by the experimental group while the control group didn't receive any treatment.

Weight bearing exercise for better balance (WEBB) program

The WEBB program has been developed from a systematic review, which established that exercise challenging balance is the key feature of successful exercise programs for the prevention of falls in older people. It includes awarm-up exercise, coordination (balance) exercises and strength/ coordination exercises. Each exercise has several levels of difficulty. The WEBB program in the current study was done five times per week for six weeks. Repetitions of each exercise of the WEBB program were increased gradually according to the patient's tolerance. The program included; 1- warm-up exercise, 2-standing with a decreased base exercise, 2-stepping in different directions exercise, 3-sit-to-stand (squatting) exercise, 4-heel raising exercise; and 5-forward and lateral step-up exercises (Sherrington *et al*., 2008). The warm-up exercise was performed at the beginning of the program by high stepping on a spot for 10 seconds five times in each limb alternatively. It also enhances strength and coordination. Standing with a decreased base exercise was done bilaterally in the following graduation; 1) Feet together and level, 2) Semi-tandem stance, 3) Tandem stance, and 4) Standing on one leg. Each graduation was done for one minute and repeated in each limb 10 times in the first two weeks of training, 15 times in the second two weeks of training, and 20 times in the third two weeks of training. Stepping in different directions exercise was done bilaterally in the following graduation; 1) Long step of narrow base of support; by asking the participant to take a long step as much as possible with a minimum base of support width of five cm and maintain this position for one minute 2) Stepping forward over an object, and 3) Stepping sideward over an object; the participant took a step forward and sideward over an object of graduated height. The object height was 15 cm in the first two weeks of training, 20 cm in the second two weeks of training, and 25 cm in the third two weeks of training. Each graduation was done for one minute and the graduations were repeated in each limb 10 times in the first two weeks of training, 15 times in the second two weeks of training, and 20 times in the third two weeks of training. Sit-to-stand (squatting) exercise was done in the following graduation; 1) Bilateral squatting with hand assistance, 2) Eliminating hand assistance to push off by crossing arms across chest, and 3) Unilateral squatting. The graduations were repeated 10 times in the first two weeks of training, 15 times in the second two weeks of training, and 20 times in the third two weeks of training. Heel raising exercise included bilateral and unilateral heel raising exercises.

They were performed 10 times in the first two weeks of training, 15 times in the second two weeks of training, and 20 times in the third two weeks of training. Each repetition lasted five seconds as represented in Figure 6. Forward and lateral step up exercises were performed over a height of 15 cm for 10 repetitions in the first two weeks of training, 20 cm height for 15 repetitions in the second two weeks of training, and finally progressed to 25 cm height for 20 repetitions in the third two weeks of training.

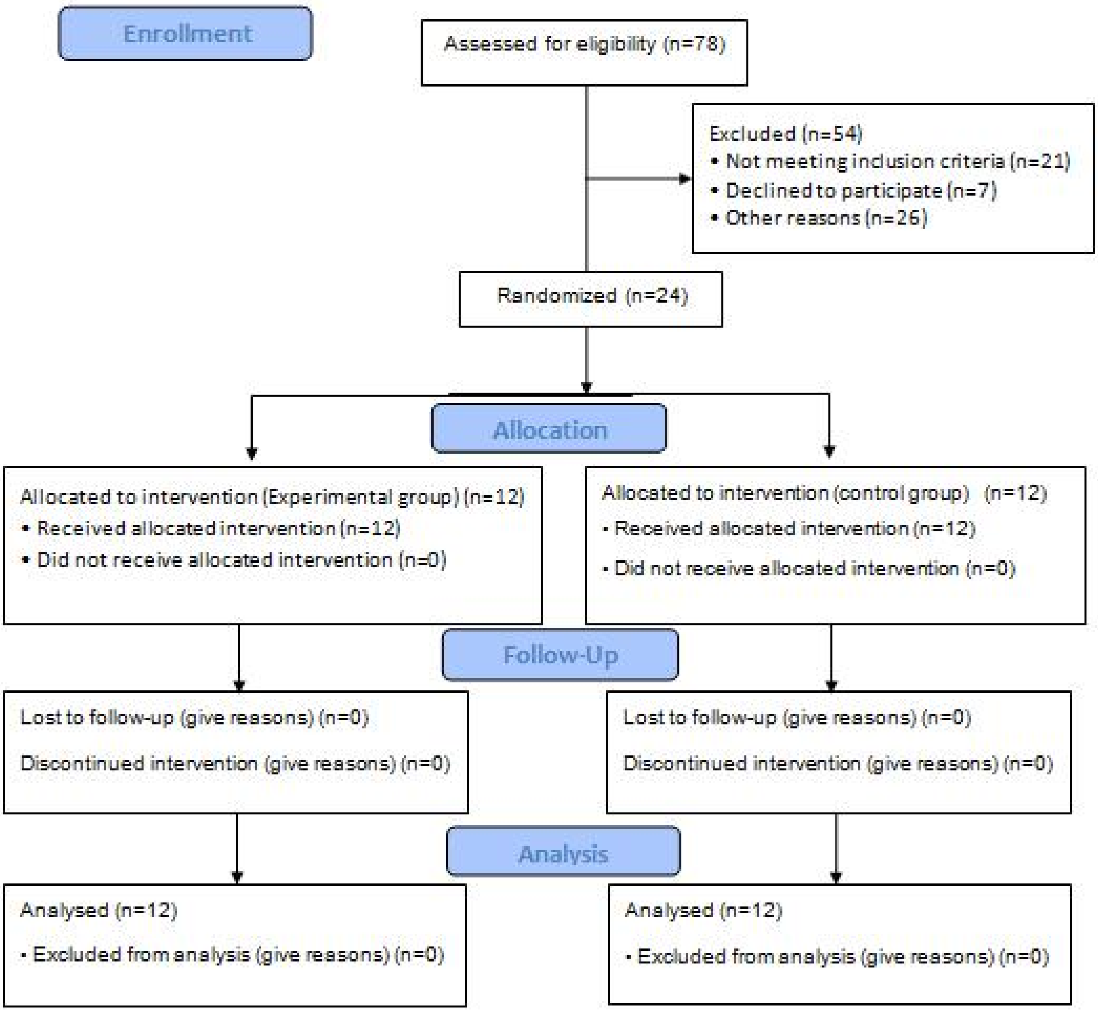

Figure 1. Flow chart diagram of the study

Outcome

T-scores of BMD were the measured outcome of the current study obtained by central DEXA scans of lumbar spine. T-score was first introduced in the late 1980s and expresses a patient's BMD measurement by taking the difference between the measured BMD and the mean BMD for a healthy young adult and expressing the result in units of the young adult population SD. It is the primary diagnostic value for osteoporosis in older adults. The BMD results can also be expressed as a Z-score by using healthy age-matched reference BMD and SDs. The Z-score is primarily used to diagnose low bone mass in young adults and children. Given these definitions, there is a frequent presumption that the T- and Z-scores should be closely similar or identical for younger populations (Blake and Fogelman, 2007).

Statistical analysis:

The data were analyzed using the statistical package for social sciences (SPSS) for Windows, version 20. Data exploration was done to assess normality. Shapiro-Wilk tests, frequency distribution curves, and box plots revealed normal distribution of data. Therefore, parametric statistics using two way mixed design Analysis of Variance (ANOVA) was conducted to test the effect of the program on BMD T-scores before and after the program and between the two tested groups. The limit for statistical significance was set at 0.05.

RESULTS

There were no significant differences in baseline demographic data between groups as shown in Table 1. Two way mixed design ANOVA was conducted in the current study to test the effect of WEBB program on BMD T-sores before and after six weeks of the WEBB program in both experimental and control groups. Also, it was used to compare the results between the two tested groups. The Levene's Test of Equality of Error Variance was insignificant indicating homogeneity between groups. Also, Mauchly's Test of Sphericity was insignificant indicating homogeneity of the within factor (testing time).

Table 1. Demographic features

	Experimental Group	Control Group	t-value	p-value
Age (years)	59.08 (±4.14)	58.58 (±3.92)	0.304	0.764
Body mass (kg)	92.50 (±11.80)	86.58 (±12.21)	1.207	0.240
Height (cm)	160.42 (±2.02)	159.33 (±1.72)	1.413	0.172

Two-way mixed design (ANOVA) revealed no statistical significant difference in the pre testing mean values of BMD T-scores between groups ($p > 0.05$). In addition, no statistical significant difference was detected in the post testing mean values of BMD T-scores in both experimental and control groups compared with the pre testing ones ($p > 0.05$). Therefore, there was no significant difference in the post testing mean values of BMD T-scores between the two tested groups (p > 0.05) as represented in Table 2.

Table 2. Descriptive and inferential statistics of BMD

T-score of BMD			
Experimental group Mean ± SD		Control group Mean ± SD	
Pre test	Post test	Pre test	Post test
1.87 (±0.57)	2.04 (±0.69)	1.88 (±0.55)	1.99 (±0.55)
Multiple pairwise comparisons			
Pre test vs. post test	Experimental		p = 0.425
	Control		p = 0.164
Experimental vs. control	Pre test		p = 0.865
	Post test		p = 0.956

DISCUSSION

The results of the current study showed that there was no significant difference between the pre and post testing mean values of BMD T-scores in both groups. Also, there was no significant difference in the post testing mean values of BMD T-scores between groups. This may be explained that the rate of gain from exercises differ according to the age. Baxter-Jones *et al*. (2011) stated that peak bone mass is reached in the twenties of age, and from then onwards, bone resorption predominates. In fact, Postmenopausal females have different BMD responses to exercises than premenopausal females. It was shown that premenopausal females significantly increased their BMD in response to training while postmenopausal females didn't (Magkos *et al*., 2007). Snow *et al*. (2000) explained this view that postmenopausal females require longer periods of intervention and higher loads because they are in a period of accelerated bone loss. Regular physical exercise has numerous benefits for individuals of all ages. There is strong evidence that physical activity early in life contributes to higher peak bone mass. Physical activity during early age is more strongly associated with higher Bone Mineral Density at all sites than physical activity in later years. However, it is clear that exercise late in life can increase muscle mass and strength twofold or more in frail individuals. It will also improve function, delay loss of independence, and improve quality of life (Ulrich *et al*., 1999). Despite reports that BMD is a good predictor of population fracture risk (Kanis *et al*., 2008), it was indicated that up to 80% of all low-trauma fractures occur in individuals who are not osteoporotic but have normal or reduced BMD; osteopenia. This finding highlights the limitations of DEXA to provide accurate measures of BMD or its ability to give relevant information about the major determinants of bone strength, such as the size, shape and structure of bone. Kelly and Kelly (Kelley and Kelley, 2004) illustrated that regular physical activity, including aerobic, weight-bearing, and resistance exercises, is effective in increasing BMD of the spine and strengthening muscles in postmenopausal females, but there are few trials establishing whether these interventions reduce the fracture risk. In the same context, small changes in bone mass distribution, cortical and trabecular structure, and bone cross-section leads to large increases in bone strength independent of significant changes in BMD (Sievanen, 2000; Jarvinen*et al*., 2005). Another important explanation for the insignificant improvement of BMD may be the insufficient training period. Six weeks of weight-bearing program may be not long enough to produce the significant difference in BMD. The total time of bone formation at bone multicellular unit is four to six months long (Bemben *et al*., 2000). This explains the opposing results of a study conducted by Kato (2005) who achieved a significant increase in BMD following six months jump training in the experimental group compared to the control group. The significant increase in BMD in that study may not only be due to long training period but also due to conducting a study on young female college students and applying another type of weight-bearing program. In the same context, many other studies supported the idea of effective long period training program. Kemmler *et al*. (2003) conducted a two-year study to evaluate the effect of strength, high-impact, and endurance exercises on bone BMD among postmenopausal females with a history ofosteopenia.Results of that study opposed the results of the current study. An increase of spine BMD by 1.3% in the experimental group and a decrease in the spine BMD of the control group 1.2% were obtained. Accordingly, it was concluded that females who are postmenopausal with osteopenia would likely benefit from a less frequent but longer period of intervention with an emphasis on monitoring and adjustment of the exercise prescription to make effective changes for increasing bone mass or preventing bone loss.

Surprisingly, Warren *et al*. (2008) obtained results that don't support the idea of the effect of training period on BMD. A two-year randomized controlled trial that included 164 healthy premenopausal females was conducted. The researchers evaluated the effectiveness of a twice-weekly strength training intervention on BMD. They found that the two years strength training program in the intervention group did not affect BMD in the lumbar spine or proximal femur. While, the control group displayed a 1.5% decrease in BMD. The insignificant effect on BMD in the experimental group in that study may be attributed to the type of exercise which didn't focus on weight bearing. Also, it was reported that a relatively brief but strenuous physical stress exercise is indicated to be a good stimulus for increasing BMD. Because an adaptive response occurs only when a loading stimulus exceeds the usual loading conditions, continued adaptation requires a progressively increasing overload (Kato, 2005). In the current study, the intensity of exercises of the WEBB program was increasing gradually in a short training period according to patients' tolerance (Sherrington *et al*., 2008) and this may be not strenuous enough to stimulate bone formation. Studies have suggested that combining medical treatment such as anabolic or anti-resorptive agents with physical activity may slightly increase bone mineral density as compared with monotherapy (Greenspan *et al*., 2003). In 2002, synthetic parathyroid hormone was the first approved anabolic agent for the treatment of postmenopausal osteoporosis. Unlike antiresorptive agents, parathyroid hormone stimulates bone remodeling by increasing bone formation. In a large randomized trial involving postmenopausal females with severe osteoporosis, 20 μg of parathyroid hormone per day administered subcutaneously markedly increased bone mineral density and reduced vertebral and non-vertebral fractures by more than 50 percent (Neer *et al*., 2001). Exercise during the later years in the presence of adequate calcium and vitamin D probably has a modest effect on slowing the decline in BMD (Ulrich *et al*., 1999).

Conclusion

It can be concluded from the current study that sufficient training period is required to gain improvements in bone BMD. The role of the WEBB program may be revealed by increasing the training period as much as possible. Future studies about the effect of long training period of the WEBB program on BMD are needed to cover the gap in this area and to accurately know the optimal training period needed for this program to obtain the preferred results. Also, generalization of the study to patients with osteoporosis as well as males suffering from osteopenia and/or osteoporosis has to be done in the future studies to obtain full results about this area of research.

REFERENCES

Baxter-Jones AD, Faulkner R.A, Forwood MR, Mirwald RL, Bailey DA. 2011. Bone mineral accrual from 8 to 30 years of age: An estimation of peak bone mass. *J Bone Miner Res*., 26, 729-731, 739.

Bemben DA, Fetters NL, Bemben MG, Nabavi N, Koh ET. 2000. Musculoskeletal responses to high and low intensity resistance training in early postmenopausal women. *Med Sci Sports Exerc*., 32: 1949-1957.

Blake GM, Fogelman I. 2007. The role of DEXA scanning in the diagnosis and treatment of osteoporosis. *J ClinDensitom*., 10:102-110.

Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, *et al*. 2003. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA*, 289(19):2560-2572.

Cummings SR, Melton LJ. 2002. Epidemiology and outcomes of osteoporotic fractures. *Lancet*, 18: 359 (9319):1761-1767.

Greenspan SL, Resnick NM, Parker RA. 2003. Combination therapy with hormone replacement and alendronate for prevention of bone loss in elderly women: A randomized controlled trial. *JAMA*, 289: 2525-2533.

Griffith JF, Genant HK. 2008. Bone mass and architecture determination: stateof the art. *Best Pract Res ClinEndocrinolMetab*., 22:737-764.

Halvarsson A, Franzen E2, Stahle A2. 2015. Balance training with multitask exercises improves fall-related self-efficacy, gait, balance performance and physical function in older adults with osteoporosis: A randomized controlled trial. *ClinRehabil*., 29:365-375.

Iwamoto, J., Suzuki, H., Tanaka, K., Kumakubo, T., Hirabayashi, H., *et al*. 2009. Preventative effect of exercise against falls in the elderly: A randomized controlled trial. *Osteoporos Int*., 20(7):1233-1240.

Jarvinen TL, Sievanen H, Jokihaara J, Einhorn TA. 2005. Revival of bone strength: the bottom line. *J Bone Miner Res*., 20:717-720.

Kanis JA, McCloskey EV, Johansson H, Oden A, Melton LJ, Khaltaev N. 2008. A reference standard for the description of osteoporosis. *Bone*, 42:467-475.

Kato T. 2005. Effect of low-repetition jump training on bone mineral density in young women. *J ApplPhysiol*., 100(3):839-843.

Kelley GA., Kelley KS. 2004. Efficacy of resistance exercise on lumbar spine and femoral neck bone mineral density in premenopausal women: a meta-analysis of individual patient data. *J Womens Health (Larchmt)*., 13:293-300.

Kemmler W, Engelke K, Weineck J, Hensen J, Kalender, WA. 2003. The Erlangen fitness osteoporosis prevention study: A controlled exercise trial in early postmenopausal women with low bone density - first year results. *Arch Phys Med Rehabil*., 84: 673-682.

Lewiecki EM, Gordon CM., Baim S, Leonard MB, Bishop NJ, *et al*. 2008. International Society forClinical Densitometry 2007 adult and pediatric official positions. *Bone*, 43 (6):1115-1121.

Madureira MM, Bonfa E, Takayama L, Pereira RM. 2010. A 12-month randomized controlled trial of balance training in elderly women with osteoporosis: improvement of quality of life. *Maturitas*, 66:206-211.

Magkos F, Yannakoulia M, Kavouras SA, Sidossis LS. 2007. The type and intensity of exercise have independent and additive effects on bone mineral density. *Int J Sports Med*., 28:773-779

Mauck KF, Clarke BL. 2006. Diagnosis, screening, prevention, and treatment of osteoporosis. *Mayo Clin Proc*., 81:662-672.

Moreira, LD, Oliveira, ML, Lirani-Galvao, AP, Marin-Mio, RV, Santos, RN, et al. 2014. Physical exercise and osteoporosis: Effects of different types of exercises on bone and physical function of postmenopausal women. *Arq Bras EndocrinolMetab*., 58(5):514-522.

Neer RM, Arnaud CD, Zanchetta JR, Prince R, Gaich GA, *et al*. 2001. Effect of parathyroid hormone (1-34) on fractures and bone mineral density in postmenopausal women with osteoporosis. *N Engl J Med*., 344:1434-1441.

Nordin C. 2011. Screening for osteoporosis: U. S. Preventive Services Task Force recommendation statement. *Ann Intern Med*., 16: 155(4):276.

Parfitt AM. 2002. Targeted and nontargeted bone remodeling: relationship to basic multicellular unit origination and progression. *Bone*, 30:5-7.

Sherrington C, Whitney J, Lord S *et al*. 2008. Effective exercise for the prevention of falls – a systematic review and meta-analysis. *J Am Geriatr Soc*., 56 (12):2234-2243.

Sievanen H. 2000. A physical model for dual-energy X-ray absorptiometry-derived bone mineral density. *Invest Radiol*., 35:325-330.

Snow CM., Shaw JM., Winters KM., Witzke KA. 2000. Long-term exercise using weighted vets prevents hip bone loss in postmenopausal women. *J Geronto A BiolSci Med Sci*., 55:489-491.

Ulrich CM, Georgiou CC, Gillis DE. Snow C.M. 1999. Lifetime physical activity is associated with bone mineral density in postmenopausal women. *J Women Health*, 8:365-75.

Vieira, S. 2013. Different land-based exercise training programs to improve bone health in postmenopausal women. *Med Sci Tech*., 54:158-163.

Warren M, Petit MA, Hannan PJ, Schmitz KH. 2008. Strength training effects on bone mineral content and density in premenopausal women. *Med Sci Sports Exerc*., 40, 1282-1288.

World Health Organization (WHO). Prevention and management of osteoporosis.World Health Organ Tech Rep Ser. 2003; 921:1-164.

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