Effects of osteoanabolic exercises on bone mineral density of osteoporotic females: A randomized controlled trial

Amna Aamir Khan¹, Ali Farhad¹, Pirzada Qasim Raza Siddiqui², Basit Ansari³

¹Department of Physical Therapy, Ziauddin College of Rehabilitation Sciences, Ziauddin University, Karachi, Pakistan, ²Professor of Physiology, Vice Chancellor Ziauddin university and a Co-PI, Ziauddin University, Karachi, Pakistan, ³Department of Health, Physical Education and Sports Sciences, University of Karachi, Karachi, Pakistan

Address for correspondence: Amna Aamir Khan, Ziauddin College of Rehabilitation Sciences, Ziauddin University, Institute, Plot # E - 40/1, Wahid Colony Block - B North Nazimabad Karachi, Pakistan. Phone: 021-36629250-51/0342-2497814. Email: akhan39@caledonian.ac.uk

OBJECTIVE

Objectives: With the increase in the life expectancy of older adults, the scoring diagnosis of osteoporosis has been highly reported hence rising the incidence of fragility fractures due to decrease in bone mineral density (BMD), thereby significantly impacting the quality of life and health status of elderly population. The aim of this study is to identify the impact of different exercise regimes in improving the BMD among osteoporotic females.

Methodology: A trial was conducted on 93 diagnosed postmenopausal osteoporotic females aged 50–75 years screened on the basis of physical activity readiness-questionnaire and YOU form randomly divided equally into three groups¹, that is, aerobic, anaerobic, and osteoanabolic exercises using an envelope method. The intervention was given on the basis of American College of Sports Medicine (ACSM), frequency, intensity, time, and type protocol for the period of 12 weeks. The pre- and post-BMD was determined to find out the improvements on the t-value of the participants. The outcome measure was calculated using a peripheral dual X-ray absorptiometry scan (bone densitometer).

Results: At 95% of confidence interval, the pre- and post-median difference observed within the osteoanabolic group was 0.4 followed by 0.3 and 0.1 in the aerobic and anaerobic groups, respectively. The level of significance was determined by applying the Friedman test revealing a statistically significant difference $P < 0.001$ between the groups. Further, post hoc analysis shows that osteoanabolic exercises were more significant in comparison with aerobic and anaerobic exercises.

Conclusion: Structured physical exercises based on ACSM protocol show improvement among the osteoporotic females; however, the impact of osteoanabolic exercises significantly increased the BMD, thus reducing the t-value. However, larger scale studies in different clinical settings are recommended for more accurate results.

Keywords: Bone mineral density, densitometry, exercises, osteoporosis, postmenopause

Introduction

Osteoporosis is a global challenge and it is estimated that around 200 million people are osteoporotic,¹ affecting one of every three women who are at a risk of having osteoporotic fracture that limits the activities of daily living and is indeed one of the causes of physical inactivity (International Osteoporotic Foundation, 2015).² According to osteoporotic facts and statistical analysis provided by the Foundation of Osteoporosis Canada in 2015, osteoporotic fractures are more common than heart attack, stroke, and breast cancer creating an estimated economic burden of around $2.3 billion Canadian dollars annually.³ According to the data provided by Wade et al. on 10 years of probabilities of osteoporotic fractures, elderly population who have sustained any previous fracture due to osteoporosis are at 50% of increased risk to future fractures. Moreover, it is also estimated that a previous wrist fracture may increase a risk for having hip and vertebral fracture with an estimated relative risk of around 1.9 and 4.4, respectively.⁴ Osteoporosis causes >8.9 million of the fractures worldwide which makes it approximately 1000 cases per hour.⁵ According to another study conducted on the population of China, it is estimated that the annual cases of osteoporotic fractures as reported during the year 2011 are 40% greater than the sum of cases reported for the breast cancer, endometrial cancer, and ovarian cancer among women.⁶
Similar findings have also been reported for male population where the incidence of osteoporotic fractures reported during the same year is 13% greater than the cases reported for prostate cancer.\(^7\) The situation in the neighboring country India is also similar where it is estimated that around 50 million people are either osteoporotic or have low bone mass.\(^8\) Besides Asian-Pacific region, the high rate of incidence of osteoporotic fractures has also been reported in the United States, Europe, and the United Kingdom.\(^9\) According to the study conducted by Clifford \textit{et al.}, in 2017, the annual incidence of osteoporotic fractures as reported in the United States is approximately 0.3 million, for Europe, the number of incidents reported is 1.7 million, and for the United Kingdoms, the incidence is reported as 400/100,000 women.\(^10\) In Pakistan, the situation is even alarming where osteopenia is reported in 64% of women population of Karachi <30 years and 55% of women <45 years of age,\(^11\) whereas 24.7% of the cases in KPK are reported as osteoporosis.\(^12\) Out of the copious risk factors of osteoporosis, general factors such as aging, gender, body composition, dietary intake, genes, and physical inactivity are classified as a primary, whereas medication and disease induced are classified as secondary risk factors.\(^13\) According to the World Health Organization, the diagnosis of osteoporosis is mainly done on the basis of bone mineral density (BMD) calculated using a dual X-ray absorptiometry (DXA) scan where \(t\)-score of \(\geq -1.0\) is considered as normal, value \(\leq -1.0\) and \(\geq -2.5\) osteopenia, \(\leq -2.5\) is osteoporosis, and \(\leq 2.5\) with fragility fracture is diagnosed as severe osteoporosis.\(^14\)

According to the study conducted in 2015, basic lifestyle modifications such as regular physical activities, plummeting risk of fall, nutritional, dietary counseling plus modification, early bone screening, and bone loss prevention are turned out to be an essential management strategy for osteoporosis.\(^15\) The estimated role of exercises is found to be significant, it not only improves bone mineral concentration but also indeed reduces the risk of fall, improves balance and agility, and increases muscle strength and muscle mass. Physiologically, the response of exercises is greatly dependent on the intensity, duration, type, and frequency of the exercise. Studies have provided evidence that aerobic and resistance exercises modestly increase the BMD through mechanical loading induced by physical activity which produces strain within the bone, providing impetus to the osteoblastic activities in the quiescent state resulting in bone remodeling and resorption. In a study conducted in 2017 on postmenopausal women, physical exercises meant to prevent and fight against the age-related bone loss;\(^16\) meanwhile, in another study conducted on the effect of short-term step, aerobic exercises among 48 postmenopausal women with low bone mass showed a significant improvement on BMD.\(^17\) The evidence provided by Zhao \textit{et al.} after pooling the effect of 24 randomized controlled trials, suggested that the combined resistance training proved to be effective in improving BMD due to its high level of mechanical strain which generates the beneficial effects on the bone health of postmenopausal women.\(^18\) Although the number of literature has provided evidence on the impact of exercise on BMD in postmenopausal women, the effects of osteoanabolic (combination of aerobic + anaerobic) exercises have not been discussed in detail, thereby create an opportunity for this research paper. Hence, the present study is aimed to determine and compare the effects of three different exercises regimes protocol, that is, aerobic, anaerobic, and osteoanabolic exercises on BMD of postmenopausal osteoporotic women.

\section*{Methodology}

A randomized controlled trial was conducted in which 93 diagnosed osteoporotic females were divided equally into three groups using an envelope method technique. The study was carried out in a tertiary care hospital of Karachi and the intervention was designed on the basis of American College of Sports Medicine (ACSM); frequency, intensity, time, and type protocol given for the period of 12 weeks. The pre- and post-BMD of the participants were determined based on \(t\)-score; the descriptions of the management strategies used in this study based on the guidelines of ACSM are given as follows:

\begin{itemize}
  \item \textbf{Group A (aerobic exercises):}
  \begin{itemize}
    \item Frequency: 6 days/week
    \item Intensity: For aerobic exercises, 55–75% of maximum heart rate for 6 days and
    \item Time: 30–60 min
    \item Type: Treadmill, cycling, and resistance exercises.
  \end{itemize}

  \item \textbf{Group B (anaerobic exercises):}
  \begin{itemize}
    \item Frequency: 3 days/week
    \item Intensity: Repetition to failure (1 RM formula)
    \item Time: Time required in performing 10–15 repetition of 10 major muscles group with low-intensity weight.
    \item Type: Dumbbell and weight lifting (resistant exercises).
  \end{itemize}

  \item \textbf{Group C (osteoanabolic exercises):}
  \begin{itemize}
    \item Frequency: 6 days/week
    \item Intensity: For aerobic exercises, 55–75% of maximum heart rate for 3 days and repetition to failure (1 RM formula) with moderate intensity 3 days/week
    \item Time: 30–60 min
    \item Type: Treadmill, cycling, and resistance exercises
  \end{itemize}

\end{itemize}

It was also taken into account that the training session was prematurely been terminated on the happening of one of the following events:

\begin{itemize}
  \item Modified Borg dyspnea scale rating of perceived exertion at level 8 or above
  \item Complain of chest pain
  \item Decrease in oxygen saturation
  \item Able to speak but not sing comfortably during the exercises.
\end{itemize}

The outcome measure was calculated using a peripheral DXA scan (bone densitometer); the measurements were taken before the start of the session, that is, on the 1st day of week 1 and

---

\textit{International Journal of Health Sciences}

Vol. 13, Issue 1 (January - February 2019)

\textbf{Khan, et al.: Osteoanabolic Exercises on BMD of Osteoporotic Females}
were compared with the measurements taken on the past day of week 12.

**Inclusion criteria**
- Age: 50–75 years\(^{[19]}\)
- Diagnosed postmenopausal osteoporotic females
- Successful screening on the basis of physical activity readiness-questionnaire form\(^{[20]}\) is a simple self-screening tool that can be filled by either patients or physical therapist who is planning to start an exercise program.

**Exclusion criteria\(^{[21,22]}\)**
- Red flags that limit recruitment of participants in exercise program, for example, vertebral fracture, malignancy, etc.
- Cardiac disease
- Mental disorders
- Neurological disorders associated with high risk of fall, for example, stroke, parkinsonism, dementia, Alzheimer, etc.

**Ethical consideration**
Ethical considerations were made according to guidelines provided under the Belmont report for human subjects. The data provided by the participants were kept confidential; consent was taken before the recruitment and participants were given opportunity to ask any question before, during, and after the completion of the study.

**Results**
A total of 93 participants were included in 12 weeks of intervention program divided into three subgroups, that is, aerobic \((n = 31)\), anaerobic \((n = 31)\), and osteoanabolic \((n = 31)\). During the course of the study, no injury or harm was witnessed to the participants.

The age frequency graph of the participants recruited in the study is given in Figure 1.

The age frequency graph showed that the maximum number of the participants in both the groups was found in between the age bracket of 56 and 60 years \((n = 25)\) followed by 61–65 years of age \((n = 18)\), 66–70 years \((n = 10)\), and 51–55 \((n = 9)\). Significant effects of exercises on BMD were observed in all three groups, that is, aerobic, anaerobic, and osteoanabolic. Wilcoxon test with 95% of confidence interval (CI) was applied that reveals a statistically significant improvement \(P < 0.001\) in the BMD of the postmenopausal women included in the study (Table 1).

At 95% of CI, the median difference (pre-post) as observed in the osteoanabolic group was greater than aerobic and anaerobic groups, respectively \((\text{osteoblastic} > \text{aerobic} > \text{anaerobic})\).

Further, *post hoc* test was run which suggested that the effects of osteoanabolic exercises were more significant in comparison to aerobic and anaerobic exercises. The results also revealed that the difference between aerobic groups was more significant than anaerobic group (Table 3).

Graphical representation of the differences in the post \(t\)-value between the groups is illustrated in Figure 2.

**Discussion**
The result of the study on the BMD of the participants depicts that exercise had a positive impact on \(t\)-value of the participants. The aerobic exercises protocol of 6 days a week for a period of 12 consecutive weeks significantly reduces...
Table 2: Comparison among the group

| Group                      | n  | Median | F       | DF 1 | DF 2 | P value |
|----------------------------|----|--------|---------|------|------|---------|
| Post-aerobic               | 31 | −2.3   | 16.35   | 2    | 60   | <0.00001|
| Post-anaerobic             | 31 | −2.5   |         |      |      |         |
| Post-osteoanabolic         | 31 | −2.2   |         |      |      |         |

Table 3: Post hoc analysis between the groups

| Group                          | Sig. (two-tailed) |
|--------------------------------|-------------------|
| BMD anaerobic - BMD aerobic     | 0.002             |
| BMD osteoanabolic - BMD aerobic | 0.313             |
| BMD aerobic - BMD anaerobic     | 0.002             |
| BMD osteoanabolic - BMD anaerobic | 0.001         |
| BMD aerobic - BMD osteoanabolic | 0.313             |
| BMD anaerobic - BMD osteoanabolic | 0.001             |

Figure 2: Difference in bone mineral density between groups

The study concluded that the impact of osteoanabolic exercises showed a significant improvement in reducing t-score (calculated using a peripheral densitometer) of the participants in comparison to aerobic and anaerobic exercise regimes.

References

1. Hernlund E, Svedbro A, Ivergård M, Compston J, Cooper C, Stenmark J, et al. Osteoporosis in the European union: Medical management, epidemiology and economic burden. A report prepared
in collaboration with the international osteoporosis foundation (IOF) and the European federation of pharmaceutical industry associations (EFPIA). Arch Osteoporos 2013;8:136.
2. Compton J. Osteoporosis: Social and economic impact. Radiol Clin North Am 2010;48:477-82.
3. Baucom K, Pizzorno L, Pizzorno J. Osteoporosis: The need for prevention and treatment. J Rest Med 2014;3:2-9.
4. Wade SW, Strader C, Fitzpatrick LA, Anthony MS, O’Malley CD. Estimating prevalence of osteoporosis: Examples from industrialized countries. Arch Osteoporos 2014;9:182.
5. Borgström F, Lekander I, Ivergård M, Ström O, Svedbom A, Alekna V, et al. The international costs and utilities related to osteoporotic fractures study (ICUROS) – quality of life during the first 4 months after fracture. Osteoporos Int 2013;24:811-23.
6. Dhanwal DK, Dennison EM, Harvey NC, Cooper C. Epidemiology of hip fracture: Worldwide geographic variation. Indian J Orthop 2011;45:15-22.
7. Liu JM, Ma LY, Bi YF, Xu Y, Huang Y, Xu M, et al. A population-based study examining calcaneus quantitative ultrasound and its optimal cut-points to discriminate osteoporotic fractures among 9352 Chinese women and men. J Clin Endocrinol Metab 2012;97:800-9.
8. Mithal A, Kaur P. Osteoporosis in India: A call to action. Curr Osteoporos Rep 2012;10:245-7.
9. Larson K, Russ SA, Kahn RS, Flores G, Goodman E, Cheng TL, et al. Health disparities: A life course health development perspective and future research directions. In Handbook of Life Course Health Development. Cham: Springer; 2018. p. 157-78.
10. Rosen CJ, De Groot LJ, Chrousos G, Dungan K, Feingold KR, Grossman A, et al. The epidemiology and pathogenesis of osteoporosis 2000.
11. Jaleel RI, Nasrullah FD, Khan AY. Osteopenia in the younger females. J Surg Pak 2010;15:29-33.
12. Frisoli A Jr., Chaves PH, Ingham SJ, Fried LP. Severe osteopenia and osteoporosis, sarcopenia, and frailty status in community-dwelling older women: Results from the women’s health and aging study (WHAS) II. Bone 2011;48:952-7.
13. Liberato SC, Maple-Brown L, Bressan J, Hills AP. The relationships between body composition and cardiovascular risk factors in young Australian men. Nutr J 2013;12:108.
14. Kanis JA, Harvey NC, Johansson H, Odén A, Leslie WD, McCluskey EV, et al. FRAX and fracture prediction without bone mineral density. Climacteric 2015;18 Suppl 2:2-9.
15. Dunneram Y, Jeewon R. Healthy diet and nutrition education program for osteoporosis and the role of physical therapy in the different domains. J Osteopor Phys Act 2017;5:1.
16. Posa G, Roka E, Sziver E, Finta R, Sziİgyi L, Koncsek K, et al. Osteoporosis and the role of physical therapy in the different domains. J Osteopor Phys Act 2017;5:1.
17. Wen HJ, Huang TH, Li TL, Chong PN, Ang BS. Effects of short-term step aerobics exercise on bone metabolism and functional fitness in postmenopausal women with low bone mass. Osteoporos Int 2017;28:539-47.
18. Zhao R, Zhao M, Xu Z. The effects of differing resistance training modes on the preservation of bone mineral density in postmenopausal women: A meta-analysis. Osteoporos Int 2015;26:1605-18.
19. Epstein RM, Alper BS, Quill TE. Communicating evidence for participatory decision making. JAMA 2004;291:2359-66.
20. Sezer I, Illeez O, Tuna SD, Balci N. The relationship between knee osteoarthritis and osteoporosis. Eurasion J Med 2010;42:124-7.
21. Thompson PD, Arena R, Riebe D, Pescatello LS, American College of Sports Medicine. ACSM’s new preparticipation health screening recommendations from ACSM’s guidelines for exercise testing and prescription, ninth edition. Curr Sports Med Rep 2013;12:215-7.
22. Smulders E, van Lankveld W, Laan R, Duyssens J, Weerdesteyn V. Does osteoporosis predispose falls? A study on obstacle avoidance and balance confidence. BMC Musculoskelet Disord 2011;12:1.
23. Lloyd RS, Faigenbaum AD, Stone MH, Oliver JL, Jeffreys I, Moody JA, et al. Position statement on youth resistance training: The 2014 international consensus. Br J Sports Med 2014;48:498-505.
24. Stanghellie B, Bentzen H, Giangregorio L, Prip AH, Bergland A. Effect of a resistance and balance exercise programme for women with osteoporosis and vertebral fracture: Study protocol for a randomized controlled trial. BMC Musculoskelet Disord 2018;19:100.
25. Mezil YA, Allison D, Kish K, Ditor D, Ward WE, Tsiani E, et al. Response of bone turnover markers and cytokines to high-intensity low-impact exercise. Med Sci Sports Exerc 2015;47:1495-502.
26. Li L, Chen X, Lv S, Dong M, Zhang L, Tu J, et al. Influence of exercise on bone remodeling-related hormones and cytokines in ovariectomized rats: A model of postmenopausal osteoporosis. PLoS One 2014;9:e112845.
27. Abrahim O, Rodrigues RP, Marçal AC, Alves EA, Figueiredo RC, de Sousa EC, et al. Swimming and cycling do not cause positive effects on bone mineral density: A systematic review. Rev Bras Reumatol Engl Ed 2016;56:345-51.
28. Carbuhn AF, Fernandez TE, Bragg AF, Green JS, Crouse SF. Sport and training influence bone and body composition in women collegiate athletes. J Strength Cond Res 2010;24:1710-7.
29. Miller E, Fredericon M, Kussman A, Krauss E, Singh S, Deakins-Roche M, et al. Youth multi-sport participation is associated with higher bone mineral density in female collegiate distance runners: 2016 board# 277 May 31 3. Med Sci Sports Exerc 2018;50:490.
30. Silva DR, Coelho AC, Dumke A, Valentinini JD, de Nunes JN, Stefani CL, et al. Osteoporosis prevalence and associated factors in patients with COPD: A cross-sectional study. Respir Care 2011;56:961-8.
31. Bonnet N, Ferrari SL. Exercise and the skeleton: How it works and what it really does. IBMS Bone Key 2010;7:235-48.
32. Helge EW, Andersen TR, Schmidt JF, Jørgensen NR, Hornstrup T, Krustup P, et al. Recreational football improves bone mineral density and bone turnover marker profile in elderly men. Scand J Med Sci Sports 2014;24 Suppl 1:98-104.
33. Ernest KM, Martinie RG, Dokins S, Hergenroeder AC. Bone health of adolescent athletes. In: A Practical Approach to Adolescent Bone Health. Cham: Springer; 2018. p. 157-78.