Effectiveness Of Physical Activity And Diet Supplementation On Body Mass Index And Bone Mineral Density Among Premenopausal Women

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DOI: 10.47750/pnr.2022.13.S07.552

Abstract

Background: Osteoporosis is a gradual and systemic skeletal disease with a low bone mass and degradation of bone structures. The condition occurs even in the premenopausal stage among women. Hence, the effectiveness of physical activity and diet supplementation on body mass index (BMI) and bone mineral density (BMD) among premenopausal women were studied.

Methods: Height, weight, BMI and BMD of 150 women (30 to 40 years) were studied before and after intervention. 150 women with low BMD (t-score of -2.5 to -1.0) were randomly assigned to control and experimental groups. The experimental group was given physical activity for five days a week and a diet supplement of finger millet-based sweet balls (ragi laddu) for three days a week, for three months. For the diet supplement, a 24-hour recall was performed, and a self-reported activity check list was maintained for physical activity.

Results: A significant decrease in the weight of experimental group post-test was observed compared to the control group (P = 0.027), without any change in the height. The BMI of experimental post-test also showed significant decrease compared to the control group (P = 0.050). The BMD showed significant improvement in the experimental group with a reduction in t-score of 0.81 from –1.73 in pre-test to –0.92 in the post-test (P < 0.001), while in the control group, the values remained same (P = 0.928).

Conclusion: Premenopausal women’s BMI decreased and BMD improved significantly in this study Physical activity and supplementation with finger millet diet showed beneficial effects.

Subjects: Women’s health, Orthopaedics, Nutrition.

Keywords: premenopausal women, body mass index, bone mineral density, osteoporosis, physical activity, finger millet diet.

INTRODUCTION:
Osteoporosis is a bone disease that causes significant changes in bone biologic material and, as a result, bone strength decreases. It affects millions of people worldwide from various ethnic groups. (Pouresmaeili et al.,2018). More than 200 million people are estimated to be affected by osteoporosis. According to the International Osteoporosis Foundation’s, one in every three women over the age of 50 and one in every five men will develop bone related fractures during lifetime (Sozen et al., 2017). Menopause and ageing are two important factors that are linked to the occurrence of osteoporosis. Fractures, which are caused by osteoporosis,
are a serious danger and one of the leading causes of disability and death among the elderly (Huang et al., 2020). Excessive bone resorption caused by estrogen deprivation is correlated to postmenopausal osteoporosis. (Zhang et al., 2021). In India, slowly advancing metabolic bone disease is frequent, and osteoprotic fractures are the leading cause of morbidity and mortality among adult. One of the risk factors for accelerated bone turnover is a low body mass index (BMI) (Patil et al., 2007). The main source of measurable determinate of high risk of occurrence of a fragility fracture in osteoporosis is bone mineral density, where a lower body mass index (BMI) is linked to a significantly higher risk of fractures (Mazoccoa and Chagasa., 2016). Obesity and osteoporosis are significant public health concerns around the world, and both are linked to a poor diet, excessive caloric consumption, and/or insufficient physical activity. Body weight and bone mineral density are connected. Obesity increases BMD and bone mineral content for a variety of reasons (Sue A. Shapses and Deeptha Sukumar., 2012). The factors affecting bone loss are age, body weight and BMI (Montazerifar et al., 2014). A bone mineral density (BMD) measurement is used in both the screening test and the diagnostic to determine bone strength (Kling et al., 2014). Variation in BMD in young individuals, particularly women, physical activity, BMI, insufficient calcium consumption and an unhealthy lifestyle play a role in osteoporosis in young women (Alghadir et al., 2015). The general practice physical activity questionnaire (GPPAQ) is a novel addition to general practice that is used to assess physical activity in adults. It takes less than a minute to complete and divides people into four categories: inactive, moderately inactive, moderately active, and active. (Ahmad et al., 2015). Millets play an important role in many people's traditional diets across the country. Millets have a number of advantages, including drought resistance, high yield in water-limited locations, and high nutritional content (Ambati and Sucharitha, 2019). Moderate physical activity is a powerful bone stimulant, and lifetime exercise is the most effective technique for increasing bone mass (in premenopausal women) and maintaining bone health (in adulthood and postmenopausal period) (Lombardi et al., 2019). All premenopausal women with osteopenia and osteoporosis should get structured health education emphasizing on the necessity of consuming a large number of calcium-rich foods such as milk and milk products, as well as frequent exercise, to enhance the BMD (John Cecily., 2018). Individuals with osteoporosis have a higher mortality rate due to fracture consequences, which are linked to a lower health-related quality of life. With early detection, it is preventable and can be treated. To address the difficulty of bone health, a multi-pronged strategy of prevention and treatment is required. The impact of physical exercise and a finger millet-based diet supplement on physiological parameters and bone mineral density (BMD) in premenopausal women was investigated in the current study.

Materials and methods

Participants: 720 women of premenopausal age (30 to 40 years), members of a private women’s organization (Kanchi Women’s Sangamam Mutual’s, Tamil Nadu, India) were initially screened for BMD. Among them, 150 women with BMD, t-score of -1 to -2.5 were included in this study. They were divided into control and experimental groups, equally by random number table. Women with mental health problem and other systemic disease were excluded from the study. This study was approved by Institutional Ethics Committee of Saveetha Medical College and Hospital, Chennai (SMCH-IEC/006/04/2019) and carried out between May 2019 to April 2020. An information sheet was provided in English and local language (Tamil) to each participant, and signed consent to participate in the study was obtained.

Methodology: Bodyweight (kg), height (cm), BMI (kg/m2). Weight was measured by a calibrated weighing scale (krupts weighing scale, manufactured by Doctor Beliram & sons, New Delhi). Height was measured by using non-stretching inch tape without shoe heals touching the walls with the back in a straight position and heads to their normal anatomic position. BMI was calculated by the formula, weight/height (m2). BMI was scored as < 18.5 underweight, between 18.5 to 24.9 normal and ≥ 25 as overweight and obese. Body Mass Index was calculated by dividing weight (in kilograms) by the square of the height (in meters). The classification of obtained BMI values (WHO, 2004) and BMD was measured by Ultrasound Bone Densitometer (CM-200, Furuno Electric Co., Ltd., Japan) for all the 720 women. The 557 premenopausal women who did not meet the criteria (BMD, t-score of -1 to -2.5 were excluded and 13 women who did not volunteer to the osteoporosis prevention program, due to personal reasons were also excluded. The 150 women who gave the signed consent...
for the intervention study were allocated randomly to the control and experimental groups. Pre-test information on demographic profile by questionnaire was recorded. The osteoporosis prevention program for the experimental group consisted of general awareness, physical activity and diet supplementation. Structured education was provided once, on osteoporosis prevention (flash cards for 20 min). The physical activity consisted of spine (resistance), hip (strengthening) shoulder (resistance) and knee (strengthening). Pamphlets were given to the experimental group women after demonstration and were instructed to continue for 5 days a week for 3 months. Ragi laddu (finger millet sweet ball) supplement was given to the experimental group, three days per week for 3 months. The laddu was prepared using ragi flour (800g), powdered jaggery (400g) and ghee (300g). 100g of ghee was heated in a frying pan and ragi was roasted for 5 min in low flame. Powdered jaggery was added slowly and remaining ghee was poured, and mixed thoroughly. After cooling the mixture was divided into 10 equal parts and made into laddu (150 g). All hygienic precautions were adhered in the preparation of the laddu by one of the investigators. The laddu was prepared every week fresh and 3 pieces were distributed to each experimental group women during the weekly meeting. A 24-hr recall assessment was carried out for the diet supplement and self-reported activity check list was maintained physical activity. The prepared laddu was certified by an approved food testing laboratory (Chennai Testing Laboratory Pvt Ltd, India). At the end of the experimentation, analysis of height, weight BMI and bone mineral density were carried out for both control and experimental groups as post-test. The physical activity was assessed by General Practice Physical Activity Questionnaire (GPPAQ).

**Statistical analysis**: The data were expressed as mean ± SE and analysed by Students unpaired and paired ‘t’ test. two-way repeated measures ANOVA with Bonferroni ‘t’ test. SigmaPlot 14.5 version (Systat software Inc., USA) was used for the statistical analysis and for plotting the graphs.

**Results**

All the 150 women completed the study. The height of the control and experimental groups women remained the same and ranged from 143 to 169 cm. The mean and SEM of weight of control pre-test, control post-test, experimental pre-test and experimental post-test were 66.3±0.8, 66.5±0.8, 67.0±0.8 and 64.0±0.8 kg respectively (Figure 2). The control and experimental groups pre-test did not show significance (P = 0.537). The control and experimental groups post-test showed significant difference (P = 0.027). The control group pre-test and post-test showed statistically significant increase (P = 0.027). The experimental group pre-test and post-test showed statistically significant decrease (P < 0.001). The mean and SEM of BMI of control pre-test, control post-test, experimental pre-test and experimental post-test were 27.6±0.3, 27.6±0.3, 28.0±0.4 and 26.7±0.4 kg/cm² respectively (Figure 3). The control and experimental groups pre-test did not show significance (P = 0.381). The control and experimental groups post-test showed significant difference (P = 0.050). The control group pre-test and post-test showed statistically significant increase (P = 0.032). The experimental group pre-test and post-test showed statistically significant decrease (P < 0.001).

The mean and SEM of BMD of control pre-test, control post-test, experimental pre-test and experimental post-test were -1.80±0.03, -1.80±0.03, -1.73±0.04 and -0.92±0.04 t-score respectively (Table 1). Two-way RM ANOVA was used for statistical significance. The groups (control and experimental). The tests (pre-test and post-test) and the interaction (group x test) showed statistical significance (P <0.001). The control and experimental groups pre-test did not show significance (P = 0.153). The control and experimental groups post-test showed significant difference (P < 0.001). The control group pre-test and post-test did not show statistical significance (P = 0.928). The experimental group pre-test and post-test showed statistically significant improvement (P < 0.001).

**Discussion**

Osteoporosis is a musculoskeletal condition characterized by decreased bone strength and bone architectural disruption (Choi MH et al., 2021). Osteoporosis that affects young, healthy people who are not postmenopausal or have other, identified secondary causes of the disease. Osteoporosis can result in hip, wrist, spine, and other types of fractures.(Wang et al.,2019).Fractures caused by osteoporosis are linked to an increased risk of death. In addition to an increased financial burden, fractures are linked to decreased physical functions, greater
disability, and poor quality of life (Lianghsu et al., 2020). Maintaining a BMI within the normal range at menarche, physical exercise including mechanical loading during adolescence, and normal pubertal development were all independently linked to increased bone mass. These findings indicate that “peak” bone mass has a bigger impact on the development of osteoporosis in adulthood than age-related bone loss (Martínez-Morillo et al., 2021). In the case of lack of these micronutrients, it is essential to provide Vitamin D and Calcium and providing adequate nutritional replacement. (Cavedon et al., 2021). Exercise is considered as a major component in the prevention and treatment of osteoporosis and the reduction of fractures. The goal of exercise is to improve bone strength, weight bearing exercise that included weight bearing only briefly during warm up and featured any type of aerobic and anaerobic loading of axial skeletal sites due to gravity, i.e. walking, running, dancing These rates may have a beneficial effect on bone (Kemmler et al., 2020). In postmenopausal women, age, BMI, menopause age, year since menopause, and educational level were all linked to an increased risk of osteoporosis. (Tian et al., 2017). One of the minor cereals, finger millet (Eleusine coracana), is noted for its health benefits. It is a significant staple food for low-income people in India. Its nutritional value is well understood due to its high calcium (0.38 percent), dietary fibre (18 percent), and phenolic compounds (0.3–3 percent) content. They’re also known for their health-promoting properties (Devi et al., 2014). In regions of eastern and central Africa, as well as India, finger millet is a staple meal. The best source of calcium and iron is finger millet. Calcium insufficiency causes bone and tooth problems (Singh and Raghuvanshi, 2012). Primary care and preventive medicine should be resumed as soon as it is deemed safe, appropriate, and practicable by healthcare providers. Local impediments to osteoporosis screening and case identification should be identified by metabolic bone experts, who should also address system-level challenges and support primary care (Narla and Adler, 2021). Regular physical activity promotes healthy behaviour in general and, when combined with other healthy lifestyle choices, helps to reduce the risk of diseases that are preventable (Mandic et al., 2020). As a result of the supplementation, BMI decreased in the experimental post-test in the current study. Increased calcium levels are necessary for bone metabolism.

**Conclusion**

The present study showed that physical activity and finger millet diet supplement is beneficial in decreasing the BMI and improving the BMD in premenopausal women. In the premenopausal stage of women, it is essential to prevent and control bone loss to avoid osteoporosis at a later stage.

**Availability of data and materials**

The data are available at the Department of Research and Development, Saveetha Institute of Medical and Technical Sciences (India).

**Declaration of conflicting interest**

The authors declare that there is no conflict of interest.

**Funding**

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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<table>
<thead>
<tr>
<th>S.No</th>
<th>Groups</th>
<th>Mean ± SEM</th>
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<tbody>
<tr>
<td>1</td>
<td>Control Pre-test</td>
<td>-1.80 ± 0.03</td>
</tr>
<tr>
<td>2</td>
<td>Control Post-test</td>
<td>-1.80 ± 0.03</td>
</tr>
<tr>
<td>3</td>
<td>Experimental Pre-test</td>
<td>-1.73 ± 0.04</td>
</tr>
<tr>
<td>4</td>
<td>Experimental Post-test</td>
<td>-0.92 ± 0.04</td>
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**S.No.** Factorial analysis

| Factor 1, Group (control, experimental) | F = 98.619  |
|                                        | P < 0.001  |

| Factor 2, Test (pre-test, post-test)   | F = 1882.681|
|                                        | P < 0.001  |

| Interaction, Group x Test             | F = 1893.870|
|                                        | P < 0.001  |

| Significance within, control pre-test and post-test | t = 0.091  |
|                                                     | P = 0.928  |

| Significance within, experimental pre-test and post-test | t = 61.454 |
|                                                        | P < 0.001  |

| Significance between, pre-test of control and experimental | t = 1.435 |
|                                                           | P = 0.153  |

| Significance between, post-test of control and experimental | t = 18.061 |
|                                                            | P < 0.001  |

**n = 75 each**
Assessment of premenopausal women for serum calcium and bone mineral density
n = 720

Serum calcium < 9.0 mg/dL
n = 372

Bone mineral density -1 to -2.5 t-score
n = 175

Combined: Ca < 9.0 mg/dL and BMD -1 to -2.5 t-score
n = 163

Exclusion criteria
n = 13

Study participants
n = 150

Control
n = 75

Experimental
n = 75

Comparative analysis
Control = 75
Experimental = 75

Figure 1: Flow diagram of the study
Figure 2: The weight of control and experimental groups of premenopausal women. Values are mean ± SE (n = 75 each)

The ‘t’ and ‘P’ Values are by Student unpaired ‘t’ test.

*Significantly different from the respective control group.

The pre-test and post-test of control and experimental groups are compared by Student’s paired ‘t’ test.

For the control group the ‘t’ and ‘P’ values are 2.257 and 0.027 respectively.

For the experimental group the ‘t’ and ‘P’ values are 33.265 and < 0.001 respectively.

*Significantly different from the respective pre-test.
Figure 3: The body mass index of control and experimental groups of premenopausal women.
Values are mean ± SE (n = 75 each)
The ‘t’ and ‘P’ Values are by Student unpaired ‘t’ test.
*Significantly different from the respective control group.
The pre-test and post-test of control and experimental groups are compared by Student’s paired ‘t’ test.
For the control group the ‘t’ and ‘P’ values are 2.186 and 0.032 respectively.
For the experimental group the ‘t’ and ‘P’ values are 32.205 and < 0.001 respectively.
*Significantly different from the respective pre-test.