

## Effect of Exercise Program and Calcium Supplements on Low Bone Mass among Young Indian Women- A Comparative Study

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**Received:** Sep 16, 2011

**Accepted:** Mar 21, 2012

**Key Words:** Calcium Supplementation; Exercise Program; Low Bone Mass; Young Women; Bone Sonometer

### Abstract

**Purpose:** Low bone mass is a major health concern among young women nowadays due to sedentary lifestyle and lack of calcium rich food intake. Therefore there is an increase in the incidence of LBM among young university women so our main purpose of study was to compare effects of exercise program and calcium supplements on bone mass in young women.

**Methods:** This single blinded, cross sectional study included data collection in the form of SOS T-scores at distal radius for 104 young university women of mean age 22.3 years using Sunlight Omnisense Bone Sonometer 7000S. Of these, 62 women with low bone mass were included in a 3 month study but 60 subjects completed the study. They were randomly divided into 3 groups: exercise group (n=21), calcium supplementation group (n=21) and control group (n=20). All participants were evaluated pre and post protocol for T-score distal radius and midshaft tibia.

**Results:** After measuring SOS T-score of 104 subjects; we found that 60.57% had low bone mass and remaining 39.43% had normal bone mass. After 3 months, the exercise group showed significant improvement in distal radius SOS T-score ( $t=5.10$ ,  $P<0.001$ ), at midshaft tibia ( $t=3.71$ ,  $P<0.001$ ) followed by improvement in calcium group at distal radius ( $t=6.28$ ,  $P<0.001$ ), midshaft tibia ( $t=2.33$ ,  $P<0.05$ ) as compared to control group which showed a marginal increase.

**Conclusions:** Exercise group showed more improvement in T-scores than calcium and control group. Exercise is important modifiable factor to improve bone accretion at this age and reduce risk of developing osteoporosis related debilitating conditions later in life.

*Asian Journal of Sports Medicine, Volume 3 (Number 3), September 2012, Pages: 193-199*

## INTRODUCTION

Osteoporosis is the second widespread public health problem after cardiovascular diseases (WHO) which is characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in fracture risk<sup>[1]</sup>. Low bone mass precedes the development of osteopenia, a term used to indicate bones that have become somewhat less dense than normal, but not as severe as in osteoporosis<sup>[2]</sup>. If not treated it may lead to osteoporosis. Though the

traditional definition/diagnosis of osteopenia and osteoporosis were made using DXA scores, which are considered to be the gold standard, practical problems associated with DXA limit its use especially in field studies. Newer methods such as quantitative US are less expensive, involve no exposure to radiations, and are cheaper and have been shown to correlate well with DXA measurements. A recent study using DXA as well as QUS has further added evidence for the use of USD as a screening tool for the detection of LBM and osteoporotic fractures<sup>[3]</sup>.

Osteoporosis and osteopenia are multifactorial in

origin as there are many determinants of bone health including nutrition and physical activity. Studies investigating the influence of physical activity on bone health hence indicated that exercise that increase the ground reaction force (e.g. running, jumping, etc.) may have a greater osteogenic stimulus than those that increase joint reaction force (e.g. resistance training)<sup>[4]</sup>. However, a judicious combination of both is recommended. Literature has also indicated that peak bone mass may be achieved by the age of 30 years as there is measurable bone gain in the third decade<sup>[5]</sup> and a program should be targeted at bone accretion in young women. There is speculation regarding the relative contribution of physical activity and calcium in bone accretion with evidence that the sedentary lifestyle may be implicated in the increasing incidence of low bone mass at younger ages.

There are a number of studies reporting the effect of different types of exercises on bone mineral density<sup>[6-13]</sup>, effect of calcium supplementation on bone mineral density<sup>[14-16]</sup> and also combined effects of calcium and exercise<sup>[17-19]</sup> but there is a paucity of studies targeting the comparative efficacy of these two interventions with each other. This study was devised with a specific objective to observe the effects of exercise program and of calcium supplementation on bone mineral density in young women of the same age and to compare the findings.

## METHODS AND SUBJECTS

### Subjects:

This single blinded, randomized and cross sectional study population consisted of 104 university women from Guru Nanak Dev University, Amritsar, India

between the ages of 19 to 30 years with mean age of 22.3 years who underwent ultrasound densitometry. The mean height, weight and BMI of 104 women were found to be 159.97 cm, 56.42 kg and 22.1 respectively. Comparison of mean age, weight, height and BMI in all the 3 groups is given in Table 1.

Sixty-four young women found to have low bone mass were contacted and requested to volunteer for the study. 62 women gave their consent and volunteered to participate. The subjects included in our study were not on any medications such as corticosteroids, prior calcium supplements; were not having any other musculoskeletal disease. These 62 subjects were randomly divided into 3 groups; exercise group (n=21), calcium supplementation group (n=21) and control group (n=20). 2 subjects left in between and 60 subjects completed the study. Pre and post protocol readings of SOS T-score were noted at 2 sites of the body i.e. distal radius and midshaft tibia in all the 3 groups.

### Bone Measurements:

Bone mass was obtained in the form of SOS T score with Sunlight Omnisense 7000S Ultrasound Bone Sonometer which measures SOS at distal 1/3 radius and midshaft tibia<sup>[20]</sup>. The same operator performed all measurements in order to minimize operator and technical inter-variability. T score is a standard deviation of a patient's BMD as compared to healthy young population. As per WHO criteria and modified by IOF, osteoporosis can be diagnosed by BMD values as follows: (i) Normal: BMD not more than 1 standard deviation (SD) below young adult mean ( $T > -1$ ), (ii) Osteopenia: BMD between 1 and 2.5 SD below young adult mean (T score between  $-1$  and  $-2.5$ ), (iii) Osteoporosis: BMD 2.5 SD or more below young adult mean (T- score at or below  $-2.5$ ). For every standard deviation below peak BMD, fracture risk increases by 50% to 100% (WHO 2003).

**Table 1:** Comparison of means of age, weight, height and BMI in all the 3 groups

Variables	Group 1 (Exercise)	Group 2 (Calcium)	Group 3 (Control)
Age	22.4	21.55	22.95
Height (cm)	159.76	160.45	160.9
Weight (kg)	55.35	55.6	56.15
Body Mass Index	21.81	21.66	21.73

**Exercise protocol group:**

The exercise protocol consisted of dynamic impact loading exercises (DILE) for the upper limb in the form of wall pushups and jumping for the lower limb. Subjects were taught the DILE during their first visit. Subjects stood facing a wall, with the shoulder flexed 90° and their elbow and wrist fully extended. The subject's feet were positioned so that their wrist was 40 cm from the wall. A distance of 40 cm reliably generated relatively high loading forces (as compared to distances of 20 and 30 cm) during the DILE [12]. We also determined the position of feet from the wall. The subjects then did wall pushing movement with both the elbows extended. Each subject was instructed and supervised until she could perform the exercise correctly. To standardize the loading events during the intervention period, subjects were instructed to perform their exercise on the same hard load-bearing surface during each exercise session. Subjects performed the loading exercise 40 cycles/day, 5 days/week for a total of 3 months. Supervision was not provided over the intervention period, because the task was simple and easily reproducible. All subjects were required to maintain their physical activity levels, exercise regimen throughout the length of the study.

Subjects also performed two-legged maximum vertical jumps 25-30 times using an arm swing in countermovement style on 5 days/wk. To ensure good compliance by the subject they were instructed to perform jumps as they get up from bed in the morning. The jumps were performed barefoot at home on a relatively hard floor. The interval of each jump was ~8-12 sec [9].

**Calcium supplementation group:**

The subjects were given 500 mg/day (Recommended Dietary Intake) of elemental calcium in form of calcium

carbonate along with vitamin D3 (250 IU) at breakfast during the 3 months of study.

**Control group:**

The subjects assigned to control group were on dietary modulation for 3 months with calcium rich foods with special emphasis on intake of milk and milk products without any other source of calcium.

**Statistical Analysis:**

Pre and post protocol readings were recorded and data was analyzed using SPSS 17.0 software. For continuous variables mean and standard deviation were calculated and for categorical variables percentage was calculated. Students T test was used for intragroup comparison of all the 3 groups. Anova and Post Hoc Scheffe's tests were used to analyze intergroup differences.

**RESULTS**

Out of 104 subjects, we found that 60.57% were having low bone mineral density out of which 47.11% were in osteopenic range and 13.46% osteoporotic and the rest 39.43% were normal.

The exercise group showed significant improvement in distal radius SOS T score (t=5.10, P<0.001) and at midshaft tibia (t=3.71, P<0.001) followed by improvement in calcium supplementation group at distal radius (t=6.28, P<0.001) and at midshaft tibia (t=2.33, P=0.031) as compared to control group which showed negligible increase in T score. Table 2 shows comparison of basal pre readings in all 3 groups for distal radius and midshaft tibia.

**Table 2:** Comparison of basal pre readings in all 3 groups for distal radius and midshaft tibia

Group	Site	Pre protocol		Group	Site	Pre Protocol		t value
		Mean (SD)	SE			Mean (SD)	SE	
Exercise	Distal Radius	-1.68 (0.64)	0.143	Calcium	DR	-1.98 (0.61)	0.14	1.53*
	Midshaft Tibia	-1.72 (1.02)	0.23		MT	-0.87 (1.22)	0.27	0.42*
Exercise	Distal Radius	-1.68 (0.64)	0.143	Control	DR	-1.69 (0.69)	0.15	0.07*
	Midshaft Tibia	-1.72 (1.02)	0.23		MT	-1.1 (1.12)	0.25	1.14*
Calcium	Distal Radius	-1.98 (0.61)	0.14	Control	DR	-1.69 (0.69)	0.15	-1.4
	Midshaft Tibia	-0.87 (1.22)	0.27		MT	-1.1 (1.12)	0.25	0.63*

\* Non significant; SD: Standard Deviation; SE- Standard Error

**Table 3:** Comparison of SOS T score distal radius and midshaft tibia pre and post protocol in all 3 groups

Group	Site	Pre protocol		Post Protocol		t value	P value
		Mean (SD)	SE	Mean (SD)	SE		
Exercise	Distal Radius	-1.68 (0.64)	0.14	-1.31 (0.54)	0.12	5.1	<0.001
	Midshaft Tibia	-0.72 (1.02)	0.23	-0.4 (0.81)	0.18	3.71	<0.001
Calcium	Distal Radius	-1.98 (0.61)	0.14	-1.81 (0.56)	0.12	6.28	<0.001
	Midshaft Tibia	-0.87 (1.22)	0.27	-0.73 (1.07)	0.24	2.33	<0.05
Control	Distal Radius	-1.69 (0.69)	0.15	-1.67 (0.64)	0.14	0.79	0.4
	Midshaft Tibia	-1.1 (1.12)	0.25	-1.01 (1.1)	0.25	1.2	0.2

SD: standard deviation; SE: standard error

Table 3 shows comparison of SOS T score of distal radius and midshaft tibia pre and post protocol in all the 3 groups.

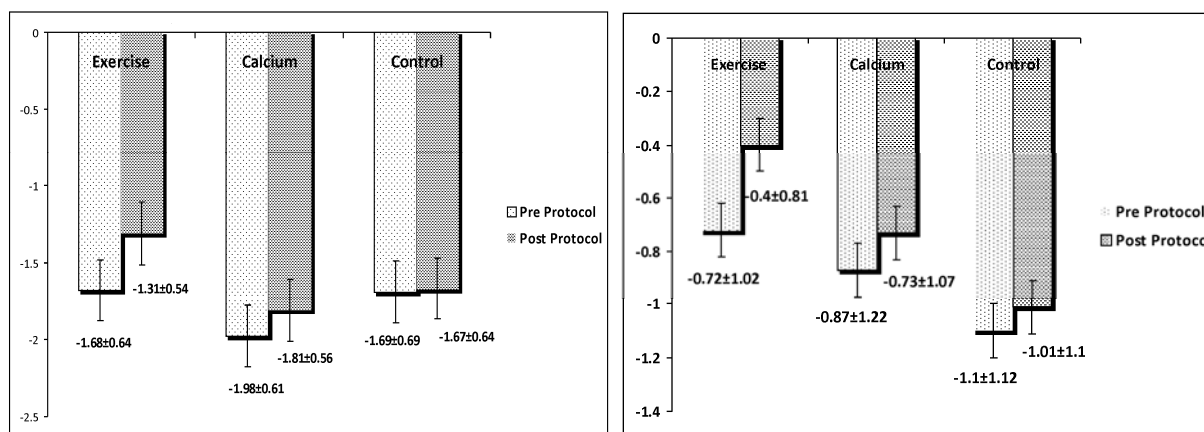
Fig. 1 shows mean  $\pm$  standard deviation of SOS T scores pre and post protocol at distal radius and midshaft tibia respectively in all the 3 groups. Table 4 shows Distribution of mean values, one way analysis of variance (ANOVA) and post hoc scheffe's test results of SOS T-score distal radius in all 3 groups.

Significant between conditions differences have been found which showed that there was overall difference in efficacy of exercise and calcium supplementation in improvement of BMD distal radius ( $P=0.03$ ) but no significant difference was noted at midshaft tibia ( $P=0.3$ ). Also significant difference was found between exercise and control group at distal radius ( $P<0.001$ ). Although differences between calcium supplementation and control group are statistically not significant, but the level of significance is higher in calcium supplementation group as shown by related t test.

## DISCUSSION

QUS measures the SOS values which reflect bone properties and bone health. In the machine that we used, the SOS values were measured. The T-score was calculated by the machine taking the difference between the patient's SOS result and the peak average SOS of young healthy population. We used quantitative ultrasound as a method of measuring bone mass as it has a T-score equivalence similar to that of dual-energy X-ray absorptiometry (DXA) [21].

We had hypothesized that as young educated women, most of our volunteers had the circumstances that would be optimal for bone health. Specifically, they had access to healthy nutrition as well as would be involved in adequate physical activity in the form of walking on a large campus. However we found that incidence of low bone mass in the range of osteopenia was high among these women. 13.46% of the women had low bone mass corresponding to the osteoporotic



**Fig. 1:** represents mean  $\pm$  standard deviation of SOS T scores pre and post protocol at distal radius (left) and midshaft tibia (right) in all the 3 groups

**Table 4:** Distribution of mean values, one way analysis of variance (ANOVA) and post hoc scheffe’s test results of SOS T-score distal radius in all 3 groups

Variable (SOS T- score)	(1)Exercise group (N=20)	(2)Calcium group (N=20)	(3)Control group (N=20)	ANOVA	Comparison Group	P value
<b>Distal radius</b>	0.37 (0.32)	0.18 (0.13)	0.02 (0.14)	F=12.647 P=0.000***	1 Vs 2	0.03
					1 Vs 3	<0.001
					2 Vs 3	0.09
<b>Midshaft tibia</b>	0.32 (0.39)	0.14 (0.27)	0.09 (0.33)	F=2.72 P=0.074 <sup>NS</sup>	1 Vs 2	0.3
					1 Vs 3	0.09
					2 Vs 3	0.9

range whereas 47.11% in osteopenic range and 39.43% normal. This indicates that these young women had low bone mass which was much lower than the peak average values expected for young women that age. A limitation of this study is the fact that we used a convenience sample of university students and the sample is not representative of the general population.

It has been recently observed that young females are also prone to low bone mineral density despite the fact that osteoporosis is usually seen in postmenopausal women. Fatima et al, 2009 also concluded that the prevalence of osteoporosis and osteopenia is high among young Pakistani women i.e. 43.4 % were osteopenic and 12.9% were osteoporotic as measured using QUS [22]. Another study also observed that frequency of decreased BMD was 64% in women < 30 years, 55% in women between 31 – 45 years and 73.9% in women > 45 years as measured with QUS [23]. A study including elite Iranian female athletes having female athlete triad showed that there is negative changes in BMD and cardiovascular biomarkers in these female athletes which may be due to functional hypothalamic menstrual dysfunction [24].

The observation of a high incidence of low bone mass critical enough to be considered osteopenia in this young population deserves further attention. On one hand it signifies that they are at a greater risk of developing osteoporosis in later life. On the other hand it may simply imply that this young population was in general slow to mature and perhaps has not developed adequate bone mineralization. On the other hand factors such as increasing sedantism and the preference for physical inactivity due to greater hours spent indoors with computers and television could also be responsible [22] for the prevalence of low bone mass in this population. Assuming that the status of risk

factors for these women does not change, a large proportion of young women will develop osteoporosis-related fractures in the future. Prevention is the only cost effective approach for identification of young people at high risk of osteoporosis by improving bone accretion at this age that will further improve health related quality of life and will reduce the personal and economic burden of osteoporosis.

The present study was also undertaken with an objective of comparing the efficacy of exercise regimen and calcium supplementation on BMD at two sites i.e. distal radius and midshaft tibia. For confirming the hypothesis that exercise regimen was better than calcium supplementation to improve BMD, 60 osteopenic and osteoporotic young women were included in the study.

The results of the study showed that the trend for SOS T score distal radius curve had increased with a 22.02% increase observed in the exercise group followed by an 8.6% increase in the calcium supplementation group. Compared to these percentage increases the control group showed a non significant increase in BMD.

The findings that exercise has a positive effect on the SOS T score is consistent with a previous study by Wang et al, 2004 which reported that impact load from dynamic impact loading exercises accounted for 58% of the variance in BMD change at the distal radius and 66% of the variance in BMD change at total distal radius site [12]. These results may be attributed to the loading characteristics i.e. dynamic impact loading exercises produce impact loads approximately 33% of body weight [12].

The results of our study showed that the values for SOS T scores at midshaft tibia had also increased with a 44.44% increase in exercise group followed by



16.09% increase in calcium supplementation group. Comparatively, control group also showed an increase in T score with 8.18% increase.

Further irrespective of the causative factors involved in the observation of the a large percentage of our population demonstrating low bone mass, the fact that exercise training using high impact loading did increase the bone mass confirms the potent role of exercise training parameters related with bone health. Further it also strengthens the notion that these young women though physically active did not meet adequate thresholds for physical activity to stimulate mineralization. It is possible that the recommendations that suggest population specific guidelines for defining cutoffs for osteopenia and osteoporosis need further analysis based on the fact that several studies, though not related to bone health have observed that Asians in general have lower levels of physical activity and are the most cause of concern when it comes to meeting the recommended guidelines [25-27].

The results of our finding confirmed the previous information by Kato et al., 2005 that jumping intervention significantly increased BMD at the femoral neck whereas BMD in the control group remained unchanged after 6 months of exercise intervention [9]. Loading with many repetitions at one time had a relatively small additional effect on bones compared with loading of only 10–40 repetitions [27]. So, we instructed the subjects to do 25-30 jumps per day. These results suggested that exercise training during adulthood, as well as youth, is very important for bone health.

The effect of calcium supplementation in our study was consistent with the previous finding that calcium supplementation significantly increases bone mineral content at various sites [18] and Daniele et al, 2004 also showed the positive effect of calcium and Vitamin D supplementation in women both peri- and post-menopausal status [29].

The improvement in BMD noted in our study despite the intervention of 3 months was due to the age group of the subjects recruited and the fact that peak bone mass is thought to be attained by the end of the third decade, the early adult years are the final opportunity for its augmentation. Since our participants did not involve themselves in any sporting activity, the sudden stimuli to the bone by increasing physical activity as well as the fact that they were still young, the osteogenic response and increase in accrual of bone mineral in young women may have been greater.

In our study, almost all the subjects showed an improvement in BMD but were not able to reach normal values; only two of the osteopenic subjects reached normal values and two of the osteoporotic reached osteopenic values in the exercise group. A longer study would have indicated the average time for remineralisation of the measured sites to achieve SOS T scores considered normal for their age.

## CONCLUSION

A large percentage of young women were found to have low bone mass. Exercise training as an intervention was found to be effective in gaining bone mass. Exercise training is an important intervention to make substantial gains in bone mass at this age and is an important modifiable factor to improve bone accretion at this age.

## ACKNOWLEDGMENTS

We thank all the subjects who participated in the study for their cooperation.

**Conflict of interests:** None

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