Original Article

# Bone mineral density and biochemical markers in evaluation of bone health in women

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**Objectives:** To determine the incidence of osteopenia and osteoporosis in women aged between 40-65 years and find the association between Bone mineral density (BMD) and biochemical parameters.

**Methodology:** The study was conducted in women aged between 40-65 years visiting Gynecology Department of Vivekanand Polyclinic & Institute of Medical Sciences, Lucknow, India. Body mass index (BMI) was calculated and BMD was measured in terms of T-scores and Z-scores. Estimation of serum biochemical and serum FSH level was done. The statistical analysis was done using SPSS v. 15.0.

**Result:** Out of 100 women, low BMD was observed in 35% out of which 30% had oesteopenia and 5% had osteoporosis. 88.6% subjects with BMI between 18 to 25 kg/m2 had low BMD, whereas only 11.4% with BMI between 24-30 kg/m2 were found to be suffering from low bone mass. Low serum calcium levels were seen in 54.3% women having low BMD. Higher levels of serum alkaline phosphatase and serum FSH seemed to be associated with low BMD.

**Conclusions:** We found that 65.7% of subjects between 40-50 years and 22.9% of cases between 51 to 60 years had low BMD. In women having serum calcium level less than 8.7 mg% chance of having osteopenia and osteoprosis was almost similar in both perimenopausal and post menopausal women. Higher FSH levels were found to be associated with bone loss. (Rawal Med J 2014;39:376-380 ).

**Key words:** Osteoporosis, bone mineral density, biochemical markers.

## INTRODUCTION

Osteoporosis is defined as a disease characterized by low bone mass and micro architectural deterioration of bone tissue leading to enhanced bone fragility and a consequent increase in fracture risk.[1] It is a global problem affecting 150 million men and women worldwide. Our knowledge of the problem in India is limited and most of the available data is from industrialized nations. About 30% of postmenopausal white women in USA are affected by osteoporosis and the proportion rises to 70% in women over the age of 80 years.[2] Osteoporosis is emerging as a major health problem in view of the increasing number of older people in India. It is estimated that in India 61 million people are affected by osteoporosis out of which 80% are female.[3] BMD testing is the preferred method to diagnose osteoporosis[2].

Biochemical markers of bone turnover have been shown to provide valuable information for the diagnosis and monitoring of metabolic bone resorption and bone formation. Therefore, they may provide a representative index of the overall skeletal bone mass. Serum calcium, serum inorganic phosphate and serum alkaline phosphatase may be used as markers of bone turnover.[4]

The aim of this study was to determine the incidence of osteopenia and osteoporosis in women aged between 40-65 years, to assess the association of BMD with age and body mass index and to find the association between BMD and biochemical parameters like serum calcium, serum inorganic phosphate, serum alkaline phosphatase, serum magnesium and serum FSH.

## METHODOLOGY

The study was conducted in women aged between 40-65 years visiting Gynecology Outpatient Department of Vivekananda Polyclinic and Institute of Medical Sciences, Lukhnow, India after approval from Institutional Ethical Committee and after an Informed Consent. Women with body weight between 40 to 80 kg were included in the study. Those suffering from hypertension, diabetes,

thyroid and parathyroid disorders, asthma, malignancies, hepatic and renal disorders and prolonged immobilization, women on corticosteroids or hormonal therapy and women with body weight <40 Kg or >80 Kg were excluded from the study.

After clinical evaluation, height (cm) and weight (kg) were determined and Body Mass Index (BMI) was calculated. BMD was measured in right calcaneum by Dual Energy X-ray Absorptiometry using DEXA (Lunar Prodigy, GE, USA). Clinical forearm software was used for scanning the calcaneus. The scan area was 100x86 mm. BMD values were measured in terms of T-scores and Z-scores. T-score was the difference between the individual patient's bone mineral density and the mean results obtained in young adult population expressed in units of young population standard deviation. Z-score was the difference between the individual patient's results and the mean results obtained in an age matched population expressed in units of the age matched population standard deviation. Osteoporosis definition was according to WHO (Table 1).

**Table 1. WHO osteoporosis definition is based on T-score results.**

| | |
|---|---|
| Normal bone mass | – T-score> = –1.0 |
| Osteopenia | – T-score –1 and –2.5 |
| Osteoporosis | – T-score < –2.5 |
| Severe osteoporosis– least one fracture | T-score < –2.5 with at |

Blood sample was analyzed for total serum calcium, serum inorganic phosphate, serum alkaline phosphatase and serum magnesium. Serum FSH level was determined by using microparticle immunoassay technique (In case of perimenopausal women, blood samples were collected between 3rd and 5th day after menstruation in follicular phase). The statistical analysis was done using SPSS V. 15.0. Level of significance was p <0.05.

## RESULTS

Out of the 100 women, 65 had normal bone mineral density, 30 had osteopenia while the remaining 5 had osteoporosis. For the purpose of analysis, they were divided into two groups:

Group I: Patients with low BMD (n = 35) (osteopenia and osteoporosis, T-score <-1.0) and

Group II: Patients with normal BMD (n = 65) (T-score ≥-1.0),

**Table 2. Association between BMI and bone mineral density.**

| Variable | Osteopenia/ Osteoporosis (n=35) (T-score <-1.0) | | Normal (n=65) (T-score ≥-1.0) | | Chi square | Statistical Significance |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | $\chi^2$ | p |
| BMI Category (kg/m$^2$) | | | | | | |
| <18 - Underweight | 0 | 0.0 | 3 | 4.6 | 32.896 | <0.001 |
| 18-25 - Normal weight | 31 | 88.6 | 19 | 29.2 | | |
| 26-30 - Overweight | 4 | 11.4 | 33 | 50.8 | | |
| >30 - Obese | 0 | 0.0 | 10 | 15.4 | | |

Of 35 women with osteopenia and osteoporosis, 23(65.7%) were of 40-50 years of age, 8(22.9%) women of 51-60 years and only 4 (11.4%) of more than 60 years. Normal BMD was observed in 65 subjects of whom 54(83.1%) were between 40-50 years and 11(16.9%) between 51-60 years. Statistically a significant association between age and low BMD was seen (p=0.013).

**Table 3. Biochemical parameters and BMD.**

| Variable | Osteopenia/ Osteoporosis (n=35) (T-score < -1.0) | | Normal (n=65) (T-score ≥-1.0) | | Chi square | Statistical significance |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | $\chi^2$ | p |
| **Serum Calcium levels** (mg%) | | | | | | |
| Low (<8.7) | 19 | 54.3 | 15 | 23.1 | 10.114 | 0.006 |
| Normal (8.7-11) | 14 | 40.0 | 46 | 70.8 | | |
| High (>11) | 2 | 5.7 | 4 | 6.2 | | |
| **Serum Inorganic Phosphate levels** (mg/dl) | | | | | | |
| Normal (2 to 5) | 32 | 91.4 | 59 | 90.8 | 0.012 | 0.912 |
| High (>5) | 3 | 8.6 | 6 | 9.2 | | |
| **Serum Alkaline Phosphatase levels** (U/L) | | | | | | |
| Normal (28-78) | 13 | 37.1 | 43 | 66.2 | 7.771 | 0.005 |
| High (>78) | 22 | 62.9 | 22 | 33.8 | | |
| **Serum Mg levels** (mg/dl) | | | | | | |
| Low (<1.7) | 1 | 2.9 | 6 | 9.2 | 3.272 | 0.195 |
| Normal (1.7-2.7) | 32 | 91.4 | 50 | 76.9 | | |
| High (>2.7) | 2 | 5.7 | 9 | 13.8 | | |

It was seen that osteopenia and osteoporosis (low BMD) were more common in lower BMI categories as compared to higher BMI groups. None of the subjects having BMI >30kg/$m^2$ were found to have low BMD (Table 1). Statistically, a significant association between BMD and BMI category was seen (p<0.001).

**Table 4. Serum FSH Levels.**

| Serum FSH Levels (IU/L) | Osteopenia/ Osteoporosis (n=35) (T-score <-1.0) | | Normal (n=65) (T-score ≥-1.0) | | Chi square | Statistical significance |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | $\chi^2$ | p |
| <15 | 6 | 17.14 | 32 | 49.23 | 18.103 | <0.001 |
| 15-25 | 1 | 2.86 | 3 | 4.62 | | |
| 26-45 | 5 | 14.29 | 15 | 23.08 | | |
| >45 | 23 | 65.71 | 15 | 23.08 | | |

Low serum calcium levels were seen in 54.3% of women with low BMD and 23.1% of women having normal BMD while high serum calcium levels were seen in 5.7% of participants having low BMD and 6.2% having normal BMD (Table 3). A significant difference was seen between the two groups (p=0.006).

Low BMD, thus, seemed to be associated with higher serum alkaline phosphatase levels (p=0.005). No significant association between serum magnesium levels and low BMD could be seen (p=0.468). Subjects with normal BMD had lower FSH levels while those with high levels (>45 U/L) of FSH had varying degree of osteopenia and osteoporosis (Table 4). Statistically, this difference was significant (p<0.001).

**Table 5. BMI and menopausal status in relation to T-score.**

| BMI Category | Perimenopausal | | | Postmenopausal | | | Significance of difference | |
|---|---|---|---|---|---|---|---|---|
| | n | Mean T-score | ±SD | n | Mean T-score | ±SD | "t" | "p" |
| Underweight | 3 | -0.500 | 0.80 | 0 | 0 | 0 | – | – |
| Normal | 33 | -1.406 | 0.61 | 17 | -1.88 | 0.74 | 2.426 | 0.019 |
| Overweight | 26 | -0.608 | 0.81 | 11 | -0.87 | 0.62 | 0.966 | 0.341 |
| Obese | 6 | 0.467 | 0.77 | 4 | -0.60 | 0.16 | 2.693 | 0.027 |

In women with normal BMI, there were 33 perimenopausal and 17 postmenopausal subjects and their mean T-scores were -1.406±0.61 and -1.88±0.74, respectively. The mean T-score of postmenopausal subjects were significantly lower as compared to that of perimenopausal subjects (p=0.019). In overweight category, there were 26 perimenopausal and 11 post-menopausal subjects, the mean T-scores of postmenopausal subjects were lower yet the difference from pre-menopausal subjects was not significant (p=0.341). Among obese category, the mean T-score of perimenopausal subjects was significantly higher as compared to that of postmenopausal group (p=0.027) [Table 5].

**Table 6. Association of biochemical parameters with T-scores in different menstrual stages.**

| Variable | | Perimenopausal | | | Postmenopausal | | | Significance | |
|---|---|---|---|---|---|---|---|---|---|
| | | n | Mean T-score | ±SD | n | Mean T-score | SD | "t" | "p" |
| **Serum Calcium** (mg %) | Low (<8.7) | 22 | -1.382 | 0.77 | 12 | -1.500 | 0.84 | 0.412 | 0.683 |
| | Normal (8.7-11) | 42 | -0.65 | 0.89 | 18 | -1.306 | 0.88 | 2.625 | 0.011 |
| | High (>11) | 4 | -0.800 | 0.84 | 2 | -1.25 | 1.06 | 0.577 | 0.595 |
| **Serum Inorganic Phosphate** (mg/dl) | Normal (2 to 5) | 59 | -0.880 | 0.92 | 32 | -1.375 | 0.85 | 2.514 | 0.014 |
| | High (>5) | 9 | -1.000 | 0.83 | – | – | – | – | – |
| **Serum Alkaline Phosphatase** (U/l) | Normal (28-78) | 40 | -0.733 | 0.91 | 16 | -1.250 | 0.72 | 2.022 | 0.048 |
| | High (>78) | 28 | -1.129 | 0.86 | 16 | -1.500 | 0.96 | 1.320 | 0.194 |
| **Serum Magnesium** (mg/dl) | Low (<1.7) | 5 | -0.860 | 0.84 | 2 | -0.550 | 0071 | 0.490 | 0.645 |
| | Normal (1.7-2.7) | 56 | -0.905 | 0.96 | 26 | -1.465 | 0.90 | 2.505 | 0.014 |
| | High (>2.7) | 7 | -0.843 | 0.47 | 4 | -1.200 | 0.37 | 1.290 | 0.229 |

In the low serum calcium category, both the groups had low T-scores. When level of serum inorganic phosphate was normal, the mean T-score in perimenopausal group was significantly higher as compared to that in postmenopausal group (p=0.014). In women with normal serum alkaline phosphatase, the mean T-score of perimenopausal group was significantly higher as compared to that in postmenopausal group (p=0.048). This implies that higher serum alkaline phosphatase level may be predictor of osteopenia/osteoporosis. It was observed that in women with low Magnesium level, mean T-score values were high for both peri and postmenopausal groups (Table 6).

## DISCUSSION

In our study, 30% had osteopenia while 5% had osteoporosis. We found that 22.9% of cases between 51 to 60 years had low BMD. Above 60 years of age all were osteoporotic but the group was small and limits to generalize the statement. Our study is comparable to Gandhi et al.[5] who reported

osteopenia and osteoporosis in 34% and 8% of women above 40 years. In their study, incidence of low bone density was 38.22% in women between 41 to 50 years and 39.36% in cases between 51 to 60 years. Similar to our findings, they observed that all women above 60 years were osteoporotic.

Another study showed that the incidence of osteoporosis was 20.25% and that of osteopenia was 36.79% with maximum number of cases in the age group of 55-64 years.[6] It was noted that after 65 years, there was an almost 100% incidence of either osteopenia or osteoporosis.[6] The increase in incidence of low bone mass in postmenopausal women might be due to low estrogenic activity.

We observed a statistically significant association between BMD and BMI; 88.6% women had low BMD when their BMI was between 18-25 kg/m$^2$. Similar findings were reported by Kirchengast et al.[7] who found that women having BMI between 25-29 kg/m$^2$ had higher BMD than normal weight women. Low body weight was associated with low bone mass.[8] It has been pointed out that the prevalence of osteoporosis in women with BMI less than 25 kg/m$^2$ was higher than in women with BMI over 25 kg/m$^2$.[9] Fawzy et al[10] from UAE reported that BMD was low in 82.4% of people with normal BMI, 78.1% among overweight, and 44.2% among obese. There was a statistically significant association between these two variables ($p<0.001$). A study from Iran showed that ageing and low BMI were risk factors associated with bone loss.[11] Obesity may produce higher bone mass due to the association of fat mass with secretion of bone active hormones, improved status of vitamin D storage in fatty tissues and due to weight bearing effect of excess soft tissue on skeleton.

Women with serum calcium level less than 8.7 mg% were prone to have osteopenia and osteoprosis in both perimenopausal and post menopausal groups (Table 3). Our findings were comparable to other studies.[4,12-14] The observations were further supported by evidences of estrogen deficiency which stimulates bone resorption and this results in modification of excretion and resorption of calcium and phosphate ions.

In our study, 37% of women with low BMD had normal serum alkaline phosphatase levels. Thus, high serum alkaline phosphatase levels seemed to be associated with low BMD. Similar findings were reported by others.[4,15] Alkaline phosphatase is an enzyme that plays an important role in osteoid formation and mineralization. In adults, with normal liver function, approximately 50% of total alkaline phophatase activity in serum in derived from bone. Total alkaline phosphatase level is a useful marker in assessing mineralization activity of osteoblasts in postmenopausal women.

In calcium and bone metabolism, magnesium plays an important role. Low Magnesium level and high mean T-score values were seen in both peri and postmenopausal women. Contradictory to our findings, Saito et al.[14] showed low magnesium levels in women with low bone density. But their study was conducted in elderly inpatients above 80 years of age.

Higher serum FSH levels were found to be associated with low BMD. Our results were comparable to another study, which showed an association between bone loss and high serum FSH levels in African-American, Caucasian, Chinese and Japanese women.[17] The limitation of the study is its small size.

## CONCLUSION

Present study suggests that various factors like age, BMI, and menopausal status affect BMD. BMD can be assessed by simple technique and common biochemical parameters like levels of calcium, alkaline phosphatase and FSH in serum may also indicate bone turnover.

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