*Biomedical & Pharmacology Journal*, December 2018. Vol. **11**(4), p. 2209-2214

# Comparison of Bone Mineral Density with Biochemical Parameters and Prevalence of Osteopenia and Osteoporosis in South Indian Population

**P. Modagan[1]*, Santhi Silambanan[1], P. Gopinath Menon[1] and P. Arunalatha[2]**

[1]Department of Biochemistry, Sri Ramachandra Medical College and Research Institute, Chennai, India.
[2]Department of Pathology, Stanly Medical College, Chennai, India.
*Corresponding author E-mail: pmodagan@gmail.com

http://dx.doi.org/10.13005/bpj/1603

(Received: 18 July 2018; accepted: 30 November 2018)

**Osteoporosis is identifying based on the bone mineral density (BMD). The bone mineral mass or BMD exposes the amount of minerals present in a particular region of bone tissue. BMD measurement by DEXA is consideredas gold standard, but it is very expensive. The people of developing countriesare not interested to check BMD until the occurrence offracture. Therefore present study focusing any association of routine biochemical markers with BMD in osteoporosis and also planning to identify disease distribution status in south India. We examined 773 participants BMD by DEXA scan and grouped into three, Group I (Normal bone mass, n=237), group II (Osteopenia, n=345) and group III (Osteoporosis, n=191). The serum calcium, phosphorous and alkaline phosphatase (ALP) were estimated by automated chemistry analyzer., and Serum 25(OH) vitamin D was analyzed by immunoassay system analyser. The prevalence of normal BMD, osteopenia and osteoporosis was 30.7%, 44.6%and 24.7% respectively.Between 60 and 69 years aged men having more prevalence of osteopenia and in women 50 to 59 years of age. While osteoporosis in men 50 to 59 years and in women's were 60 to 69 years of age. The serum calcium, ALP and 25 (OH) vitamin D levels were statistically significant (p< 0.001) between the three groups.The higher percentage of low bone mineral density (osteopenia) is the alarming signalto the bone health and this could be continued leads to osteoporosis, which affects the quality of life. This study suggests to determining BMD along with biochemical markers are useful to identify osteoporosis in earlier stage. Therefore routine screening of BMD may prevent the risk of osteoporosis.**

**Keywords:** Osteoporosis, Osteopenia, DEXA, South Indian, BMD, Fractures.

Osteoporosis is a systemic skeletal disease attributed by impaired mineralization and disturbs in the microarchitecture of bone tissue, which in turnleads fragility and susceptibility to bone fractures. This is considerable to increase disease and deathrate[1,2]. The prevalence of osteoporosis in Asia and Africa (developing countries) varies from 5% to 68% among women aged greater than 50 years and osteoporotic fractures estimation in south East Asia was 17.4%, given by WHO and International osteoporosis fact sheet[3]. In India very few studies have been carried out to determine the prevalence of osteoporosis among post-menopausal women.The prevalence of

osteoporosis (very low bone mass) and osteopenia (low bone mass) in Indian women over the age of 50 years approximately 46 million women's having osteoporosis (year 2015) and 50 million women's having osteopenia (year 2013); this was reported inKhadilkar and Mandlikstudies. The other few studies osteoporosis prevalence rate from 8% to 62% has been reported[4].

Bone mineral density is a major factor, which determines the strength and quality of bone; any degree of decline in the normal level of BMD leads to future risk of fracture. BMD measurements by DEXA scan as "Gold standard" for the diagnosis of osteoporosis in post-menopausalwomen. When reporting the BMD results the DEXA scan provides T score. This was major supporting elementsin the clinician for diagnosis of disease. This T score was compared and calculated form the reference standard of gender specific young normal adult skeletal status. Based on the WHO criteria[5], osteoporosis is identified by "T-score value of bone mineral density more than 2.5 SD below the mean for young healthy normal adult women (T-score < -2.5). Patients with BMD values between 1 and 2.5 SD below the mean for young adults (T-score between -1.0 and -2.5) are classified as having osteopenia"[6].

Proper nutrition and maintenance of standard bone mass in first, second and third decades of life may reduce osteoporosis and fracture risk in further decades of life. Several epidemiological studies conclude that a 10% increase in peak bone mass from childhood may decrease adult bone fracture risk in 50%. Thus it is difficult to increase peak bone mass during the first two decades of life, when up to 90% of peak bone mass is gained. Several factors are deciding the optimal skeletal acquisition such as heredity, physical activity, and diet containing Vitamin D and calcium etc[7,8]. Once body growth under normal, the concentrations of bone markers in biological fluids return to a level much below those seen during normal puberty and growth. This stabilisation usually occurs during the 3rd decade and levels of the markers remain more or less unchanged until 70 years of age[9].

Several studies on osteoporosis traced out the related factors for loss of BMD. They are advanced aging, sex, smoking, menopause, body weight, height, obesity, fat deposition, intake of alcoholic beverages, supplementation of calcium, muscle strength, family history of osteoporosis etc.,[2]. This study was mainly concentrating the prevalence of osteoporosis and osteopenia in both male and female adult population and to determine the importance of biochemical markers with BMD in osteoporosis.

## MATERIALS AND METHODS

This cross sectional study was carried out at Sri Ramachandra Medical College and Research Institute, Chennai, Tamil Nadu, India, during the period of August 2016 to March 2018. The study protocol was reviewed and approved by the institutional ethics committee based on ICMR guidelines on biomedical research in human beings and clinical practice. The written informed consent was obtained from participants voluntarily involved in the study.

**Study participants**

The individuals attending master health check-up department for whole body health check-up who were referred further for BMD measurements to the DEXA scan and those who willing to answer the study questionaries' were enrolled in the study. A total of 773 participants with the age group between 30-90 years of both sexes were selected for research study. They were grouped according to T score of BMD into three, Group I = Normal bone mass (n=237), Group II = Osteopenia (n=345) and Group III = Osteoporosis (n=191).

**Exclusion Criteri**

Patients with malignancy, chronic kidney and liver disease, rheumatoid arthritis, ankylosing spondylitis,hyperparathyroidism, thyroid disease, chronic smokers, patients on drugs - steroids, Immunosuppressive therapy,antiepileptic's, bisphosphonates, vitamin-D, calcitonin and teriparatide.

Detailed history of demography, diet, exercise, smoking, menstrual history, medication and previous bone fractures and family history of bone disease were taken.

**BMD Measurement**

The BMD was assessed using the DEXA densitometer (GE Lunar Prodigy., Advance Bone Densitometer., US) at Left proximal femur (total hip, femoral neck, shaft, Ward's triangle, and trochanter) and anteroposterior (AP) lumbar spine

(L2–L4, L2-L3, and L3-L4) by experienced same technician for entire study. BMD values were expressed as the amount of bone mineral content per $cm^2$ area and the obtained values. Every Day before starting DEXA scan a quality assurance block and spine phantom tools were used in measuring the accuracy and performance of the scanner. The T-score was determined based on WHO definition of osteoporosis and osteopenia for Caucasian women: "Normal = T-score at or above -1.0 SD; Osteopenia = -1.0 to -2.5 SD; Osteoporosis = T- score at or below -2.5 SD"[10].

**Anthropometric characteristics**

The electronic digital scale was used to measure participants actual weight to the nearest 0.1 kg and height was measured using a stadiometer and the body mass index (BMI) was calculated by weight in kg / height in $m^2$. Waist-to-hip ratio, waist circumference in cm / hip circumference in cm was determined according to the standard procedure.

**Biochemical Analysis**

The venous blood (5ml) was collected after overnight fasting. The serum was separated and analysed for the biochemical parameters – 25(OH) vitamin D by chemiluminescencemicroparticle enhanced immunoassay (CMIA) method (Unicel DXI 600., Access Immuno Assay system., BECKMAN COULTER., US) and the CRP by particle enhanced turbidimetric immunoassay (PETIA) method,calcium by O-Cresolphthaleincomplexone method**,** phosphorus by Fiske and Subbarow method and ALP by pNPP- AMP method (AU680., Chemistry system BECKMAN COULTER., US).

**Statistical analysis**

The continuous variables were expressed as mean ± standard deviation and the categorical variables were presented as percentages. One way ANOVA was used to determine statistical difference between group means among the three groups and Tukey's HSD post hoc test was used to identify and conform where the difference occurred between groups by SPSS software, version 20 (IBM SPSS Statistics, 20., US). The p value <0.05 is considered statistically significant.

## RESULTS

The prevalence of osteoporosis and osteopenia were 24.7% and 44.6 % respectively and normal bone mass was 30.7% among the 773 south Indian study population of Tamil Nadu. In the whole study population, 69.3% of people have low bone mineral density, which was combined osteoporosis and osteopenia group and only 30.7% of people have normal BMD. The normal and diseased ratio was 1.0:2.2.

## DISCUSSION

A bone mineral density examination can provide a progress of your bone health, identification of osteoporosis, osteopenia or low bone mass and determination of risk of fractures and monitored the treatment responses. The most widely recognized BMD test called DEXA scan, this was used to identify people with osteoporosis[11].

Bala S *et al* reported that the prevalence of osteoporosis in rural and urban post-menopausal women of Hyderabad 51% and 35% respectively and osteopenia 16% and 38% respectively. Another study among the post-menopausal rural Haryana and urban Delhi found that 78% and 58%[3].

We found that low bone mass and very low bone mass was 69.3% (osteopenia (44.6%) and osteoporosis (24.7%)) and normal bone mass was 30.7% among the 773 participants. In the female study population the osteopenia was higher in post-menopausal women (14.9%) and osteoporosis was higher in pre-menopausal women (10.3%).

Our study reveals that the highest prevalence of osteopenia in male was observed in the age group of 60 to 69 years and in the female 50 to 59 years. While osteoporosis in male was 50 to 59 years and in females were 60 to 69 years of age.

According to Asian criteria the BMI ranges from 18.5 to 22.9 is considered normal weight, 23 to 24.9 overweight, 25 to 29.9 pre obese and >30 obese[12].

Based on this criteria our study participants of osteopenia group reached in the pre-obese state (27.02 ± 4.9) and in the osteoporosis group is in normal (23.6 ± 4.9). The BMI significantly raised in osteopenia group (< 0.001) compared with the other two groups. Similarly the waist hip ratio also increased in osteopenia group (1.05±0.5) compared with normal bone mass and osteoporosis group.

Morin *et al*. had previously confirmed that obese people having high BMD[13]. But in our study

report was contrast from the above study result.

KhatakePD*et al* reported that the mean serum calcium was 8.34±0.47 in postmenopausal women. Calcium ion is an essential structural and integral component of the bone. Estrogens deficiency leads to increased loss of calcium by indirect effects of extra skeletal calcium regulation and impaired calcium absorption in intestinal tissue, this was occurring in women with after menopause. Deficiency of calcium, due to hormonal dysregulation and malabsorption may lead to disorders of bone mainly in the case of osteopenia and osteoporosis[14].

Our study result represents the mean serum calcium levels in osteopenia and osteoporosis were 9.1mg/dl and 8.9 mg/dl respectively. And the

**Table 1.** Percentage distribution of three groups of study participants

| Total no. of participants = 773 | Male 380 (49.1%) | Female 393 (50.9%) | Pre-menopausal 157(20.3%) | Post-menopausal 236(30.6%) |
|---|---|---|---|---|
| Group – I (n=237, 30.7%) | 131 (16.9%) | 106 (13.8%) | 21 (2.8%) | 85 (11%) |
| Group – II (n=345, 44.6%) | 174 (22.5%) | 171 (22.1%) | 56 (7.2%) | 115 (14.9%) |
| Group – III (n=191, 24.7%) | 75 (9.7%) | 116 (15%) | 80 (10.3%) | 36 (4.7%) |

**Table 2.** Age group wise percentage distribution of three groups of study participants

| Age group (years) | Group-I (n=237) | | Group-II (n=345) | | Group-III (n=191) | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| 30-39 | 20(8.4%) | 24(10.1%) | 22(6.4%) | 17(4.9%) | 5(2.6%) | 3(1.6%) |
| 40-49 | 26(11%) | 39(16.5%) | 43(12.5%) | 31(9.0%) | 10(5.2%) | 9(4.7%) |
| 50-59 | 35(14.8%) | 28(11.8%) | 40(11.6%) | 63(18.2%) | 27(14.1%) | 27(14.1%) |
| 60-69 | 34(14.3%) | 12(5.1%) | 52(15.1%) | 47(13.6%) | 17(9%) | 52(27.2%) |
| 70-79 | 14(5.9%) | 3(1.4%) | 16(4.6%) | 12(3.5%) | 12(6.3%) | 20(10.5%) |
| 80-89 | 2(0.8%) | - | 1(0.3%) | 1(0.3%) | 4(2.1%) | 5(2.6%) |

**Table 3.** ANOVA results of anthropometric, biochemical and DEXA findings of the study participants

| Characteristics | Group - I (n=237) Mean ± SD | Group - II (n=345) Mean ± SD | Group – III (n=191) Mean ± SD | p value |
|---|---|---|---|---|
| Age(years) | 51±12 | 54±11 | 60±11 | < 0.001 |
| BMI(kg/m$^2$) | 24.3±3.4 | 27.02±4.9 | 23.6±4.9 | < 0.001 |
| WR | 1.0±0.5 | 1.05±0.5 | 1.02±0.6 | < 0.001 |
| Calcium(mg/dl) | 9.5±0.3 | 9.1±0.3 | 8.9±0.5 | < 0.001 |
| Phosphorous(mg/dl) | 3.8±0.4 | 3.9±1.1 | 3.8±0.4 | 0.632 |
| ALP(U/L) | 92.8±16.3 | 92.2±31 | 103.6±42 | < 0.001 |
| 25OH Vit. D(ng/ml) | 19.8±7.4 | 22.7±9.4 | 14.3±7.5 | < 0.001 |
| NF BMD(g/cm$^2$) | 1.09±0.16 | 0.890±0.11 | 0.704±0.1 | < 0.001 |
| NF T score | 0.03±0.9 | -1.5±0.425 | -2.9±0.49 | < 0.001 |
| LS BMD(g/cm$^2$) | 1.16±0.1 | 0.964±0.08 | 0.801±0.09 | < 0.001 |
| LS T Score | 0.1±1.05 | -1.6±0.43 | -3.0±0.76 | < 0.001 |

SD: standard deviation, BMI: body mass index, WR: waist hip ratio, ALP: alkaline phosphatase, 25 OH Vit. D: 25 hydroxy vitamin D, NF BMD: neck of femur bone mineral density, NF T score: neck of femur T score, LS BMD: lumbar spine bone mineral density, LS T Score: lumbar spine T Score

**Table 3a.** Results of tukey's HSD post hoc test (biochemical and DEXA findings) among the three groups

| Characteristics | Group | Std. Error | 95% Confidence Interval Lower Bound | Upper Bound | p value |
|---|---|---|---|---|---|
| Calcium(mg/dl) | I vs II | .03425 | .2977 | .4586 | <0.0001 |
| | I vs III | .03947 | .4961 | .6815 | <0.0001 |
| | II vs III | .03661 | .1247 | .2966 | <0.0001 |
| Phosphorous(mg/dl) | I vs II | .06998 | -.2283 | .1004 | 0.632 |
| | I vs III | .08065 | -.2074 | .1714 | 0.973 |
| | II vs III | .07481 | -.1297 | .2216 | 0.812 |
| ALP(U/L) | I vs II | 2.65976 | -5.6008 | 6.8907 | 0.968 |
| | I vs III | 3.06546 | -17.9807 | -3.5837 | <0.001 |
| | II vs III | 2.84329 | -18.1039 | -4.7504 | <0.0001 |
| 25-OH Vit. D(ng/ml) | I vs II | .71213 | -4.4997 | -1.1551 | <0.0001 |
| | I vs III | .82075 | 3.5945 | 7.4492 | <0.0001 |
| | II vs III | .76127 | 6.5616 | 10.1369 | <0.0001 |
| NF BMD($g/cm^2$) | I vs II | .01093 | .1764 | 0.2278 | <0.0001 |
| | I vs III | 0.01260 | .3580 | .4172 | 0.000 |
| | II vs III | 0.01169 | .1580 | .2129 | 0.000 |
| LS BMD($g/cm^2$) | I vs II | 0.01281 | .1676 | .2277 | 0.000 |
| | I vs III | 0.01476 | .3261 | .3954 | 0.000 |
| | II vs III | 0.01369 | .1309 | .1953 | 0.000 |

ALP: alkaline phosphatase, NF BMD: neck of femur bone mineral density, NF T score: neck of femur T score, LS BMD: lumbar spine bone mineral density, LS T Score: lumbar spine T Score

baseline levels of serum phosphorous were not statistically significant among the three groups.

Bandeira F*et al* reported that vitamin D (25 OH) deficiency was associated with lower BMD at neck of femur. Labronici PJ *et al* found that 91.1% of patients (osteopenia) have low BMD associated with least vitamin D levels and 62.5% of patients with osteoporosis have low BMD associated with vitamin D deficiency[15]. In concordance with above studies the low BMD and 25 (OH) vitamin D deficiencies (14.3ng/dl ±7.5) is highly associated in osteoporosis and highly statistical significant difference (< 0.001) was observed between the three groups.

The present study reveals that the serum ALP level significantly increased in osteoporosis (<0.001) and there was no statistical difference in normal bone mass (92.8±16.3) and osteopenia (92.2±31). Therefore ALP level could be used as a preclinical assessment tool for osteoporosis.

## CONCLUSION

The occurrence of osteoporosis and osteopenia is not restricted to post-menopausal women; it is found to be prevalent in men and pre-menopausal women as well. The complication of osteoporosis cause clinical and economic burden of people living in developing countries, this may due to lack of awareness and expensive screening test leads to complete decline in quality of life. More number of studies needed for simple and low cost screening test for BMD. Osteoporosis is a preventable disease therefore routine BMD measurement along with biochemical markers estimation would giveabetter understanding of disease and improves the clinical and nutritional management.

## ACKNOWLEDGEMENT

This study was supported by Founder Chancellor Sri N.P.V.RamasamyUdayar Research Fellowship in Sri Ramachandra Medical College and Research Institute.

## REFERENCES

1. Leali PT, Muresu F, Melis A, Ruggiu A, Zachos A, Doria C. Skeletal fragility definition. *Clinical*

*Cases in Mineral and Bone Metabolism.;* **8**(2):11-13 (2011).

2. Annamalai D, Lal D. Correlation of anthropometric measurements with bone mineral density in south Indian population. *International Journal of Orthopaedics Sciences.*; **4**(1):221-224 (2018).
3. Bala S, Prabha M, Krishna T. Prevalence and risk factors of low bone mineral density with quantitative ultrasonography among south Indian postmenopausal women. *International Journal of Community Medicine and Public Health.*; **3**(7):1735-1740 (2016).
4. Khadilkar A, Mandlik R. Epidemiology and treatment of osteoporosis in women: an Indian perspective. *International Journal of Women's Health.;* 7:841-850 (2015).
5. Mohamed WW, Abas MA.Bone Mineral Density Assessment in Pre- and Postmenopausal Women: Comparison Between T-Scores by Heel QUS and DXA in HRPZII. *The Medical Journal of Malaysia.*; **67**:487-490.
6. Blake G, Fogelman I. The role of DXA bone density scans in the diagnosis and treatment of osteoporosis. *Postgraduate Medical Journal.;* **83**(982):509-517 (2007).
7. Bergh JJPW Van Den. Need of Calcium and Vitamin D in Patients after a Recent Fracture. *Food Nutr Sci.;* **3**: 539–47 (2012).
8. Bauer DC. Calcium Supplements and Fracture Prevention. N Engl J Med [Internet].; **369**(16):1537–43 (2013). Available from: http://www.nejm.org/doi/10.1056/NEJMcp1210380
9. Yousef F. MA. Peak Bone Mass and Prevention of Osteoporosis in Adolescence: Role of Vitamin D and Calcium. *World Journal of Medical Science.;* **12**(2):170-182 (2015).
10. Labronici PJ, Blunck SS, Lana FR, Esteves BB, Franco JS, Fukuyama JM, *et al*. Vitamin D and its Relation to Bone Mineral Density in Postmenopause Women. Rev Bras Ortop (English Ed [Internet]. *Sociedade Brasileira de Ortopedia e Traumatologia;* **48**(3):228–35 (2013). Available from: http://linkinghub.elsevier.com/retrieve/pii/S2255497113000578
11. Small RE. Uses and Limitations of Bone Mineral Density Measurements in the Management of Osteoporosis. *Medscape General Medicine.;* **7**(2):3 (2005).
12. Lim J, Lee J, Kim J, Hwang Y, Kim T, Lim S *et al*. Comparison of World Health Organization and Asia-Pacific body mass index classifications in COPD patients. *International Journal of Chronic Obstructive Pulmonary Disease;* **12**: 2465-2475 (2017).
13. Morin S, Tsang JF, Leslie WD. Weight and body mass index predict bone mineral density and fractures in women aged 40 to 59 years. *Osteoporosis International.*; **20**(3):363–70 (2009).
14. Khatake PD, Jadhav SS, Afroz S. Relation between Serum Calcium Level, Bone Mineral Density and Blood Pressure in Postmenopausal Women. *International Journal of Recent Trends in Science and Technology.*; **7**(3): 86-88 (2013).
15. Bandeira F, Griz L, Freese E, Lima DC, Thé AC, Diniz ET, *et al*. Vitamin D deficiency and its relationship with bone mineral density among postmenopausal women living in the tropics. *Arq Bras Endocrinol Metabol;* **54**(2):227–32 (2010).
16. Wright NC, Looker AC, Saag KG, *et al*. The recent prevalence of osteoporosis and low bone mass in the United States based on bone mineral density at the femoral neck or lumbar spine. *J Bone Miner Res.*; **29**(11):2520-6 (2014).
17. Tian L, Yang R, Wei L, *et al*. Prevalence of osteoporosis and related lifestyle and metabolic factors of postmenopausal women and elderly men: A cross-sectional study in Gansu province, Northwestern of China. Medicine (Baltimore); **96**(43):e8294 (2017).
18. Cho JH, Kim MT, Lee HK, Hong IS, Jang HC. Factor analysis of biochemical markers associated with bone mineral density in adults. *J Phys Ther Sci.;* **26**(8):1225-9 (2014).
19. Garg N, Kumar A, Goel P. Prevalence of osteoporosis in a rural population of Muzaffarnagar district. *JIACM*; **13**(3):185-8 (2012).
20. Ho-Pham LT, Nguyen UD, Pham HN, Nguyen ND, Nguyen TV. Reference ranges for bone mineral density and prevalence of osteoporosis in Vietnamese men and women. *BMC* Musculoskelet Disord. 2011;12:182. Published 2011 Aug 10. Doi: 10.1186/1471-2474-12-182.