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# Correlation of anthropometric measurements with bone mineral density in south Indian population

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**Abstract**
There is no data or very limited data available about the relation between anthropometric measurements like weight and height, and bone mineral density based on sex and age of South Indian population. Identifying persons at risk of sustaining osteoporotic fractures is crucial for the prevention of fracture. Therefore the present was undertaken for the identification, prevention and timely treatment of osteoporosis. The study population consisted of 350 patients (both male and female patients). The study was conducted during the period of January 2016 to November 2017. Patients with risk factors for osteoporosis as per WHO criteria were included for the study. Patients with Osteomyelitis, fracture, tumor pathology or trauma in bone were excluded from the study. Out of 350 patients, 110 were male subjects (31.5%) and 240 females (72.2%). Correlation analysis was used to investigate the continuous variables related with bone mineral density (BMD). Data were analyzed by means of SPSS version 16.0 using t-test and one way ANOVA. There is high prevalence of osteoporosis among men and women of this population. It can be concluded that certain anthropometric parameters (BMI and weight) can considerably affect one's risk of developing osteoporosis. Therefore, weight and BMI can be used as to screen those at risk of developing osteoporosis and its related complication.

**Keywords:** Osteoporosis, South Indian population, Bone mineral density, height, weight, body mass index.

## Introduction

Osteoporosis is a common public health problem, growing in both developed and developing countries [1, 2]. Fractures in hip and spine are known to be the most important complication of the disease which leads mortality and serious morbidity [3]. Osteoporosis is a systemic skeletal disease characterized by low bone mass and deterioration of bone tissue with consequent increase in bone fragility and susceptibility to fractures (1). Bone mineral density (BMD) is a significant determinant of fracture risk [4 - 6].

In osteoporosis, bone is normal but reduced in density (bone mass per unit volume of bone tissue). DEXA (Dual Energy X-ray absorptiometry) is the gold standard in quantitatively estimating bone mineral density [3-5]. Ultrasonic densitometers do not have a risk of radiation, are portable and there are reports to show that the sensitivity is similar to DEXA. However they have a limitation of their use in spine. DEXA and bone densitometer enable early diagnosis of this disorder [3-6].

Recent studies on osteoporosis traced out the related factors for loss of Bone mineral density. They are aging, sex, smoking, menopause, body weight, height, obesity, fat deposition, alcohol consumption, calcium intake, muscle strength, family history of osteoporosis etc [7-10].

There is no data or very limited data available about the relation between anthropometric measurements like weight and height, and bone mineral density based on sex and age of South Indian population. Identifying persons at risk of sustaining osteoporotic fractures is crucial for the prevention of fracture. Several instruments are available to identify osteoporosis risk in people of different ages who are likely to have osteoporosis. Hence it is better, they should undergo bone densitometry. Hence, it is important to determine the best clinical strategy to identify osteoporotic people who at high risk of fracture. Therefore the present was undertaken for osteoporosis identification, prevention and timely treatment. Aim of the present study is to know the relationship of body mass index (BMI) and bone mineral density (BMD) and also to

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study the relationship of anthropometric measurements like height, weight and BMD.

## Material and Methods

The study population consisted of 350 patients (both male and female patients) visiting outpatient department of Orthopaedics of Karpaga Vinayaga Hospital, a teaching hospital and tertiary care center in Kancheepuram district of Tamilnadu, India. The study was conducted during the period of January 2016 to November 2017. The study was approved by the institutional ethics committee. The mean age of the males (110) participating in the study was 56±14 years and that of the females (240), was 52±11 years.

The study consists of 350 patients in the age range of 40 years who had one or more of the risk factors for osteoporosis as per WHO criteria. Patients with Osteomyelitis, fracture, tumor pathology or trauma in bone were excluded from the study.

Measured anthropometric indices included height, weight; waist circumference (WC) and hip circumference (HC) were measured by a trained person and a single method in all centers. Weight was measured using a digital electronic weighing scale without shoes with ±100 grams accuracy. Height was measured without shoes, in standing posture, by a tape meter stadiometer with 1 mm accuracy.

Body mass index was calculated by dividing weight to square of height, and subjects were categorized to four groups of underweight (BMI<18.5 kg/m2 ), normal (BMI= 18.5-24.9 kg/m2), overweight (BMI= 25-29.9 kg/m2) and obese (BMI≥ 30 kg/m2) (16). Waist and hip circumferences were measured using the standard protocols and Waist-to-hip ratio (WHR) was simply calculated by dividing WC to HC.

The instrument used was Achilles express bone ultra densitometer. Bone Mineral Density measurements using QUS (Quantitative Ultra Sound) parameters were taken at three different locations: neck of femur, total femur, and lumbar spines. The subjects were classified based on these results as per WHO criteria into normal, Osteopenia, and Osteoporosis or severely osteoporotic. The measurement was done by the same technician over the whole duration.

Data were analyzed by means of SPSS version 16.0 using t-test and one way ANOVA (for comparing the mean of BMD in BMI categories). Variables were normally distributed and there was a linear relationship between the dependent and independent variables. Categorical variables were expressed as percentages and compared using Chi-square. Linear regression analysis was done to determine the independent effect of variables related with BMD.

## Results and Discussion

Data were completely available for 350 subjects, consisting of 110 males (31.5%) and 240 females (72.2%). A summary of demographic and anthropometric features of the population are presented in table 1. Correlation analysis was used to investigate the continuous variables related with BMD. BMD showed significant positive correlation with height, weight, BMI ($P< 0.01$, Table 2) while there was a negative correlation was found between age and BMD. This association existed regardless of the location of BMD measurement (correlation coefficient was equal to 0.392 for height vs femoral neck BMD and 0.475 and 0.482 for neck of femur vs BMD, BMI vs BMD respectively). With comparing the mean of BMD in BMI categories, there were significant differences between groups. Post hoc analysis showed that all groups were different from each other ($P<0.001$, Table 3). Furthermore, there was a rising trend in BMD means when BMI raised in

BMI categories (Table 3). Further analyses showed that a linear regression model fit for the effects of age, current smoking, physical activity less than 3 times per week and BMI on BMD was statistically significant for all of the variables in different BMD sites ($P<0.001$, Table 4).

Assessing the results for adjusted data for sex and age revealed that the weight has the most partial correlation with BMD at total hip and femoral neck (Table 2). Regression Analysis yielded a model for predicting BMD values at L1-L4 and total hip using weight as the strongest predictor. The model accounted for 22% of the variance of BMD at L1-L4, and 28% of the variance of total hip. The ratio of standardized coefficients of weight to age showed a twofold greater effect of weight on BMD at L1-L4 and total hip compared with age (Table 4).

In this study there were 240 females of which 191 were menopausal and they were above 45 years of age. 49 were non-menopausal and they were below 45 years. There were 56 females in obese group (23.4%), 127 normal (52.9%) and 57 lean (23.7%). Of the obese group out of 56 there were 35 (62.5%) above 45 years of age, the remaining 21 (37.5%) were below 45 years of age. In normal group out of 127 females 79 (62.2%) were above 45 years and 39 (30.78) were below 45 years of age (Table 3 and table 4). Above 45 years of age females there were 100 (51.4%) normal, 47 (24.6%) osteopenia, 44(23%) osteoporotic. This observation shows that obesity in females confers protection against bone mineral loss especially in postmenopausal group.

In the present study there were 110 men of which 90 were above 50 years and 20 were below 50 years. There were 110 males out of which, 51 (46.4%) were having normal bone mineral loss, 37 (33.6%) were lean, 18 (16.4%) were obese (Table 3 and table 4). The normal group of the 55 men, there were 36 (32.7%) of them above 50 years and the rest 19(67.3%) of them were below 50 years. In the lean group out of the 37, above 50 years 10 males (27%) were normal, 12 (32.4%) were osteopenic and 9 (24.3%) were osteoporotic. In obese group out of the 18 above 50 years males there were 4 (22.2%) osteopnic, 2 (11.2%) osteopenic. This observation showed that obesity did not show any protection against bone mineral loss [11-13].

In this study average weight of men was 66 kg which is almost same as that of osteoporotic men which was 64 kg. The average body weight of osteoporotic females is 56 kg., which is lower as compared to non-osteoporotic female which is 54 kg. So in our study we observed that the body weight show significant correlation with BMD in both males and females (Table 1). The average height of women was 158 cm. In osteoporotic women was 155 cm. The males in our study of had average height of 169 cm whereas the non osteoporotic group had a mean height of 165 cm. So there was no significant difference. So in our study we observed that the height show significant correlation with BMD in females but it did not show significant correlation in both males and females.

Nearly more than 61 million Indians are reported to be osteoporotic, of these 80% are females [12 -14]. With the increase in age the number is going to rise. Thus osteoporosis is a formidable health problem in our country and globally. Peak bone mass is reached at around 25-35 years thereafter bone loss occurs steadily. It is about 6% decrease in Indians [15-17]. Malhotra N [15] observed that India has the highest prevalence of osteoporosis and osteopenia in world followed by Japan and also that bone loss may commence earlier in them.

Osteoporosis is an important public health problem particularly in older adults. It is more common in postmenopausal women and not only gives rise to morbidity but also markedly diminishes the quality of life in this population. Many factors have so far been linked with osteoporosis and bone loss. Aging is considered as the strongest factor contributing to bone loss and osteoporosis [16]. Nutritional factors, lifestyle habits, including the daily diet and physical activity, as well as anthropometric factors are other parameters ranking first in the long list of osteoporosis-related risk factors [16-18].

Morin *et al.* had previously confirmed that higher weight is accompanied by higher mineral density and lower risk of fractures in women aged 40 to 59 years [16]. Weight loss regimens and surgeries are in wide use around the world. Weight loss could result loss in bone mineral density, especially in obese women. This effect may vary depending on the method used for weight loss [17–19]. We also noted a positive correlation between weight and bone mineral density in our study sample. Our data could not be used for further investigation about the effect of weight loss one BMD, due to the cross-sectional design of the study. Another limitation of this study is that nutritional state of this population was not evaluated exactly and these parameters may have impact on bone density.

Sadatsafavi *et al.,* reported that body weight and weight changes theoretically affect the precision of spine and hip density in DXA measurements [18]. Saarelainen *et al.,* also reported that obesity (BMI of 30 kg/m2) delays the incidence of osteopenia by 5 years (at the spine) and 9 years (at the femoral neck). They suggested that high baseline BMD of the obese or the fact that higher fat mass in the obese alters X-ray attenuation can explain the finding [20].

Ozeraitiene *et al.,* similarly, reported that women with osteoporosis were older and overweight, had lower height and body weight, indicating that fat reserves are significantly related to low bone mineral density [21]. DargentMolina *et al.,* concluded that selecting women for BMD testing based on their weight is the simplest, but most effective screening method for identifying osteoporotic women as well as those at high risk of fracture [22].

**Table 1:** Anthropometric measurements of male and female patients of the study population

| Anthropometric variables | Gender | |
|---|---|---|
| | Male (n=110) Mean ± SD | Female (n=240) Mean ± SD |
| Age (years) | 56 ± 14 | 52 ± 11 |
| BMD L1 – L4 (g/cm$^2$) | 1.04 ± 0.19 | 1.02 ± 0.16 |
| BMD Femoral Neck (g/cm$^2$) | 0.85 ±0.13 | 0.81 ± 0.15 |
| BMD Total Hip (g/cm$^2$) | 0.90 ± 0.15 | 0.93 ± 0.16 |
| Height (cm) | 169 ± 6 | 158 ± 8 |
| Weight (Kg) | 66 ± 8.2 | 56 ± 7.5 |
| BMI (Kg/m$^2$) | 23.4 ± 6.2 | 22 ± 5.9 |
| Waist Circumference (WC) | 88 ± 11 | 86 ±9 |
| Hip Circumference (HC) | 93 ± 8 | 101 ± 6 |

**Table 2:** Pearson correlation of anthropometric measures and BMD values of the study population

| Parameter | BMD L1 – L4 | BMD femoral neck | BMD total HIP |
|---|---|---|---|
| Age | -0.391* | -0.414* | -0.254 |
| Height | 0.309 | 0.392* | 0.250 |
| Weight | 0.455** | 0.388* | 0.490** |
| BMI | 0.395* | 0.475** | 0.482** |
| WC | 0.359* | 0.463** | 0.521** |
| HC | 0.410* | 0.357* | 0.342 |

*Pearson Correlation is significant at the 0.05 Level and ** Pearson Correlation is significant at the 0.01 Level

**Table 3:** Age wise distribution of patients and comparison with bone mineral density

| Age | | Bone Mineral Density | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Normal | | Osteopenia | | Osteoporosis | | |
| | | n | % | n | % | n | % | |
| 40 – 50 years | Male | 9 | 8.2 | 5 | 4.5 | 6 | 5.5 | 20 |
| | Female | 22 | 9.2 | 17 | 7.1 | 14 | 5.8 | 53 |
| 51 – 60 years | Male | 30 | 27.2 | 15 | 13.6 | 10 | 9.1 | 55 |
| | Female | 64 | 26.6 | 39 | 16.3 | 24 | 10 | 127 |
| >60 years | Male | 18 | 16.4 | 7 | 6.4 | 10 | 9.1 | 35 |
| | Female | 26 | 10.8 | 13 | 5.5 | 21 | 8.7 | 60 |

**Table 4:** Distribution and association of BMI with bone mineral density

| BMI | | Bone Mineral Density | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Normal | | Osteopenia | | Osteoporosis | | |
| | | n | % | n | % | n | % | |
| Normal | Male | 41 | 37.2 | 8 | 7.3 | 6 | 5.5 | 55 |
| | Female | 98 | 40.8 | 17 | 7.1 | 12 | 5 | 127 |
| Lean | Male | 12 | 11.0 | 15 | 13.5 | 10 | 9.1 | 37 |
| | Female | 12 | 5 | 21 | 8.7 | 24 | 10 | 57 |
| Obese | Male | 12 | 11.0 | 4 | 3.6 | 2 | 1.8 | 18 |
| | Female | 29 | 12.2 | 13 | 5.4 | 14 | 5.8 | 56 |

**Conclusion**

There is high prevalence of osteoporosis among men and women of this population. It can be concluded that certain anthropometric parameters (BMI and weight) can considerably affect one's risk of developing osteoporosis. Therefore, height, weight and BMI can be used as to screen those at risk of developing osteoporosis and its related complication; further research, however, are needed to assess the efficacy of height in this regard. The present study confirms the presence of a positive association between anthropometric measures like weight and body mass index with bone mineral density in different locations. It should also be noted that the present study has not adjusted the data for clustering effect; further studies are therefore needed to overcome this limitation. Another limitation of this study is that nutritional status of this population, which was not evaluated and may have impact on bone density.

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