Prevalence of osteoporosis and osteopenia in an apparently healthy Indian population - a cross-sectional retrospective study

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1. Introduction

Osteoporosis is a global public health problem affecting over 200 million people worldwide. It is a disease characterized by reduction in the bone mass and disruption of bone architecture leading to impaired skeletal strength and an increased predisposition for fractures [1–3]. Osteoporosis has clinical and public health implications because of the mortality, morbidity, and cost of medical care related with osteoporotic fractures [4]. Hip fractures are a useful surrogate for determining the international burden of osteoporosis [5,6]. About 1.6 million hip fractures occur each year worldwide and the incidence is set to increase to 6.3 million by 2050 with major increase projected outside of Europe and the United States [7]. It is estimated that more than about 50% of all osteoporotic hip fractures in the world will occur in Asia by the year 2050 [8]. In India, there were around 26 million osteoporosis cases in 2003, while in 2013, 50 million people were either osteoporotic or had low bone mass. An annual incidence rate (hip fractures) of 163 and 121 per 100,000 per year in women and men, respectively, above the age of 55 years has been reported in a study in North India [9].
Although osteoporosis occurs in all populations, not all populations are at equal risk [10]. Studies have reported that Asian women have higher predisposition for osteoporosis than their Caucasian counterparts [11]. Reasons attributed for lower bone mineral density (BMD) in Indians include possible genetic differences, nutritional deficiency and smaller skeletal size [9]. In a review article, Lei et al. [12] noted that though osteoporosis is a serious health problem in both Caucasians and Asians, both are 2 distinct major ethnic groups, which may have differential genetic determination underlying complex genetic diseases such as osteoporosis. Bone phenotypes are determined by both genetic and environmental factors and their interactions. Rapidly accumulating data have reported that the genetic factors can explain about 50%–90% of total BMD variation. A number of bone-related candidate genes, such as the estrogen receptor gene and vitamin D receptor gene, alpha2-HS-glycoprotein and parathyroid hormone, have been investigated for their association with bone phenotypes [12]. Additionally, there are differences in bone health between ethnic groups in both men and in women. Variations in body size and composition are likely to contribute to contributed differences [12].

An understanding of BMD pattern in a population is crucial for prevention, diagnosis of osteoporosis and management of its complications in later life [14]. There is not much data on prevalence of osteoporosis/osteopenia in healthy Indian population. We undertook current investigation to examine the prevalence of osteoporosis/osteopenia and related risk factors in an apparently healthy Indian population.

2. Methods

This was a single-center, cross-sectional investigation in which retrospective data were collected in Max Super Specialty Hospital, Saket, New Delhi (a tertiary care hospital) after requisite approvals from Scientific Committee and the Institutional Ethics Committee of Max Super Specialty Hospital (TS/MSHH/SKT-21/ENDO/IEC/15–11). There was no direct contact with the subjects in this retrospective study; therefore, requirement for informed consent was waived off. This study did not involve any intervention or therapy, and the research involved no risks to the subjects. Subjects were identified by subject ID numbers only, and their names and identity were not disclosed in any way during or after this database review study. Hence, subject data confidentiality has been maintained.

We reviewed the medical records of adult males and females who had voluntarily visited the hospital for general health check-up and had willingly chosen the health plans including measurement of BMD and laboratory investigations. The consecutive sampling method was used to collect the data.

2.1. Data collection

The data on sex, age (year), weight (kg), height (cm), body mass index (BMI, kg/m²), history of smoking, alcohol consumption, exercise status (presence/absence for all) and dietary habits (vegetarian/nonvegetarian diet) were recorded. Subjects who underwent bone scanning with dual-energy-X-ray absorptiometry (DXA) machine (Lunar Prodigy Advance DXA System, GE Healthcare) during health check-ups. The absolute areal BMD values (g/cm²) and T scores were available for care) during health check-ups. The absolute areal BMD values (g/cm²) and T scores were available for...

2.2. Statistical analysis

Descriptive data were presented as mean ± standard deviation or number (%), unless specified. Univariate analysis was done by Student t-test, chi-square test and 1-way analysis of variance as appropriate. Pearson correlation was calculated to assess the relationship between BMD with age and other parameters at various skeletal sites. We reassessed the relationships by partial correlation analysis after adjustment for the known confounders for low BMD as applicable. A stepwise multiple regression analysis was done to identify the significant associated factors with BMD. A 2-sided P-value of <0.05 was considered statistically significant. Bone status analysis was done using World Health Organization classification based on T score: normal BMD (T score ≥ –1), osteopenia (T score < –1 and > –2.5) and osteoporosis (T score ≤ –2.5). Statistical analysis was performed using IBM SPSS Statistics ver. 20.0 (IBM Co., Armonk, NY, USA).

3. Results

We studied 524 subjects (age, 50.0 ± 12.4 years; range, 20–85 years) who were categorised into 2 groups based on sex. Study population included 216 females (41.2%) and 308 males (58.8%) with a mean age of 50.7 ± 11.9 years and 49.6 ± 12.8 years (P < 0.313), respectively (Table 1).

3.1. Baseline characteristics and laboratory parameters

The baseline characteristics and laboratory parameters of the study population stratified by sex are presented in Table 1. Height and weight were significantly higher in males (both P < 0.001) as compared to females. Males had significantly higher VLDL, TG, UA (all P < 0.001) and bicarbonate levels (P = 0.039); and significantly lower ALP (P = 0.015), HDL and phosphorus levels (P < 0.001) as compared to females. There were no significant differences in BMI, TC, LDL, bicarbonate, calcium, vitamin D, glucose (fasting), and glycosylated hemoglobin levels (P > 0.05) between both the sexes. Smoking and alcohol consumption were reported more in males (15% and 26.1%, respectively) as compared to females (11% and 3.4%, respectively). Some kind of physical activity was reported by 39.1% females and 54.3% males. Nonvegetarian diet intake was reported by 23.9% females and 31.4% males.

3.2. BMD status

Table 2A, B shows the results of the DXA measurements and the proportion of subjects who had osteoporosis, osteopenia, and normal BMD at different skeletal sites in total population, males, and females.

3.2.1. Absolute BMD and T scores

Absolute BMD (g/cm²) was significantly higher in males (P < 0.001) as compared to females at all bone sites. Males had significantly higher T scores at lumbar spine, left femur neck, and right femur neck (all P < 0.001) whereas T scores at left total femur (P = 0.510) and right total femur (P = 0.639) were comparable in both the sexes (Table 2A).

3.2.2. Prevalence of osteoporosis and osteopenia

In total population, prevalence of osteoporosis was 6.9%, 5.0%, 2.9%, 1.9%, and 2.7% at lumbar spine, left femur neck, right femur neck, left total femur, and right total femur, respectively, whereas measured in mg/dL, glycosylated hemoglobin (%), and vitamin D (ng/mL).
osteopenia was reported in 27.7%, 34.0%, 33.2%, 27.3%, and 26.9% subjects at these bone sites respectively. In females, prevalence of osteoporosis was 11.1%, 6.0%, 4.2%, 3.2%, and 4.2% at aforementioned sites respectively, while it was 3.9%, 4.2%, 1.9%, 1.0%, and 1.6% in males at these bone sites respectively. Prevalence of osteopenia in females was 31.9%, 39.8%, 40.3%, 25.9%, and 27.3% at lumbar spine, left femur neck, right femur neck, left total femur, and right total femur, respectively, whereas osteopenia was reported in 24.7%, 29.9%, 28.2%, 28.2%, and 26.6% males at these bone sites respectively (Table 2B).

### Table 2A

| Bone mineral density and T scores of patients with osteoporosis and osteopenia at measured sites. |
|---------------------------------------------------------------|
| **Variable** | **Total population (n = 524)** | **Females (n = 216)** | **Males (n = 308)** | **P-value** |
|-----------------|---------------------------------|----------------------|--------------------|------------|
| Bone mineral density, g/cm² |                                |                      |                    |            |
| Lumbar spine    | 1.130 ± 0.160                   | 1.077 ± 0.172        | 1.166 ± 0.140      | <0.001*    |
| Left femur neck | 0.959 ± 0.150                   | 0.913 ± 0.150        | 0.991 ± 0.141      | <0.001*    |
| Right femur neck| 0.962 ± 0.142                   | 0.911 ± 0.134        | 0.999 ± 0.136      | <0.001*    |
| Wilcoxon P⁴     |                                 | 0.669                | 0.041              |            |
| Left total femur| 0.995 ± 0.141                   | 0.951 ± 0.140        | 1.025 ± 0.135      | <0.001*    |
| Right total femur| 0.988 ± 0.139                   | 0.942 ± 0.142        | 1.021 ± 0.128      | <0.001*    |
| Wilcoxon P⁴     |                                 | 0.008                | 0.016              |            |
| T scores        |                                |                      |                    |            |
| Lumbar spine    | −0.6 ± 1.3                      | −0.8 ± 1.4           | −0.4 ± 1.2         | <0.001*    |
| Left femur neck | −0.7 ± 1.1                      | −0.9 ± 1.1           | −0.6 ± 1.1         | 0.002*     |
| Right femur neck| −0.7 ± 1.0                      | −0.9 ± 1.0           | −0.5 ± 1.0         | <0.001*    |
| Left total femur| −0.5 ± 1.0                      | −0.5 ± 1.1           | −0.5 ± 0.9         | 0.010*     |
| Right total femur| −0.5 ± 1.0                      | −0.5 ± 1.1           | −0.5 ± 0.9         | 0.639*     |

Values are presented as mean ± standard deviation. Based on aforementioned, considering highest prevalence rate at any site, osteoporosis was present in 6.9% subjects (female, 11.1%; male, 4.2%) and osteopenia in 34% subjects (female, 40.3%; male, 29.9%) in this dataset of apparently healthy population.

3.2.3. Discordances of BMD between right and left skeletal sides

We compared bilateral BMD (g/cm²) at different parts of the femur in males and females. Significant discordances of BMD

### Table 2B

| Variable | Osteoporosis | Osteopenia | Normal BMD |
|----------|--------------|------------|------------|
| Lumbar spine |              |            |            |
| Left femur neck |              |            |            |
| Right femur neck |              |            |            |
| Left total femur |              |            |            |
| Right total femur |              |            |            |
| Females (n = 216) |              |            |            |
| Lumbar spine | 24 (11.1) | 69 (31.9)  | 123 (56.9) |
| Left femur neck | 13 (6) | 86 (39.8)  | 117 (54.2) |
| Right femur neck | 9 (4.2) | 87 (40.3)  | 120 (55.6) |
| Left total femur | 7 (3.2) | 56 (25.9)  | 153 (70.8) |
| Right total femur | 9 (4.2) | 59 (27.3)  | 148 (68.5) |
| Males (n = 308) |              |            |            |
| Lumbar spine | 12 (3.9) | 76 (24.7)  | 220 (71.4) |
| Left femur neck | 13 (4.2) | 92 (29.9)  | 203 (65.9) |
| Right femur neck | 6 (1.9) | 87 (28.2)  | 215 (68.8) |
| Left total femur | 3 (1.0) | 87 (28.2)  | 218 (70.8) |
| Right total femur | 5 (1.6) | 82 (26.6)  | 221 (71.8) |

Values are presented as number (%). BMD, bone mineral density.

⁴ Prevalence analysis done using the World Health Organization classification based on T score: normal BMD (T score ≥ −1), osteopenia (T score < −1 and ≥ −2.5), and osteoporosis (T score ≤ −2.5).
between right and left sides of femur neck and total femur were seen according to the Wilcoxon signed ranks test ($P < 0.05$) in males. In females, though discordance was significant at total femur in line with Table 2A ($P < 0.05$), BMD did not differ significantly ($P = 0.669$) between 2 sides at femur neck in line with Table 2A (Table 2A).

### 3.3. Relationship between BMD and age in both the sexes

#### 3.3.1. Age wise distribution of prevalence

The study participants were divided into 5 age groups: 30–39, 40–49, 50–59, 60–69, and ≥70 years. The prevalence for osteoporosis in females at lumbar spine was 3%, 3.4%, 14.3%, 18.6%, and 36.4% in the age groups of 30–39, 40–49, 50–59, 60–69, and ≥70 years, respectively; while in males it was 0%, 4%, 6.5%, 4.3%, and 5.6%, respectively. Foregoing distribution conveys that prevalence of osteoporosis increased with age in females while there was no specific trend in prevalence of osteoporosis in males with age at lumbar site. Osteoporosis rates at other bone sites also reported no significant trend of increase with age in females. However, no such trend of increase in prevalence of osteoporosis was seen in males at other sites (Table 3).

#### 3.3.2. Pearson bivariate and partial correlation between BMD and age

On Pearson correlation analysis, age was negatively and significantly, associated with BMD ($r = -0.180$ to $-0.316$) at all bone sites in females ($P < 0.05$) (Table 4). This remained significant at all bone sites after independently controlling for known risk factors for low BMD that is for BMI ($P < 0.05$); BMI, weight and height ($P < 0.05$); and lifestyle factors (smoking, alcohol use, physical activity, and diet; $P < 0.05$) in partial correlation analysis. In males, negative and significant association between BMD and age was seen at left femur neck ($r = -0.268$) and right femur neck ($r = -0.209$) only (both $P < 0.05$), which remained significant after controlling for similar confounders as used in females in partial correlation. No significant association between age and BMD at lumbar spine, left total femur and right total femur was seen in males (Table 4).

### 3.4. Pearson analysis between BMD and other parameters

On Pearson correlation analysis (Table 5), height ($r = 0.234$–$0.358$), weight ($r = 0.305$–$0.388$), and BMI ($r = 0.143$–$0.285$) were positively; and ALP ($r = -0.133$ to $-0.203$) was negatively correlated with BMD (all $P < 0.01$) at all sites. Physical activity ($r = 0.136$–$0.153$), alcohol use ($r = 0.211$–$0.250$), and smoking ($r = 0.099$–$0.150$) were positively associated with BMD at all bone site (all $P < 0.05$). Glycosylated haemoglobin showed positive correlation at right total femur ($r = 0.087$, $P < 0.05$). However, when adjusted for age and sex in partial correlation, only BMI, height, weight, physical activity (all positively) and ALP (negatively) remained significantly ($P < 0.01$) associated with BMD. No correlation was noted between serum 25-hydroxyvitamin D (25(OH)D), bicarbonate, calcium, phosphorus, and fasting sugar levels; and BMD ($P > 0.05$) at any site.

### 3.5. Multiple regression analysis

We conducted multiple regression analysis in males and females by including the variables that significantly correlated with BMD in correlation analysis, after checking for collinearity. A stepwise selection of the variables was implemented in which the dependent variables were BMD values of the respective skeletal site. The standardized $β$, $P$-value for each significant variable in a model and $R^2$ for that model are depicted in Table 6.

In females, in stepwise multiple regression analysis; BMI, ALP and age were found to be the only significant factors ($P < 0.05$, all) that predicted the BMD at any respective skeletal site. Physical activity did not contribute to the BMD prediction at any site in females (Table 6). In males, stepwise multiple regression analysis revealed that BMI, ALP, age, and physical activity were the 4 significant factors ($P < 0.05$, all) that predicted the BMD at right and left femur neck (Table 6). At left and right total femur, ALP and physical activity were the only predicting factors ($P < 0.05$, all) for BMD. At lumbar spine, BMI and ALP were the contributing factors ($P < 0.05$, all) towards BMD prediction.

### 4. Discussion

We conducted this retrospective study in a tertiary care hospital and included subjects from urban community that had willingly visited the hospital for primary health check-ups. Present study reported significantly higher absolute BMD in males as compared to females at all bone sites which is in concurrence with literature [15] and [16].

Our analysis shows higher prevalence of osteoporosis and osteopenia in females compared to males at all bone sites. Osteoporosis was present in 6.5% subjects (female, 11.1%; male, 4.2%) and osteopenia in 34% subjects (female, 40.3%; male, 29.9%) in this apparently healthy urban population, considering highest prevalence rate at any site. These findings are in concurrence with another study reporting prevalence rates in urban community from India. That study yielded a similar prevalence of 12.85% in females.
and 3.7% in males for osteoporosis, and 41.4% in females and 33.3% in males for osteopenia respectively [17]. However, previous literature has reported wide variation in the prevalence data for osteoporosis in Indian population. For instance, a study including 200 healthy males (mean age, 62.6 years) reported osteoporosis and osteopenia rates of 8.5% and 42% respectively with Vitamin D deficiency as the main risk factor [18]. Another study in urban males (n = 252; mean age, 58 years) noted 20% osteoporosis and 54.3% females and males respectively using DXA. Risk factors included vitamin D and calcium deficiency as risk factors [23].

In a hospital based study among 158 urban women aged >25 years utilizing calcaneal quantitative ultrasound, 20.2% and 36.8% were suffering from osteoporosis and osteopenia respectively [20]. Another retrospective study of 40–60 years old Indian women documented 18.41% osteoporotic and 47% osteopenics [21]. A study in 158 females (mean age, 42.5 years) reported osteoporosis and osteopenia rates as 13.3% and 48.1% respectively. Increasing age of the women, higher gravidity status and menopausal status, low body weight and lesser physically active status were identified as risk factor [14]. Another study in an urban area including 808 females with mean age of 57.3 years and 792 males (mean age, 58.0 years) reported osteoporosis in 42.5% and 44.9%, and osteopenia in 24.8% and 54.3% females and males respectively using DXA. Risk factors included vitamin D and calcium deficiency and increasing age [22]. A study reported osteoporosis in 15% of reproductive potential females (n = 55; mean age, 38 years) and in 28% of 136 postmenopausal females (mean age, 53 years). Vitamin D and calcium deficiency were identified as risk factors [23].

In another study in 105 females with mean age 50.5 years, osteoporosis and osteopenia rates were 14.3% and 31.4% with time since menopause, lower socioeconomic status, calcium intake as main risk factors. Women from the lower socioeconomic strata had a significantly higher percentage of osteopenia and osteoporosis (P < 0.001) [24]. Osteoporosis was reported in 25.8% post-menopausal urban females (n = 92; age, 40–75 years) in a study. Vitamin D deficiency, increasing age, low weight, menopause, low intakes of calcium, poor sunlight exposure were documented risk factors [25]. In a study in rural India including 538 females and 71 males (mean age, 52.7 years), prevalence of 44.1% in females and
28.2% in males for osteoporosis, and 41.1% in females and 36.7% in males for osteopenia respectively were reported with increasing age being documented as the main associated risk factor [26]. Another study in 150 females (mean age, 60.1 years) from semi-urban area reported 43% osteoporosis prevalence rates. The risk factors included low BMI, body mass index.

In present study, difference between right and left hip BMD was seen in males and females. Similar finding about right and left hip BMD discordance have been reported in literature in females [35–37] as well as in males [38]. Though, in our study, we did not evaluate the analytical variations due to data limitations about DXA instrument. It has been reported that only part of the difference appeared to be due to analytical problems in an earlier study [37]. The explanations for the discordance may include genetic variation, immobilization, dominance of the extremity etc. Higher BMD in the dominant stroke arm has been reported in professional tennis players due to mechanical stimulation and hypoxia of the constantly strained extremity [39]. It has been debated that a significant number of subjects with osteoporosis may possibly be classified differently when scanning only one hip because of the high prevalence of left-right differences in BMD. The undiagnosed cases of osteoporosis may go unnoticed and may suffer fragility fractures due to nonintervention. So from a public health viewpoint, the practice of scanning both hips is recommended [40].

Table 6

| Variable                        | Females Standardized β | P-value | Males Standardized β | P-value |
|--------------------------------|------------------------|---------|----------------------|---------|
| Lumbar spine                   |                        |         |                      |         |
| Age                            | −0.319                 | <0.001  | −                    | −       |
| BMI                            | 0.186                  | 0.006   | 0.232                | <0.001  |
| Alkaline phosphatase R2        | −0.210                 | 0.002   | −0.119               | 0.043   |
| Left femur neck                |                        |         |                      |         |
| Age                            | −0.285                 | <0.001  | −0.284               | <0.001  |
| BMI                            | 0.164                  | 0.017   | 0.215                | <0.001  |
| Alkaline phosphatase R2        | −0.153                 | 0.025   | −0.124               | 0.029   |
| Physical activity              | −                      |         | 0.144                | 0.011   |
| R2                             | 0.120                  |         | 0.152                |         |
| Right femur neck               |                        |         |                      |         |
| Age                            | −0.267                 | <0.001  | −0.224               | <0.001  |
| BMI                            | 0.245                  | <0.001  | 0.273                | <0.001  |
| Alkaline phosphatase R2        | −0.182                 | 0.007   | 0.122                | 0.031   |
| Physical activity              | −                      |         | 0.163                | 0.004   |
| R2                             | 0.042                  |         | 0.157                |         |
| Left total femur               |                        |         |                      |         |
| Age                            | −0.221                 |         | −0.217               | <0.001  |
| BMI                            | 0.342                  | <0.001  | 0.317                | <0.001  |
| Alkaline phosphatase R2        | −0.135                 | 0.045   |                      |         |
| Physical activity              | −                      |         | 0.148                | 0.010   |
| R2                             | 0.152                  |         | 0.119                |         |
| Right total femur              |                        |         |                      |         |
| Age                            | −0.240                 | <0.001  | −                    | −       |
| BMI                            | 0.386                  | <0.001  | 0.306                | <0.001  |
| Alkaline phosphatase R2        | −0.196                 | <0.001  | −0.130               | <0.001  |
| Physical activity              | −                      |         | 0.159                | <0.001  |
| R2                             | 0.203                  |         | 0.116                |         |

BMI, body mass index.
respectively. On Pearson correlation analysis too, the association \((r = 0.075)\) was not significant \((P = 0.086)\) between BMI and ALP. Thus, ALP did not show any correlation with BMI and obesity.

Physical activity was positively associated with BMD showing that physical activity increase BMD which is in agreement with [10]. Our data set of population uncovered physical activity generates strains of adequate degree \([53\, 55]\), ascribed to the activation of osteocytes, that alters the balance between bone resorption and formation, causing modeling, if physical activity increases BMD that is in agreement with [10]. On Pearson correlation analysis too, the association respectively.

Though literature widely reports positive association between BMD and Vitamin D \([56]\), our data set of population uncovered physical activity increase BMD which is in agreement with [10]. On Pearson correlation analysis too, the association respectively.

5. Conclusions

To conclude, osteoporosis is widely prevalent in otherwise healthy Indian population with higher prevalence in females compared to males.

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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