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Original article

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

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ABSTRACT

Objectives: An understanding of bone mineral density (BMD) pattern in a population is crucial for prevention and diagnosis of osteoporosis and management of its complications in later life. This study aimed to screen the bone health status and factors associated with osteoporosis in an apparently healthy Indian population.

Methods: A retrospective review of medical records was done in a tertiary-care hospital for the subjects who had undergone preventive health-check-ups that included BMD measurements at femur-neck, total-femur, and lumbar-spine.

Results: We evaluated 524 subjects (age, 50.0 ± 12.4 years) including 41.2% female and 58.8% male subjects. Osteoporosis was present in 6.9% subjects (female, 11.1%; male, 4.2%) and osteopenia in 34% subjects (female, 40.3%; male, 29.9%). Absolute BMD was higher in male subjects ($P < 0.001$) compared to female subjects at all bone sites. Prevalence of osteoporosis increased with age in female subjects, but not in male subjects. Osteoporosis rates in the age-groups of 30–39, 40–49, 50–59, 60–69, and ≥70 years were 3%, 3.4%, 14.3%, 18.6%, and 36.4%, respectively in female subjects while prevalence in male subjects was 0%, 4%, 6.5%, 4.3%, and 5.6%, respectively, at lumbar spine. Height ($r = 0.234–0.358$), weight ($r = 0.305–0.388$), body mass index ($r = 0.143–0.285$) and physical activity ($r = 0.136–0.153$) were positively; and alkaline phosphatase ($r = -0.133$ to -0.203) was negatively correlated with BMD (all $P < 0.01$) at all sites. These parameters retained significant correlation after controlling for age and sex. No correlation of serum 25-hydroxy-vitamin-D and calcium was noted with BMD ($P > 0.05$) at any site.

Conclusions: Further data on absolute BMD, T scores, and prevalence rates of osteoporosis/osteopenia on multiple bone sites have been presented in this article.

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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].

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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 reported differences [13].

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/MSSH/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/m^2), history of smoking, alcohol consumption, exercise status (presence/absence for all) and dietary habits (vegetarian/nonvegetarian diet) were recorded. Subjects had undergone 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/cm^2) and T scores were available for five bone sites, that is, lumbar spine (L1–4), femoral neck (both right and left), and total femur (both right and left). Laboratory data were collected for uric acid (UA), total cholesterol (TC), low-density lipoprotein (LDL), very low-density lipoprotein (VLDL), high-density lipoprotein (HDL), triglycerides (TG), alkaline phosphatase (ALP), serum calcium, serum phosphorus, serum bicarbonate, fasting glucose (all measured in mg/dL), glycosylated hemoglobin (%), and vitamin D (ng/mL).

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 (1.1% 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/cm^2) was significantly higher in males (both $P < 0.001$) 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 lumber spine, left femur neck, right femur neck, left total femur, and right total femur, respectively, whereas

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Table 1
Baseline characteristics and laboratory parameters.

Variable	Total population (n = 524)	Females (n = 216)	Males (n = 308)	P-value
Demographic characteristics				
Age, y	50.0 ± 12.4	50.7 ± 11.9	49.6 ± 12.8	0.313
Height, cm	170 ± 10	160 ± 10	170 ± 10	<0.001*
Weight, kg	74.8 ± 13.4	68.2 ± 11.4	79.4 ± 12.9	<0.001*
Body mass index, kg/m^2	27.3 ± 4.2	27.5 ± 4.8	27.2 ± 3.8	0.445
Lifestyle characteristics[a], n (%)				
Nonsmokers	393 (84.0)	195 (41.5)	198 (42.5)	<0.001*
Smokers	75 (16.0)	5 (1.1)	70 (15.0)	
No alcohol consumption	330 (70.5)	184 (39.3)	146 (31.2)	<0.001*
Alcohol consumption present	138 (29.5)	16 (3.4)	122 (26.1)	
No exercise	31 (6.6)	17 (3.6)	14 (3.0)	0.159
Exercise present	437 (93.4)	183 (39.1)	254 (54.3)	
Vegetarian diet	209 (4.7)	88 (18.8)	121 (25.9)	0.805
Nonvegetarian diet	259 (55.3)	112 (23.9)	147 (31.4)	
Laboratory parameters				
Alkaline phosphatase, mg/dL	68.6 ± 23.2	71.5 ± 27.8	66.5 ± 19.1	0.015*
Total cholesterol, mg/dL	179.3 ± 41.5	180.3 ± 39.9	178.5 ± 42.6	0.630
HDL, mg/dL	41.6 ± 9.3	45.5 ± 10.0	38.8 ± 7.8	<0.001*
LDL, mg/dL	116.9 ± 37.0	114.8 ± 34.9	118.3 ± 38.5	0.297
VLDL, mg/dL	29.8 ± 19.5	25.6 ± 12.8	32.8 ± 22.6	<0.001*
Triglycerides, mg/dL	146.9 ± 83.3	128.0 ± 63.9	160.1 ± 92.4	<0.001*
Uric acid, mg/dL	5.5 ± 1.3	4.8 ± 1.2	5.9 ± 1.2	<0.001*
Glucose (Fasting), mg/dL	108.6 ± 34.8	105.6 ± 35.1	110.8 ± 34.5	0.097
Glycosylated Hemoglobin, %	6.0 ± 1.2	5.9 ± 1.05	6.0 ± 1.2	0.109
Bicarbonate, mg/dL	25.3 ± 2.3	25.1 ± 2.4	25.5 ± 2.2	0.039*
Phosphorus, mg/dL	3.5 ± 0.5	3.7 ± 0.5	3.5 ± 0.5	<0.001*
Calcium, mg/dL	9.3 ± 0.4	9.3 ± 0.38	9.3 ± 0.36	0.731
25 Hydroxy-vitamin D, ng/dL	23.6 ± 16.8	25 ± 13.7[b]	22.8 ± 18.1[c]	0.397

Values are presented as mean ± standard deviation or number (%).
HDL, high-density lipoprotein; LDL, low-density lipoprotein; VLDL, very low-density lipoprotein.
[a]n = 468. [b]n = 65. [c]n = 131. *P < 0.05.

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 lumber 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	All subjects (n = 524)	Females (n = 216)	Males (n = 308)	P-value
Bone mineral density, g/cm^2				
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 P[a]	–	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 P[a]	–	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	0.510
Right total femur	−0.5 ± 1.0	−0.5 ± 1.1	−0.5 ± 0.9	0.639

Values are presented as mean ± standard deviation.
[a] P (Wilcoxon signed ranks test): difference between right and left sided BMD.

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/cm^2) at different parts of the femur in males and females. Significant discordances of BMD

Table 2B
Prevalence[a] of patients with osteoporosis and osteopenia at measured sites.

Variable	Osteoporosis	Osteopenia	Normal BMD
Total Population (n = 524)			
Lumbar spine	36 (6.9)	145 (27.7)	343 (65.5)
Left femur neck	26 (5.0)	178 (34.0)	320 (61.1)
Right femur neck	15 (2.9)	174 (33.2)	335 (63.9)
Left total femur	10 (1.9)	143 (27.3)	371 (70.8)
Right total femur	14 (2.7)	141 (26.9)	369 (70.4)
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 (69.8)
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.
[a] 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).

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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 femur neck ($P < 0.05$), BMD did not differ significantly ($P = 0.669$) between 2 sides at total femur (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 similar 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).

Table 3
Age wise distribution of prevalence of osteoporosis (%) and osteopenia (%) at multiple skeletal sites in both the sexes.

Skeletal site	Age, y						P-value
	30–39	40–49	50–59	60–69	≥70	Total[a]	
Females (n = 216)							
Lumbar spine							
Osteoporosis	3.0	3.4	14.3	18.6	36.4	11.1	<0.001*
Osteopenia	21.2	22.4	36.5	48.8	27.3	31.9	
Left femur neck							
Osteoporosis	0	0	7.9	11.6	27.3	6.0	0.001*
Osteopenia	30.3	37.9	36.5	58.1	36.4	39.8	
Right femur neck							
Osteoporosis	0.0	1.7	3.2	9.3	18.2	4.2	0.05*
Osteopenia	39.4	32.8	41.3	53.5	36.4	40.3	
Left total femur							
Osteoporosis	0	0	3.2	7.0	18.2	3.2	0.017*
Osteopenia	18.2	19.0	25.4	39.5	27.3	25.9	
Right total femur							
Osteoporosis	0	0	1.6	9.3	27.3	4.2	0.002*
Osteopenia	27.3	22.4	31.7	32.6	18.2	27.3	
Males (n = 308)							
Lumbar spine							
Osteoporosis	0	4.0	6.5	4.3	5.6	3.9	0.527
Osteopenia	15.5	28.0	24.7	27.7	27.8	24.7	
Left femur neck							
Osteoporosis	0.0	2.7	6.5	6.4	11.1	4.2	0.002*
Osteopenia	17.2	20.0	38.7	38.3	50.0	29.9	
Right femur neck							
Osteoporosis	0	2.7	3.2	0	5.6	1.9	0.018*
Osteopenia	13.8	20.0	37.6	38.3	38.9	28.2	
Left total femur							
Osteoporosis	0	1.3	2.2	0	0	1.0	0.366
Osteopenia	17.2	24.0	32.3	31.9	44.4	28.2	
Right total femur							
Osteoporosis	0	1.3	2.2	0	11.1	1.6	0.018*
Osteopenia	17.2	21.3	31.2	29.8	44.4	26.6	

Values are presented as the percentage of total subjects in each age group.
[a]Table 2 also depicts the total prevalence rates. *P < 0.05.

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-hydroxy-vitamin 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 6.9% 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 33.33%

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Table 4
Pearson bivariate and partial correlation (r) between bone mineral density and age.

Variable	Lumbar spine	Left femur neck	Right femur neck	Left total femur	Right total femur
Total population (n = 524)					
Model 1	−0.167*	−0.273*	−0.227*	−0.139*	−0.132*
Females (n = 216)					
Model 1	−0.316*	−0.278*	−0.250*	−0.180*	−0.200*
Model 2	−0.342*	−0.306*	−0.295*	−0.250*	−0.277*
Model 3	−0.252*	−0.219*	−0.193*	−0.153*	−0.182*
Model 4	−0.316*	−0.277*	−0.237*	−0.182*	−0.204*
Males (n = 308)					
Model 1	−0.039#	−0.268*	−0.209*	−0.100#	−0.071#
Model 2	−0.032#	−0.269*	−0.211*	−0.097#	−0.069#
Model 3	0.031#	−0.251*	−0.188*	−0.101#	−0.081#
Model 4	−0.069#	−0.265*	−0.206*	−0.108#	−0.073#

Model 1, uncontrolled bivariate correlation; model 2, body mass index (BMI) controlled partial correlation; model 3, BMI, weight and height controlled partial correlation; model 4, smoking, alcohol use, physical activity, and diet controlled partial correlation.
*P < 0.05.
#P > 0.05.

Table 5
Pearson bivariate and partial correlation (r) between body mineral density and baseline variables.

Variable	Lumbar spine	Left femur neck	Right femur neck	Left total femur	Right total femur
Model 1					
BMI	0.148**	0.143**	0.204**	.278**	0.285**
Height	0.358**	0.299**	0.340**	.234**	0.254**
Weight	0.345**	0.305**	0.378**	.376**	0.388**
Alkaline phosphatase	−0.203**	−0.151**	−0.162**	-.133**	−0.152**
25-Hydroxy-vitamin D	−0.113	−0.057	−0.110	−0.09	−0.104
Bicarbonate	0.037	0.082	0.083	0.082	0.079
Calcium	0.008	0.043	0.041	−0.035	−0.043
Phosphorus	−0.036	0.007	0.001	0.005	−0.025
Glucose (Fasting)	0.022	0.003	0.040	0.059	0.074
Glycosylated hemoglobin	0.002	0.001	0.044	0.081	0.087*
Physical activity	0.137**	0.136**	0.138**	0.153**	0.142**
Alcohol use	0.246**	0.250**	0.247**	0.219**	0.211**
Smoking	0.132**	0.135**	0.150**	0.099*	0.107*
Diet type	−0.067	−0.030	−0.053	−0.057	−0.065
Model 2					
BMI	0.177**	0.182**	0.247**	0.309**	0.318**
Height	0.207**	0.099*	0.128**	0.042	0.056
Weight	0.255**	0.210**	0.278**	0.298**	0.306**
Alkaline phosphatase	−0.184**	−0.132**	−0.139**	−0.110**	−0.128**
Alcohol use	0.065	0.048	0.039	0.026	0.015
Smoking	0.045	0.052	0.051	0.014	0.017
Physical activity	0.132**	0.139**	0.137**	0.147**	0.135**

Model 1, uncontrolled bivariate correlation; model 2, age and sex controlled partial correlation.
*P < 0.05. **P < 0.01.

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 58% osteopenia rates reporting vitamin D deficiency, hypogonadism and lack of physical activity as risk factors [19].

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 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 gravida 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% postmenopausal 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

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Table 6
Multiple regression analysis to identify significant factors associated with body mineral density in females and males.

Variable	Females		Males	
	Standardized β	P-value	Standardized β	P-value
Lumbar spine				
Age	−0.319	<0.001	–	–
BMI	0.186	0.006	0.232	<0.001
Alkaline phosphatase	−0.210	0.002	−0.119	0.043
R^2	0.167		0.069	
Left femur neck				
Age	−0.285	<0.001	−0.284	<0.001
BMI	0.164	0.017	0.215	<0.001
Alkaline phosphatase	−0.153	0.025	−0.124	0.029
Physical activity	–	–	0.144	0.011
R^2	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	−0.182	0.007	0.122	0.031
Physical activity	–	–	0.163	0.004
R^2	0.042		0.157	
Left total femur				
Age	−0.221	0.001	–	–
BMI	0.342	<0.001	0.317	<0.001
Alkaline phosphatase	−0.135	0.045	–	–
Physical activity	–	–	0.148	0.010
R^2	0.152		0.119	
Right total femur				
Age	−0.240	<0.001	–	–
BMI	0.386	<0.001	0.306	<0.001
Alkaline phosphatase	−0.196	<0.001	–	–
Physical activity	–	–	0.159	<0.001
R^2	0.203		0.116	

BMI, body mass index.

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, low dietary calcium intake, vitamin D-insufficiency, menopause and high parity [27]. In a study in 289 females from a low-income group (mean age, 41 years), prevalence of osteoporosis and osteopenia were 29% and 52% respectively at femoral neck. Authors reported inadequate nutrition, low body weight, increasing age, menopause status, and low calcium intake as risk factors [28].

The reason for such a wide variation in prevalence of osteoporosis may be ascribed to several reasons. These include the method of data collection; bone sites at which BMD was documented; age and sex of the participants; and other risk factors such as socio-economic status, vitamin D deficiency, BMI, sun exposure, menopausal status in females, life-style factors and confounders controlled for while analyzing the data.

In our study, age of the subjects was negatively correlated with BMD, though this was statistically significant at all sites in females only. Similar findings have been reported in an another Indian study [29]. Prevalence of osteoporosis increased significantly with age in females at all sites. At lumbar site, osteoporosis prevalence was 3.4% between 40–49 years of age that consistently increased every decade to reach 36.4% in females aged 70 years and above. However, there was no specific trend in prevalence of osteoporosis in males with age which is similar to earlier reported Indian study [22]. Dy et al., 2011 observed that despite its prevalence across both sexes, osteoporosis does not affect males and females equally; there are important sex- and sex-based differences between them. Females experience rapid bone resorption as they enter into menopause, leading to loss of microarchitecture that may remain unreversed; while males undergo a slow attrition of bone with age [30,31]. The growth period is also crucial to skeletal development and results in larger bones in males than in females. The sudden drop in estrogen levels that characterizes the menopause contrasts with the gradual decline in sex hormones seen in aging men, and the proportion of individuals with hypogonadism is considerably lower among older men than among older women [32]. The changes in BMD with age have been reported to be associated with many factors including race, heredity, environment, region, life-style, nutrition, etc.; and significant differences in BMD between peer age groups of different sexes have also been reported [33,34].

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 hyperemia 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].

In our study, BMI, height, weight were positively correlated with BMD indicating their protective role for bones which is in line with widely reported literature [22,41–43]. Wu and Du [43] discussed that the basic correlation mechanisms are multidimensional, including mechanical load, hormones, and nutritional status. High weight and BMI provide individuals with the capability to endure larger mechanical load thereby reducing bone resorption and stimulating bone formation. Secondly, large body weight and BMI reflect the nutritional status, and malnutrition directly affects bone remodelling. Also in postmenopausal females, higher BMI causes elevated levels of free sex hormones due to reduced production of sex hormone-binding globulins leading to increased osteoprotegerin expression and reduced osteoclast activity. Estrogens also stop bone absorption of parathyroid hormones and promote bone formation [43]. Additionally, the cross-talk between bone and fat probably constitutes a homoeostatic feedback where adipokines and molecules secreted by osteoblasts and osteoclasts represent the connection of an active bone-adipose axis. This protective effect of obesity is also called the “obesity paradox” or “reverse epidemiology” and is controversial. The exact mechanism(s) by which all these events occur remains unclear [44,45]. This is to inform that the results for the correlation analysis between BMD and serum UA in a subset of this population have recently been published [46].

Total ALP was negatively associated with BMD in our study. Though bone-ALP is the specific parameter for monitoring changes in bone formation, literature notes that in healthy adults, there exists a good correlation between bone specific and total ALP. Total ALP provides a good impression of the extent of new bone formation and osteoblast activity [47–50]. This is to mention that our study included otherwise healthy subjects. As literature also reports positive correlation between ALP and obesity [51], we analyzed data to clarify possibility of association of high ALP with obesity. Comparable ALP levels (70.9 ± 22.7 mg/dL and 68.0 ± 23.3 mg/dL, $P = 0.247$) were seen between obese (BMI ≥ 30 kg/m^2) and nonobese (BMI < 30 kg/m^2) subjects respectively. On Pearson correlation analysis too, the association

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($r = 0.075$) 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 earlier literature [52]. The effects of exercise on bone mass may be ascribed to the activation of osteocytes, that alters the balance between bone resorption and formation, causing modeling, if physical activity generates strains of adequate degree [53–55].

Though literature widely reports positive association between BMD and Vitamin D [56], our data set of population uncovered finding of no relationship between the two. However similar findings have been reported by other colleagues too [57–60]. The conflicting findings can partially be elucidated by ethnic differences in the populations and wider age groups (20–80 years). Additionally, role of bioavailable 25(OH)D but not total 25(OH)D as an independent determinant for BMD is also under debate [61,62] and may be a reason for no association.

The present study has several limitation. Because this was a retrospective investigation, the study data is dependent on accurate and complete documentation in the medical records. The details of menopausal status were not available. Subjects in this study were not from general community but from a single tertiary hospital located in an urban area and subjects had come willingly for voluntary health check-ups. These check-up plans have some cost associated with them. Therefore, we implicate that most of our study subjects belonged to high-income strata and may not be representative of low-income population. The study did not include longitudinal data. Strength of our study was a well-characterized cross-sectional study and the results add to our knowledge of prevalence variations with age in both the sexes.

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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