Original Research Article

Nationwide assessment of bone mineral density: A comprehensive cross-sectional bone-fit study in the Indian population

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Abstract

Background: Low bone mineral density (BMD) is associated with osteopenia and osteoporosis, posing health risks. The study aims to assess the prevalence of these conditions across India and their age and sex variations.

Materials and Methods: Data on the age, sex, state/zone, and BMD of apparently healthy adults (≥18 years) were retrospectively collected from screening camps (across India) between May 2023 to December 2023. The BMD of the participants was measured through ultrasonography of the calcaneus bone on the heel. They were classified as having a normal BMD (>-1 SD), osteopenia (-1 to -2.5 SD), or osteoporosis (<-2.5 SD).

Results: Overall prevalence of osteopenia was higher than that of osteoporosis (45.62% and 11.51%, respectively). Among young adults (18-49 years), osteopenia affected 43.91% of women and 42.17% of men. Similarly, among postmenopausal women, the prevalence of osteopenia was higher than that of osteoporosis (49.05% and 22.67%, respectively). Across all regions, middle-aged adults in the West showed the highest osteopenia prevalence (52.66% vs. 48.53% East vs. 50.39% North vs. 46.99% South). Among the elderly, osteoporosis prevalence was highest in the East (33.56%), while in young adults, osteopenia was more prevalent in the West (45.96%).

Conclusion: Approximately half the population was affected by osteopenia, while one in 10 individuals had osteoporosis, indicating the need for targeted interventions and public health strategies focusing on middle-aged adults and post-menopausal women and raising awareness among the young population are crucial.

Keywords: Osteopenia, Osteoporosis, Bone mineral density, Postmenopausal women, Nationwide assessment

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1. Introduction

Osteopenia refers to a decrease in bone mass or bone mineral density (BMD) to levels below the normal reference range; these levels are not sufficiently low to be considered indicative of osteoporosis, which is the most common sequela of osteopenia and is characterized by severe BMD loss.[1-4] The World Health Organization (WHO) defines osteopenia as a T-score between -1 to -2.5; values less than -2.5 are diagnostic for osteoporosis. Microarchitectural disruption of the bone is indicated by decreased BMD, resulting in osteopenia and osteoporosis, which are quantitative bone mineralization disorders.[5-6]

According to a meta-analysis from 2022, the global prevalence of osteopenia was 40.4%, much higher than that of osteoporosis (19.7%).[7] Current statistics suggest that osteopenia affects approximately 34 million Americans, with an anticipated exponential rise in the incidence as the population ages with each passing decade.[6,8] The geriatric population of the United States is expected to increase from 13% to >20% between 2010 and 2030.[6,8] Females demonstrate a four-fold higher overall prevalence of osteopenia than males; however, males are more likely to demonstrate secondary causes of decreased bone mass.[6] The incidence rate of osteopenia was reported to be 42% in men and 51% in women in the Australian subcontinent.[6] Certain subgroups demonstrate predictable patterns and trends in the

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development of secondary osteopenia and osteoporosis irrespective of age.[6] Data sources reveal that 54% of postmenopausal women in the United States are osteopenic, and an additional 30% are considered osteoporotic.[6]

Globally, region-wise average T-scores have been reported to be lowest in Asia.[6] In 2005, the incidence of osteopenia in the Indian population was found to be 52%.[6] The peak incidence of osteopenia and osteoporosis in India reportedly occurs 10–20 years earlier than in developed countries, placing a significant strain on healthcare and economic resources.[9,10] Concurrently, the geriatric population of India is expanding due to an increase in average life expectancy from the current estimate of around 67 years to a projected 71 years by 2025 and 77 years by 2050.[11-12] Further, ~10% of the Indian population comprises individuals >50 years of age.[11,13] This combination of increased life expectancy and a growing older population (>50 years of age) could be a major contributing factor to higher incidences of osteopenia and osteoporosis in the near future.[11]

Significant bone density loss in the Indian population occurs due to varied lifestyle habits, primarily attributed to dietary deficiencies. Habitual low intake of calcium, which affects the peak bone mass built up during pubertal years, has been reported in most of the Indian population.[11,14-16] Furthermore, phytates and oxalates found in the predominant vegetarian fiber-rich Indian diet hamper the absorption of calcium from a limited source.[17] Hypovitaminosis D in Indians can be attributed to several factors, including limited sunlight exposure due to sociocultural practices, environmental pollution, and elevated levels of the 25(OH)-d-24-hydroxylase enzyme. Additionally, the Indian diet includes reduced intake of oily fish and vitamin D-rich foods. Only around 1% of vitamin D intake is from dietary sources due to lack of availability of vitamin D-fortified food products.[11] Moreover, alcohol consumption and cigarette smoking lead to increased bone reabsorption compared to bone formation, increasing osteoclast activity, elevating the risk of developing low bone BMD, and potentially leading to osteopenia and osteoporosis. [18-21]

Hormonal imbalances during menopause are another major factor influencing BMD loss in the Indian population. Estrogen levels undergo major fluctuations and subsequent significant decline during menopause, resulting in accelerated bone tissue loss.[22] The sudden decline in estrogen levels leads to increased bone resorption by osteoclasts (cells responsible for breaking down bone tissue), resulting in rapid bone loss with an immediate and drastic effect on bone health.[23]

Moreover, variations in lifestyle habits and dietary practices are known to influence the regional disparities in osteopenia and osteoporosis incidence across India.[24] The study aimed to determine the prevalence of osteopenia and osteoporosis in apparently healthy adult populations across India. The findings of this study will be crucial in raising awareness about bone health and aiding healthcare professionals and policymakers in developing primary prevention strategies for the high-risk Indian population.

2. Materials and Methods

2.1. Study design

This was a retrospective, record-based study using anonymized data collected from bone mineral density (BMD) screening camps conducted across India between May 2023 and December 2023. These camps were organized as community service initiatives and were not part of a predefined research study at the time of data collection.

2.2. Ethical approval

Since the study used de-identified, retrospective data collected during routine health screening, the ethics committee granted a waiver of informed consent, in accordance with national ethical guidelines for retrospective studies involving minimal risk and non-identifiable data under Project ID: LU/01/100325.

2.3. Study participants

Participants were individuals aged 18 years or older who voluntarily attended the BMD screening camps and provided verbal consent to participate. All data analyzed in this study were anonymized prior to analysis to protect participant privacy.

2.4. BMD measurement and data collection

The BMD of each participant was assessed through ultrasonography of the calcaneus bone on the heel (just below the area of the ankle) using the SONOST-3000 model (OsteoSys Co., Ltd, Seoul, Republic of Korea) and standard protocol.[25] Based on WHO guidelines, participants were classified as osteoporotic, osteopenic, or normal (without bone loss) when the T-score (defined as the number of standard deviations SDs of the patient's measured BMD from a reference peak BMD man BMD of - sex-matched young adults) was ≤-2.5, -1 to -2.5, and ≥-1 SD, respectively.[19,24,26,29] Quality control (QC) procedures were performed as per the manufacturer's recommendations. The phantom supplied by the manufacturer was regularly used to determine the instrument variation.[25]

2.5. Outcome measures

The primary outcome measure was the prevalence of osteopenia and osteoporosis among apparently healthy adults at the pan-India level. Secondary outcomes included regional prevalence (state/zone wise) and the differences in the pan-India and state/zone wise prevalence of osteopenia and osteoporosis between men and women and between young adults (18-49 years), middle-aged individuals (50-64 years), and the elderly (65+ years).

2.6. Statistical analysis

Data were entered and analyzed using Microsoft Excel 2016 software. Data are presented as frequencies and percentages for qualitative variables and as means and SD for quantitative variables. The chi-square test was used to determine statistically significant differences in categorical variables in different groups. The Student's t-test was performed to compare the mean BMD scores. Statistical significance was set at $p<0.05$.

3. Results

3.1. Baseline demographic characteristics

In this study, data from 49,209 participants were evaluated. **Table 1** shows the participants' baseline demographic characteristics. Their mean age was 45.42 years, and 10.73% were elderly. Of the total number of participants, 54.42% were men and 45.58% were women. Among women, 9,139 (40.74%) were in the post-menopausal age group (>50 years). There was an equivalent proportion of participants from North and East India (29.03% and 29.35%, respectively), whereas the distribution in South India was relatively low (14.04%). In terms of states, the maximum number of participants was recruited from Uttar Pradesh (n=9,001, 18.30%), followed by Maharashtra (n=8,605, 17.50%), and West Bengal (n=6,370, 13.00%). In contrast, the least number of participants was from the Andaman and Nicobar Islands (n=1, 0.00%).

Table 1: Baseline demographic characteristics according to the current database in India

Variable(s)	N=49,209
Age groups	
Mean age (years)	45.42
18-49 (young adults)	30,019 (61.00%)
50-64 (middle age)	13,913 (28.27%)
65+ (elderly)	5,277 (10.73%)
Sex	
Male	26,778 (54.42%)
Female	22,431 (45.58%)
Postmenopausal female (age >50 years)	9,139 (40.74%)
Zone	
North	14,284 (29.03%)
South	6,909 (14.04%)
East	14,444 (29.35%)
West	13,572 (27.58%)

Please note that:
North Zone: Chandigarh, Delhi, Haryana, Himachal Pradesh, Punjab, Uttar Pradesh, and Uttarakhand.
South Zone: Andaman and Nicobar Island, Andhra Pradesh, Karnataka, Kerala, Lakshadweep, Tamil Nadu, Telangana
East Zone: Assam, Bihar, Chhattisgarh, Jharkhand, Meghalaya, Nagaland, Odisha, and West Bengal
West Zone: Gujarat, Madhya Pradesh, Maharashtra, Rajasthan
This zonal distribution is based on the Indian government. Source: DCMSME 2024

Table 2: Prevalence of normal BMD, osteopenia, and osteoporosis: Correlation between age groups and sex (women) according to the current database in India

Women					
	18-49 years (young adults)	**50-64 years (middle age)**	**≥65 years (elderly)**	**Total (Female)**	**p-value**
Normal	6,331 (47.63%)	2,115 (30.69%)	469 (20.86%)	8,915 (39.74%)	<0.001
Osteopenia	5,837 (43.91%)	3,471 (50.37%)	1,012 (45.01%)	10,320 (46.00%)	
Osteoporosis	1,124 (8.40%)	1,305 (18.93%)	767 (34.11%)	3,196 (14.24%)	
Grand Total	13,292	6,891	2,248	22,431	

As per the data, the chi-square value was 1,635.6512, and the p-value was <0.001. This shows that age group has a significant association with BMD in females.
BMD: bone mineral density

Table 3: Prevalence of normal BMD, osteopenia, and osteoporosis: Correlation between age groups and sex (men) according to the current database in India

Men					
	18-49 years (young adults)	**50-64 years (middle age)**	**≥65 years (elderly)**	**Total (Male)**	**p-value**
Normal	8,462 (50.58%)	2,737 (38.97%)	986 (32.55%)	12,185 (45.50%)	<0.001
Osteopenia	7,055 (42.17%)	3,481 (49.57%)	1,591 (52.52%)	12,127 (45.28%)	
Osteoporosis	1,210 (7.23%)	804 (11.44%)	452 (14.92%)	2,466 (9.20%)	
Grand Total	**16,727**	**7,022**	**3,029**	**26,778**	

The chi-square statistic was 588.2026. The p-value was < 0.001. This shows that there is a significant impact of age on BMD in males as well.
BMD: bone mineral density

Table 4: Prevalence of normal BMD, osteopenia, and osteoporosis: Correlation between age groups and sex (men and women) according to the current database in India.

Sex-wise distribution					
	Normal	**Osteopenia**	**Osteoporosis**	**Total**	**p-value**
Female	8,915 (42.25%)	10,320 (45.97%)	3,196 (56.45%)	22,431 (45.58%)	<0.001
Male	12,185 (57.75%)	12,127 (54.03%)	2,466 (43.55%)	26,778 (54.42%)	
Grand Total	**21,100**	**22,447**	**5,662**	**49,209**	

The chi-square statistic was 365.2028. The p-value was < 0.001. This shows that female are more prone to osteoporosis than male.
BMD: bone mineral density

Table 5: Age-wise distribution of BMD (T-score) at various camps according to the current database in India

Age groups (years)	BMD (T-score) mean (SD)			
	Overall (n=49,209)	**Male (n=26,778)**	**Female (n=22,431)**	**p-value***
18-49	0.65 (12.77)	0.99 (14.2)	0.22 (10.71)	**<0.01**
50-64	-0.76 (6.25)	-0.47 (7.24)	-1.06 (5.02)	**<0.01**
65+	-1.26 (4.36)	-0.96 (5.17)	-1.67 (2.90)	**<0.01**
All age groups	0.05 (10.64)	0.39 (11.97)	-0.36 (8.77)	**<0.01**

*p-value was determined by comparing the male and female T-scores. The Student's t-test was performed to compare the BMD scores.
BMD: bone mineral density; SD: standard deviation

Table 6: BMD (T-scores) mean score (state-wise).

States	Average BMD (*T-scores*)	Standard Deviation
Andaman and Nicobar Islands	-1.89	NA
Andhra Pradesh	-0.80	2.15
Assam	-1.52	1.00
Bihar	12.45	35.34
Chandigarh	-1.82	1.05
Chhattisgarh	-1.15	0.85
Delhi	-0.36	3.53
Gujarat	-0.85	1.89
Haryana	-0.83	1.11
Himachal Pradesh	-0.85	0.25
Jharkhand	-2.55	0.98
Karnataka	0.97	10.83
Kerala	-0.38	0.96
Lakshadweep	0.61	0.22
Madhya Pradesh	-1.17	1.51
Maharashtra	-1.10	2.19

Meghalaya	-1.47	0.85
Nagaland	-1.18	1.01
Odisha	-1.11	0.89
Punjab	-0.85	1.31
Rajasthan	-0.93	1.18
Tamil Nadu	-0.85	1.22
Telangana	-0.81	1.26
Uttar Pradesh	-1.08	1.44
Uttarakhand	-0.90	0.87
West Bengal	-0.75	5.98

BMD: bone mineral density; NA: not applicable.

Table 7: State-wise distribution of osteopenia and osteoporosis.

| States	Normal	Osteopenia	Osteoporosis	Total
Andaman and Nicobar Islands	0 (0%)	1(100.0%)	0 (0%)	1(100.0%)
Andhra Pradesh	612 (49.3%)	584 (47.1%)	45 (3.6%)	1241 (100.0%)
Assam	445 (26.3%)	1039 (61.4%)	209 (12.3%)	1693 (100.0%)
Bihar	1251 (36.0%)	1252 (36.0%)	977 (28.1%)	3480 (100.0%)
Chandigarh	32 (21.2%)	86 (57.0%)	33 (21.9%)	151 (100.0%)
Chhattisgarh	359 (40.7%)	495 (56.1%)	29 (3.3%)	883 (100.0%)
Delhi	1345 (59.3%)	783 (34.5%)	141 (6.2%)	2269 (100.0%)
Gujarat	701 (53.0%)	534 (40.4%)	88 (6.6%)	1323 (100.0%)
Haryana	758 (53.6%)	585 (41.4%)	70 (5.0%)	1413 (100.0%)
Himachal Pradesh	3 (100.0%)	0 (0%)	0 (0%)	3 (100.0%)
Jharkhand	102 (13.0%)	288 (36.6%)	397 (50.4%)	787 (100.0%)
Karnataka	1379 (58.3%)	908 (38.4%)	78 (3.3%)	2365 (100.0%)
Kerala	3 (75.0%)	1 (25.0%)	0 (0%)	4(100.0%)
Lakshadweep	3 (100.0%)	0 (0%)	0 (0%)	3 (100.0%)
Madhya Pradesh	983 (39.7%)	1083 (43.7%)	412 (16.6%)	2478 (100.0%)
Maharashtra	3382 (39.3%)	4418 (51.3%)	805 (9.4%)	8605 (100.0%)
Meghalaya	111 (28.5%)	233 (60.0%)	45 (11.5%)	389 (100.0%)
Nagaland	20 (41.7%)	23 (47.9%)	5 (10.4%)	48 (100.0%)
Odisha	368 (46.4%)	378 (47.6%)	48 (6.0%)	794 (100.0%)
Punjab	465 (55.0%)	310 (36.6%)	71 (8.4%)	846 (100.0%)
Rajasthan	533 (45.7%)	563 (48.3%)	70 (6.0%)	1166 (100.0%)
Tamil Nadu	931 (49.4%)	843 (44.7%)	112 (5.9%)	1886 (100.0%)
Telangana	657 (46.6%)	659 (46.8%)	93 (6.6%)	1409 (100.0%)
Uttar Pradesh	3818 (42.4%)	4334 (48.2%)	849 (9.4%)	9001 (100.0%)
Uttarakhand	318 (52.9%)	268 (44.6%)	15 (2.5%)	601 (100.0%)
West Bengal	2521 (39.6%)	2779 (43.6%)	1070 (16.8%)	6370 (100.0%)

Table 8: Zone-wise distribution of BMD by sex according to the current database in India

|	East		West		North		South	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
Normal	1,919 (30.62%)	3,258 (39.83%)	2,454 (38.28%)	3,145 (43.91%)	2,886 (44.12%)	3,853 (49.46%)	1,656 (50.79%)	1,929 (52.86%)
Osteopenia	2,838 (38.11%)	3,649 (42.41%)	3,115 (48.59%)	3,483 (48.63%)	2,949 (45.40%)	3,417 (43.86%)	1,418 (43.49%)	1,578 (43.24%)
Osteoporosis	1,509 (24.08%)	1,271 (15.54%)	841 (13.12%)	534 (7.45%)	660 (10.16%)	519 (6.66%)	186 (5.70%)	142 (3.89%)
Total	6,266	8,178	6,410	7,162	6,495	7,789	3,260	3,649

BMD: bone mineral density
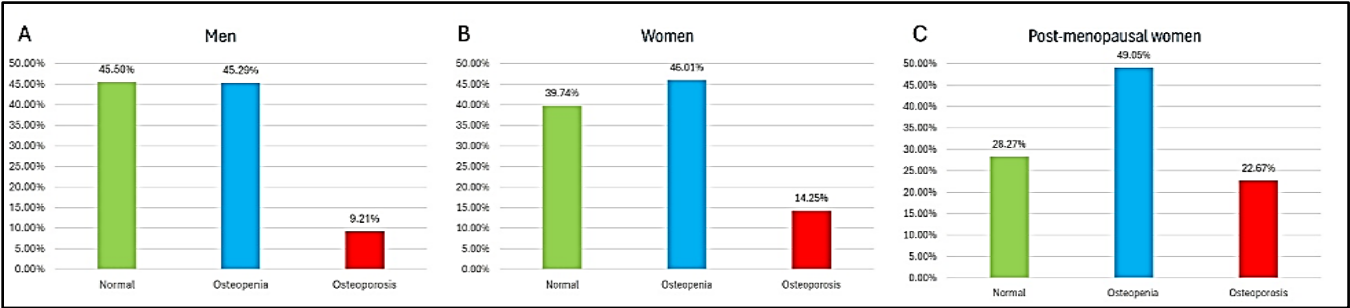
Figure 1: Prevalence of normal bone mineral density, osteopenia, and osteoporosis among (A) men, (B) women, (C) post-menopausal women at various camps according to the current database in India
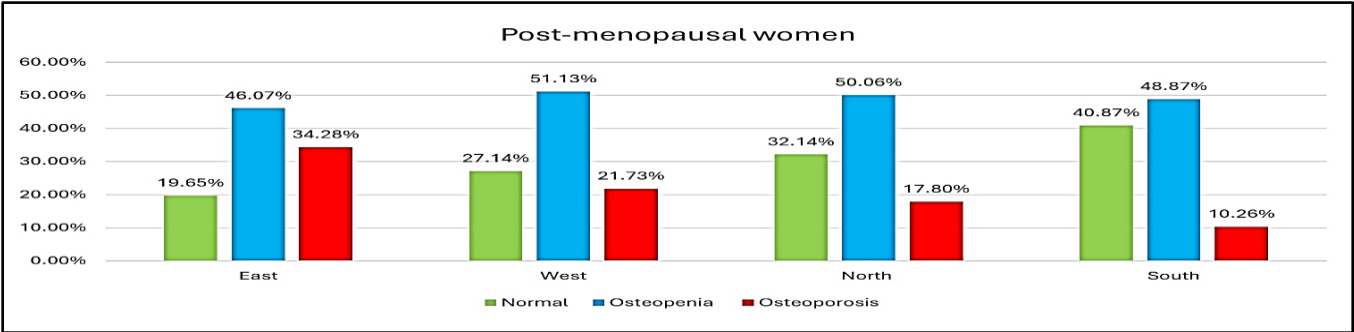
Figure 2: Zone-wise distribution of bone mineral density in postmenopausal women at various camps according to the current database in India
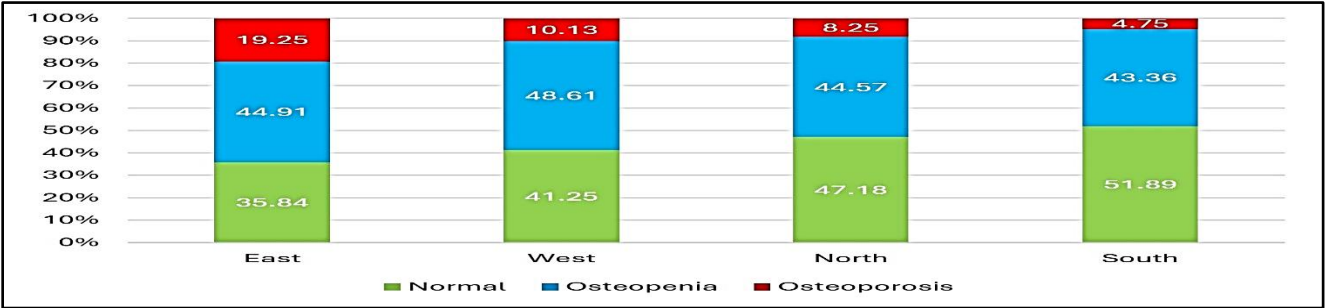
Figure 3: Zone-wise distribution of bone mineral density at various camps according to the current database in India
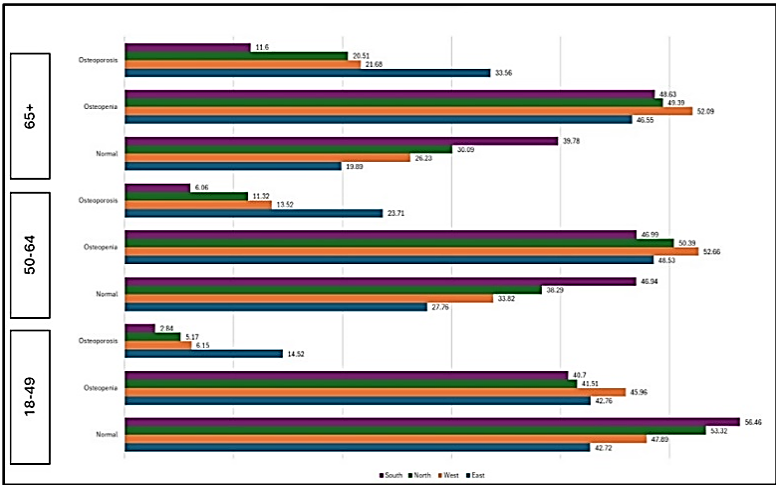
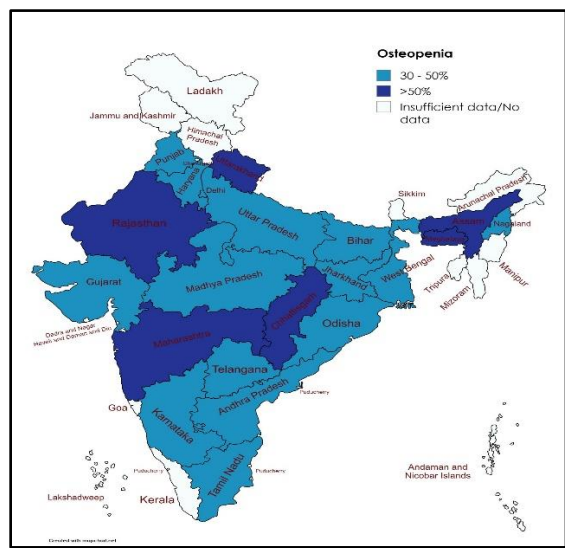**Figure 4:** Distribution of bone mineral density with regard to age group in India

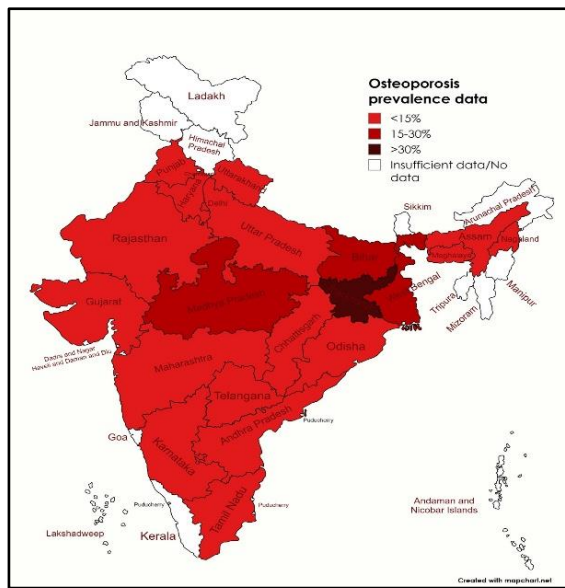**Figure 5:** Prevalence of osteopenia in India

Figure 6: Prevalence of osteoporosis in India

3.2. Sex-wise distribution of osteopenia and osteoporosis

The overall prevalence rates of osteopenia and osteoporosis were 45.62% and 11.51%, respectively. Among men and women of all age groups, the prevalence of osteopenia was 45.29% and 46.01%, respectively, and that of osteoporosis was 9.21% and 14.25%, respectively. Among postmenopausal women, the prevalence of osteopenia and osteoporosis was 49.05% and 22.67%, respectively (Figure 1A, B, and C). Osteoporosis was more common among elderly women (34.11%), and osteopenia was more common among elderly men (52.52%). Among middle-aged men and women, osteopenia was more common (49.57% and 50.37%). Among young adults of both sexes, the prevalence of osteopenia was 42.17% in men and 43.91% in women (**Table 2**, **3, and 4**). This trend was observed across different regions: East (46.07% vs. 34.28%), West (51.13% vs.

21.73%), North (50.06% vs. 17.80%), and South (48.87% vs. 10.26%) (**Figure 2**).

3.3. Age-wise distribution of osteopenia and osteoporosis

The age-wise distribution of the participants' BMD (T-scores) is presented in Supplementary

Table 5. Across all age groups and sexes, the overall mean (SD) T-score was observed to be 0.05 (10.64), with individual mean (SD) T-scores of men being women being 0.39 (11.97) and -0.36 (8.77), respectively (p<0.01). Furthermore, across all age groups, the mean (SD) T-scores were significantly higher among men than in women (18–49 years: 0.99 14.2 vs. 0.22 10.71; 50-64: -0.47 7.24 vs. -1.06 5.02; 65+: -0.96 5.17 vs. -1.67 2.90). The highest and lowest mean (SD) T-scores for men were observed in the 18–49 (young adults) and 65+ (elderly) year age groups (0.99 14.20 and -0.96 5.17, respectively). A similar trend was

observed among women. Additionally, the mean (SD) T-scores ranged from the highest (12.45 35.34) in Bihar to the lowest (-2.55 0.98) in Jharkhand (Supplementary **Table 6**). Supplementary

Figure 4 presents the bone density levels across different age groups and regions. Among adults aged 18–49 years, the prevalence of osteoporosis ranged from 2.84% in the South to 14.52% in the East, while the prevalence of osteopenia ranged from 40.7% in the South to 45.96% in the West. In the 50–64 year age group, the West showed the highest incidence of osteopenia at 52.66%, while osteoporosis rates varied from 6.06% in the South to 23.71% in the East. Among those aged ≥65 years, osteoporosis prevalence peaked at 33.56% in the East, while the West region has the highest incidence of osteopenia at 52.09%.

3.4. Zone-wise distribution of osteopenia and osteoporosis

The prevalence of osteopenia varied from 43.36% in the South to 48.61% in the West. The overall prevalence of osteoporosis was highest in the East at 19.25% and lowest in the South (4.75%) (**Figure 3**). The prevalence of osteopenia was relatively higher than that of osteoporosis across all states except Jharkhand (36.60% vs. 50.40%) (Supplementary **Table 7**). Supplementary **Table 8** presents the zone-wise distribution of BMD among men and women. Women exhibited higher rates of osteoporosis, ranging from 5.70% to 24.08%, with the East having the highest prevalence. In contrast, men showed lower rates, ranging from 3.89% to 15.54%, with the East having the highest prevalence. Osteopenia was more prevalent in the West among both sexes (48.59% in women and 48.63% in men). Overall, across all the zones, the prevalence of osteopenia ranged from 38.11% to 48.59% among women and 42.41% to 48.63% among men, respectively. The overall prevalence of osteopenia and osteoporosis in India is illustrated in Supplementary **Figure 5** and **Figure 6**, respectively.

4. Discussion

Individuals in their 40s display an increase in BMD loss, leading to reduced compressive and/or torsional bone strength and an increased risk of fragility fractures.[30] Thus, the early detection of BMD loss is essential to reduce the burden of fractures resulting from osteopenia and osteoporosis. The current study is one of its kind, encompassing national and regional BMD data collected across diverse age groups from a cohort of 49,209 healthy individuals.

In the current study, the overall prevalence of osteopenia (45.62%) was much higher than that of osteoporosis (11.51%) across all age groups. Similarly, another retrospective study conducted between 2018–2019 in India reported a 49.90% and 18.30% prevalence of osteopenia and osteoporosis, respectively.[24] The higher prevalence of osteopenia is attributable to several factors,[6,24] including aging population, ethnicity, genetic predisposition, geographical diversity, dietary variations, alcoholism, smoking, and sedentary lifestyle. These primary and secondary factors contribute to early BMD loss in the Indian subcontinent, translating into a higher number of osteopenic cases.[6,24]

Osteopenia is more prevalent compared to osteoporosis because it occurs earlier in the bone health continuum and affects a broader population. Among men and women of all age groups, the prevalence of osteopenia (45.29% and 46.01%, respectively) was higher than that of osteoporosis (9.21% and 14.25%, respectively). A community-based cross-sectional study reported similar results, where the prevalence rates of osteopenia among male and female participants were 35.58% and 43.94%, respectively, and those of osteoporosis were 2.51% and 11.72%, respectively.[31] Similarly, a cohort study from North India reported the prevalence of osteopenia at 54.3% and 44.9% and osteoporosis at 24.8% and 42.5% among males and females, respectively.[32]

In India, early-onset menopause and nutritional deficiencies in women are associated with a greater risk of osteopenia and osteoporosis. In early menopause, bone loss is accelerated (2–5% per year); it reduces to 1% per year after 5–7 years of menopause.[33] In the present study, the prevalence of osteopenia (49.05%) was higher than that of osteoporosis (22.67%) among post-menopausal woman. Studies on Indian cohorts indicate that one of two (~47.5%) women and one of three (~33.1%) women in the postmenopausal period have osteopenia and osteoporosis, respectively.[24] A cohort study of post-menopausal women in North India reported a 44.9% and 42.4% prevalence of osteopenia and osteoporosis, respectively.[32] More specifically, in this study, the prevalence of osteopenia and osteoporosis among women aged 50–64 years was 50.37% and 18.93%, respectively. Similarly, the prevalence rates of osteopenia and osteoporosis among women aged >65 years were 45.01% and 34.11%, respectively. Our data are in agreement with a previously published study, which showed a higher prevalence of osteopenia in adults than in the elderly (51.6% vs. 44.7%) irrespective of sex.[24]

Owing to the vast geographical diversity, ethnic variations, and dietary patterns observed in the Indian subcontinent, regional variation in the prevalence of osteopenia and osteoporosis is expected. In this study, the prevalence of osteopenia varied from 43.36% in the South to 48.61% in the West. Compared with osteopenia, the prevalence of osteoporosis was much lower that is, 10.13% in the West, 8.25% in the North, 19.25% in the East, and 4.75% in the South. Similar results were obtained in a retrospective cohort study, which demonstrated that the prevalence of osteopenia ranged from 47.4% in South India to 55.6% in North India, and that the prevalence of osteoporosis ranged from 16.3% to 20.7% across the Indian subcontinent.[24]

An observation from this study is the prevalence of osteoporosis in adults (18–49 years old). Although osteoporosis is traditionally linked with postmenopausal women and older men, it can also affect younger adults (<50 years old) with less frequency. Research indicates that bone loss begins between the ages of 30 and 40 years in both men and women.[15] It occurs in scenarios such as chronic illness, intake of medications affecting bone health, and other risk factors. This could account for the incidence of osteoporosis in adults <50 years old in this study; however, the underlying causes remain undetermined.

In the current study, West India had the highest prevalence of osteopenia across all age groups, the East had a high prevalence of osteoporosis, and the South had the highest prevalence of normal BMD among all age groups. A retrospective cohort study from 2017 reported a 47.9% and 29.4% prevalence of osteopenia and osteoporosis, respectively, among adults from East India.[24,34] The prevalence of osteopenia and osteoporosis in the East has also been reported at 51.3% and 18.4%, respectively, with nearly similar rates among males and females.[24] The higher prevalence of osteoporosis in the East could be attributed to the dietary deficiency of bone-improving vitamins such as vitamin D, calcium, vitamin C, vitamin B12, vitamin K, omega 3 fatty acids, and carotenoids.[24]

Lastly, the current study also reported that among postmenopausal women, the prevalence of osteopenia was relatively higher than that of osteoporosis across all regions, that is, the East (46.07% vs. 34.28%), West (51.13% vs. 21.73%), North (50.06% vs. 17.80%), and South (48.87% vs. 10.26%). Compared to previously published osteoporosis data in post-menopausal women, ours is the first study to include an in-depth analysis of the prevalence of osteopenia in this population across different regions of India.

5.   Limitation

As this study is based on data from voluntary participation in screening camps rather than a probability-based sample, the findings may overestimate the true population prevalence of osteopenia and osteoporosis. Nonetheless, the study offers valuable insights into regional trends and risk patterns, paving the way for future large-scale, cohort-based research to systematically assess modifiable and non-modifiable factors influencing bone mineral density (BMD). Other limitation of the study is the lack of historical data on genetic predisposition for osteoporosis and the lack of medical history, especially fragility fractures that might have occurred in participants. Furthermore, missing nutritional/dietary supplement data could have added value to the zonal epidemiological data. However, the current study paves way for large cohort-based studies to extensively evaluate all modifiable and non-modifiable parameters affecting BMD, enabling better diagnosis and management of osteopenia and osteoporosis.

6.   Conclusions

The current study reported that about half of the population is affected by osteopenia, whereas osteoporosis affects one in 10 individuals. Among postmenopausal women, roughly one in two developed osteopenia. Compared with osteoporosis, a higher prevalence of osteopenia was observed among men and women across all age groups. The highest prevalence of osteopenia was observed in the West region and that of osteoporosis in the East region across all age groups and sexes.

In conclusion, based on the findings of the current study, which reported the prevalence of osteopenia in approximately 50% of the population, a significant portion of the Indian population is at an elevated risk of developing osteoporosis in the foreseeable future. Our study elucidates the national and regional epidemiological patterns to assist healthcare professionals and policymakers in devising strategies to mitigate the risk of bone loss among the high-risk Indian population.

7.   Source of Funding

8.   Conflicting Interest

All three authors are employees of Lupin Limited Pharmaceutical Company, Mumbai, Maharashtra, India. The authors did not receive an honorarium for the study.

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