Prevalence of osteoporosis in India: A systematic review and meta-analysis

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Abstract---Osteoporosis is a common metabolic disorder associated with reduced bone strength and the most common cause of bone fracture, especially in the elderly. There is no synthesized evidence to inform policy on its prevalence and distribution across India. Therefore, this systematic review and meta-analysis aim to estimate and summarize the prevalence of osteoporosis among adults in India. The systematic review and meta-analysis were conducted following the PRISMA criteria. A comprehensive systematic search was performed until May 23, 2022, in the following electronic databases: Medline (via PubMed), Embase, and ProQuest. After screening, twelve eligible studies were included in the study reporting the prevalence of osteoporosis among adults aged 18 years and for subsequent methodological quality assessment and data extraction using predefined standardized tools. Random and fixed effects models for meta-analysis were used to arrive at summary estimates for prevalence with 95% confidence intervals. The included studies used data from 5261 study participants in total. The prevalence of osteoporosis among children in India is 22.9% (95% CI: 14.9-32.0%), and that of osteopenia was 44.8% (95% CI: 38.9-50.7%). Prevalence of Osteoporosis was significantly higher among females at 26.3% (95% CI: 16.9-37.0%) as compared to males at 10.9% (95% CI: 4.5-19.7). A robust and comprehensive prevalence estimate will facilitate health policy decision-making and help plan and provide necessary facilities

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for people with osteoporosis. This study is the first to synthesize a report on the prevalence of osteoporosis and osteopenia in India. Improved access to health services, other health systems and policy research are required to initiate and enhance the uptake of screening and treatment of Osteoporosis in India.

Keywords---osteoporosis, systematic review, metanalysis, bone disorders, prevalence.

Introduction

Osteoporosis is a common metabolic disease associated with reduced bone strength and is defined operationally by bone mineral density (BMD). WHO describes Osteoporosis when BMD lies 2.5 standard deviations or more (T-score of less than -2.5) SD [1–3]. Osteoporosis is the most common cause for bone fracture, particularly in the elderly population; symptoms typically do not appear until bone fracture [4]. In case of decreased BMD, minor stress can induce fracture, and the associated chronic pain severely affects everyday activities [4]. In a systematic review, the prevalence of osteoporosis in women was reported to be 23.1 (95% CI 19.8–26.9), while the prevalence of osteoporosis among men worldwide was 11.7 (95% CI 9.6– 14.1) [3]. Osteoporosis is mainly classified as primary and secondary types in which primary osteoporosis is seen primarily in postmenopausal women and the elderly population above the age of 70 years [5]. Diseases (Systematic and endocrine), lifestyle conditions and treatments are causes of secondary osteoporosis[5]. To diagnose Osteoporosis, BMD is measured by dual-energy X-ray absorptiometry (DXA) or by the speed of sound (SOS) measured by ultrasound imaging [6,7].

Risk factors for osteoporosis are gender, age, race, genetic characteristics, heavyweight, smoking, alcohol consumption, and physical inactivity. The risk factors are more prevalent in women with premature menopause and loss of ovarian function [8,9]. The incidence of fractures in the elderly population due to osteoporosis is one of the leading causes of death [6]. Usually, fractures occur in three areas; vertebrae, distal arm and hip and are more common in women [10]. Osteoporosis is a problem for both sexes, but most research on osteoporosis has focused on women [10]. So far, many studies have been conducted on the prevalence of osteoporosis in different parts of the world. There have been various studies in India but with small sample size and a limited geographic area. A survey in India with 773 study participants aged between 30 and 90 showed that the prevalence of osteoporosis was 24.7%. Prevalence in women was 15%, of which 10.3% was related to postmenopausal women and 4.7% to premenopausal women. In the same survey, the prevalence in men was reported to be 9.7% [11]. In another study in India, the prevalence of osteoporosis between the ages of 20 and 85 was reported 6.9%, 11.1% of which were women, and 3.9% were men [12].

These discrepancies in reports of the prevalence of osteoporosis can be seen in research in other parts of India. It is essential to have consistent information on the prevalence of Osteoporosis in India. Determining the

prevalence and incidence of osteoporotic fractures is the first step in adopting the necessary strategies to reduce the burden of this challenge and concerns. Due to the difference in reports related to the prevalence of osteoporosis in the different regions of India, based on small and large samples, and the lack of estimates of the prevalence in India, we decided to have a systematic review of all studies conducted in this field. Using meta-analysis tools, we will also examine India's pooled prevalence of Osteoporosis and osteopenia. Therefore, this study aims to investigate the systematic analysis of evidence and studies to report the prevalence of Osteoporosis in India.

Method

This systematic review was conducted with an *a priori* protocol with no deviations in accordance with the Joanna Briggs Institute methodology for systematic reviews of prevalence and incidence. The following selection criteria were used for studies:

Study Participants

All studies that reported osteoporosis in adults (age 18 years and above) and carried out in any region/state of India, in part or exclusively, were included in our review.

Condition

We included studies that reported the prevalence of osteoporosis, diagnosed by measuring the Bone Mineral Density (BMD) by standard equipment (such as DEXA densitometer, Quantitative ultrasound (QUS)) either as part of primary or secondary objectives of the study or even reported as a covariate.

Context

The focus of this systematic review is to summarize the prevalence of osteoporosis among adults in India, so we have considered surveys or screening programs in the general population/schools/hospitals for the review. We have excluded all the studies for which full text was not available/accessible and for studies in which age classification was not provided. In the studies where from the same sample duplicate data has been provided, we have considered only one data. We have excluded studies where mortality estimates are provided and any modelling studies from our review.

Types of studies

Descriptive or analytical observational studies, including baseline reports of longitudinal cohort and analytical cross-sectional studies, were considered for inclusion. Experimental studies and qualitative designs were excluded. We also excluded conference abstracts or presentations, protocols, books/book chapters,

preprints, reviews—narrative or systematic, letters/news articles/opinions/commentaries.

Search strategy

A comprehensive systematic search was performed on May 23, 2022, in the following electronic databases: Medline (via PubMed), Embase, and ProQuest. In order to keep the search strategy sensitive enough, the databases were searched for those studies that mentioned the name of India or any of the states in India, along with variations of the terms related to Osteoporosis, Osteopenia with prevalence and cross-sectional studies within their abstracts and titles. The detailed search strategy template used is provided in Appendix-1 for MEDLINE. The search strategy, including all identified keywords and index terms, was adapted for each included database and information source. The reference list of all included sources of evidence was screened for additional studies.

Study selection

Following the search, all identified citations were collated and uploaded into a reference management software , and duplicates were removed. Titles and abstracts were screened by two reviewers independently for assessment against the inclusion criteria. Potentially relevant studies were retrieved in full, and their citation details were imported into the JBI System for the Unified Management, Assessment and Review of Information (JBI SUMARI) (JBI, Adelaide, Australia).[13] The full text of included articles was assessed in detail against the inclusion criteria by two reviewers. Reasons for excluding papers after full-text review that do not meet the inclusion criteria were recorded and reported. The discrepancies were discussed and resolved by consensus. In case of a disagreement, a third author made the decision.

Assessment of methodological quality

Two independent reviewers critically appraised eligible studies for methodological quality using standardized critical appraisal instruments from JBI for observational studies.[14] Any disagreements that arose were resolved through discussion. All studies, regardless of the results of their methodological quality, underwent data extraction and synthesis (where possible). Sample size appropriateness was judged by pre-calculated cut-offs based on an estimated community prevalence of 1% for osteoporosis. [15]

Data extraction

Data were extracted from studies included in the review by two independent reviewers using a modified version of the standardized data extraction tool for prevalence and incidence in JBI SUMARI. The data extracted included specific details about the condition, populations, study methods, and proportions of interest for osteoporosis.

Data synthesis

A narrative synthesis of relevant findings from the included studies and the subgroups of interest was done. Studies, where possible, were pooled in a statistical meta-analysis using R software packages (Meta and metafor). [16] Effect sizes were expressed as a proportion with 95% confidence intervals around the summary estimate. Statistical analyses were performed using both random and fixed-effects models using the double arcsine transformation approach. Subgroup analyses were conducted where there was sufficient data to investigate. Heterogeneity was assessed statistically using the standard chi-squared, tau, and I-squared tests. Publication bias was assessed using funnel plots.

Results

Study inclusion

We included a total of 12 articles in this review that were identified from the screening of 638 articles from database searches. The details of exclusions and reasons are shown in the PRISMA flow chart below (Figure 1)
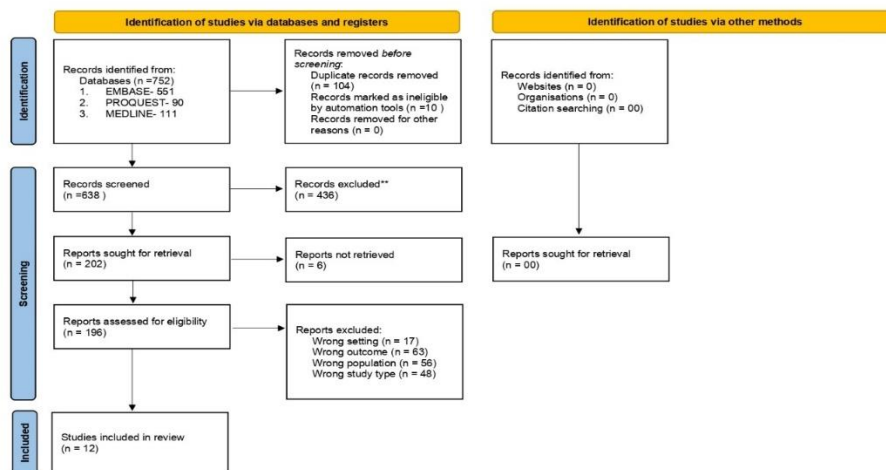
Figure 1- PRISMA flow chart

Methodological quality of the included studies

The methodological quality of the included studies as a whole was adequate based on the results of the critical appraisal. All studies were adequate in terms of the sampling frame used, sample size, Osteoporosis identification and measurement methods. While 83.33% of the studies had done detailed data analysis, and 58.33% have provided detailed study settings. The details of the critical appraisal findings of the included studies are provided in table 1.

Table-1 Methodological quality of included studies

Study ID	Appropriate Sample frame	Appropriate Sampling	Adequate Sample size	Detailed Study setting	Adequate Data analysis	Adequate Methods for Osteoporosis identification	Reliable Measurement of Osteoporosis	Appropriate Statistical analysis	Adequate Response rate
Chhibber 2007	Y	N	Y	Y	Y	Y	Y	Y	U
Neema 2009	Y	Y	Y	Y	Y	Y	Y	Y	Y
Aggarwal 2011	Y	U	Y	N	N	Y	Y	Y	U
Agrawal 2012	Y	N	Y	N	Y	Y	Y	Y	Y
Agrawal 2013	Y	N	Y	Y	Y	Y	Y	Y	Y
Kaur 2013	Y	Y	Y	N	N	Y	Y	Y	Y
Bhat 2016	Y	U	Y	U	Y	Y	Y	Y	U
Modagan 2018	Y	U	Y	Y	Y	Y	Y	Y	Y
Kaushal 2018	Y	U	Y	Y	Y	Y	Y	Y	Y
Kadam 2018	Y	Y	Y	Y	Y	Y	Y	Y	Y
Padmanabhan 2019	Y	U	Y	N	Y	Y	Y	Y	Y
Khinda 2022	Y	Y	Y	Y	Y	Y	Y	Y	Y
%	100%	33.33%	100%	58.33%	83.33%	100%	100%	100%	75%

Characteristics of included studies

The review synthesized results from 5261 participants collected between 2007 and 2022. We found the reported studies from five states and two union territories of India, and one reported study has not mentioned the study location. All the reported studies have provided age distribution, with three studies from both genders. The majority of the participants, 60% (6) of the studies, included only female participants, and only one study included only male participants. While seven studies reported findings from community-based settings rest were carried out in the hospital-based setting. All the studies except two BMD measurements were carried out using the DEXA densitometer, which is the gold standard for testing BMD. Two of the studies used Quantitative ultrasound. The descriptive characteristics of the included studies are summarized in the table-2 below.

Study ID	Year	State	Participant characteristics			Conditions and measurement methods	Description of main results				
			Age groups included-	Gender- (Males=%)]	Setting-		N=	Prevalence of Osteoporosis=	Prevalence of Osteopenia=	Gender wise:	Remarks
Chhibber 2007	2007	New Delhi, Haryana	60 years and above	Female	Community-based setting	BMD measurement using DXA machine Hologic densitometer QDR4500A	430	61.63%	29.30	Females 61.63%	Post-Menopausal 61.63%
Neema	20	Mahara	40-	Femal	Comm	BMD	11	15.4%		Fem	Premeno

2009	09	shtra	60 years	e	unity based setting	measurement using Quantitative ultrasound (QUS) measurement,	22			ales-15.4%	pausal-1.9% Post-Menopausal-13.5%
Aggarwal 2011	2011	Chandigarh	45 years above	Female	Community-based setting	BMD measurement using the DEXA Densitometer	200	53%		Females-53%	
Agrawal 2012	2010		35 years and above	Female	Community-based setting	BMD measurement using Quantitative ultrasound (QUS) measurement	158	13.3	48.1	Females-13.3%	Premenopausal-5.7 % Post-Menopausal- 7.6 %
Agrawal 2013	2010-2011	Uttar Pradesh	50 years and above	Male - 100%	Hospital-Based setting	The BMD was measured by dual-energy X-ray absorptiometry (DXA; Lunar DPX-NT, GEMedical System, USA)	200	8.5	42%	Male-8.5%	
Kaur 2013	2011	Punjab, Haryana, Chandigarh	45-80 years	Females	Community-based setting	BMD measurement using the DEXA Densitometer	250	26.4%		Females-26.4%	Post-Menopausal- 26.4 %
Bhat 2016	2014-2015	UP	60 and above	Males	Community based setting	BMD measurement using dual-energy X-ray absorptiometry (DXA, Hologic QDR 4500 A, Bedford, MA)	241	19%	56% Male-56%	Male-19%	
Modagan 2018	2018	Tamil Nadu	30-90	Both Males - 49.15	Hospital-based setting	BMD measurement using	773	24.7%	44.6% Male-22.5% Female	Males-9.7% Fem	Premenopausal-10.3% Post-

				%		the DEXA Densito meter			-22.1%	ales-15%	Menopau sal- 4.7%
Kaushal 2018	2018	New Delhi	18 years above	Both Males - 58.77 %	Hospital-based setting	BMD measurement using dual-energy-X-ray absorptiometry (DXA) machine	524	6.9%	34.1% Male-17.5% Female -16.6%	Males-2.4% Females- 4.5%	
Kadam 2018	2014-2016	Maharashtra	40-75	Both Male-45.84 %	Community-based setting	BMD measurement using Lunar DPX-PRO total body pencil beam Densitometer	421	16.4%	49.8% Males-25.6% Females-24.2 %	Males-6.7% Females-9.7%	
Padmanabhan 2019	2018	Tamil Nadu	30-70	Females	Community-based setting	BMD measurement using Quantitative ultrasound (QUS) measurement	270	15.9%	57.4%	Females-15.9 %	Premenopausal-4.4% Post-Menopausal-11.5%
Khinda 2022	2019-2020	Punjab	50-80	Females	Community-based setting	BMD measurement using dual energy X-ray absorptiometry (DXA)	672	30.50%	44.19 % Females-44.19 %	Females-30.50%	Post-Menopausal-11.5%

Review findings

The pooled prevalence of osteoporosis among adults in India is 22.9% (95% CI: 14.9-32.0%). Osteoporosis prevalence was higher among females at 26.3% (95% CI: 16.9-37.0%) as compare to males at 10.9% (95% CI: 4.5-19.7).The forest plots for the meta-analysis is given in the figure-2, 3 and 4 below.
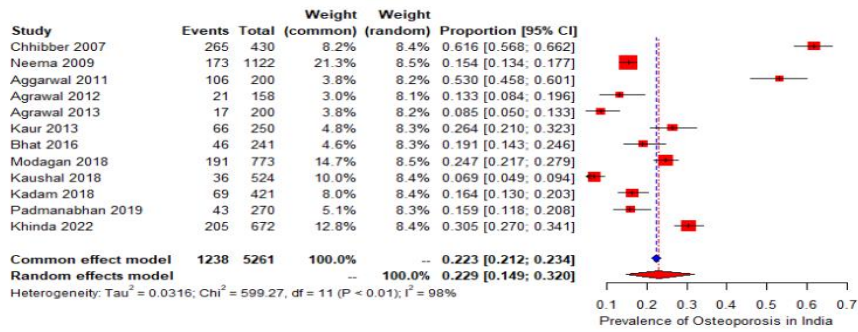
Study	Events	Total	Weight (common)	Weight (random)	Proportion [95% CI]
Chhibber 2007	265	430	8.2%	8.4%	0.616 [0.568; 0.662]
Neema 2009	173	1122	21.3%	8.5%	0.154 [0.134; 0.177]
Aggarwal 2011	106	200	3.8%	8.2%	0.530 [0.458; 0.601]
Agrawal 2012	21	158	3.0%	8.1%	0.133 [0.084; 0.196]
Agrawal 2013	17	200	3.8%	8.2%	0.085 [0.050; 0.133]
Kaur 2013	66	250	4.8%	8.3%	0.264 [0.210; 0.323]
Bhat 2016	46	241	4.6%	8.3%	0.191 [0.143; 0.246]
Modagan 2018	191	773	14.7%	8.5%	0.247 [0.217; 0.279]
Kaushal 2018	36	524	10.0%	8.4%	0.069 [0.049; 0.094]
Kadam 2018	69	421	8.0%	8.4%	0.164 [0.130; 0.203]
Padmanabhan 2019	43	270	5.1%	8.3%	0.159 [0.118; 0.208]
Khinda 2022	205	672	12.8%	8.4%	0.305 [0.270; 0.341]
Common effect model	**1238**	**5261**	**100.0%**	--	**0.223 [0.212; 0.234]**
Random effects model			--	**100.0%**	**0.229 [0.149; 0.320]**

Heterogeneity: $Tau^2 = 0.0316$; $Chi^2 = 599.27$, df = 11 (P < 0.01); $I^2 = 98\%$

Prevalence of Osteoporosis in India

Figure 2- Prevalence of Osteoporosis in India

Study	Events	Total	Weight (common)	Weight (random)	Proportion [95% CI]
Agrawal 2013	17	200	18.5%	24.6%	0.085 [0.050; 0.133]
Modagan 2018	75	380	35.1%	25.6%	0.197 [0.159; 0.241]
Jha 2018	12	308	28.5%	25.3%	0.039 [0.020; 0.067]
Khadilkar 2018	28	193	17.9%	24.5%	0.145 [0.099; 0.203]
Common effect model	**132**	**1081**	**100.0%**	--	**0.113 [0.095; 0.133]**
Random effects model			--	**100.0%**	**0.109 [0.045; 0.197]**

Heterogeneity: $Tau^2 = 0.0146$; $Chi^2 = 49.14$, df = 3 (P < 0.01); $I^2 = 94\%$

Prevalence of Osteoporosis in Male

Figure 3- Prevalence of Osteoporosis in Male

Study	Events	Total	Weight (common)	Weight (random)	Proportion [95% CI]
Chhibber 2007	265	430	10.9%	10.1%	0.616 [0.568; 0.662]
Neema 2009	173	1122	28.5%	10.2%	0.154 [0.134; 0.177]
Aggarwal 2011	106	200	5.1%	9.9%	0.530 [0.458; 0.601]
Agrawal 2012	21	158	4.0%	9.8%	0.133 [0.084; 0.196]
Kaur 2013	66	250	6.4%	10.0%	0.264 [0.210; 0.323]
Modagan 2018	116	393	10.0%	10.1%	0.295 [0.250; 0.343]
Kaushal 2018	24	216	5.5%	9.9%	0.111 [0.073; 0.161]
Kadam 2018	41	228	5.8%	9.9%	0.180 [0.132; 0.236]
Padmanabhan 2019	43	270	6.9%	10.0%	0.159 [0.118; 0.208]
Khinda 2022	205	672	17.1%	10.1%	0.305 [0.270; 0.341]
Common effect model	**1060**	**3939**	**100.0%**	--	**0.258 [0.245; 0.272]**
Random effects model			--	**100.0%**	**0.263 [0.169; 0.370]**

Heterogeneity: $Tau^2 = 0.0333$; $Chi^2 = 454.58$, df = 9 (P < 0.01); $I^2 = 98\%$
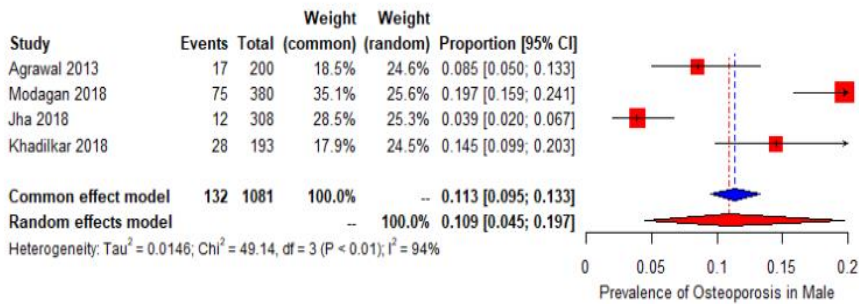
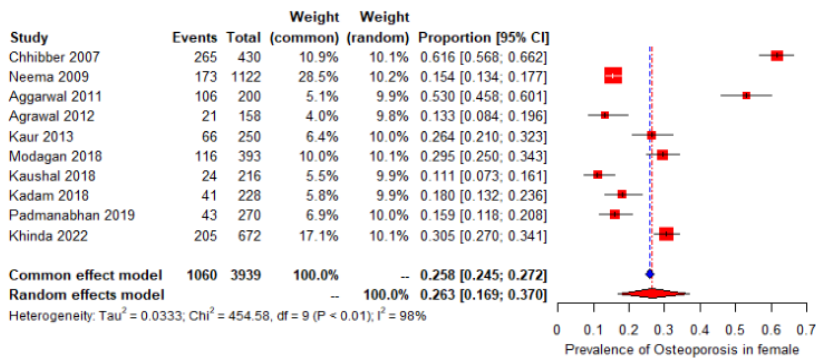Prevalence of Osteoporosis in female

Figure 4- Prevalence of Osteoporosis in female

The pooled prevalence of osteopenia among adults in India was 44.8% (95% CI: 38.9-50.7%). The prevalence of osteopenia among males was 45.7% (95% CI: 36.1-55.6), and in females, 43.6% (95% CI: 37.2-50.2). All meta-analyses reported a high degree of heterogeneity in the study results. The forest plot for meta-analysis is given in figure-5,6 and 7 below
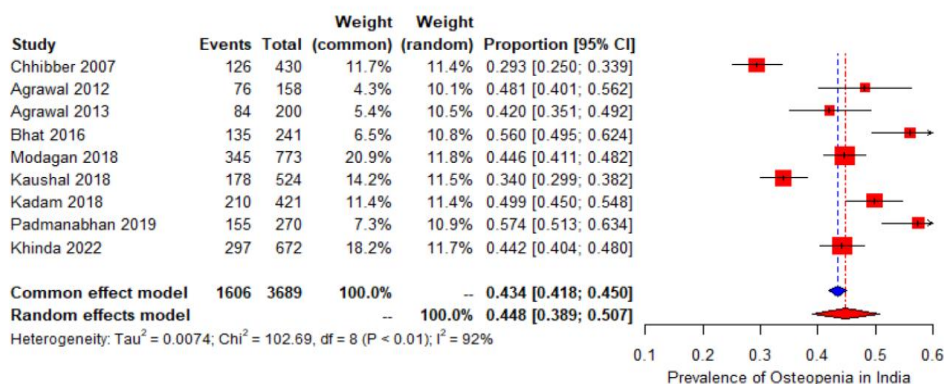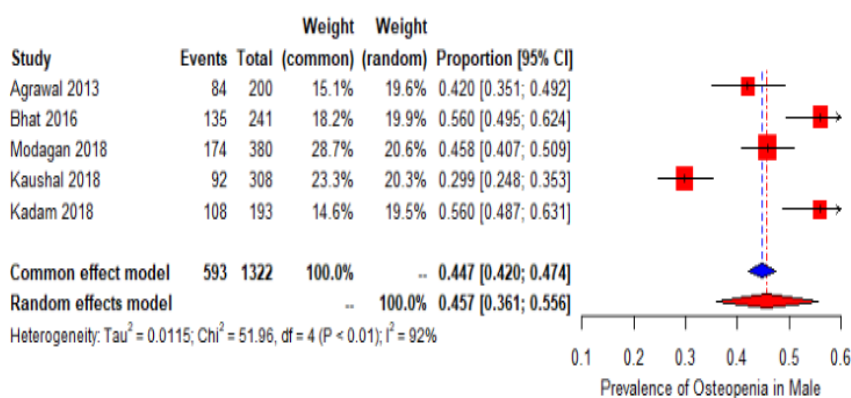
Study	Events	Total	Weight (common)	Weight (random)	Proportion [95% CI]
Chhibber 2007	126	430	11.7%	11.4%	0.293 [0.250; 0.339]
Agrawal 2012	76	158	4.3%	10.1%	0.481 [0.401; 0.562]
Agrawal 2013	84	200	5.4%	10.5%	0.420 [0.351; 0.492]
Bhat 2016	135	241	6.5%	10.8%	0.560 [0.495; 0.624]
Modagan 2018	345	773	20.9%	11.8%	0.446 [0.411; 0.482]
Kaushal 2018	178	524	14.2%	11.5%	0.340 [0.299; 0.382]
Kadam 2018	210	421	11.4%	11.4%	0.499 [0.450; 0.548]
Padmanabhan 2019	155	270	7.3%	10.9%	0.574 [0.513; 0.634]
Khinda 2022	297	672	18.2%	11.7%	0.442 [0.404; 0.480]
Common effect model	1606	3689	100.0%	--	0.434 [0.418; 0.450]
Random effects model			--	100.0%	0.448 [0.389; 0.507]

Heterogeneity: $Tau^2 = 0.0074$; $Chi^2 = 102.69$, df = 8 (P < 0.01); $I^2 = 92\%$

Figure 5- Prevalence of Osteopenia in India

Study	Events	Total	Weight (common)	Weight (random)	Proportion [95% CI]
Agrawal 2013	84	200	15.1%	19.6%	0.420 [0.351; 0.492]
Bhat 2016	135	241	18.2%	19.9%	0.560 [0.495; 0.624]
Modagan 2018	174	380	28.7%	20.6%	0.458 [0.407; 0.509]
Kaushal 2018	92	308	23.3%	20.3%	0.299 [0.248; 0.353]
Kadam 2018	108	193	14.6%	19.5%	0.560 [0.487; 0.631]
Common effect model	593	1322	100.0%	--	0.447 [0.420; 0.474]
Random effects model			--	100.0%	0.457 [0.361; 0.556]

Heterogeneity: $Tau^2 = 0.0115$; $Chi^2 = 51.96$, df = 4 (P < 0.01); $I^2 = 92\%$

Figure 6- Prevalence of Osteopenia in Male

Study	Events	Total	Weight (common)	Weight (random)	Proportion [95% CI]
Chhibber 2007	126	430	18.2%	14.9%	0.293 [0.250; 0.339]
Agrawal 2012	76	158	6.7%	13.1%	0.481 [0.401; 0.562]
Modagan 2018	171	393	16.6%	14.8%	0.435 [0.385; 0.486]
Kaushal 2018	86	216	9.1%	13.8%	0.398 [0.332; 0.467]
Kadam 2018	102	228	9.6%	13.9%	0.447 [0.382; 0.514]
Padmanabhan 2019	155	270	11.4%	14.2%	0.574 [0.513; 0.634]
Khinda 2022	297	672	28.4%	15.3%	0.442 [0.404; 0.480]
Common effect model	1013	2367	100.0%	--	0.427 [0.407; 0.447]
Random effects model			--	100.0%	0.436 [0.372; 0.502]

Heterogeneity: $Tau^2 = 0.0070$; $Chi^2 = 60.77$, df = 6 (P < 0.01); $I^2 = 90\%$
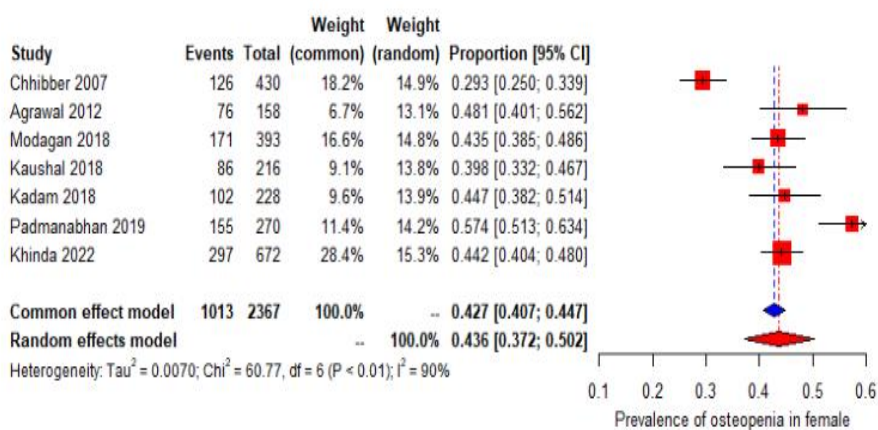

Figure 7- Prevalence of Osteopenia in female

Discussion

This present review summarized and synthesized findings from 12 studies from India among adults that included 5261 participants. The pooled prevalence of osteoporosis was 22.9% and for osteopenia was 44.8%. The prevalence was higher as compared to the global prevalence of osteoporosis found in the systematic review by Salari et al., which was 18.3% [3]. The difference can be attributed to the difference in genetic characteristics, gender, and race of study participants. However, the prevalence found in our review was lower than in China reported by Chen et al., which was 27.96% [17].

In our review, we found a high prevalence of osteoporosis among female participants, 26.3%, compared to males, 10.9%. The findings were similar to the review by Salari et al. They found a prevalence of 25.9% in females compared to 11.7% in males. In our review of 12 studies, only 3 have taken both genders as study participants, and 7 studies have only female study participants. Two studies have only male study participants. In three papers, only postmenopausal female participants were taken, and prevalence was calculated. In our review we have considered osteoporosis and osteopenia prevalence by BMD measurement, irrespective of the measurement site. In three of the papers, osteoporosis and osteopenia differentiation is not provided.

While our review considered only peer-reviewed published data, a significant source of government data generated from screening programs in various states that do not meet the criteria above may also be available. State-wise data is not consistently available, limiting generalizations made for the country from regional studies. The overall studies considered only study participants from five states and two union territories, which highlights that most states are left behind. While this review attempts to answer a highly relevant and focused research question, its strengths include a robust methodology, use of standardized tools and a highly sensitive search strategy. It has a few limitations as well. Another limitation was the high degree of heterogeneity reported in our study. The review has included studies with moderate to good methodological quality. However, individual study variations in populations, settings and other potential bias may impact the findings.

Our systematic review that synthesized data from around 5261 participants is the first from India to summarize the prevalence of Osteoporosis and Osteopenia. With one of the leading causes of death in elderly population Osteoporosis is still being neglected as a major health issue in India. Improved access to screening services, further implementation research and health systems interventions are required to enhance the uptake screening for osteoporosis.

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