



# Prevalence and Distribution of Osteopenia in Chinese Population: A System Review and Meta-Analysis

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## Abstract

**Background:** The number of patients with osteoporosis ranks first in the world in China and as a precursor state of osteoporosis, the number and incidence of osteopenia are much higher than that of osteoporosis. This meta-analysis was conducted to evaluate the incidence and distribution of osteopenia in adults in mainland of China over 10 years to provides reference for the early prevention of osteoporosis and policymaking.

**Methods:** Relevant data were extracted from the databases including CNKI, Wanfang, VIP, Web of Science, PubMed, EMBASE, and Medline about the surveys on osteoporosis and bone loss from 2010 to 2021 by searching. The random effects model was adopted for Meta-analysis, and the funnel plot was used to test publication bias.

**Results:** Forty-seven literatures were included in this study, covering 27 provinces and 38 regions in the mainland of China, with the study of 135,688 cases, showing that the prevalence of osteopenia in adults in the past decade was 28.3%(95% CI 24-33%), aged 40~60 yr old, reaching the highest level. The incidence of osteopenia in males was higher than that in females ( $P<0.05$ ), without significant difference in south and north China.

**Conclusion:** There is a large population with osteopenia in China, especially middle-aged population, both men and women should pay attention to osteopenia to delay its further progression.

**Keywords:** Osteopenia; Meta-analysis; Prevalence; China; Osteoporosis

## Introduction

With the rapid growth of aging population worldwide, osteoporosis has become an important public issue facing the world (1). In 2001, about 18 million people had osteoporosis in the US, and those with low bone mass was 1.8 times greater than those with osteoporosis (2). Approximately 22 million males and 5 million females

have been diagnosed with osteoporosis in the EU, resulting economic burden amounting to €37 billion (3). Osteopenia is the precursor of osteoporosis, with a hidden onset, once it develops into osteoporosis, it will not only increase the risk of fracture in patients, causing physical and psychological effects on patients, but also bring



heavy burden to the family and society. Prevention is the key to the clinical management of osteoporosis. Therefore, it is of great significance to concern about the population with osteopenia and to carry out early intervention for the prevention and treatment for osteoporosis.

In China, the total number of patients with osteoporosis ranks first in the world, so it is particularly important to focus on the population with low bone mass and give early warning. Although there have been many clinical studies and epidemiological investigations on osteoporosis in China, there is a lack of large-scale epidemiological investigation on patients with osteopenia. Therefore, it is significance to identify the prevalence of osteopenia in adults and strengthen effective intervention for the prevention and mitigation of osteoporosis.

Therefore, we aimed to estimate the prevalence of osteopenia in the Chinese adult in order to provide reference.

## Materials and Methods

### Registration

This study has been registered in the INPLASY (INPLASY2021120009; DOI: 10.37766/inplasy2021.12.0009, <https://inplasy.com/inplasy-2021-12-0009/>).

### Data Sources and Searches

The following databases were searched: 1) English database: Web of science (Via Ovid), PubMed (Via Ovid), EMBASE (Via Ovid), Medline (Via Ovid); 2) Chinese database: CNKI (Via Ovid), Chinese Wanfang database (Via Ovid), VIP database (Via Ovid), Search terms: ‘osteoporosis’, ‘OP’ ‘osteopenia’, ‘low bone mass’, ‘low bone mineral density’, ‘bone’, ‘prevalence’, ‘cross-sectional’, ‘epidemiology’, ‘China’, and ‘Chinese’ were used as our search strategies. The language was restricted to Chinese and English, with the year of publications from 2010 to 2021. Two investigators (Yinzhen Zhang and Lanbo Zhao) searched these databases independently, Original papers were obtained whenever possible, and the

reference lists of these articles were further searched for relevant trials. Whenever necessary, the authors were contacted for additional information if necessary.

### Inclusion Criteria

1. Test method: Dual-energy Xray absorptiometry was adopted (DXA).
2. Period: The year of the studies published was restricted from January 2010 to April 2021.
3. Research method: Cross-sectional study, baseline investigation or prospective study were included in this study.
4. Information: Studies directly or indirectly provided information about the sample size or incidence of osteopenia with or without age specific estimates were included.

### Exclusion criteria

1. The subjects that specifically group (including specific profession or Postmenopausal women) were excluded.
2. Republished literature.
3. The studies failing to meet the inclusion criteria were excluded.
4. Reviews, commentaries, and case reports were also excluded.

### Date Extraction

Two investigators (Yinzhen Zhang and Lanbo Zhao) extracted the data independently, including author, year of publishing, equipment used for BMD measurement, diagnostic criteria, province, research design, research quality score, sample size of osteopenia. All the differences were settled by discussion between the two researchers. A third reviewer (Changwei Zhao) resolved the disagreements of data extraction.

### Quality assessment

The quality of each included study was assessed with the Quality assessment criteria of literatures (4), including 5 criteria with score 1~5. Briefly, the 5 criterion are as follows: National epidemiological investigation report with a large sample size ( $\geq 10000$ ) and a random pattern sampling (1 score); Provincial epidemiological reports with a

large sample size ( $\geq 1000$ ) and a random pattern sampling (2 score); Epidemiological reports randomly sampled but investigated in a limited number of specific units (e.g., 2 or 3 county-level cities or institutes) (3 score); Reports that are not sampling in a random pattern, but with a large sample size ( $\geq 1000$ ) (4 score); Reports that are not sampled in a random pattern with a small sample size ( $< 1000$ ) (5 score).

**Statistical analysis**

Statistical analysis was carried out with R-studio 12.0. The prevalence of osteopenia with 95% confidence intervals (CIs) for both overall and subgroups. The original study rates were first subjected to Log-transformed, Logit-transformed, arcsine square root-transformed,

Freeman-Tukey Double arcsine transformed, and then normal tests were carried out respectively. After the normal test, the original rate or converted rate most consistent with the normal distribution was selected for Meta-analysis (5). Heterogeneity test of each outcome was conducted by chi-square test, if  $I^2 < 50\%$ , the fixed effect model was adopted for a Meta-analysis, otherwise, the random effects model was performed. Egger’s Test were used for qualitative judgement of bias.  $P < 0.05$  shows statistically significant.

**Results**

Fig. 1 shows the flow diagram for selection from databases.

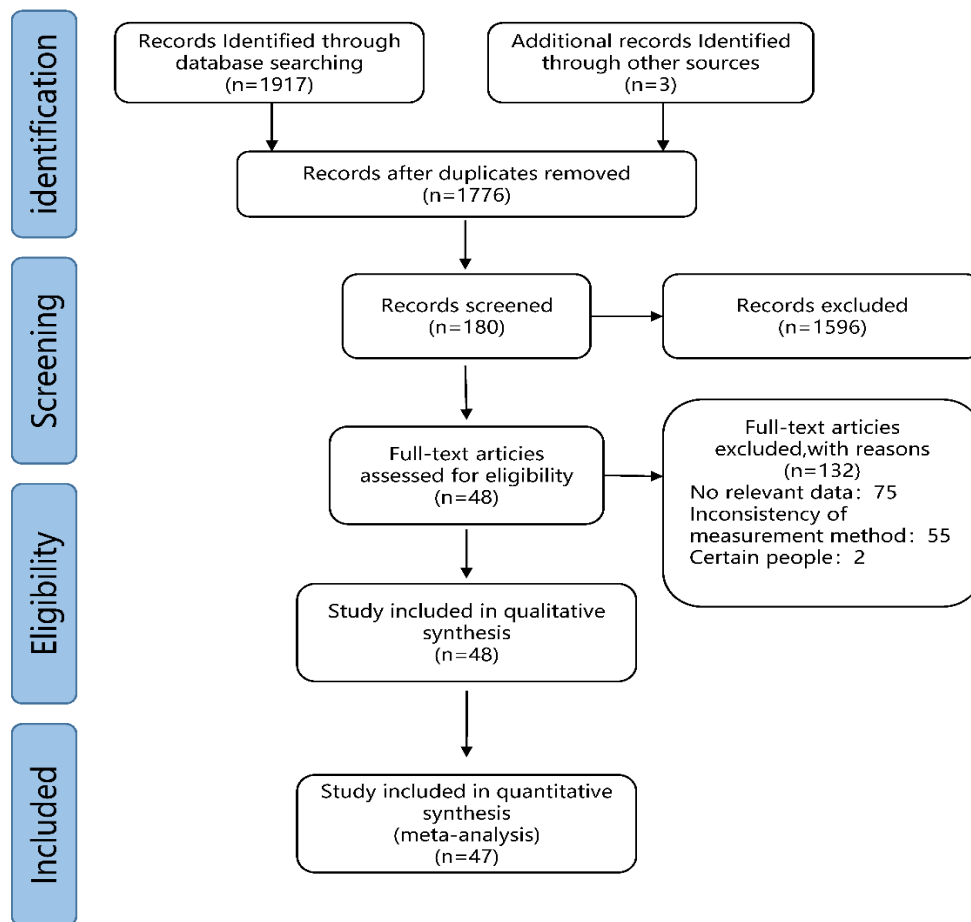


Fig. 1: Flow diagram for identifying studies

The 47 studies included in this meta-analysis are shown in Table 1. Among them, year of publishing was restrained from 2010 to 2020, the sample size ranged from 167 to 20,899, covering 27 of total 34 provinces and 38 cities in China, including 48,290 cases of males and 63,566 cases of females (The data of men and women were not reported in 7 literatures (6-12)). In terms of regional distribution, there were 25 papers involv-

ing south China and 22 studies involving north China. There were 42 literatures taking the WHO as the standard for osteopenia, and 4 literatures based on the Chinese standard. The included subjects ranged in age from 18 to 100 yr old, with the average literature quality score of 3.4 points, which indicates that the literature quality was below the medium level.

**Table 1:** Basic information of included studies

<i>Study ID</i>	<i>Region</i>	<i>Equipment</i>	<i>Sam- ple</i>	<i>Diagnostic criteria</i>	<i>Quality score</i>
Wang.et al.2017(13)	Changchun, Jilin	American GE Lunar- Prodigy Advance	167	M-1.0S~2.5S	3
Wang.et al.2016(14)	Danyang, Jiangsu	American GE Lunar	1123	M-1.0S~2.5S	2
Pan.et al.2011(6)	Shanghai	America Norland XR-36	1157	M-1.0S~2.5S	2
Zeng.et al.2020(7)	Changsha, Hunan	DEXA	1245	M-1.0S~2.5S	2
Gao.et al.2019(15)	Beijing	America Hologic- Discovery W	2198	M-1.0S~2.5S	3
Zhang.et al.2020(16)	Beijing	America Discovery DEXA	346	M-1.0S~2.5S	3
Yang.et al.2011(17)	Beijing	DTX-200	19609	M-1.0S~2.5S	2
Liu.et al.2019(18)	Beijing	American GE Lunar- Prodigy	821	M-1.0S~2.5S	3
Huang.et al.2016(19)	Chengdu, Sichuan	American GE Lunar- Prodigy Advance	15273	M-1.0S~2.5S	2
Yang.et al.2012(20)	Chifeng, Inner Mongolia	American GE Dpx Bravo	4623	M-1.0S~2.5S	4
Li.et al.2014(8)	Dalian, Liaoning	DEXA	1026	M-1.0S~2.5S	3
Yang.et al.2017(21)	Gansu	DTX-200	12085	M-1.0S~2.5S	2
Xu.et al.2014(9)	Nantong, Jiangsu	Italy DEXA	2757	M-1.0S~2.5S	4
Huang.et al.2012(22)	ZhanJiang, Guang- dong	American Hologic QDR 4500A	480	M-1.0S~2.5S	5
Yang.et al.2013(23)	Guiyang, Guizhou	American GE Lunar- Prodigy Advance	534	M-1.0S~2S	5
Zhou.et al.2020(24)	Haikou, Hainan	America Hologic-AST- 00409	2176	M-1.0S~2.5S	2
Chen.et al.2010(25)	Haikou, Hainan	American GE Lunar DPX-MD	531	M-1.0S~2.5S	3
Ye.et al.2017(10)	Hainan	NR	7286	M-1.0S~2.5S	4
Li.et al.2011(26)	Inner Mongolia	American GE Lunar Bra- vo	1000	M-1.0S~2S	4
Liang.et al.2016(27)	Hulunbeier, Inner Mongolia	France MEDIX90	3123	M-1.0S~2.5S	2
Chen.et al.2010(28)	Shiyan, Hubei	DTX-200	3026	M-1.0S~2S	4

Chen.et al.2011(29)	Shaoyang, Hunan	American GE DPX Bravo	4003	M-1.0S~2.5S	2
Zeng.et al.2020(11)	Changsha, Hunan	DEXA.NR	1245	M-1.0S~2.5S	4
Tan.et al.2013(30)	Huizhou, Guangdong	DXEA.NR	906	M-1.0S~2.5S	5
Zhang.et al.2016(31)	Sunan, Jiangsu	America Hologic-Discovery W	4972	NR	4
Hao.et al.2019(32)	Kunshan, Jiangsu	American GE Lunar DPX-NP	1551	M-1.0S~2.5S	2
Zong.et al.2020(33)	Qingdao, Shandong	American GE Lunar	1180	M-1.0S~2.5S	4
Huang.et al.2017(34)	Nanning, Guangxi	America Hologic DEXA	20899	M-1.0S~2.5S	2
Huang.et al.2015(12)	Taiyan, Shanxi	American GE DXA	2324	M-1.0S~2.5S	4
Zeng.et al.2012(35)	Xi'an, Shanxi	America Hologic ODR-2000	564	M-1.0S~2.5S	3
Bing.et al.2017(36)	Ningxia	MED IX-90	1925	M-1.0S~2.5S	4
Shang.et al.2020(37)	Xinjiang	DEXA.NR	1846	M-1.0S~2.5S	2
Liao.et al.2010(38)	Kelamayi, Xinjiang	America Hologic DEXA	2513	M-1.0S~2.5S	2
Chen.et al.2020(39)	Xining, Qinghai	American GE DXA	1373	M-1.0S~2.5S	4
Ma.et al.2018(40)	Taiyuan, Shanxi	America Hologic-Discovery WI	6000	M-1.0S~2.5S	4
Gou.et al.2016(41)	Lanzhou, Gangu	France MRI-OSTEO - Core	432	M-1.0S~2.5S	3
Guo.et al.2017(42)	Liangshan, Sichuan	American GE Lunar DPX-MD	760	NR	5
Huang.et al.2016(43)	Mianyang, Sichuan	NR	5039	M-1.0S~2.5S	4
Zhang.et al.2011(44)	Dandong, Liaoning	American D'TX-200	732	M-1.0S~2.0S	5
Wang.et al.2016(45)	Ningbo, Zhejiang	American GE Lunar prod-igy	444	M-1.0S~2.5S	5
Zhang.et al.2017(46)	Fuzhou, Fujian	American GE DEXA	504	M-1.0S~2.5S	5
Chen.et al.2010(47)	Guangdong, Guangzhou	France DMS Lexxox	1024	M-1.0S~2.5S	4
Lu.et al.2017(48)	Beijing	Korea Osteosys EXA-3000	1296	M-1.0S~2.5S	4
Zhou.et al.2014(49)	Changdu, Sichuan	Ltaly 85/A41100	454	M-1.0S~2.5S	5
Zhao.et al.2017(50)	Taiyuan, Shanxi	America Hologic DEXA	529	M-1.0S~2.5S	3
Wu.et al.2013(51)	Wuhan, Hubei	America Hologic Discovery	183	M-1.0S~2.5S	3
Liu.et al.2021(52)	Shanghai	America Hologic	1098	M-1.0S~2.5S	4

### ***Overall incidence of osteopenia***

Meta-analysis of all the included studies showed that the overall incidence of osteopenia in China was 28.3% (95% CI:24-33%) (Fig. 2), which began to rise among those more than 40 yr old and

peaked between 60~70 yr old, then began to decrease. There was no significant difference in the prevalence of osteopenia between the groups aged 15~30 yr old and 30 ~40 yr old ( $P>0.05$ ). The incidence by age group is shown in Fig. 3.

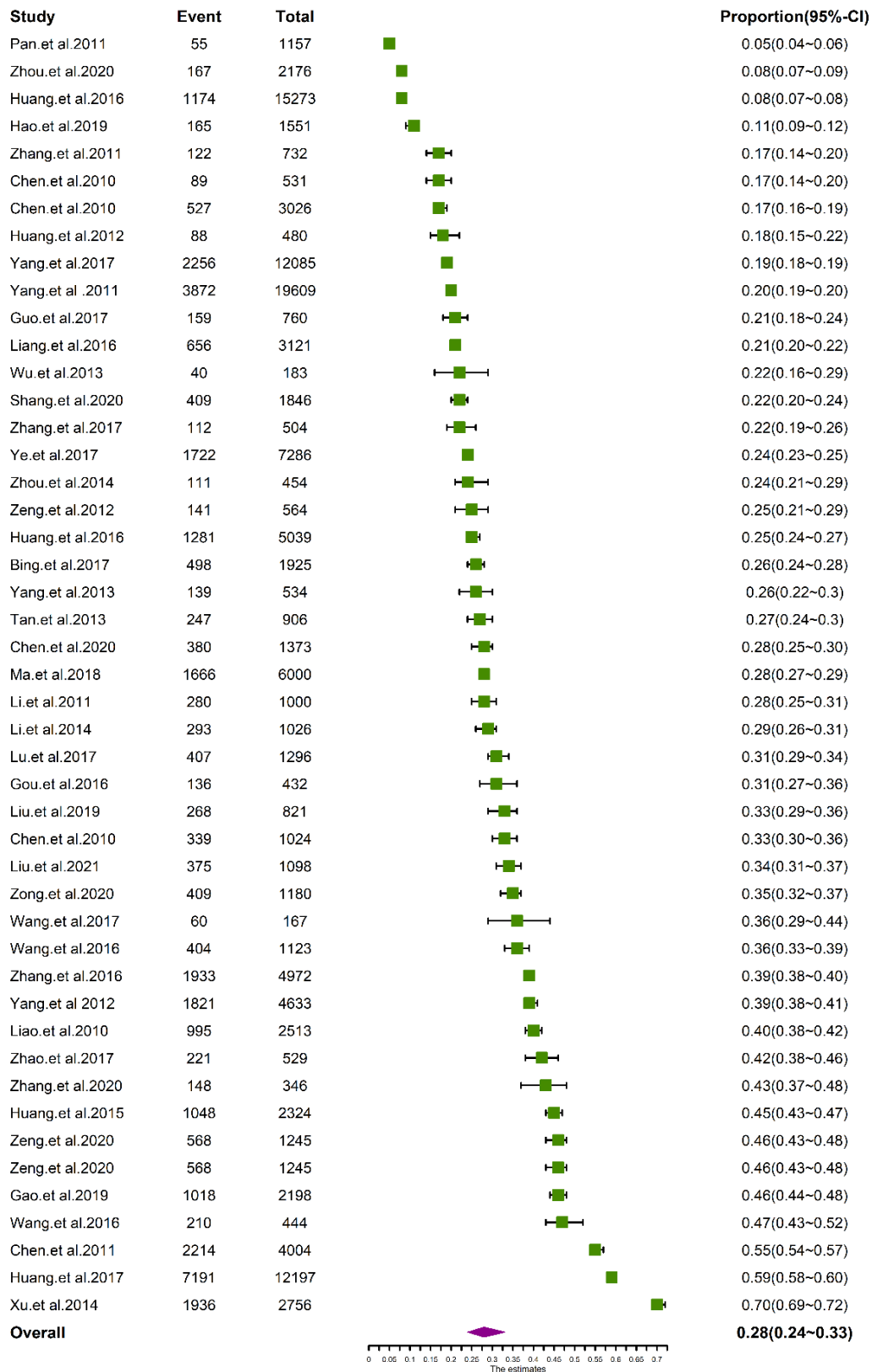


Fig. 2: Forest plot of prevalence of osteoporosis for total people



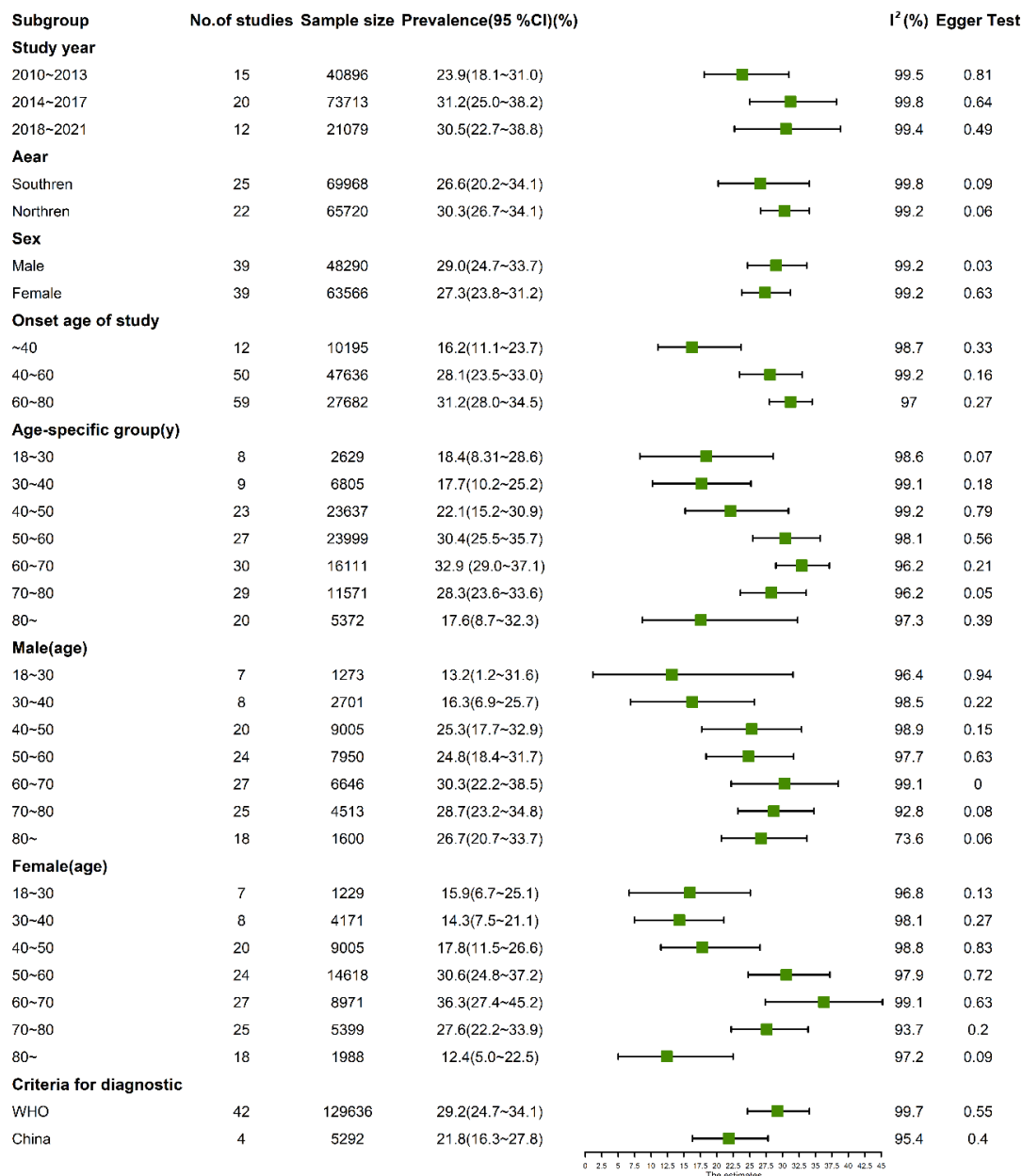


Fig. 3: Prevalence of osteoporosis according to subgroups

### Years of publishing

In recent 10 years, the incidence of osteopenia increased, including 23.9% from 2010 to 2013, which was a obviously higher between 2014~2017 than that between 2010~2013 (31.2%, 95% CI:25.0~38.2%), reaching to 30.5% between 2018-2020 (95% CI: 22.7~38.8%).

### Region

Among the included literatures, there were 15 literatures involving 65,720 cases from north China and 22 literatures involving 69,968 cases from south China. The incidence of osteopenia was 26.6 % (20.2~34.1%) in the south, and 30.3% (26.7~34.1%) in north China, which was slightly higher than the south, with no significant difference ( $P>0.05$ ).

**Men and women**

The results of men and women at all ages are showed in Fig. 3. Overall incidence of osteopenia in men was higher than that in women ( $P<0.05$ ). Among people aged 30~40 yr old, the incidence of osteopenia in men was higher than that in

women ( $P<0.05$ ), which was significantly higher in women than that in men who aged 40~70 yr old ( $P<0.05$ ), and the situation among people aged more than 70 yr was similar to those aged 30~40 yr old. Details of trend of osteopenia in males and females showed in Fig. 4.

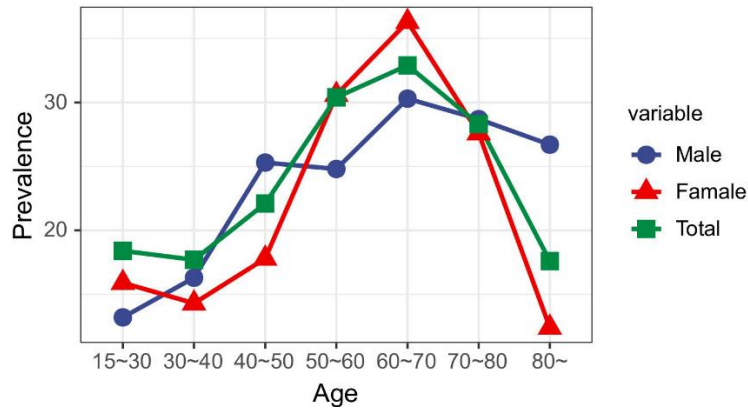


Fig. 4: Trend of osteopenia in male and female

**Meta-regression and Publication bias**

In this study, the overall incidence showed high heterogeneity, therefore, we explored the source of heterogeneity through the meta-regression analysis. The year of publication, area, source of research objects, diagnostic criteria, sample size, quality of document, type of paper, and measurement site of included literatures were not associated with high heterogeneity, and the subjects

over 60 yr old was one of the sources of high heterogeneity (Table 2). However, not all sources of heterogeneity can be fully explained. The results of publication bias for overall incidence showed no significant publication bias ( $P=0.51$ ) (Fig. 5), but there was some publication bias in the subgroup analysis of included literatures, as shown in Fig. 3.

Table 2: Meta-regression for overall incidence of osteopenia

Covariate	Meta-regression coefficient	95 % Confidence interval	P-value
Year of publication	0.0017	-0.0644~0.0677	0.9604
Area (northern vs southern)	-0.1583	-0.5768~0.2602	0.4585
Source (Hospital vs General)	0.0291	-0.4317~0.4900	0.9031
Criteria(WHO vs China)	0.5102	-0.2783~1.2987	0.2047
Sample Size	0.0000	-0.0000~0.0001	0.7551
Quality	0.1456	-0.0611~0.3522	0.1674
Type of paper(Dissertation vs Journal article )	-0.0842	-0.6513~0.4829	0.7710
Measuring parts	0.5454	-0.0603~1.1511	0.0776
Age 60~	-0.8976	-1.5509~-0.2442	0.0071



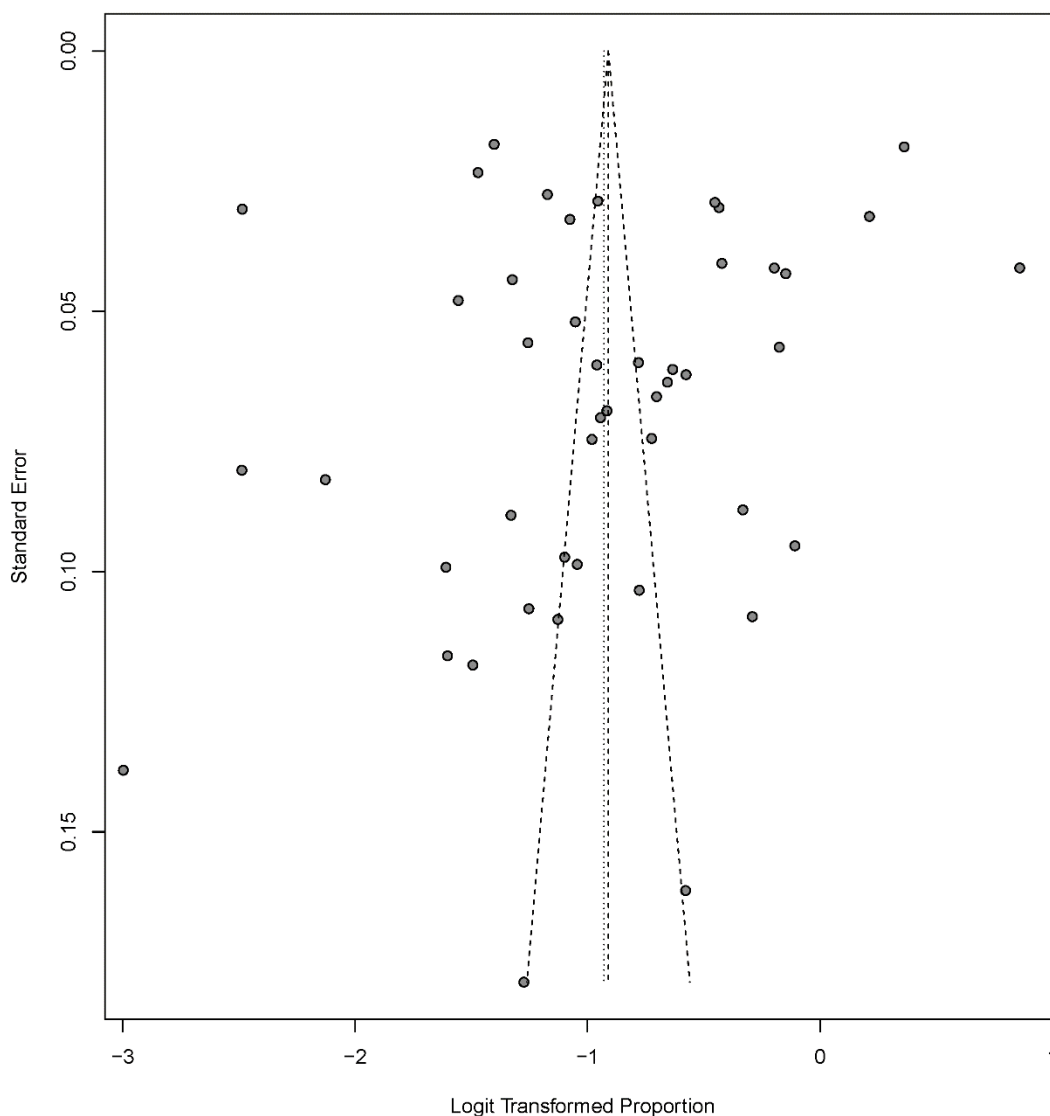


Fig. 5: Funnel plot for publication bias

## Discussion

This study has several features that should be pointed out including: 1. Nearly a third of Chinese adults suffer from osteopenia, which continues to grow. In 2006, China has about 70 million people with osteoporosis, and about 210 million people with osteopenia (53). According to this study, by 2020, China has had 3.4 million people with osteopenia. 2. The incidence of bone loss was higher in males than in females, with different characteristics at different age stages. Among the people aged 30-40 yr old and more

than 70 yr old, the incidence of bone loss was higher in males than in females which, however, was significantly higher in females than in males among those aged 40~70 yr old.3. There was no significant difference in the incidence of osteopenia between north and south China. 4. The incidence of bone loss taking the WHO as the diagnostic criteria was significantly higher than that by China criteria.

Age is an important factor affecting bone metabolism, and our study shows that the incidence of bone loss increased with age. Neelam Kaushal et al. (54) measured bone mineral density at the

lumbar spine and both hips in healthy adults, and showed that the incidence of bone loss gradually increased among people aged between 30~70 yr old. In another survey (55), 1,871 women showed a 40.8% incidence of bone loss in women less than 51 yr old and more than 66 yr old, the percentage rose to 57.7%. In the United States, the incidence of osteopenia in Americans over 50 yr old was 43.9% in 2010 (56). Among all age groups, the incidence of bone loss was the highest in middle-aged and old people aged 40-70 yr old. A survey (57) on women over 25 yr old showed that the incidence of bone loss reached 36.79% in women aged 55-64 yr old. Another study (58) showed that the incidence of bone loss reached 41.7% among people between 65~69 yr old, which ranked the highest among all age groups of women. Fifty percent of all postmenopausal white women in the United States had bone loss and 30% had osteoporosis (59). Moreover, some studies (60, 61) recommended regular group screening for middle-aged and elderly people with bone loss. Nayak et al. (62) also suggested that early screening for postmenopausal women aged 55 yr old, is the most cost-effective prevention and treatment strategy for osteoporosis. All these demonstrates the importance of early screening and intervention for middle-aged and elderly population. In this study, the incidence of bone loss decreased after reaching 70 yr old, the peaking age. Similar characteristics showed with this study (58,63), because on the one hand, the population proportion of people over 70 yr old decreased (56), and on the other hand, bone loss further developed into osteoporosis.

Gender is another important factor affecting osteoporosis. Although in many of the past studies, overall incidence of osteoporosis in women was higher than that in men, in our study, the incidence of osteopenia between men and women shows the opposite trend. In south India, although the incidence of osteoporosis was higher in women than that in men, the incidence of osteopenia had the opposite tend (64). A study of 75,321 adults in China, found that the incidence of bone loss was greater in men than that in women over 50 yr old (63). These studies are

consistent with our results, which may be due to a later onset of peak bone mass in men (65) and a faster decline in bone mass in women with the change of hormone levels than in men (66-68). Women, especially postmenopausal women, are more likely to develop osteoporosis than bone loss. Although the incidence of osteoporosis is higher in women at all ages, the opposite trend in the incidence of bone loss suggests that men should pay more attention to the early prevention for bone loss and adopt the same attitude as women to guard against the further development of bone loss.

The difference of osteoporosis in north and south China has been reflected in previous studies. According to the meta-analysis on the incidence of osteoporosis in healthy adults in China (69), the incidence of osteoporosis in south China was 23.17% and that in north China was 20.13%. The study on the incidence of osteoporosis in middle-aged and elderly people in China (70) showed that the incidence of osteoporosis in north China was lower than that in south China, which is inconsistent with the North-South distribution trend in Iran (71). This is related to the differences in living environment, diet, daily life and living customs between the north and the south. In this study, the incidence of bone loss in the north was slightly higher than that in the south, without any significant difference, suggesting that regional factors may not be the main factor affecting bone loss. However, there is still a lack of large-scale epidemiological investigation on the difference in the incidence of osteopenia between north and south China, and further research is needed.

At present, China still refers to the WHO criteria as the diagnostic criteria for osteoporosis. In this study, there were only 4 articles by Chinese standards (72), founded in 1999, which refers that the peak bone mineral density was 1~2 lower than the normal bones of local people standard deviation or a reduction of 13~ 24% was diagnosed with osteopenia, M-1~ 2.0s., M-1~ 2.0s. The incidence of osteopenia in the WHO criteria was higher than that in the China criteria. Western criteria may result in a misleading high level

in the diagnosis of osteoporosis in Eastern populations (58). There is no current consensus on the diagnostic criteria of osteoporosis in China, which not only restricts the clinical statistical work, but also is one of the limitations of this study.

This paper also has some limitations. First, the quality of included literatures is low, which will affect the results to a certain extent. Secondly, only dual-energy X-ray is included in the measurement method, and the error can be reduced by the conversion method for instruments between different manufacturers. As the original data were not provided, standardization and unification were not carried out, which may also have a certain impact on the results, and need to be verified by large-scale epidemiological investigation.

## Conclusion

Incidence of osteopenia in the mainland China over 10 years was 28.3%, which was higher in males than that in females. Due to the large population base in China, there are a large number of people with osteopenia, with the highest incidence rate among people aged 40~60. Therefore, the early warning should be strengthened for them, and both men and women should pay attention to the osteopenia in order to preventing disease before it occurs.

## Journalism Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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## Conflict of interest

The authors declared that there are no conflict of interests.

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