Original Article

Association of Osteoporosis with Anthropometric Measures in a Representative Sample of Iranian Adults: The Iranian Multicenter Osteoporosis Study

Abstract

Background: Osteoporosis and obesity are two major public health problems worldwide. Considering the conflicting results about the association between anthropometric measurement and bone mineral density (BMD) and also differences between various races, this study was designed to examine the relationship between anthropometric measurements and BMD in a sample of Iranian adults. **Methods:** This cross-sectional population-based study was conducted on 2625 Iranian adults aged 18 and above who were selected using multistage, cluster sampling method from Sanandaj and Arak (two cities of Iran). The evaluated variables included age, sex, height, weight, body mass index (BMI), BMD, and waist and hip circumferences. The correlations between anthropometric measures and BMD in three bone areas (total hip, femoral neck, and spine) were observed in four sex/age groups (men <50 years, men ≥50 years, and pre- and postmenopausal women). **Results:** Of all the 2625 participants in the Iranian Multicenter Osteoporosis Study, 2022 (1303 women and 719 men) entered into our survey and were stratified into four sex/age groups. According to the results, increasing BMI was directly associated with BMD increase, while an inverse association was observed between waist-to-hip ratio (WHR) and total hip BMD. In a similar analysis on the femoral neck and WHR, the correlation coefficients in premenopausal women and men ≥50 years were reported as being the highest and the lowest, respectively, among the four groups. **Conclusions:** Our results showed that high BMI is a protective factor (positive correlation), and high WHR is a risk factor for osteoporosis, although it should be reminded that we could not specifically define which factors including lean tissue mass, fat mass, and total weight are really affecting BMD increase in the overweight/obese participants.

Keywords: *Abdominal obesity, body mass index, bone mineral density, obesity, osteoporosis, waist-to-hip ratio*

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Introduction

Osteoporosis is a highly prevalent multifactorial skeletal disease characterized by microarchitectural decline and low bone mass which results in an increased risk of fragility fractures, disability, severe comorbidities, and mortalities.[1,2] Osteoporosis has become an important global health problem due to its potentially damaging consequences.[3] Patients with osteoporosis are more likely to be involved (40%) in bone fractures during their lifetime. The most common bones involved in fracture are hip, vertebral column, and wrist, which may affect the quality of life (QOL).[4] Approximately, 75 million people in Europe, Japan, and the United States have osteoporosis.[5,6] About 9 million bone fractures occur around the world due to osteoporosis, of which about half happen in the Americas and Europe.[7] Based on a meta-analysis conducted in 2013 in Iran, the general prevalence of osteoporosis and osteopenia in the lumbar spine was 17% and 35%, respectively. Besides, the prevalence of osteoporosis was 12%, 3%, and 19% among men and pre- and postmenopausal women, respectively.[8]

On the other hand, obesity, as a dramatically growing challenge around the world, is also an important public health issue that may underlie many diseases.[9] National studies have reported a range of 27.0%–38.5% as the prevalence of obesity and overweight among Iranian adults.[10] Hence, osteoporosis and obesity are the two major public health problems worldwide

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due to their associated morbidity, mortality, and costs, as well as their growing prevalence.[11]

Most of the studies,[3,12,13] including a meta-analysis by the World Health Organization (WHO),[14] reported that the risk of bone fracture decreases with increasing body mass index (BMI). Accordingly, low body weight may be considered as an important future fracture risk. Therefore, BMI seems to be involved as a protective factor against fracture. It should be noted, however, that some studies have reached conflicting results.[15-18] Some of these controversial articles which were assessed in a review article published in 2014[19] showed that central obesity is a risk factor for osteoporosis, whereas when measured as BMI, obesity decreases the risk for osteoporosis. The association of waist-to-hip ratio (WHR) and waist circumference (WC) with osteoporosis has recently been studied as well.[20]

To the best of our knowledge, the protective role of obesity with regard to osteoporosis still remains obscure. In addition, considering the conflicting results about the association between anthropometric measurements and bone mineral density (BMD), as well as the differences between various races, we designed this study to examine the relationship between BMI, WHR, and WC with BMD and osteoporosis in Iranian adults using data of the third phase of Iranian Multicenter Osteoporosis Study (IMOS).

Methods

This study was a cross-sectional population-based study conducted during March 2012–March 2013 using data of the third phase of IMOS in the urban area of Sanandaj and Arak (two provincial capital cities located in the west and north of Iran, respectively). The IMOS was developed as a collaborative project of Endocrinology and Metabolism Research Center of Tehran University of Medical Sciences and Ministry of Health and Medical Education to assess the prevalence of osteoporosis among the Iranian population.[21]

IMOS project was conducted among 2022 Iranian adults, aged 18 years and above, using random cluster sampling. Based on a detailed description of the study protocol which has been published previously,[22] non-Iranians and individuals, who had moved to these cities within the last 12 months, were not included in the study. Individuals with any mental disorders and those unable to collaborate with the interviewers were excluded. Moreover, those with defect or deformity in the spine, hip, or lower extremities that would affect the BMD results, as well as those hospitalized for more than 2 weeks or immobilized for more than 3 consecutive months during the previous year, were excluded. Individuals suffering from infertility, acute or chronic renal failure, advanced liver failure, any type of cancer, chronic diarrhea, and malabsorption, as well as those taking any type of Vitamin D during the past 6 months, were also dismissed.

Considering the exclusion criteria, 2022 of all the 2625 IMOS participants (about 77%) were allowed to enter into the study. The participants gave written consent to confess their interest to take part in the study. The questionnaires included demographic factors (age and gender), anthropometric factors (height, weight, BMI, and waist and hip circumferences), and skeletal status (history of previous fractures in the hip, spine, and femoral neck and BMD).

Based on the WHO,[23] BMD were classified as normal, osteopenic, and osteoporotic. BMD was conducted using dual-energy X-ray absorptiometry scan method, and T/Z scores were recorded to assess the bone density in the lumbar spine, femoral neck, and total hip areas. Osteoporosis was defined as a BMD lower than or equal to −2.5 standard deviations (SDs) in young adults (T-score −2.5 or more), and BMD −1 to −2.5 SD or below (T-score −1 to −2.5) was considered osteopenia.

The height and weight were measured using a wall-mounted stadiometer (SECA) and a mobile digital scale (Seca), respectively. BMI was calculated based on weight divided by height squared, and then categorized as normal weight ($18 \leq \text{BMI} < 25$ kg/m^2), overweight ($25 \leq \text{BMI} < 30$ kg/m^2), and obese ($30 \leq \text{BMI}$ kg/m^2).

Waist and hip circumferences were measured in the standing position using a nonelastic tape.

WHR was calculated by dividing WC by hip circumference. Abdominal obesity was found to be present if their WCs were >94.5 cm in men and women based on Iranian criteria and >102 cm in men and >88 cm in women based on the WHO criteria. The prevalence of general obesity and abdominal obesity was assessed.

BMD measurements were done in the anteroposterior position at the lumbar spine, proximal femur, and hip regions. BMD was also compared based on age in men (≥50 and <50 years) and menopausal (the natural cessation of menstruation that usually occurs between the ages of 45 and 55 years) status in women (pre- and postmenopausal). Finally, the association between anthropometric measures and BMD in the three bone areas was assessed in different sex and age groups.

All statistical analyses were stratified by sex and age groups (men <50 years, men ≥50 years, and pre- and postmenopausal women). Continuous and categorical data are reported as mean (SD) and number (percentage), respectively. A mean difference of continuous variables was assessed using *t*-test. Categorical variables were compared by Chi-square test. The Pearson's correlation test was used to assess the correlation between continuous variables. The correlation coefficient was practiced to assess the correlation between anthropometric measures and BMD.

$P < 0.05$ was considered statistically significant. All statistical analyses were performed by SPSS version 16 (IBM, Armonk, New York).

Results

Totally 2022 (1303 women and 719 men) were included in our survey and were studied in four age groups according to their sex (488 men <50 years, 231 men ≥50 years, 949 premenopausal women, and 354 postmenopausal women), with a mean age ± SD of 41.85 ± 13.95 years (range: 18–88 years).

Age, height, weight, WC, WHR, hip circumference, history of fracture, the average distribution of densitometry values including T-score and Z-score, distribution and frequency of BMI categories, and abdominal obesity based on the Iranian and WHO criteria were reported in four groups as shown in Table 1. The results showed a statistically significant difference in all groups of variables ($P < 0.001$). A substantial proportion of the participants (39.2%) were overweight, whereas only 0.9% were identified as morbidly obese (BMI ≥40). Nearly half of the men ≥50 (48.7%) and a considerable number of postmenopausal women (39.5%) were overweight. The highest prevalence of abdominal obesity based on WHO criteria was seen in men ≥50 years (49.4%) and postmenopausal women (89.3%). This prevalence based on the Iranian criteria was reported in the same groups as 49.4% and 66.9%, respectively.

Most of the participants did not have a history of bone fracture (94.3%), while 5.7% had a positive history in the wrist (n = 54), hip (n = 8), and spine (n = 5). The associations between history of fracture and one of the anthropometric measures (BMI, WC, and WHR) were statistically significant in all age/sex groups except WHR in postmenopausal women ($P = 0.003$). The results revealed statistically significant differences between BMD in the all bone areas and groups ($P < 0.001$).

Prevalence of osteoporosis and osteopenia is shown by sex and age in different bone areas in Table 2. According to the T-score, 3.6%, 2.7%, and 7.2% of the participants suffered from osteoporosis in the spine, total hip, and femoral neck, respectively. The correlation between BMD with anthropometric measures in different bone areas is shown in Table 3 by sex and age group. The highest negative correlation between BMI and BMD was observed in the total hip area of premenopausal women-(0.007). In the assessment of the correlation coefficient between WC and total hip BMD, the highest correlation was seen among premenopausal women ($r = 0.27$), while men aged under 50 had the lowest one ($r = 0.08$). Besides, the increase in BMI was also directly associated with total hip BMD.

In a similar analysis on the femoral neck and WHR, the correlation coefficients in premenopausal women and men ≥50 were reported as being the highest and the lowest (r = 0.15 and 0.001) among the four groups, respectively. The correlation between WC and femoral neck was higher in postmenopausal women (0.32). There was an inverse association of correlation coefficient between WHR and lumbar spine BMD in three different bone areas.

In premenopausal women, 1 unit increase in the BMI of the lumbar area causes an increase of 0.3 times in BMD. Also, an increase of 1 cm in WC resulted in a reduction of BMD by 2.82 times. In postmenopausal women, an increase of 1 cm in WC led to a reduced WHR and BMD by 4.71 and 0.02 times, respectively, in lumbar area. In postmenopausal women, an increase of 1 cm in WC resulted in a reduction in WHR and BMD by 4.19 and 0.02 times, respectively, in femoral neck area [Table 4].

Discussion

Osteoporosis is a high-burden disease which increases the rate of mortality and morbidity and affects the QOL.[24] Due to the multifactorial nature of obesity and osteoporosis and their growing prevalence, a great attention is paid to these health issues in the recent decades.[8]

Considering that WC has been anticipated as the most reliable replacement of central obesity in epidemiologic surveys,[2] the association of central obesity and osteoporosis has been emphasized herein but not discussed in detail. Similar to our study, some studies showed positive correlations between WC and WHR with osteoporosis.[12,25] In a study conducted by Kim *et al*. among postmenopausal women, WC was negatively related to BMD in lumbar and femur regions whereas body weight was still positively related to BMD.[26] The same authors in another study demonstrated that fat mass was negatively associated with bone mineral content (BMC). Furthermore, abdominal obesity as measured by WC was significantly associated with BMC independent of total fat mass.[27] The results of a recent review article by Widyaningsih showed that increase in BMI may decrease the risk of osteoporosis, whereas central obesity is a risk factor for osteoporosis.[19] Similar to this review, our study found an inverse association between WHR and BMD and a direct association between BMI and BMD.

As our study concerns, most of the studies[12,13,28,29] have provided evidences that there is a positive correlation between high BMI and BMD, which may recall the hypothesis of the protective effect of weight on bone fractures. The morbidity among obese individuals with past medical history of fracture, may be higher than nonobese ones.[7] Some studies have reached similar results among men and women. Some others, however, found different results. In a cross-sectional study by Szklarska and Lipowicz, increased BMI was reported as being potentially protective for osteoporosis among very thin women, whereas no significant differences were seen among men.[30] Contrary to these findings, there are some other studies reporting a negative correlation between BMI and BMD as well.[8,15-17] In a retrospective study in Southwest China, obesity increased the risk of female osteoporosis which

Table 1: Baseline characteristics of participants by sex and age group

Variables	Sex					
	Men (*n*=719)			Women (*n*=1303)		
	<50 (*n*=488)	≥50 (*n*=231)	*P*	Premenopausal (*n*=949)	Postmenopausal (*n*=354)	*P*
Age (years) (mean±SD)	33.9±8.9	59.8±8.1	<0.001	35.5±9.3	58.0±8.0	<0.001
Height (cm) (mean±SD)	173.2±7.0	168.0±6.8	<0.001	158.4±6.2	155.2±5.9	<0.001
Weight (kg) (mean±SD)	77.6±12.5	75.4±12.7	<0.001	69.0±12.2	69.9±12.0	<0.001
BMI (kg/m²) (mean±SD)	25.4±4.0	26.7±3.9	<0.001	27.5±4.8	29.2±4.5	<0.001
WC (cm) (mean±SD)	89.5±9.7	95.6±10.1	<0.001	88.5±11.3	95.2±10.2	<0.001
Hip circumference (cm) (mean±SD)	99.1±6.9	100.0±7.3	<0.001	101.0±9.3	103.0±9.0	<0.001
WHR (mean±SD)	0.90±0.06	0.94±0.06	<0.001	0.87±0.07	0.92±0.05	<0.001
Abdominal obesity (WC) based on Iranian cutoff, *n* (%)	141 (28.9)	120 (51.9)	<0.001	281 (29.6)	193 (54.5)	<0.001
Abdominal obesity (WHR) based on Iranian criteria, *n* (%)	107 (21.9)	114 (49.4)	<0.001	373 (39.3)	237 (66.9)	<0.001
Abdominal obesity based on WHO criteria, *n* (%)	107 (21.9)	114 (49.4)	<0.001	602 (63.6)	316 (89.3)	<0.001
History of fracture	40 (8.2)	12 (5.2)	<0.001	30 (3.2)	33 (5.7)	<0.001
BMI in categories, *n* (%)						
Normal weight	225 (46.1)	76 (33.0)	<0.001	316 (33.5)	76 (21.6)	<0.001
Overweight	202 (41.1)	112 (48.7)	<0.001	332 (35.2)	139 (39.5)	<0.001
Obese	61 (12.5)	42 (18.3)	<0.001	296 (31.4)	137 (38.9)	<0.001
BMD in different bone areas (mean±SD)						
Femoral neck						
BMD	0.90±0.15	0.79±0.12	<0.001	0.84±0.12	0.73±0.13	<0.001
T-score	−0.91±1.26	−1.8±1.15	<0.001	−0.60±1.06	−1.6±1.12	<0.001
Z-score	−0.40±1.15	−0.34±0.93	<0.002	0.18±1.06	−0.26±0.95	<0.001
Total hip						
BMD	0.98±0.15	0.92±0.12	<0.001	0.93±0.12	0.82±0.13	<0.001
T-score	−0.81±1.19	−1.2±1.21	<0.001	−0.14±0.98	−0.94±1.05	<0.001
Z-score	−0.52±1.12	−0.34±0.98	<0.001	0.02±1.0	−0.08±0.95	<0.001
Lumbar						
BMD	1.04±0.141	1.0±0.158	<0.001	1.06±0.14	0.90±0.15	<0.001
T-score	−1.15±0.94	−1.3±1.0	<0.001	−0.73±0.9	−1.8±1.2	<0.001
Z-score	−1.02±0.97	−0.93±1.08	<0.001	0.55±0.97	−0.94±1.07	<0.001

BMI was classified as normal weight (BMI <25 kg/m²), overweight (25< BMI <30 kg/m²), or obese (BMI ≥30 kg/m²). Abdominal obesity was present if the WC is >94.5 cm in men and women based on Iranian cutoff and >102 cm in men and >88 cm in women based on WHO criteria. T-score=A bone density that is two and a half SDs below the mean of a 30-year-old man/woman. Normal T-score is −1.0 or higher. Osteopenia is defined as between −1.0 and −2.5. Osteoporosis is defined as −2.5 or lower, Z-score=How many standard deviations an element is from the mean, *n*=Number of participants, SDs=Standard deviations, BMI=Body mass index, WC=Waist circumference, WHR=Waist-to-hip ratio, WHO=World Health Organization, BMD=Bone mineral density

provided a theoretical basis for its prevention in developing countries.[15] Although in a study by Greco *et al*., women with high BMI seem to be protected against osteoporosis, severe obesity may not be always reflected as a protective factor in both female and male populations.[31]

In addition, in a cohort study among postmenopausal women, a paradoxical association was reported between BMI and fracture so that both overweight and underweight conditions increased the risk of bone fractures in different bone areas.[32]

We found a positive relationship between BMI and BMD in both pre- and postmenopausal women. As of ours, some other similar studies among women[28,26] revealed that BMI may decline the risk of fractures due to the positive correlation between BMD and BMI. However, there are some reports indicating a raised risk of fracture among postmenopausal women with lower in normal range of BMD.[29] A population-based cohort conducted on Canadian women aged 50 years and older with major osteoporotic fractures showed that major osteoporotic fracture rates decreased considerably and linearly by improvements in BMD rather than greater rates of obesity or osteoporosis treatment.[33]

Although the prevalence of osteoporosis in women is usually reported more than men, it may be accompanied by some adverse effects as well, especially by growing age. In a study conducted by Abolhassani *et al*.[24] in 2004, mortality rate due to hip fracture was reported more among men than women. Therefore, the importance of osteoporosis

Table 2: Prevalence of osteoporosis and osteopenia by sex and age in different bone areas' densitometry

BMD citation	Men (*n*=719)			Women (*n*=1303)		
	<50 (*n*=488)	≥50 (*n*=231)	*P*	Premenopause (*n*=949)	Postmenopause (*n*=354)	*P*
Femoral neck *n* (%)						
Nl	446 (91.6)	55 (24.0)	<0.001	918 (96.9)	110 (31.1)	<0.001
Osteopenia	41 (8.4)	114 (49.8)		29 (3.1)	157 (44.4)	
Osteoporosis	0	60 (26.2)		0	87 (24.6)	
Total hip *n* (%)						
Nl	438 (89.9)	99 (43.4)	<0.001	932 (98.4)	187 (52.8)	<0.001
Osteopenia	49 (10.1)	93 (40.8)		15 (1.6)	147 (41.5)	
Osteoporosis	0	36 (15.8)		0	20 (5.6)	
Lumbar *n* (%)						
Nl	409 (84.0)	80 (34.6)	<0.001	892 (94.2)	78 (22.0)	<0.001
Osteopenia	78 (16.0)	125 (54.1)		55 (5.8)	174 (49.2)	
Osteoporosis	0	26 (11.3)		0	102 (28.8)	

BMD=Bone mineral density, *n*=Number of participants, N1=Normal

Table 3: Correlation between bone mineral density in different bone areas with anthropometric measures by sex and age group

BMD in different bone areas by groups	Groups	Anthropometric measures					
		BMI (kg/m^2)		WHR		WC (cm)	
		Coefficient	*P*	Coefficient	*P*	Coefficient	*P*
Lumbar	Male <50 years	−0.002	0.10	−0.06	0.13	0.009	0.83
	Male ≥50 years	0.11	0.09	−0.63	0.34	0.18	<0.001
	Female-premenopause	0.01	0.70	−0.54	<0.001	0.12	<0.001
	Female-postmenopause	0.05	0.32	−0.50	<0.001	0.22	<0.001
Femoral neck	Male <50 years	0.11	0.01	−0.07	0.11	0.02	0.71
	Male ≥50 years	0.25	<0.001	0.001	0.10	0.17	0.01
	Female-premenopause	0.30	<0.001	0.16	<0.001	0.30	<0.001
	Female-postmenopause	0.34	<0.001	0.07	0.21	0.33	<0.001
Total hip	Male <50 years	0.20	<0.001	−0.03	0.54	0.08	0.06
	Male ≥50 years	0.40	<0.001	0.08	0.20	0.24	<0.001
	Female-premenopause	0.42	<0.001	−0.007	0.83	0.27	<0.001
	Female-postmenopause	0.40	<0.001	−0.09	0.08	0.24	<0.001

BMI=Body mass index, BMD=Bone mineral density, WHR=Waist-to-hip ratio, WC=Waist circumference

should not be ignored among men. In our study, the prevalence of osteoporosis in total hip among men (>50) was higher than that of postmenopausal women (15.8% and 5.6%, respectively); however, the prevalence of osteopenia was concluded as similar in both.

Result of a multinational observational cohort study (Global Longitudinal study of Osteoporosis in Women), published in 2014, demonstrated that fractures in obese postmenopausal women was a reason of 23% of prior and 22% of incident fractures happening during 2 years of follow-up.[7] In another study conducted on pre- and postmenopausal women, parameters such as weight, WC, BMI, hip circumference, and degree of obesity showed an overall negative correlation with BMD.[34] It has been shown that chemical messengers (e.g., tumor necrosis factor-alpha, interleukin-6, advance glycation end product, and leptins) that are upregulated or downregulated as a result of obesity act as negative regulators of osteoblasts, osteocytes, and muscles, as well as positive regulators of osteoclasts. These additive effects of obesity ultimately raise the risk of osteoporosis and muscle atrophy.[35]

Conclusions

Our results revealed an inverse association between WHR and BMD, whereas a direct relationship was seen between BMI and BMD. Hence, it seems that BMI might be a protective factor, and high WHR needs to be considered as a risk factor for osteoporosis, although it should be reminded that we could not clearly specify which factors including lean tissue mass, fat mass, or total weight are really affecting BMD increase among overweight/obese participants. A cohort designed study among people with severe obesity and consequently with the higher incidence of bone fractures is still needed to adequately assess osteoporosis as a final outcome.

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Nil.

Table 4: β coefficient (standard error) for bone mineral density in different bone areas with anthropometric measures by sex and age group

BMD in different bone areas by groups	Groups	Anthropometric measures					
		BMI (kg/m²)		WHR		WC (cm)	
		β coefficient (SE)	P	β coefficient (SE)	P	β coefficient (SE)	P
Lumbar	Male <50 years						
	Crude	2.59 (1.28)	0.04	−0.014 (0.02)	0.448	1.7212 (3.1)	0.581
	Adjusted	0.392 (0.66)	0.556	0.016 (0.1)	0.089	1.65 (1.6)	0.303
	Male ≥50 years						
	Crude	6.86 (1.67)	<0.001	0.015 (0.03)	0.572	11.66 (4.44)	0.009
	Adjusted	0.736 (1.1)	0.507	−0.02 (0.018)	0.255	−3.24 (2.95)	0.273
	Female-premenopause						
	Crude	7.67 (1.14)	<0.001	−0.01 (0.018)	0.585	12.84 (2.72)	<0.001
	Adjusted	0.338 (0.86)	<0.001	−0.23 (0.013)	0.084	−2.82 (2.05)	<0.001
	Female-postmenopause						
	Crude	11.32 (1.48)	<0.001	−0.067 (0.02)	<0.001	13.63 (3.45)	<0.001
	Adjusted	−0.307 (0.79)	0.699	−0.022 (0.01)	0.025	−4.71 (1.83)	0.01
Femoral neck	Male <50 years						
	Crude	2.85 (1.16)	0.015	−0.025 (0.2)	0.136	1.48 (2.82)	0.599
	Adjusted	0.389 (0.66)	0.558	0.017 (0.01)	0.11	1.67 (1.6)	0.3
	Male ≥50 years						
	Crude	7.93 (1.97)	<0.001	0.001 (0.03)	0.991	13.4 (5.24)	0.011
	Adjusted	1.18 (1.1)	0.285	−0.02 (0.01)	0.274	−2.46 (2.95)	0.405
	Female-premenopause						
	Crude	10.9 (1.19)	<0.001	0.107 (0.02)	<0.001	27.82 (2.78)	<0.001
	Adjusted	0.196 (0.845)	0.817	−0.024 (0.01)	0.074	−3.09 (1.97)	0.115
	Female-postmenopause						
	Crude	12.05 (1.66)	<0.001	0.007 (0.02)	0.735	23.89 (3.73)	<0.001
	Adjusted	0.315 (0.78)	0.689	−0.028 (0.01)	0.005	−4.19 (1.75)	0.017
Total hip	Male <50 years						
	Crude	5.186 (1.13)	<0.001	−0.01 (0.02)	0.582	5.41 (2.77)	0.051
	Adjusted	0.215 (0.65)	0.743	0.016 (0.01)	0.09	1.43 (1.6)	0.372
	Male ≥50 years						
	Crude	11.96 (1.78)	<0.001	0.042 (0.03)	0.164	18.85 (4.93)	<0.001
	Adjusted	0.833 (1.04)	0.427	−0.02 (0.02)	0.253	−3.03 (2.9)	0.297
	Female-premenopause						
	Crude	17.08 (1.19)	<0.001	0.013 (0.02)	0.514	26.45 (2.96)	<0.001
	Adjusted	−0.556 (0.79)	0.487	−0.024 (0.01)	0.077	−4.23 (1.99)	0.034
	Female-postmenopause						
	Crude	12.72 (1.54)	<0.001	−0.06 (0.02)	0.004	17.15 (3.6)	<0.001
	Adjusted	12.77 (1.56)	0.82	−0.024 (0.01)	0.015	−4.65 (1.8)	0.01

Adjusted for history of fracture. BMI=Body mass index, BMD=Bone mineral density, WHR=Waist-to-hip ratio, WC=Waist circumference, SE=Standard error

Conflicts of interest

There are no conflicts of interest.

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