Association of osteoporosis with different risk factors in a sample of Egyptian women

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Received: 22 October 2020
Revised: 1 November 2020
Accepted: 26 November 2020
Published: xx xx 2020

Journal of The Arab Society for Medical Research 2020, 15:90–97

Background/aim
Both obesity and osteoporosis represent global health problems, as they are associated with major morbidity and mortality risks. The present work is aimed at assessing association of osteoporosis with different risk factors in a sample of Egyptian women.
Patients and methods
The study was a cross-sectional one conducted at National Research Center, Giza. It included 90 healthy women, with age range from 21 to 60 years. Data on sociodemographic characteristics and nutritional habit were collected by a trained physician. BMI was calculated, and bone mineral density was measured by dual-energy radiograph absorptiometry.
Results
Of all women, 87.8% were overweight/obese and 42.2% were osteoporotic. Women with normal BMI were more at risk of developing osteoporosis compared with obese women [odds ratio (OR)=17.86, confidence interval (CI)=2.171–146.86]. Postmenopausal women were three times more at risk of developing osteoporosis than premenopausal women (OR=2.86, CI=1.18–6.89). Women using loop and those exposed to sunray regularly were less likely to develop osteoporosis than those not using loop and those not exposed to sun (OR=0.31, CI=0.12–0.78 and OR=0.24 and CI=0.076–0.762, respectively). Women eating cheese were less likely to develop osteoporosis than those not eating cheese (OR=0.41, CI=0.166–0.966). Multiple binary logistic regression detected that women with normal BMI, postmenopausal women, women not using loop, and women not eating cheese were more at risk of developing osteoporosis.
Conclusion
The current study revealed that women with normal BMI (nonobese), postmenopausal, not using loop, and not eating cheese were more at risk of developing osteoporosis. It also supports the assumption that obesity has a protective role in the development of osteoporosis in studied women population.

Keywords:
bone mineral density, BMI, obesity, osteoporosis, women

J Arab Soc Med Res 15:90–97

1687-4293

Introduction

Obesity, that is, excessive storage of body fat, is a disease that occurs due to chronic imbalance between energy intake and consumption [1]. The prevalence of obesity has increased markedly in recent decades with the condition predicted to affect more than one billion people by 2030 [2,3]. Comorbidities, including cardiovascular, metabolic disease, type II diabetes, inflammations, and some types of cancer, are usually associated with obesity [4,5].

Osteoporosis, the most common metabolic bone disease, characterized by decreased bone mineral density (BMD) and alterations of bone tissues, is usually associated with higher risk of low-trauma fractures [6]. The prevalence of osteoporosis ranges between 6 and 11% worldwide; according to the National Health and Nutrition Examination Survey estimates. Because of the worldwide increase in the life expectancies, osteoporosis has become a major public health crisis. Osteoporosis affects 30% of postmenopausal women and 20% of men aged more than 50 years, and both were predicted to experience

osteoporosis-related fracture throughout their lifetime. Risk of fractures, among postmenopausal women and older men, results in a significant burden of costs, disability, and mortality [7–9].

Several studies view obesity as a defensive mechanism against osteoporosis, whereas others concluded that obesity had a negative effect on BMD with higher risk of fractures [10–13]. Several factors including estrogen synthesis enzyme, adiponectin, leptin, and proinflammatory cytokines (secreted by adipocytes) control bone remodeling [14,15]. Among obese postmenopausal women, adipose tissue represents the major source of estrogen synthesis, through the activity of aromatase enzyme. This adipose tissue plays a potential protective mechanism for bone. Adipose tissue also secretes leptin, which is highly correlated with body fat mass. Bone formation is modulated by leptin through enhancing bone marrow stromal cell differentiation into osteoblasts, and via inhibiting osteoclasts generation. In contrast to leptin, adiponectin concentrations, which are lower among obese individuals, are found to be associated with higher BMD loss in women [16,17]. Bone marrow mesenchymal stem cells are common origin progenitors for adipocytes and osteoblasts. Many researchers have proved overlapping genetic susceptibility in osteoporosis and obesity [18,19].

Several studies revealed the endocrine regulatory role of bone-derived factors (e.g. osteocalcin and osteopontin) on body weight and glucose homeostasis. Such studies proposed that the influence of osteopontin on the adipogenic process, in the bone marrow of obese women, contributes to the development of osteoporosis. Osteoblasts produce osteocalcin (a collagen protein), which is involved in bone deposition and calcium homeostasis. It can protect against high-fat-induced obesity [20,21]. Neuropeptide Y (NPY), the fundamental regulator of both bone mass and obesity, as well as a coordinator of interactions between them [22], represents a major pathway for obesity-dependent changes occurring to bone mass. Diet-induced obesity results in both leptin and insulin resistance, which in turn increase the NPY levels [23,24]. NPY is recognizes as a key mediator driving obesity-induced cortical bone loss [25].

Although previous studies examined the association between BMI and BMD, yet the effect of obesity upon the skeleton remains controversial. The present work aimed to assess the association between osteoporosis and both obesity and social and nutritional status in a sample of premenopausal and postmenopausal Egyptian women.

Patients and methods

Patients

The current study included 90 healthy women recruited from the employee at the National Research Center (NRC) and their relatives with an age range between 21 and 60 years.

Study design

This was a cross-sectional study conducted between July 2016 and May 2018 at NRC at Giza. Participants fulfilling the following criteria were excluded from the current study: women having history of diseases that might affect bone metabolism, those with history of hypertension, conditions affecting inflammatory markers, thyroid diseases, diabetes mellitus, malignancies, those on drugs affecting BMD, being pregnant, women with cardiovascular disease (including heart failure), acute or chronic infections, and hepatic or renal diseases.

Ethical considerations

A written informed consent was obtained from all participants after being informed about the purpose of the study. This research paper was derived from a cross-sectional survey of a project funded by National Research Centre (NRC) Egypt, 2016–2019 entitled 'Bone mass among overweight and obese women: mechanism and intervention' (11th Research Plan of the NRC), with an approval obtained from Ethics Committee of NRC (Registration Number is 16/127).

Methods

Data on sociodemographic characteristics including age, smoking habit, job and education, methods of contraception, and family history of cardiovascular-related diseases were collected by a trained physician. Assessment of women's practice was carried out by using questions to current dietary intake (e.g. milk, cheese, cake, and yoghurt) in the last month and current physical activity (e.g. walking, running, and swimming) during the last week. Participants underwent clinical examination of chest, heart, abdomen, and central nervous system, in addition to evaluation of blood pressure.

Anthropometric measurements

Participants' body weight was determined to the nearest 0.01 kg, with the participant wearing minimal clothes and without shoes, using a Seca Scale Balance. In addition, body height was measured, to the nearest 0.1 cm, using Holtain Stadiometer (The Harpenden Portable Stadiometer, Wales, UK). After each measurement, scales were recalibrated following the recommendations of the International Biological

Program [26]. BMI (kg/m^2) was calculated using the following formula: body weight (kg)/body height squared (m^2). Then the reference BMI cutoff points recommended by WHO were applied as follows: overweight (25.00–29.99), obese (≥30.00), and normal (>18–24.9) [27].

Assessment of bone mineral density

Evaluation of 'BMD' (g/cm^2), at the neck of femur, was done using dual-energy radiograph absorptiometry (Norland XR-46, version 3.9.6/2.3.1; USA) in the Medical Excellence Research Center of the NRC. Dual-energy radiograph absorptiometry scan, based on the woman's age, weight, and height, was performed with the participant keeping the precise distance between her arms and legs according to the machine instructions manual. A well-qualified operator executed and evaluated all analyses using the same protocol for all assessments. BMD *t* score was calculated on the basis of the reference database. The diagnostic criteria established by the NIH Consensus Statement on Osteoporosis Prevention, Diagnosis, and Therapy [28] in adults were used. Based on BMD *t* score at neck of femur, bone density status was defined as follows: 'osteoporotic' when it is less than −2, 'osteopenic' between −2 and −1.0, and normal when it is more than −1. However, the BMD *t* score value of −2 was used to discriminate nonosteoporotic and osteoporotic women groups.

Statistical analysis

Statistical analyses were carried out using Statistical Package for the Social Sciences, version 21 for Windows (IBM Corp., Armonk, New York, USA). Student *t* test (expressed as mean±SD, minimum and maximum) was used to compare the continuous data of the two groups. Categorical data were expressed as frequencies and percentages, and were analyzed with the two-tailed χ^2 test. Odds ratio (OR) and 95% confidence interval (CI) and multiple regression analysis were used to find the risk factors for osteoporosis. Statistical significance was considered when *P* value less than 0.05.

Results

The current study included 90 participant women with a mean age of 46.29±10.32 years and with a mean BMI of 36.43±10.33 kg/m^2. Of all women, 87.8% were overweight/obese and 42.2% were osteoporotic (Table 1).

Women with normal BMI (18-24.9 kg/m^2) were 18 times more at risk of developing osteoporosis compared with obese women (BMI ≥25 kg/m^2) (OR=17.86, CI=2.171–146.86), which means obesity may have a protective effect on osteoporosis. Postmenopausal women were three times more at risk of developing osteoporosis than premenopausal women (OR=2.86, CI=1.18–6.89). Moreover, women using loop and those exposed to sunray regularly were less likely to develop osteoporosis than those not using loop and those not exposed to sun (OR=0.31, CI=0.12–0.78 and OR=0.24 and CI=0.076–0.762, respectively). Smoking, physical activity, using contraceptive pills, and ovariectomy had no significant association with osteoporosis (*P*>0.05) (Table 2).

Table 3 shows the association between women social characteristics regarding job, education, marital status, and husband job and education and osteoporosis. No significant associations were found between osteoporosis and all the selected variables (*P*>0.05). No significant difference was found regarding age of menarche between osteoporotic and nonosteoporotic women (mean age of menarche: 12.73±1.80 and 13.08 ±1.168, respectively; *P*>0.05) (Table 4).

In Table 5, associations between osteoporosis and different food stuff were studied. No significant associations were found regarding milk, vegetables, fruits, spinach, sesame, fish, and eggs (*P*>0.05). Women eating cheese were less likely to develop osteoporosis than those not eating cheese (OR=0.41, CI=0.166–0.966). Multiple binary logistic regression analysis was done to detect the predictors of

Table 1 Age, BMI, and bone mineral density of the studied women

	n (%)	Minimum	Maximum	Mean	SD
Age (years)		21.00	60.00	46.2882	10.32057
BMI (kg/m^2)		19.91	66.83	36.4341	10.32749
BMI					
Normal	11 (12.2)				
Overweight/obese	79 (87.8)				
BMD					
No osteoporosis	51 (56.7)				
Osteoporosis	38 (42.2)				

BMD, bone mineral density.

Table 2 Association between osteoporosis, obesity, and sociodemographic variables

Variable	Osteoporosis [*n* (%)]	OR	95% CI	*P*
BMI				
Normal	10 (90.9)	17.857	2.171–146.855	0.007*
Overweight/obese	28 (35.9)			
Smoking				
Smokers	1 (11.1)	0.146	0.017–1.229	0.077
Nonsmokers	35 (46.1)			
Menopause				
Postmenopause	26 (54.2)	2.856	1.184–6.888	0.019*
Premenopausal	12 (29.3)			
Physical activity				
Yes	21 (47.7)	1.686	0.687–4.136	0.254
No	13 (35.1)			
Pill users				
Yes	12 (41.4)	0.930	0.369–2.343	0.878
No	22 (43.1)			
Loop users				
Yes	12 (26.6)	0.309	0.123–0.777	0.012*
No	22 (56.4)			
Ovariectomy				
Yes	1 (33.3)	0.632	0.055–7.271	0.713
No	34 (44.2)			
Sun exposure				
Yes	13 (19.4)	0.241	0.076–0.762	0.015*
No	8 (50)			

CI, confidence interval; OR, odds ratio. **P* value less than 0.05 is significant.

osteoporosis. Women with normal BMI, postmenopausal women, women not using loop, and women not eating cheese were more at risk of developing osteoporosis ($P<0.05$) (Table 6).

Discussion

During the recent decades, both obesity and osteoporosis represent major global health problems with increasing prevalence and greater effect on both mortality and morbidity rates. The risk of developing both obesity and osteoporosis, which affect millions of women, increases with increased age, and with higher risk in women. Musculoskeletal degradation and increased adiposity is attributed mainly to sedentary lifestyles combined with ageing [29].

Recent studies have revealed that both obesity and osteoporosis are influenced by shared/common genetic and environmental factors. Although obesity is regarded as a risk factor for health, yet it has positive beneficial effect on bone formation through the mechanical loading exerted by high body mass. On the contrary, other studies that achieved no clear consensus suggested that excessive fat mass or obesity may not protect against osteoporosis, instead it could be rather damaging to bone. However, muscle functioning and soft-tissue thickness are contributory and bone protective factors [30,31].

In the present study, women with normal BMI were more at risk of developing osteoporosis, supporting that obesity may have a protective effect on osteoporosis. Postmenopausal women were three times more at risk of developing osteoporosis than premenopausal. Dietary habit (eating cheese) was a protective factor against osteoporosis. The beneficial effect of BMI and fat mass on BMD could be owing to the fact that increase in the fat mass leads to greater mechanical stress on bone, which in turn leads to increase in bone mass. In agreement with the current study, several previous studies demonstrated that BMI was beneficial for BMD.

In 2019, Tomlinson *et al.* [32] at UK studied 190 participants (aged 18–80 years) to assess obesity indices 'BMD' and concluded that higher BMI combined with ideal balanced diet (both quality and quantity) and moderate to vigorous activity represent the positive modulators of bone heath.

A study done in China by Wu *et al.* [33], concluded that obese patients have lower osteoporosis risk (OR=0.493, 95% CI=0.405–0.600, $P<0.001$) than normal-weight individuals, after adjusting for various conventional osteoporosis risk factors. Wang *et al.* [34] postulated that all adiposity indices, in the Chinese population, were positively correlated with BMD of all

Table 3 Association between osteoporosis and social characteristics

	Osteoporosis	χ^2	*P*
Women job			
House wife	7 (63.6)		
Secretary	0 (0.0)		
Employee	19 (44.2)	4.319	0.365
Technician	2 (66.7)		
Student	6 (31.6)		
Women education			
Read and write	2 (100.0)		
Primary	0 (0.0)		
Preparatory	1 (25.0)		
Secondary	9 (47.4)	11.783	0.067
University	20 (47.6)		
Diploma	1 (7.7)		
Illiterate	2 (66.7)		
Marital status			
Unmarried	8 (72.7)		
Married	17 (32.1)	7.170	0.067
Divorced	3 (42.9)		
Widow	7 (53.8)		
Husband job			
Teacher	2 (40.0)		
Free work	11 (40.7)		
Employee	12 (36.4)	2.743	0.740
Technician	3 (50.0)		
No work	2 (66.7)		
Work sometimes	1 (100)		
Husband education			
Read and write	2 (66.7)		
Primary	7 (53.8)		
Preparatory	2 (50.0)		
Secondary	6 (35.3)	5.283	0.508
University	10 (35.7)		
Diploma	1 (14.3)		
Illiterate	2 (66.7)		

All data are insignificant.

Table 4 Comparison of age of menarche according to osteoporosis

	Mean	SD	*t* test	*P*
Age of menarche				
Osteoporosis	12.7344	1.79598	−1.010	0.316
No osteoporosis	13.0833	1.16826		

All data are insignificant.

sites for both sexes, which were in agreement with the current study.

A cross-sectional investigation was done in Brazil in 2016 by Freitas *et al*. [35], assessing BMD and fat-free mass in adults and elderly people. They found an independent and protective effect of central and peripheral fat body mass on the presence of osteoporosis or osteopenia.

A hospital-based study (carried out in Changsha, China, and included 269 postmenopausal women) has concluded that the BMD of obese women was significantly higher than that of the normal weight ones [36].

Berg *et al*. [37] showed that all anthropometric parameters (such as BMI, waist circumference, as well as abdominal fat volume) were positively correlated to bone stiffness in the German adult population. Both visceral adipose tissue and abdominal subcutaneous adipose tissue, the potential predictors of bone stiffness, were not superior to the easily accessible anthropometric parameters such as BMI or waist circumference.

The protective association between obesity and osteoporosis was confirmed by Lloyd *et al.* [38], in USA, who concluded a positive correlation (that did not vary by sex or race) between BMI and BMD. They concluded that a 10 U increase in BMI (i.e. from normal BMI to obese) shifts an individual from an osteoporotic BMD level to a normal BMD level.

In medical practice, obesity and osteoporosis are still two major emerging challenges. In contrasts to the results of the current study, several studies revealed obesity to be associated with osteoporosis. The study carried out by Bansal and Bansal [39] in India in year of 2017 revealed no statistically significant relationship between BMI and BMD in women, indicating a non-protective role of obesity in the development of osteoporosis.

A total of 255 apparently healthy women were evaluated in India for BMI and BMD by Kumar *et al.* [40]. Their results revealed that in premenopausal women, BMI was significantly correlated with decreased BMD at both lumbar spine and femoral neck. On the contrary, such association was missing in postmenopausal ones. Moderate to morbid obesity might not actually be a preventive factor for osteopenia.

In China at year 2015, the study carried out by Kang *et al.* [41] revealed that fat mass was positively significant with BMD in normal-weight adult men. Percentage body fat and fat mass index showed statistically negatively significant association with BMD in overweight and obesity adult men.In agreement with the current study, no consistent relationship between diet and BMD was found by Langsetmo *et al.* [42] in a study done on Canadian men and women in 2010.

A study was done to update the evidence regarding dairy intake, osteoporotic fracture risk, and prospective

Table 5 Association between osteoporosis and dietary habits

Dietary habits	Osteoporosis [*n* (%)]	OR	95% CI	*P*
Milk				
≥4 glasses/week	15 (46.9)	1.412	0.579–3.442	0.447
<4 glasses/week	20 (38.5)			
Juice				
>4 glasses/week	5 (25)	0.379	0.123–1.172	0.092
<4 glasses/week	29 (46.8)			
Fruits				
>4 times/week	16 (35.6)	0.552	0.229–1.332	0.186
<4 times/week	19 (50)			
Vegetables				
>4 times/week	16 (35.6)	0.552	0.229–1.332	0.186
<4 times/week	19 (50)			
Fish				
Yes	9 (50)	1.600	0.560–4.574	0.380
No	25 (38.5)			
Sesame				
Yes	5 (83.3)	8.276	0.921–74.389	0.059
No	29 (37.7)			
Spinach				
Yes	4 (40)	0.956	0.248–3.680	0.947
No	30 (41.1			
Eggs				
Yes	17 (34.7)	0.531	0.217–1.298	0.165
No	17 (50.0)			
Cheese				
Yes	14 (31.1)	0.406	0.166–0.966	0.049*
No	20 (52.6)			

CI, confidence interval; OR, odds ratio. **P* value less than 0.05 is significant.

Table 6 Multiple binary logistic regression analysis for predictors of osteoporosis

	B	SE	Wald	DF	Significance	OR	95% CI for OR	
							Lower	Upper
Obesity	–2.137	0.695	9.450	1	0.002*	0.118	0.030	0.461
Menopause	1.550	0.677	5.237	1	0.022*	4.713	1.249	17.779
Loop	1.694	0.644	6.931	1	0.008*	5.442	1.542	19.213
Exposure to sun	1.635	0.846	3.739	1	0.053	5.132	0.978	26.927
Cheese	1.633	0.649	6.332	1	0.012*	5.120	1.435	18.271
Physical activity	–0.199	0.631	0.100	1	0.752	0.819	0.238	2.824
Constant	–4.204	2.181	3.715	1	0.054	0.015		

CI, confidence interval; OR, odds ratio. **P* value less than 0.05 is significant.

BMD evolution assessed by dual-energy radiograph absorptiometry in Europeans and non-Hispanic whites from North America [43]. They concluded that the highest consumption of dairy products did not show a clear association with the total osteoporotic fracture or hip fracture risks; however, a diminished risk of vertebral fracture could be described. The results regarding BMD change were heterogeneous and did not allow for a definitive conclusion.

In contrast to the current study, a study examined links between markers of social inequality (assessed using income, marital status, and area of residence) and fracture risk in the Danish population in 2018 and demonstrated that high income and being married are associated with a significantly lower risk of bone fracture in people 50 years and more [44].

Strength of the present study is including social class and nutritional habit in addition to BMI in assessing the risk factors for osteoporosis. The cross-sectional study design and the relatively small sample size represented major limitations to the present study, and consequently, the causality or mechanism of the relationship between obesity and osteoporosis and reliance on a nutritional questionnaire as some answers could be falsely ideal could not be determined.

Conclusion

In conclusion, the current study revealed women with normal BMI (nonobese), postmenopausal, not using loop, and not eating cheese were more at risk of developing osteoporosis. The current study supports the assumption that obesity has a protective role in the development of osteoporosis in female population. Well-designed follow-up studies with larger sample size and careful data analysis are recommended to clearly reveal the real effect of fat mass on BMD. Moreover, studies based on genetic and molecular approaches might help recognize the regulatory pathways and hence help in developing new therapeutic interventions for both osteoporosis and obesity.

Acknowledgements

The authors acknowledge the institute 'National Research Centre, Egypt,' as without its fund this study could not have been done. The authors also acknowledge everybody who participated in this study; the employers of the institute who were the participants of this study, the technicians who helped in the laboratory analysis and the doctors who participated in collection of the data.' Without their help, this study could not have been completed.

Author contributions: Nayera E. Hassan conceived and designed the study; she is the PI of the project from which these data were derived. Saneya A. Wahba and Samia A. W. Boseila designed the questionnaires about the data on sociodemographic characteristics and dietary intake. Sahar A. El-Raufe El-Masry performed analysis and interpretation of the data; she is the Co-PI of the project from which these data were derived. Moanes Shady, Enas R. Abdelhami, Inas R. El-Alameey, and Tarek S. Ibrahim participated in collection of socioeconomic and dietary intake data. Salwa R. El-Batrawy, Manal M Ali, and Aya Khalil were responsible about anthropometric assessment. All authors contributed to the collection of references, drafting of the article, and final approval of the version to be submitted. All the authors have accepted responsibility for the entire content of this submitted manuscript and approved submission.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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