

Prevalence of osteoporosis and its associated work-related factors and obesity among a sample of Egyptian women indoor workers and employees

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Background/aim

Obesity and osteoporosis are progressive diseases with complex etiology. They constitute a major public health concern nowadays. This study aimed to assess the prevalence of osteoporosis, vitamin D profile, and its relation to obesity, bone markers, and leptin among a sample of Egyptian women indoor workers and employees at the National Research Centre.

Patients and methods

A cross-sectional study that included 116 Egyptian women aged 25–60 years. Anthropometric measurements (body weight, height, and BMI), dual-energy radiograph absorptiometry [bone mineral density (BMD) and its *T* score at both lumbar spines and neck of the femur], and laboratory investigations (leptin, calcium, vitamin D, and C-terminal peptide) were done for all participants. They were classified according to their BMI and BMD-*T* scores at lumbar spines and femur neck.

Results

Osteoporosis was diagnosed among 11.2, 25.2, and 6.8% of participants using the BMD-*T* score at lumbar spines, femur neck, and at the two sites respectively; osteopenia was diagnosed among 44.8, 51.3, and 25%, respectively. Osteoporosis was significantly more frequent among normal weight women than overweight/obese ones. Normal weight osteoporotic women had significantly higher values of vitamin D and C-terminal peptide, and lower values of leptin and BMI than the nonosteoporotic ones. Among osteoporotic women, BMI had a significant negative correlation with vitamin D. BMI had significant positive correlations with BMD at both lumbar spines and femur neck and their *T* scores among nonosteoporotic women and total sample. BMI had a significant positive correlation with the C-terminal peptide among the osteoporotic, nonosteoporotic, and total sample, with leptin and age among the osteoporotic and total sample.

Conclusion

BMI had a significant positive correlation with hypovitaminosis D, C-terminal peptide, leptin, and age. It had a significant positive correlation with BMD among nonosteoporotic women, but not among osteoporotic ones. Obesity protects from osteoporosis. Dual-energy radiograph absorptiometry at lumbar spines underestimate the diagnosis of osteoporosis and osteopenia.

Keywords:

BMI, C-terminal peptide, indoor worker and employee women, leptin, osteoporosis, vitamin D

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Introduction

The ‘sunshine’ hormone or vitamin D is crucial not only for bone health and calcium homeostasis but also for many processes in the immune and neuromuscular systems. Extensive varieties of health problems, including autoimmune diseases, Alzheimer’s disease, infectious diseases, impaired bone homeostasis, cardiovascular disease, cancers, dementia, diabetes, and inflammatory bowel disease, were found to be associated with vitamin D deficiency or insufficiency [1].

Indoor workers and employees who spent longer periods of time without exposure to sunshine, and thus receiving insufficient sunlight, are at a higher risk of acquiring vitamin D insufficiency/deficiency and its associated health risks, in particular osteoporosis. Such higher risks are attributed to the

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exposure of relatively low intensity of type B ultraviolet characterized by the middle energy [1].

Leptin, the peptide hormone which is synthesized and secreted from the white adipose tissue as a product of the obese (*ob*) gene, binds to its leptin receptors and activates them to perform many different vital functions, including regulating food intake, body weight, reproductive functions and fetal growth, lipolysis, angiogenesis, and proinflammatory immune responses [2].

According to WHO's most recent report, 1.9 billion adults are overweight, of which more than 650 million are obese. However, the two most common characteristics of obesity are hyperleptinemia and resistance to weight loss [3].

Studies have revealed that the prevalence of both obesity and osteoporosis increases with the advanced age. Obesity is defined as increased BMI due to abnormal or excessive accumulation and storage of fat, which leads to many health hazards [4], while osteoporosis is a systemic disease characterized by the destruction of the ultra-architecture of bone tissue and decreased bone mass due to an abnormal bone turnover rate, and hence result in bone fragility and higher risk of fracture [5].

The undesirable outcomes of both diseases, obesity and osteoporosis, interfere with the sustainable health goal number SDG 3: ensuring healthy lives and promoting well-being, at all ages with special concern on maternal and child health that is essential to achieve sustainable development [6].

Depending on the skeletal area, most women attain maximum bone mass during the second or the third decade of their life, where childhood, adolescence, and young adulthood represent the most active periods of bone growth. However, bone loss usually increases with advanced age, particularly in postmenopausal women, due to decreased levels of both estrogen and testosterone, resulting in decreased bone mineral density (BMD), which is associated with a higher risk of bone fracture [7].

BMD of a patient is usually measured using dual-energy radiograph absorptiometry (DEXA); although other screening modalities can be used, DEXA is regarded as the gold standard and the most accurate test. It is usually shown in units of g/cm^2 , as the *T* score [where patient's BMD is compared with that of healthy young adults (25–35 year, of the

same sex)] or as the *Z* score (where patient's BMD is compared with that of people of the same age, race, and sex) [7]. The SD is the difference between your BMD and that of the healthy young adults.

A high body mass has a positive effect on bone formation, due to the mechanical loading effect. However, it is questionable whether mass resulting from an excessive fat accumulation is useful to the bone or not [8]. However, most recent studies have concluded associations between obesity and decreased serum 25-hydroxyvitamin D [*s*25(OH)D] level, increased serum leptin level, as well as higher BMD. Such studies have also demonstrated correlations between obesity and both vitamin D metabolism and osteoblast genesis, through which leptin may protect the bone of obese individuals from low *s*25(OH)D through its direct effects on both vitamin D-metabolism and osteoblast differentiation [9].

The main objective of the study was to assess the prevalence of osteoporosis, vitamin D profile, and its relation to obesity, bone markers, and leptin, among a sample of indoor workers and Egyptian women employees in the National research Centre 'NRC.'

Patients and methods

Patients and study design

The population sample of this cross-sectional study included 116 Egyptian women, with age in the range of 25–60 years, and mean age of 48.85 ± 9.88 years. The participants were recruited and randomly selected from employees and workers in the National Research Centre, and belonging to all social classes. The selection of this sample was chosen serving the aim of this study as it is limited to the indoor employees and workers of the NRC, who stay indoors from 8 a.m. up to 3 p.m. unexposed to sunlight for 5 days per week.

Ethical approval

The present study was conducted in accordance with the Code of Ethics of the World Medical Association, according to the principles expressed in the Declaration of Helsinki. This study was approved by the local Ethics Committee of National Research Centre under approval number 16/127. Written informed consents were obtained from all participants, after clarifying the objectives of the study.

Methods

A perfectly designed questionnaire was used to gather sociodemographic data and life style factors of all participants. Clinical variables were measured by the

professional staff, using standardized instruments. The following parameters were assessed for each participant woman: anthropometric measurements, DEXA, and laboratory investigations.

Anthropometric measurements

Body weight and height were measured, following the recommendations of the International Biological Program [10]. Body weight was determined to the nearest 0.01 kg using a Seca Scale Balance. Body height was measured to the nearest 0.1 cm using a Holtain portable anthropometer. BMI was calculated as weight (kg)/height (m^2). Participant women were classified according to their BMI into two groups: group 1 included 37 women with normal body weight ($BMI < 25 \text{ kg/m}^2$) and group 2 included 79 overweight/obese women ($BMI \geq 25 \text{ kg/m}^2$).

Dual-energy radiograph absorptiometry measurements

DEXA apparatus 'DXA' (DXA Norland, XR-46 version 3.9.6/2.3.1, USA) was used to measure both BMD (g/cm^2) and BMD-*T* score at two sites: neck femur and lumbar spine. DEXA scan for every participant woman (based on her age, weight, and height) was executed keeping accurate distance between her arms and legs, following the recommendations of the machine's manual. A professional machine operator performed the recommended scan and evaluated all analyses, following the same protocol for all participant women. Following the WHO diagnostic criteria and depending on the BMD-*T* score at any of the two recommended sites (femur neck and lumbar spine) [11], the participant women were classified into three groups: group 1 included women with healthy bone (*T* score > -1), group 2 women with osteopenia (*T* score -1 to > -2.5), and group 3 included women with osteoporosis (*T* score < -2.5) (NIH Consensus Statement) [12]. Furthermore, BMD-*T* score -1 was used to group the participating women into a nonosteoporotic or an osteoporotic group.

Laboratory investigations

In the morning, venous blood samples were collected from every participant woman (who was fasting overnight for 8 h) using venipuncture. The collected blood samples were then left to clot, after that they were centrifuged at 5000 rpm for 10 min to separate sera. Serum was stored at -80°C till leptin, calcium, vitamin D, and C-terminal peptide levels were assessed.

The assay of human leptin in serum was performed by the ELIZA method, using kits of BioLegend Inc. (San

Diego, California, USA), according to the method of Considine *et al.* [13].

Serum calcium level was measured using the automated clinical chemistry analyzer Olympus AU400 analyzer (Japan), according to the manufacturing instruction. Serum vitamin D and C-terminal peptide were measured using the ELISA kit of Sunlong Biotech Co. Ltd. (Hangzhou, Zhejiang, China), according to the instruction manual of each kit.

Statistical analysis

Data were statistically analyzed using the Statistical Package for the Social Sciences (SPSS/Windows Ver. 16; SPSS Inc., Chicago, Illinois, USA). Normality of data was tested using the Kolmogorov-Smirnov test. Most of the investigated variables were not normally distributed, for example data of DEXA, weight, BMI, and calcium. Therefore, the nonparametric tests were used.

According to their BMI, the participant women ($N=116$) were classified into two groups, and each group was further subclassified according to BMD-*T* score into osteoporotic and nonosteoporotic subgroups. Parametric data were expressed as mean $\pm$ SD, while qualitative ones were expressed as number and percentage (%). Mann-Whitney test for independent groups was used to analyze and compare all variables of the two groups. Correlations between BMI, among osteoporotic and nonosteoporotic groups, as well as other investigated variables were tested using Spearman's correlation. For all used tests, *P* value less than 0.05 was regarded as a statistically significant value.

Results

Osteoporosis was diagnosed among 11.2% of participated women using BMD-*T* score at lumbar spines, 25.2% using BMD-*T* score at femur neck, and 6.8% only using BMD-*T* score at the two sites. While osteopenia was diagnosed among 44.8% of the participated women using BMD-*T* score at lumbar spines, 51.3% using BMD-*T* score at femur neck, and 25% only using BMD-*T* score at the two sites. Osteoporosis and osteopenia at either lumbar spines or femur neck or both sites were significantly more frequent among normal weight women than overweight/obese ones (Table 1).

Among normal weight women, depending on the BMD-*T* score at lumbar spines, seven (18.9%) women were diagnosed as having healthy BMD

Table 1 Frequency distribution of the current sample according to BMI and bone mineral density-*T* score

	Total (N=116) [n (%)]	Normal weight (N=37) [n (%)]	Overweight/obese (N=79) [n (%)]	χ^2
T score at lumbar spines				
Healthy bone	51 (44.0)	7 (18.9)	44 (55.7)	0.000**
Osteopenia	52 (44.8)	21 (56.8)	31 (39.2)	
Osteoporosis	13 (11.2)	9 (24.3)	4 (5.1)	
T score at femur neck				
Healthy bone	28 (23.5)	0	28 (35.4)	0.000**
Osteopenia	59 (51.3)	23 (62.2)	36 (45.6)	
Osteoporosis	29 (25.2)	14 (37.8)	15 (19.0)	
T score at the two sites				
Healthy bone	24 (30.4)	0	24 (30.4)	
Osteopenia	29 (25.0)	13 (35.1)	16 (20.3)	
Osteoporosis	8 (6.8)	6 (16.2)	2 (2.5)	

**Highly significant differences at *P* value less than 0.01.

(while they were diagnosed as having osteopenia using BMD-*T* score at femur neck), 21 (56.8%) women were diagnosed as having osteopenia (13 of them had osteopenia using BMD-*T* score at the two sites while eight of them were diagnosed as having osteoporosis using the BMD-*T* score at femur neck) and nine (24.3%) women had osteoporosis (six of them had osteoporosis using BMD-*T* score at the two sites and three had osteopenia using BMD-*T* score at femur neck). Depending on the BMD-*T* score at femur neck, 23 (62.2%) women were diagnosed as having osteopenia (seven of them had healthy BMD and 13 had osteopenia by using BMD-*T* score at the two sites, and three were diagnosed as having osteoporosis by using BMD-*T* score at lumbar spines) and 14 (37.8%) women had osteoporosis (six of them had osteoporosis using BMD-*T* score at the two sites and eight had osteopenia using BMD-*T* score at lumbar spines) (Table 1).

Among overweight/obese women, depending on the BMD-*T* score at lumbar spines, 44 (55.7%) women were diagnosed as having healthy BMD (24 only out of them had healthy BMD using the BMD-*T* score at the two sites, 18 had osteopenia, and two had osteoporosis using the BMD-*T* score at femur neck), 31 (39.2%) women were diagnosed as having osteopenia (16 only out of them had osteopenia using BMD-*T* score at the two sites, four had healthy BMD, and 11 had osteoporosis using BMD-*T* score at femur neck) and four (5.1%) women had osteoporosis (two of them had osteoporosis using the BMD-*T* score at the two sites and two had osteopenia using the BMD-*T* score at femur neck).

Depending on the BMD-*T* score at femur neck, 28 (35.4%) women were diagnosed as having healthy BMD (24 only out of them had healthy BMD using

the BMD-*T* score at the two sites, 18 had osteopenia using BMD-*T* score at femur neck), 36 (45.6%) women had osteopenia (18 of them had healthy BMD and two had osteoporosis using BMD-*T* score at lumbar spines, and 16 had osteopenia using BMD-*T* score at the two sites) and 15 (19%) women had osteoporosis (two of them only had osteoporosis using the BMD-*T* score at the two sites, two had healthy BMD, and 11 had osteopenia using the BMD-*T* score at lumbar spines) (Table 1). This means that DEXA at lumbar spines underestimate the diagnosis of osteoporosis and osteopenia.

Comparing the osteoporotic and nonosteoporotic women among the normal weight (Table 2) and overweight/obese groups, Table 3 showed that normal weight women and osteoporotic women had significantly higher values of vitamin D and C-terminal peptide, and significantly lower values of leptin and BMI than the nonosteoporotic ones. There was insignificant difference in age among normal weight women, while the osteoporotic overweight/obese women were significantly older than nonosteoporotic ones. Among the two groups, BMD at both lumbar spines and femur neck and their *T* scores were significantly higher in nonosteoporotic than osteoporotic women. Among overweight/obese women, nonosteoporotic women were significantly taller and heavier than the osteoporotic ones, but there were insignificant difference in their BMI.

Among osteoporotic women, BMI had significant negative correlation with vitamin D (Table 4). BMI had significant positive correlations with BMD at both lumbar spines and femur neck, and their *T* scores among nonosteoporotic women and total sample. Moreover, BMI had significant positive correlations with C-terminal peptide among the osteoporotic,

Table 2 Comparison between the nonosteoporotic and osteoporotic women with normal BMI

Variables	Women with normal BMI		P
	Nonosteoporotic (N=23)	Osteoporotic (N=14)	
Age (years)	44.30±9.16	40.94±12.66	0.314
Anthropometry			
Weight (kg)	54.85±4.99	53.26±3.92	0.270
Height (cm)	154.44±5.21	156.79±3.95	0.233
BMI (kg/m ²)	22.99±1.76	21.66±1.16	0.005**
Laboratory			
Leptin (ng/ml)	13.03±10.07	5.29±6.31	0.014
Calcium (mg/dl)	9.23±0.89	9.13±.518	0.289
Vitamin D (ng/ml)	21.40±2.68	28±9.55	0.041*
C-terminal peptide (pg/ml)	926.50±32.65	1160±313.7	0.039*
DEXA			
BMD at lumbar spines (g/cm ²)	0.92±0.14	0.75±0.08	0.000**
BMD-T score at lumbar	-0.11±0.89	-0.23±0.05	0.000**
BMD at femur neck (g/cm ²)	0.74±0.05	0.64±0.05	0.000**
BMD-T score at femur	-2.22±0.41	-3.07±0.45	0.000**

All data are expressed as mean±SD. BMD, bone mineral density; DEXA, dual-energy radiograph absorptiometry. *Significant difference at P value less than 0.05, using Mann-Whitney test. **Highly significant differences at P value less than 0.01 using Mann-Whitney test.

Table 3 Comparison between the nonosteoporotic and osteoporotic women with overweight/obesity

Variables	Overweight/obese women		P
	Nonosteoporotic (N=64) Mean±SD	Osteoporotic (N=15) Mean±SD	
Age (years)	46.84±10.12	52.61±11.12	0.036
Anthropometry			
Weight (kg)	88.03±15.45	76.25±23.21	0.003**
Height (cm)	157.59±5.48	149.07±8.66	0.000**
BMI (kg/m ²)	35.45±5.71	34.69±11.80	0.066
Laboratory			
Leptin (ng/ml)	15.08±10.15	18.67±9.84	0.163
Calcium (mg/dl)	9.25±0.74	9.21±0.52	0.628
Vitamin D (ng/ml)	24.10±10.67	21.54±4.79	0.466
C-terminal peptide (pg/ml)	1768.92±1688.86	1470.08±707.42	0.521
DEXA			
BMD at lumbar spines (g/cm ²)	0.99±0.21	0.81±0.14	0.000**
BMD-T score at lumbar	-0.56±1.13	-0.19±0.91	0.000**
BMD at femur neck (g/cm ²)	0.87±0.13	0.65±0.05	0.000**
BMD-T score at femur	-1.03±1.09	-2.96±0.33	0.000**

All data are expressed as mean±SD. BMD, bone mineral density; DEXA, dual-energy radiograph absorptiometry. **Highly significant differences at P value less than 0.01, using Mann-Whitney test.

nonosteoporotic and total sample, leptin and age among the osteoporotic and total sample.

Discussion

The present day prevalence of obesity, which dramatically increases worldwide, greatly affects and puts burden on both health and sustainable development [6]; hence, health-care providers together with the international community should not neglect such role throughout the process of health policy formulation and implementation. However, obesity should be regarded as a complicated health issue that necessitates a wide-ranging cross-sectorial action and,

as Rutter [14] reported, 'the single most important (obesity) intervention is to understand that there is no single most important intervention.' Moreover, this rule is implemented in the United Nations Sustainable Development Goals 'UN SDGs,' as obesity, in reality, threaded and infiltrated throughout the world populations. Therefore, obesity might be addressed more effectively if thoughtful attempts to achieve at least 14 of the 17 SDGs were made [6].

Obesity, as many noncommunicable diseases, is to some extent caused by economic development. The advantages realized due to industrialization,

Table 4 Spearman correlation between BMI and different variables among osteoporotic and nonosteoporotic women

Variables	BMI					
	Nonosteoporotic (N=87)		Osteoporotic (N=29)		Total	
	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
Age (years)	0.168	0.121	0.641**	0.000	0.270**	0.003
Laboratory						
Leptin (ng/ml)	0.091	0.413	0.779**	0.000	0.258**	0.007
Calcium (mg/dl)	-0.003	0.982	0.267	0.179	0.033	0.730
Vitamin D (ng/ml)	-0.121	0.280	-0.481*	0.017	-0.167	0.089
C-terminal peptide (pg/ml)	0.305**	0.005	0.338	0.016	0.272**	0.005
DEXA						
BMD at lumbar spines (g/cm ²)	0.297**	0.005	0.131	0.498	0.388**	0.000
BMD-T score at lumbar	0.334**	0.002	0.131	0.498	0.418**	0.000
BMD at femur neck (g/cm ²)	0.462**	0.000	0.185	0.338	0.487**	0.000
BMD-T score at femur	0.460**	0.000	0.196	0.308	0.485**	0.000

BMD, bone mineral density; DEXA, dual-energy radiograph absorptiometry. *Significant correlation at *P* value less than 0.05. **Highly significant correlation at *P* value less than 0.01.

urbanization, and globalization are often characterized by their inability to be sustainable for people's health and the planet; moreover, such advantages greatly contribute to the widespread intake of unhealthy diets (junk/fast foods), sedentary life style, physical inactivity, and poor air quality [15].

The prevalence of osteoporosis in Egypt is estimated to be 21.9% in men and 28.4% in postmenopausal women, while 53.9% of woman as having osteopenia. A recent study has concluded a higher prevalence (47.8%) of osteoporosis among rural postmenopausal women [16]. A recently published systematic review included 71 studies, representative of many different populations of the globe has revealed that occupation is regarded as a major factor contributing to suboptimal vitamin D levels, and indoor workers are at a higher risk of osteoporosis compared with outdoor ones, where 78% of indoor workers were vitamin D deficient compared with 48% of outdoor peers [1,17].

The present study assessed the effect of workplace (indoor) and its relation to both hypovitaminosis D and obesity in a sample of Egyptian women working at the NRC, aiming to improve the diagnosis and preventing osteoporosis to reduce not only a significant economic but also a social burden to Egyptian women.

The results of the study have shown a significant association between workplace and vitamin D levels. This is in agreement with the results of the study conducted in Multi-Ethnic Southeast Asian Country workers [1]. Also according to Grant [18], the percentage of the adult population with s25(OH)D

levels less than 50 nmol/l was 35–40% in Croatia, Italy, and Spain, 75% in Turkey, and 86% in Algeria. Moreover, Muslim countries showed the highest predominant rates of deficient 25(OH)D levels, where Muslims, according to the Islamic religious morals, wear concealing clothing.

Although, the exposure to solar type B ultraviolet is regarded as a good way to synthesis vitamin D, in addition to other health benefits, the exposure to sunshine does not usually yield enough vitamin D concentrations, as nowadays, people usually spend shorter time outdoors, where they often wear sunscreen. However, daily adequate exposure to sunshine, when the solar elevation angle is more than 45° (where an object's shadow is shorter than its real length) represents a good way to synthesize sufficient vitamin D levels [19].

The current study revealed that osteoporosis and osteopenia, at either lumbar spines or femoral neck or both sites, were significantly more frequent among normal weight women than overweight/obese ones. These findings are consistent with those concluded by Hiremath *et al.* [20], in India, who found that the prevalence of osteoporosis was 8.5%, and that of osteopenia was 45.7% in 233 middle-aged women. In Australia, Teichtahl *et al.* [21] studied 153 participants, aged 25–60 years, and found that there was no osteoporosis, but there was 12.4% having osteopenia based on their *T* score at different body sites.

In Egypt, Elwakil *et al.* [22] conducted a study on 77 postmenopausal women, and found that, among obese women, 47.5% had normal BMD, 37.5% had osteopenia, and 15% had osteoporosis. On the other

hand, they found that in nonobese women, 24.2% had normal BMD, 40.5% had osteopenia, and 35.3% had osteoporosis. In the UK, Evans *et al.* [23] concluded that obese adults showed a higher BMD, denser and thicker cortices, and a greater number of bone trabeculae than those in normal ones. In contrast, Bachmann *et al.* [24] found that Bostonian patients with anorexia nervosa had impaired femoral geometry, assessed by hip-structural analysis, hip BMD, and risk factors for hip fracture attenuated by soft tissue; moreover, this was more/superior in obesity. These findings suggested a higher risk of hip fracture among anorexia nervosa patients, and a lower risk among obese ones. In Canada, Yang and Shen [25] conducted a cross-sectional study on 5287 men and women in the age range of 8–69 years and found a positive association between higher BMI and hip circumference with the higher BMD, at both the lumbar spine and femoral neck sites.

Shariati-Sarabi *et al.* [26] studied 714 healthy Iranian women aged 42–52 years, and found that ~35% had osteopenia, 8% osteoporosis (femur BMD), 42% had osteopenia, and 12% had osteoporosis (lumbar BMD), while in Spain, Gutierrez-Buey *et al.* [27] found that all participant women had normal BMD, at the time of enrollment. But after 5 years, 35.9% of these women had normal BMD, 57.8% had low BMD, and only 6.3% became osteoporotic. Hence, it has been concluded that osteopenia and osteoporosis increase with advanced age of patients. These are consistent with the results of the present study, as osteoporosis and osteopenia are more frequent in older participants.

As regards vitamin D, and in accordance with our results, Samuel and Borrell [28] found that 25-hydroxy vitamin D deficiency (<30 ng/ml) was more frequent among obese American women aged 44–65 years compared with normal weight ones. The same findings are consistent with other studies [29,30]. Similarly, levels of both free 25(OH)D and 1,25(OH)(2)D, which reflect the vitamin D status, were lower in obese individuals. Lagunova *et al.* [31] studied 1779 Chinese adults and found that patients with increased body weight have lower concentrations of serum 1,25(OH)(2)D.

Vimaleswaran *et al.* [32] studied 42 024 British adults, aged more than 18 years and found an association between elevated BMI and decreased 25(OH)D level. In KSA, Ardawi *et al.* [33] attributed the high prevalence of vitamin D deficiency, observed among premenopausal and postmenopausal healthy Saudi women, to a number of risk factors including

obesity, less exposure to sunlight, and poor dietary vitamin D supplementation.

The results of the present study showed significant positive correlations between BMI with C-terminal peptide among the two groups (osteoporotic, non-osteoporotic) and total sample, with leptin and age among the total sample and osteoporotic group only, and with BMD at all sites among total sample and non-osteoporotic group only. Elwakil *et al.* [22] concluded that BMI did not significantly correlate with the BMD in both patients and control groups, whereas patients' mean serum leptin level was significantly higher than that of the control group. These findings are consistent with those concluded by Hussein and Sharara [34], who conducted a study on 48 obese Egyptian patients (27 females) with knee osteoarthritis patients, as they found that leptin was significantly correlated with BMI, as well as with knee pain, functional impairment, inflammatory cytokines, and cartilage degradation. In this study, leptin was significantly lower in osteoporotic than in nonosteoporotic women; at the same time, it was higher in those with a higher BMI (consequently with less osteoporosis, as the results show), so that we can attribute a higher leptin level to higher fat mass, and if we need to confirm an independent correlation between osteoporosis and leptin, our results show that it was higher in normal weight nonosteoporotic women than in normal weight osteoporotic ones.

In Vietnam, Ho-Pham *et al.* [35] found that the mean level of leptin in women was almost three fold higher than that in men. As expected, leptin significantly correlated with fat mass. It has been found that in women higher serum leptin levels were positively correlated with BMD of both femoral neck, lumbar spine sites, but not with whole body BMD.

Negative correlations were found between serum 25(OH)D and body weight, BMI, and fat mass; subsequently, the prevalence of vitamin D deficiency is more prominent among obese adults than in normal weight ones in different regions (e.g. Saudi Arabia, Northern and Southern Europe, Australia, New Zealand, Latin America, and the United States) [36].

Although it has been concluded that obese adults have increased BMD, denser and thicker cortices, and greater number of bone trabeculae than those in normal ones, obese people may not be truly vitamin D deficient. Therefore, it might be suggested that although serum 25(OH)D level is lower, due to reduced bioavailability of cholecalciferol sequestered

by the adipose tissue, their whole-body total vitamin D stores are greater. This can be explained by sufficient vitamin D supply and their body adipose tissue reservoir, which maintains equilibrium with serum 25(OH)D [36]. Moreover, the prevalence of vitamin D deficiency is expected to be lower in populations adopting intervention policies to reduce BMI.

To summarize, regular vitamin D screening programs should be performed for office, workshop, and night shift workers, as well as incorporated substantial workplace policies and wellness programs. These indoor workers and employees should be allowed to take adequate outdoor breaks, to go for sufficient sunlight exposure, thus allowing vitamin D synthesis. Moreover, they should be encouraged to consume adequate amounts of vitamin-D-rich foods, in order that they can maintain optimal vitamin D levels, as the role of vitamin D supplements remains debatable.

Conclusion

Obesity protects humans from osteoporosis. Serum leptin and C-terminal peptide might be independent factors that protect against osteoporosis. BMI had significant positive correlation with BMD among nonosteoporotic women, but not among osteoporotic ones. DEXA on lumbar spines underestimates the diagnosis of osteopenia and osteoporosis.

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Conflicts of interest

There are no conflicts of interest.

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