Vitamin D, calcium and caffeine intake relationship to bone mineral density

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Abstract

Purpose – This study aims to evaluate the caffeinated drinks, levels of vitamin D and calcium in the blood, and their relationship to bone mineral density (BMD) in osteoporotic women in Al-Ahsa Saudi Arabia.

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Institutional review board statement: The study was conducted in accordance with the Declaration of Helsinki. Ethical clearance and approval were obtained from the Kingdom of Saudi Arabia, King Fahd Hospital in Hofuf, Department of Training, Research, and Continuing Education. No. 9/9/1439 dated 13 May 2018; King Abdullah International Medical Research Center, affiliated to the Ministry of National Guard for Health Affairs No. SP18/006/A dated 5 March 2018; Al-Mousa Specialist Hospital. Moreover, written consent was obtained from all volunteer participants. Their privacy was preserved. Participants were informed about the aim and benefits of the study. The study participants were informed that they had every right not to fill out the questionnaire.

Informed consent statement: Informed consent was obtained from all subjects involved in the study.

Data availability statement: The data presented in this study are available in the article.

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Design/methodology/approach – This study included 85 women over approximately 18 months with ages ranging from 40 to 70 years who were evaluated in the laboratory via blood analysis. Moreover, sociodemographic data and information on health and nutritional awareness were collected via a questionnaire. The BMD was measured by dual-energy X-ray absorptiometry (DXA) and considered osteopenia when the *T* value total of the lumbar spine or hip was between −1 and −2.5 and osteoporosis < −2.5. Blood levels of vitamin D and calcium were measured via blood analysis.

Findings – There were 54.1% and 45.9% of women who suffered from osteoporosis and low BMD, respectively. There was a significant difference in the number of osteoporotic, and low bone mineral mass groups in marital status ($p = 0.04$), but no difference was found in age and educational level. A significant difference ($p = 0.01$) between low bone mass and osteoporosis groups in heights. BMD was significantly and negatively correlated with vitamin D in the blood in individuals with osteoporosis ($r = -0.358$, $P = 0.014$). In addition, there was a significant negative correlation between calcium in the blood and total samples ($r = -0.355$, $P = 0.0578$). There was a negative significant relationship between calcium supplements and BMD in individuals with low BMD ($rt = -0.279$, $P = 0.041$). There was a significant association between cola intake with the occurrence of low BMD ($p = 0.027$), whereas tea drinking was not associated with risk in both groups.

Originality/value – The study indicated that there is a direct relationship between osteoporosis and low bone mass with different variables. This study was conducted to address the lack of research related to the levels of vitamin D and calcium in the blood and their relationship with BMD in women with low BMD and osteoporosis in Al-Ahsa province-KSA.

Keywords Bone mass, Bone minerals, Vitamin D, Calcium, Osteoporosis

Paper type Research paper

Introduction

Osteoporosis is the most common metabolic bone disease. Low bone mass and irregular bone structure are the hallmarks of osteoporosis, a serious public health issue that increases bone fragility and fracture risk. Low bone mineral density (BMD) is a significant contributor to osteoporosis and the fractures that result from it (Sadat-Ali, Al-Habdan, Al-Turki, & Azam, 2012).

Calcium and vitamin D are essential nutrients for achieving peak bone mass and reducing age-associated bone mass loss. When the body is exposed to the ultraviolet components of sunlight, it produces vitamin D. However, with age, the production of vitamin D in the skin becomes less efficient, and this must be compensated for and obtained by eating foods fortified with vitamin D, such as milk, or through the consumption of nutritional supplements such as fish oil (Adams *et al.*, 2014). Vitamin D status affects the rate of bone turnover, bone mineralization and the occurrence of fractures. Epidemiological research found a link between low BMD and vitamin D insufficiency. Muscle weakness, a greater chance of falling and poor energy fractures are all significant outcomes. In different regions of the world, vitamin D insufficiency is more common than in others (Hadi, 2022).

Numerous minerals (calcium and magnesium) and vitamins (vitamin D and B12) are linked to BMD (Rondanelli *et al.*, 2021). Even though elderly women have been thought to be more at risk for low BMD (Thompson, Taylor, & Dawson, 2004), BMD deficiencies have recently been reported in younger people (Kyvernitakis, Kostev, Nassour, Thomasius, & Hadji, 2017; Tamm *et al.*, 2021). In addition to nutrition (Fabiani, Naldini, & Chiavarini, 2019), age and sex (Singh, Arora, Kaur, Ghildiyal, & Kumar, 2018), bone density is affected by, among other things, physical activity (PA) (Segev, Hellerstein, & Dunsky, 2018). People frequently are not aware of their bone health since bone loss does not produce pain before osteoporosis and fractures take place (Mattia, Coluzzi, Celidonio, & Vellucci, 2016). Areal BMD is the most consistent predictor of osteoporotic fracture and is not usually determined in young healthy adults (Nguyen, Pongchaiyakul, Center, Eisman, & Nguyen, 2005).

Caffeine: Caffeine is an ingredient in coffee, tea and soft beverages (sodas), which may reduce calcium absorption and cause bone loss. Tea and/or coffee use over three cups per day (>300 mg/day) has been linked to bone loss (Rapuri, Gallagher, Kinyamu, & Ryschon, 2001). Cola and soda beverages frequently include phosphorus and caffeine, both of which may contribute to bone loss. The risk of fracture increases and BMD decreases when seven or more colas are consumed weekly (Fung *et al.*, 2014). In addition, a cross-sectional study of 140

females aged 40 years was conducted (Al-Diwan, Ahmed, & Saleh, 2021). When compared to people who did not consume caffeinated beverages, there was a significant correlation between high salt intake and coffee use with the development of osteoporosis (77.3% and 83.3%, respectively, $p = 0.001$). Osteoporosis was significantly associated with participants who regularly drank caffeinated beverages. The study group of Iraqi women's BMD and incidence of osteoporosis appears to be negatively impacted by excessive consumption of salty foods and caffeinated beverages.

Osteoporosis occurs much earlier among Saudi women than among women in the USA and other Western countries (Nguyen *et al.*, 2005). In addition, the prevalence of osteoporosis in Saudi society is estimated to be approximately 35–48%. In the eastern region, the annual cost of treating fractures resulting from osteoporosis is estimated to be approximately USD 12.78 million, and this cost is expected to increase due to the increasing life expectancy. Women are more likely to develop osteoporosis than men, with approximately 80% of patients with osteoporosis being women. Generally, women's bones are thinner and smaller than those of men. There is also a sharp decrease in estrogen production in post-menopausal women, which increases the loss of bone mass (Al-Daghri *et al.*, 2014).

Osteoporosis has attracted global attention over the past two decades, as it is both widespread and a silent disease in the elderly, and in the Kingdom of Saudi Arabia, the situation was found to be similar. Epidemiological studies show that 34% of healthy Saudi women and 30.7% of men aged between 50 and 79 years suffer from osteoporosis. Lifestyle plays an important role in the high prevalence of the disease, with a low dietary intake of calcium, a lack of physical activity and vitamin D deficiency being risk factors. These factors are considered among the most important causes of disease in the Kingdom of Saudi Arabia. There are approximately 8,768 hip fractures in Saudi Arabia annually, the treatment cost of which is in the billions, and endemic vitamin D deficiency raises a real concern for bone health in the Kingdom of Saudi Arabia (Alwahhabi, 2015).

This study was conducted due to a lack of research related to the levels of vitamin D, calcium in the blood and caffeinated drinks intake for their relationship with BMD in women with low BMD and osteoporosis in the Kingdom of Saudi Arabia in general and in Al-Ahsa province in particular.

Materials and methods

Study sample

This is a descriptive cross-sectional study conducted from March 2018 to December 2019 at King Fahd Hospital in Hofuf, Department of Training, Research, and Continuing Education, King Abdullah International Medical Research Center affiliated with the Ministry of National Guard for Health Affairs, and Al-Mousa Specialist Hospital. From about ($n = 230$) women of hospital attendants, only apparently who suffer from low BMD and osteoporosis women, are not pregnant, non-lactation were invited to participate with informed consent county ($n = 183$), the women were asked to respond to a food frequency questionnaire (FFQ). The proportion of women who returned a completed questionnaire was 60% ($n = 110$) through structured interviews, each participant was interviewed individually by the researcher. Women were excluded if they reported excessively irrational values for height and weight, as well as if they did not fit within the age range of 40–70 years, erroneous or missing ID numbers. In total, 85 women made up the final sample as a result.

Data collection

Questionnaire. A structured questionnaire was used to collect the study information through personal interviews. The questionnaire underwent validity and reliability analyses. It included the main sections:

Sociodemographic information: Marital status, age and education level.

Anthropometric measurements: Height and weight were measured by a researcher to calculate Body Mass Index (BMI) and then classified according to guidelines of the World Health Organization (2000).

Health information and physical activity: Number of pregnancies, If the women are in the menopause stage: yes or no, osteoporosis duration, history of osteoporosis, Lactose intolerance and exercising (<30 min/day and ≥30 min/day).

Dietary Intake of Supplements and Caffeine: information regarding the dietary intake of vitamin D supplements and calcium tablets, and the average amount of coffee, tea and cola consumed were explored during the past 12 months by using a FFQ. Vitamin D supplements and calcium tablets were estimated by evaluating consumed per never, day, week and month. The FFQ included questions on consumption of regular coffee tea and cola beverage, the participants were asked how often on average (Never, one serving per month, 4 servings per month and 30 servings per month) specifying the size of the serving for each type (60, 125 and 250 ml), and it was calculated by dividing the serving size by the number of days in the month.

Diagnostic tests

Collecting blood samples. The results of vitamin D and calcium levels in the blood among the study sample were obtained from the hospitals. Vitamin D analyses were performed by taking blood samples from the participants and measuring the level of the compound calcifediol (nmol/L), according to Arneson and Arneson (2013). When measuring calcium levels, participants were forbidden to take calcium supplements in the 12 h before the calcium examination, i.e. before a blood sample was drawn from the patient. The analysis was performed according to Yu *et al.* (2017).

Bone mineral density (BMD) measurement

BMD of the lumbar spine and left femur of the hip region, and lumbar spine BMD included lumbar vertebrae L1–L4 was measured by DXA (Wilmerding, Gibson, Mermier, & Bivins, 2003) All DXA measurements were performed by the same densitometer (Hologic, Discovery W[S/N 70991]). A total of 85 women from 3 locations were measured by DXA and expressed as the amount of mineral (g) divided by the area scanned (cm^2). World Health Organization (1994) was used to classify BMD and osteoporosis, A T-score of −1.0 and greater is considered normal, a T-score between −1.0 and −2.5 is considered low bone mass (osteopenia) and a T-score of −2.5 and less is considered osteoporosis.

Statistical analysis

The data were analyzed using the SPSS statistical analysis program. Independent sample t-test and chi-square (χ^2) test were used for comparisons. The Pearson test coefficient was used to measure the relationship between two quantitative variables: blood vitamin D level and BMD for women with low BMD and osteoporosis women. The significance of the p-value was considered at < 0.05.

Results

Sociodemographic information

Table 1 shows the sociodemographic information of the study sample. As the results show, the percentage of women with low bone mass was 45.9% and the percentage of women with osteoporosis was 54.1%, i.e. most of the women in the study suffered from osteoporosis. There was a significant difference in the number of osteoporotic, and osteopenic in marital

	Total number (n = 85) (%)	T-score Low bone mineral density (n = 39) (%)	Osteoporosis (n = 46) (%)	Chi square
Marital status				
Single	2 (2.4%)	0	2 (4.3%)	0.04*
married	73 (85.9%)	38 (97.4%)	35 (76.1%)	
divorced	3 (3.5%)	0	3 (6.5%)	
widow	7 (8.2%)	1 (2.6%)	6 (13%)	
Age (years)				
number	85	38	47	0.18
Age M + SD	57.54 + 6.74	56.45 + 6.45	58.43 + 7	*t*-test
Education level				
illiterate	21 (24.1%)	13 (33.3%)	8 (17.4%)	0.48
primary	29 (34.7%)	11 (28.2%)	18 (39.1%)	
intermediate	9 (10.6%)	4 (10.3%)	5 (10.92%)	
secondary	10 (11.8%)	5 (12.8%)	5 (10.9%)	
postgraduate	16 (18.8%)	6 (15.4%)	10 (21.7%)	

Note(s): *$p < 0.05$
Source(s): Authors' calculation based on survey results

Table 1. Comparison of low bone mineral density and osteoporotic subjects according to marital status, age and educational level

status ($p = 0.04$). The percentage of married women was 85.9% of the total sample, constituting 97.4% of the low bone mineral density group and 76.1% of the osteoporosis group. Regarding the average age of women, there was no significant difference ($p \leq 0.05$) in the age of women with low bone mineral density 56 years compared to the osteoporosis group 58 years. Regarding education level, no significant differences between participants, it was found that there was a convergence in the level of education among women lacking bone mass and suffering from osteoporosis: The illiteracy category comprised 24.1% of the total group, which was the highest percentage, followed by university education or above.

Anthropometric measurements

Both groups with low BMD and osteoporosis had higher BMI and a majority of women in the obese category, Table 2 shows the average body mass index statistics; this value was 32.5 + 6.69 kg/m^2 for the sample as a whole, 32.58 + 5.69 kg/m^2 for the bone mass deficiency group, and 32.42 + 7.47 kg/m^2 for the osteoporosis group. Regarded the average heights of the sampled women, it can be observed that there was a significant difference ($p = 0.01$) between low bone mass and osteoporosis groups.

Participant health information and physical activity

Table 3 shows the number of children that the participating women have. The percentage of women who had more than five pregnancies was 61.2% in the total sample. It was found that there was a convergence insignificant in the proportions of the two categories in the two research groups (low BMD and osteoporosis). Concerning the menopause stage, the results show no significant differences between participants, the percentage of women from the total sample who were in menopause was 89.45%, with 91.3% of women with osteoporosis being in the menopausal stage. In addition to osteoporosis disease duration, the results show that most of the women, i.e. 84.7% of the total sample, had a disease duration of 10 years or less, while 15.3% of the total sample had a disease duration of more than 10 years. Given the relatives with osteoporosis observed that 38.8% of the participants had family members who

suffered from osteoporosis. This was the case for 41% of the women with low bone mass and 37% of the group with osteoporosis. Referring to the presence of lactose intolerance among the participating women the results show that the percentage of participants who were lactose intolerant was 47.1%. Of these, 53.8% suffered from low bone mass and 41.3% from osteoporosis.

As shown in Table 3 the majority of women had physical levels at low levels 60.9% of the osteoporosis group and 76.9% of the bone mass deficiency group exercised for less than 30 min/per day. The low bone mass group was the lowest in terms of the level of physical activity.

Table 2. Anthropometric measurements of the study sample

Anthropometric measurements	Total number (n = 85) M ± SD	T-score Low bone mineral density (n = 39) M ± SD	T-score Osteoporosis (n = 46) M ± SD	P t-Test
Average weight (kg)	76.39 ± 15.07	77.7 ± 13.8	75.32 ± 16.13	0.47
Average height (m)	1.53 ± 5.5	1.54 ± 5.23	1.52 ± 4.8	0.01*
Average body mass index (kg/m^2)	32.50 ± 6.69	32.58 ± 5.69	32.42 ± 7.47	0.91

Note(s): *$p < 0.05$
Source(s): Authors' calculation based on survey results

Table 3. Health Information and physical activity of the study sample

	Total number (n = 85) (%)	T-score Low bone mineral density (n = 39) (%)	T-score Osteoporosis (n = 46) (%)	P Pearson
Number of pregnancies				
5 or fewer	33 (38.8%)	15 (38.5%)	18 (39.1%)	1
more than 5	52 (61.2%)	24 (61.5%)	28 (60.9%)	
If the women in menopause stage				
Yes	76 (89.4%)	34 (87.2%)	42 (91.3%)	0.72
No	9 (10.6%)	5 (12.8%)	4 (8.7%)	
Having osteoporosis				
10 years or less	72 (84.7%)	36 (92.3%)	36 (78.3%)	0.12
More than 10 years	13 (15.3%)	3 (7.7%)	10 (21.7%)	
Relatives with osteoporosis				
Yes	33 (38.8%)	16 (41%)	17 (37%)	0.82
No	52 (61.2%)	23 (59%)	29 (63%)	
Lactose intolerance				
Yes	40 (47.1%)	21 (53.8%)	19 (41.3%)	0.28
No	45 (52.9%)	18 (46.2%)	27 (58.7%)	
Physical activity				
<30 min/day	27 (30.6%)	9 (20.5%)	18 (39.1%)	0.43
≥30 min/day	58 (68.2%)	30 (76.9%)	28 (60.9%)	

Source(s): Authors' calculation based on survey results

Dietary intake of supplements and caffeine

As shown in Table 4, the percentage of women who took a vitamin D supplement daily was 70.6%. It was also noted that the percentage of women who never took a vitamin D supplement was 8.2%, with the results being similar and insignificant among the groups. In addition to 71.8% of the sample, i.e. most of the sample took calcium supplements daily (of whom 74.4% had low bone mass and 69.6% osteoporosis). Looking at the average intake of beverages, it became clear that the average amount of tea consumed was 174.38 mL per serving, followed by coffee with an average of 90.05 mL per serving and then cola drinks, with an average of 4.61 mL per day.

		T-score		
	Total number (n = 85) (%)	Low bone mineral density (n = 39) (%)	Osteoporosis (n = 46) (%)	P Pearson
Vitamin D Supplements				
Never	7 (8.2%)	4 (10.3%)	3 (6.5%)	0.15
Monthly	4 (4.7%)	3 (7.7%)	1 (2.2%)	
Weekly	14 (16.5%)	3 (7.7%)	11 (23.9%)	
Daily	60 (70.6%)	29 (74.4%)	31 (67.4%)	
Calcium Supplements				
Never	13 (15.3%)	8 (20.5%)	5 (10.9%)	0.18
Monthly	1 (1.2%)	0	1 (2.2%)	
Weekly	10 (11.8%)	2 (5.1%)	8 (17.4%)	
Daily	61 (71.8%)	29 (74.4%)	32 (69.6%)	
Coffee drinking rate				
Never	25(29.4%)	12(30.8%)	25(29.4%)	0.74
1 serving/ month	1 (1.2%)	0	1 (1.2%)	
4 serving/ month	22 (25.9%)	9(23.1%)	22 (25.9%)	
30 serving/ month	37 (43.5%)	18(46.2%)	37 (43.5%)	
Tea drinking rate				
Never	16 (18.8%)	7(17.9%)	9(19.6%)	0.45
1 serving/ month	1(1.2%)	1(2.6%)	0	
4 serving/ month	5(5.9%)	1(2.6%)	4(8.7%)	
30 serving/ month	63(74.1%)	30(76.9%)	33(71.7%)	
Cola drinking rate				
Never	68(80%)	31(79.5%)	37(80.4%)	0.77
1 serving/ month	10(11.8%)	4(10.3%)	6(13%)	
4 serving/ month	7(8.2%)	4(10.3%)	3(6.5%)	
30 serving/ month	0	0	0	
Average quantities drunk mL (M + SD)				P t-test
Coffee	90.05 ± 11.63	103.03 ± 18.24	79.04 ± 14.92	0.3
Tea	174.38 ± 11.65	175.63 ± 16.97	173.32 ± 16.95	0.92
Cola	4.61 ± 1.37	6.19 ± 2.52	3.27 ± 1.37	0.29

Source(s): Authors' calculation based on survey results

Table 4. Vitamin D, calcium supplements and the average amount of coffee, tea and cola consumed

Diagnostic tests of the average calcium and vitamin D blood levels

The mean concentration of calcium in the blood was higher in the low BMD group with a highly significant difference between the two groups t (84) $p = 0.000$ (Table 5) while the mean concentration of vitamin D in the blood shows no significant difference between groups. The concentrations of calcium and vitamin D in the blood are indicators that have a direct effect on osteoporosis.

The relationship between variables and the average bone mineral density according to the T-score

The results in Table 6 showed a significant positive correlation between age and T-score (osteopenia and osteoporosis) (r = −0.238, $p = 0.029$ at df 83). The relationship between BMD (osteopenia) and BMI showed a significant indirect proportional (r = −0.373, $p = 0.029$ at df 83). A significant negative correlation was found between calcium supplementation and mean BMD within the low BMD group (45% rt = −0.279 *, $p = 0.041$). There was a significant positive correlation between the intake of cola (rt = 0.300 *, P = 0.027 at df 83) and low BMD.

Discussion

As osteoporosis is a public health problem among Saudi women. The purpose of this study is to evaluate the levels of vitamin D and calcium in the blood and their relationship to BMD in osteoporotic women in Al-Ahsa Saudi Arabia. The present study found that most of the women in the study suffered from osteoporosis, as compared to the Saudi Health Ministry which reported that the prevalence of osteoporosis and osteopenia in Saudi Arabia (KSA) is 37.8% and 28.2% in men and women above the age of 50 years. Marital conditions had more effect in developing osteoporosis and low BMD as compared to the effect of age and educational level on bone status. Recently, a study in Poland stated the specific function of marital conditions in both skeletal status and hormone replacement therapy (HRT) usage (Tariq, 2019). Regarding the average age of women, this age grouping for osteoporosis and low BMD corresponds to the study of Al-Mogbel (2012), who reported a prevalence of this disease among Saudi women over the age of 50 years. He reported that osteoporosis is remarkably prevalent among Saudi women, noting that the research he recently conducted showed that a large percentage of Saudi women suffer from the disease. Among women between the ages of 50 and 60 years, the prevalence was approximately 34%, while it was approximately 50% among women between the ages of 50 and 80 years. The present study indicates that a small proportion of the sample had a university level of education or above.

Table 5.
The average amount of calcium and vitamin D in the blood and the average bone mineral density (T-score) for the study sample

		T-score		
	Total number ($n = 85$) (M + SD)	Low bone mineral density ($n = 39$) (M + SD)	Osteoporosis ($n = 46$) (M + SD)	p Value
The mean concentration of calcium in the blood (mmol/L)	2.41 ± 0.12	2.46 ± 0.12	2.36 ± 0.1	0.000**
The mean concentration of vitamin D in the blood (nmol/L)	80.97 ± 31.51	83.61 ± 32.24	78.74 ± 31.05	0.48
The mean mineral density	−2.48 ± 0.57	−1.99 ± 0.33	−2.89 ± 0.35	0.000**

Note(s): **$p < 0.001$

Source(s): Authors' calculation based on survey results

Descriptive variables	Total number (n = 85)	T-score Low bone mineral density (n = 39) 45%	Osteoporosis (n = 46) 54%
Age	r = 0.238 *	r = 0.184	r = 0.214
P value	0.029	0.268	0.154
BMI	r = −0.167	r = −0.373 *	r = −0.192
P value	0.13	0.021	0.2
Vitamin D level in the blood	r = −0.139	r = 0.149	r = −0.358 *
P value	0.205	0.366	0.014
Intake of vitamin D supplements	r_t = 0.049	r_t = 0.094	r_t = −0.139
P value	0.578	0.482	0.264
Level of calcium in the blood	r = −0.355 *	r = −0.106	r = −0.087
P value	0.0578	0.482	0.264
Intake of calcium supplements	r_t = 0.045	r_t = −0.279 *	r_t = −0.006
P value	0.613	0.041	0.962
Coffee intake	r_t = 0.002	r_t = 0.014	r_t = 0.058
P value	0.98	0.916	0.632
Tea intake	r_t = −0.024	r_t = −0.014	r_t = 0.047
P value	0.788	0.92	0.706
Cola intake	r_t = 0.096	r_t = 0.300 *	r_t = 0.174
P value	0.284	0.027	0.184

Note(s): *p < 0.05, **p < 0.001
Source(s): Authors' calculation based on survey results

Table 6. The relationship between the descriptive variables of the participants and the mean bone mineral densities (T-scores) of the study sample

Hence, the lack of education had an impact on the increase in the prevalence of osteoporosis and lacking bone mass.

Based on the classification of the World Health Organization (2000), the participating women were, on average, in the obese category, which is a risk factor for osteoporosis. The results were consistent with those of Greco *et al.* (2010), insofar as an association was found between obesity (BMI >30) and low bone mineral mass. Regarded the average heights of the sampled women, many studies indicate that osteoporosis causes fractures in the spine, and this may lead to short stature with age, especially since the incidence of osteoporosis increases with age (Coin *et al.*, 2008). Thornton, Sedlak, and Doheny (2004) found that measured height change, as a predictor of osteoporosis risk, should be considered a component of a comprehensive osteoporosis health assessment.

Concerning the menopause stage, the results show no significant differences between participants. The postmenopausal stage, associated with the end of menstruation, is an important health factor in the study of osteoporosis. A decrease in estrogen, which is a natural consequence of menopause, is directly linked to a decrease in bone density. The longer estrogen levels drop, the greater the likelihood of a decrease in bone density, which can lead to osteoporosis. A sharp decline in estrogen production increases bone mass loss in postmenopausal women (Al-Daghri *et al.*, 2014). In addition to osteoporosis disease duration, Sandhu and Hampson (2011) mentioned that BMD decreases with age; thus, primary osteoporosis mainly occurs in women 10–15 years after menopause and elderly men around 75–80 years of age. The duration of osteoporosis correlated to the health awareness of the participants in this research sample. Given the relatives with osteoporosis, it appears that a family member with osteoporosis is one of the indicators of osteoporosis, that is, it may be hereditary for women. This is in line with the study of Al-Otaibi (2015), in which women with

a family history of osteoporosis had lower BMD. Referring to the presence of lactose intolerance, our results are in accordance with the results of (Hodges, Cao, Cladis, & Weaver, 2019) who indicated that lactose intolerance is linked to calcium deficiency, which leads to osteoporosis. Lactose intolerance prevents the intake of foods that contain milk. Thus, sufferers cannot benefit from the calcium contained therein (Baldan *et al.*, 2018). Optimal physical activities are necessary for increasing bone mass and reducing the risk of osteoporosis by improving bone mass. Recent studies among Saudi women reported similar to our finding, Hammad and Benajiba (2017) conducted a study in 2017 that found that one of the factors that led to osteoporosis was a decrease in exercise, with the incidence rate in the sample of 101 women being 33%. The results of the current study are consistent with those of Alabbad (2017) which indicated that female students and female employees often do not practice any strenuous sports activity (62.4% and 72%, respectively) ($p < 0.05$). This is considered a risk factor that increases the possibility of osteoporosis.

Vitamin D and calcium supplementation reduce rates of bone loss and also fracture rates in adults. Our finding follows the study carried out by Al-Otaibi (2015) who reported that women with a family history of osteoporosis had a significantly higher intake of calcium and vitamin D supplements which could be selves more than they perceived themselves are more at risk of osteoporosis than women without a family history. Hadi, Ouda, and Alboaklah (2022) mentioned that Vitamin D and Calcium (Ca/Vit D) insufficiency is a key risk factor for osteoporosis along with postmenopausal estrogen decrease, old age and inactivity. Bone resorption by osteoclasts is controlled by vitamin D to maintain equilibrium in the urinary and digestive systems. Vitamin D deficiency and a lack of calcium delivery led to an increase in bone resorption which lowers bone mass and quality.

Many studies have evaluated calcium and vitamin D in the blood and linked them to osteoporosis. In addition, many researchers have referred to blood vitamin D and calcium contents in humans and their relationship to osteoporosis (Alshanbari, Alsofyani, Almalki, & Alswat, 2018). The calcium concentration in males ranges from 2.15 to 2.55 mmol/L, and in women, it ranges from 2.15 to 2.60 mmol/L (UCLA Endocrine Center, 2022). The quantities of calcium recorded here are close to this range and so within the permissible limits. This may be due to the intake of medicinal supplementation of calcium and vitamin D, in addition to the nutritional behaviors common in Saudi society, e.g. not drinking cola or caffeinated coffee. The appropriate level of vitamin D in the blood, as indicated by Tello (2016), ranges between 30 and 32 ng/mL (75–80 nmol/L). He also indicated that blood vitamin D levels should not be lower than 30 ng/mL and that a level higher than 100 nanograms/milliliter is toxic. A study conducted in the eastern region of the Kingdom of Saudi Arabia demonstrated a low prevalence of vitamin D deficiency and showed that only 30% of young females between the ages of 25 and 35 were vitamin D deficient (Al-Turki, Sadat-Ali, Al-Elq, Al-Mulhim, & Al-Ali, 2008). This study found that the T-score in the total research sample averaged -2.48 ± 0.57. The bone mass deficiency group averaged -1.99 ± 0.33 and the osteoporosis group averaged -2.89 ± 0.35. This indicates that the research sample suffered from low BMD. These results are consistent with the study conducted by the National Campaign for Awareness of Osteoporosis from the Saudi Ministry of Health to measure the rate of osteoporosis among menopausal Saudi women between the ages of 52 and 62, with an average age of 55 years. It was found that 164 (34%) had osteomalacia and 116 (24%) had osteoporosis. This study concluded that bone mass deficiency and osteoporosis are common diseases among Saudi women in menopause, and they should be taken seriously in Saudi society. For example, bone density must be measured so that we can classify patients and know how to treat them. Moreover, additional studies are required to establish other causes of osteoporosis and the recommended levels of vitamin D (Ministry of Health in the Kingdom of Saudi Arabia, 2019).

A significant positive correlation between age and T-score low bone mineral and osteoporosis indicated that as age increases there is a significant increase in women with both

osteopenia or osteoporosis but it was found that there is more correlation in women with osteoporosis 54%(r = 0.214) than women with osteopenia 45% (r = 0.184), as having osteopenia this increases the risk for developing the osteoporosis (Bansal & Bansal, 2016). This result is consistent with those of Al-Shawish (2008), which indicates that osteoporosis increases with age and those aged 76 years or over have higher rates of osteoporosis as compared to younger people, according to the T-score classification. The prevalence of osteoporosis in the latter study was higher among women over 66 years (31.8%) than those under 55 years. Low BMD and BMI showed a significant indirect proportion. This study is in agreement with that of Bonte *et al.* (2013), which found a significant relationship between BMI and osteoporosis. A low BMI indicates lower bone mass and increases the risk of fracture. A significant negative association between vitamin D levels and Osteoporosis was found (54% r = - 0.358 *, p = 0.014 at df 83). Recent research has shown that adequate levels of vitamin D prevent fractures from osteoporosis (De Martinis *et al.*, 2020; Hadi *et al.*, 2022). Alkhenizan *et al.* (2017) indicated that vitamin D deficiency is widespread among the Saudi population. A negative significant relationship between calcium supplements and mean BMD in individuals with low BMD. Bailey *et al.* (2020) stated that although individuals who took calcium supplements at baseline had a lower femoral neck and spine BMD, they also had a lower rate of loss of BMD across time, after adjustment for potential confounding variables. There was a significant positive correlation between the intake of cola (rt = 0.300 *, P = 0.027 at df 83) and low BMD. Caffeine has been reported to increase urinary calcium excretion and it has also been suggested that caffeine decreases intestinal calcium absorption efficiency. These pathways may encourage a low calcium balance, which may be important for bone loss, especially when caffeine consumption is high and calcium absorption is poor (Hammad & Benajiba, 2017). Very active women (such as elite athletes) who consume soft drinks may be at a greater risk of fracture than sedentary women because their lower endogenous estrogen levels increase susceptibility to injury (Wyshak & Frisch, 1994). In addition, meta-analyses of postmenopausal women not using estrogen showed no association between soft drinks and bone mineral density. The results of the research are consistent with those of Sözen, Özışık, and Başaran (2017), whose study showed that calcium levels in the blood and bones are affected by the consumption of soft drinks. These drinks disrupt calcium absorption due to the carbonate they contain, which helps to precipitate calcium, hindering its absorption into the blood.

Conclusions

The research showed that taking nutritional supplements, such as vitamin D and calcium, is essential for maintaining bone health and even positively contributes to disease improvement. It was concluded that BMD was significantly and negatively correlated with vitamin D in the blood in individuals with osteoporosis, while there was a significant negative correlation between calcium in the blood and osteoporosis and low BMD in the total sample. The results of the study also indicated that there is a direct relationship between osteoporosis and cola intake.

Limitations/implications and directions for future studies

The study collected data only from Hospitals, which led to the fact that all the samples took calcium and vitamin D supplements before the start of the study. Future studies can be extended to collect data before going to the hospital, and thus there will be a control group that does not take supplements. The research sample had difficulty determining the healthy amount of cola, tea and coffee that was consumed. Many hospital patient visitors suffer from osteoporosis and loss of bone mass, they refuse to cooperate in completing the questionnaire,

which led to a limited sample. The number of hospital visitors was limited in the period from 2018 to the end of 2019 because during the last year, an outbreak of the Crohn's virus occurred, which led to a limited number of patients. In addition to, the fact that the silent disease and the difficulty of the person knowing that he has osteoporosis until after exposure to the fracture resulted in a lack of hospital visits and a limited sample. Future studies can be extended at a later time, with an increase in the sample collection period to allow for more samples.

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