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Lifestyle Factors Related to Femoral and Spinal Bone Density in Young Saudi Adult Women

Lina F Hammad[1*], Nada Benajiba[2], Layal K. Jambi[1], Alhanouf F Alshedi[1]

Abstract

Introduction: Many lifestyle factors are contributors to osteoporosis; a major health problem worldwide that can be measured using Dual-energy X-ray Absorptiometry (DXA). Aim: To evaluate the correlation between some lifestyle factors and Bone Mineral Density (BMD) in young Saudi adult women.

Methods: BMD (gm/cm^2) measurements in the femoral neck area and the lumbar spine (L2-L4) were performed using DXA in 101 females aged 20–24.9 years. BMD, T-score and Z-score were evaluated. Lifestyle factors were assessed through a questionnaire.

Results: Milk & dairy product consumption, sun exposure, calcium & vitamin D supplements and Exercise had a significant positive correlation with some BMD scores. Soft drink consumption was significantly negatively correlated with all DXA parameters. Multiple linear regression demonstrated that; the factor with the strongest significant association with Z-score$_{n..femur}$ and T-score$_{n.femur}$ was exercising, followed by calcium and vitamin D supplements in Z-score$_{n..femur}$ and by BMI in T-score$_{n.femur}$. BMI and animal protein consumption were significantly associated with BMD$_{n.femur}$.

Conclusion: Dairy and milk consumption, physical activity and sun exposure were the factors that showed significant association with BMD parameters. Limited calcium and Vitamin D intake and high consumption of soft drinks are the major contributors to low bone density in young females.

Keywords: Lifestyle factors; Osteopenia; Osteoporosis; Saudi Arabia; Young women

Introduction

Osteoporosis is a common disease that affects the global population, characterized by reduced bone mass with modification in microarchitecture which leads to bone fragility and increased risk of fracture [1]. In Saudi Arabia, the prevalence of osteoporosis is increasing [2]. Low bone quality was reported by Zeidan and colleagues in 9% of young healthy adult Saudi women [3]. The National Plan for Osteoporosis Prevention and Management recommendations of the Ministry of Health in the Kingdom of Saudi Arabia (KSA) include; education and health programs, early screening and intervention, regulation of post-fracture care to control secondary fractures, in addition to further research as contributors to reduce the onset of osteoporosis within Saudi Arabia [4]. Some risk factors have been implicated in the pathophysiology of osteoporosis. These factors could be categorized into,

Affiliation:

[1]Radiological Sciences Department, College of Applied Medical Sciences, King Saud University, Riyadh, KSA

[2]Regional Designated Center of Nutrition AFRA/IAEA, (Ibn Tofail University-CNESTEN), Morocco

***Corresponding Author**
Lina Fahmi Hammad, Lhammad@ksu.edu.sa

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major non-changeable and modifiable risk factors. The non-changeable factors include age, gender, genetic history, race, menopause, hypogonadism and rheumatoid arthritis [5]. Modifiable risk factors that could be changed to manage the reduction in BMD and the increase in osteoporosis include; alcohol, smoking, high intake of glucocorticoid, vitamin D deficiency, mull nutrition, insufficient exercise, low dietary and calcium intake [6, 7]. In addition to that, Saudi adolescents demonstrate vitamin D deficiency, low dairy consumption, lack of physical activity, and avoidance of sun exposure [8] and inadequate knowledge about osteoporosis crucial for disease prevention were found in young Saudi female college students [9]. Previous studies recommended improving lifestyle factors that could maintain muscle and bone strength, including exercise, and sufficient vitamin D and calcium supplements [10]. Early in life, physical activity contributed to a higher peak bone mass [11]. Studies have suggested that calcium and protein intakes are important for bone mass gain during and after puberty [12]. Furthermore, milk and calcium-enriched foods affected bone accumulation positively and influenced total body bone mineral content [13]. Factors contributing to low bone mass include low calcium intake, limited dairy product consumption, insufficient fruit and vegetable intake, and an exaggerated intake of soft drinks [2]. A change in lifestyle patterns in young Saudis in recent years is well documented [14,15], which suggests the importance of studying their effects on bone health. This study aimed to examine the correlation between lifestyle factors including smoking, exercising, calcium and vitamin D supplements intake, sun exposure, soft drinks, animal protein, and dairy products intake and BMD in young Saudi females.

Materials and Methods

Study Design

The research work was designed as a cross-sectional study, implemented at the King Saud University campus. Of the young females (age range 20–24.9 years), all were of Saudi Arabic nationality. Exclusion criteria self-reported by the participant included using medication interacting with calcium metabolism before and during the study time, suffering from any health condition affecting bone metabolism, parathyroid diseases, having a history of any fracture or major systemic disorder; being pregnant or at any terminal illness stage. A total sample of 110 young females meeting the criteria were found suitable to be recruited for the study. Before taking measurements, the study protocol was explained to participants, and the informed consent was signed upon their agreement before inclusion in the study.

Bone Mineral Density (BMD) measurements

Measurements of BMD (gm/cm^2) in the femoral neck area and the lumbar spine (L2-L4) were performed using DXA scans (Lunar IDXA™ - GE Healthcare). The Middle East reference population was used to calculate the Z-score. A standard protocol supplied by the manufacturer was used, including a quality control test using a standard phantom provided by the manufacturer. The Z-score obtained is defined as the number of standard deviations a patient's BMD differs from the average BMD of their age, sex, and ethnicity [16]. Based on the criteria defined by the International Society for Clinical Densitometry (ISCD) guidelines [17].

Anthropometric measurements and lifestyle patterns of the studied population

An eye-level beam scale with a height rod from Detecto™ USA was used to measure height and weight. Body mass index (BMI) (kg/m^2) was calculated after measuring the weight (Kg) and height (m) by the investigator. Classification of participants based on their BMI was done following the WHO guidelines. A participant was considered underweight if her BMI <18.50 kg/m^2, normal if the BMI ranged between 18.50-24.99 kg/m^2, overweight if the BMI ranged between 25.00-29.99 kg/m^2 and obese if BMI was≥30.00 kg/m^2 [18]. Lifestyle factors thought to influence bone health were assessed through a validated questionnaire by the authors. Participants were requested to answer questions related to smoking, exercising, sun exposure, calcium, and vitamin D supplement intake. Food-frequency questionnaire was used to assess the intake of main foods related to bone health (animal protein, soft drinks, and dairy products), which include food consumption per week, portion size and number of soft drink cans per day. The questionnaire was developed for the study and validated by the authors. The questions were taken from a previously published paper by Oommen & AlZahrani and similar to the questionnaire used by Lim and colleagues [19,20].

Statistical Analysis

All statistical analysis was performed using SPSS software (Version 24.0) (IBM Corporation, N.Y., USA). Results were expressed as *percent*, *means ± standard deviation (SD)*. *T-test* and *ANOVA tests* were used to measure the difference between the groups. A significant difference was set at a cut-off $p<0.05$. A two-step multiple linear regression analysis was performed to assess lifestyle factors with a significant association with the three studied parameters BMD, T-score or Z-score in the neck of the femur and in the spine. Step 1 consisted of examining the presence of a significant correlation. In step 2, factors significantly correlated ($p<0.05$) were entered into multiple linear regression models to identify factors with the strongest association.

Results

Of the 110 subjects recruited, 9 subjects have withdrawn from the study citing unavailability of time. The general characteristics of the studied population are demonstrated in Table 1. The mean age was 21.3±0.8 years and the mean BMI was 22.2±3.7 kg/m^2.

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Table 1: General characteristics of the studied population (n=101)

Parameter	*Mean ± SD*
Age (year)	21.3±0.8
Height (m)	1.6±0.1
Weight (kg)	55.9±9.4
BMI (Kg/m²)	22.2±3.7
BMI category	**N (%)**
Underweight	14 (13.8)
Normal	69 (68.3)
Overweight	14 (13.8)
Obese	4 (3.9)

BMI (kg/m²) = Body mass index. BMI categorization is based on the WHO guidelines: Underweight: <18.5 kg/m², Normal: 18.5 - 24.9 kg/m², Overweight ≥25.0 kg/m² and obese ≥30.0 kg/m² [18].

The cut-off point is a Z-score of -2 or lower defined as "below the expected range for age" and a Z-score above -2.0 is "within the expected range [17].

As shown in Table 2 according to Z-score classification, 5% of the studied subjects had a femoral BMD below normal range at the neck of the femur. Moreover, in studying the BMD of the spine, about 8% of the participants had BMD below the normal range.

Table 2: Distribution of the studied population-based on Z-score classification of BMD in the neck of femur and in the spine (n=101)

	***N*=101(%)**	***Mean ± SD* (g/m²)**	
BMD in the neck of femur			
Normal range (>-2)	96 (95.1)	-0.42 ±0.81	*p* <0.001
Below normal range (£-2)	5 (4.9)	-2.20±0.11	
Total	101 (100)	-0.51 ±0.80	
BMD in the Spine			
Normal range (>-2)	93 (92.1)	-0.39±0.92	*p* <0.001
Below normal range (£-2)	8 (7.9)	-2.31±0.30	
Total	101 (100)	-0.55±1.03	

The effect of BMI and different lifestyle factors on the three parameters (Z-score, T-score and BMD of both neck of the femur and spine is tabulated in Table 3. A positive association was observed between BMI and the three above parameters, though only statistically significant in BMD and T-score in both neck of femur and spine. On the other hand, the high frequency of milk and dairy product consumption significantly increases the averages of the three studied parameters, except for BMD$_{n.femur}$.

The increased frequency of animal protein consumption was associated with an increase in the three parameters, though statistically significant in the BMD$_{n.femur}$. Sun exposure affected the three evaluated parameters' mean values positively, though statistically significant in the spine area only.

In the present study, participants who do take vitamin D and Calcium supplements had significantly higher Z-score$_{spine,}$ and Z-score$_{n.femur}$ and T-score$_{n.femur}$ values compared to the group who did not, in contrast to the above finding; soft drinks consumption had a statistically significant inverse relationship with all the parameters expect T-score$_{n.femur}$. The present study results revealed that participants who exercised showed significantly higher values of Z-score$_{n.femur}$, T-score$_{n.femur}$ and T-score$_{spine}$ than others who did not.

The present study evaluated the correlation coefficients (***r***²) of the studied parameters (BMD, T-score and Z-score) in the neck of the femur and the spine with the different lifestyle factors and results are represented in Table 4.

BMI showed a significant positive correlation with all the evaluated parameters, the highest correlation was obtained with T-score$_{spine}$ (r^2=0.38). However, the smoking lifestyle factor showed a non-significant correlation with all the examined parameters. Both factors; milk and dairy products consumption and sun exposure exhibited a significant positive correlation with all the evaluated parameters except with BMD$_{femur}$. The highest correlation was found between Z-score$_{spine}$ and milk and dairy products consumption (r^2=-0.43) and T-score$_{spine}$ with sun exposure (r^2=-0.32). For Calcium & Vitamin D supplements, results revealed a significant positive correlation with only the T-score and Z-score at both neck of the femur and spine, the highest correlation was with T-score$_{femur}$ (r^2=0.25). Nonetheless, there was a non-significant correlation with BMD. A significant positive correlation was found between animal protein consumption and only T-Score and BMD$_{femur}$ (r^2=0.27) parameters. Additionally, there was a significant positive correlation between exercise and Z-score$_{femur}$, T-score at both the neck of the femur and spine and BMD$_{femur}$. A significant negative correlation was found between soft drink consumption and all investigated parameters. The models obtained from multiple linear regression were significant for the three parameters Z-score, T-score and BMD in both the neck of the femur and the spine (p <0.05) (**Table 5**).

For the neck of the femur, they accounted for 21%, 29% and 25 % in Z-score$_{n.femur}$, T-score$_{n.femur}$ and BMD$_{n.femur}$, respectively. For the spine, models explained a higher percent of the response data variability by 35% in Z-score$_{spine}$, 50% in T-scores$_{pine}$ and 28% in BMD$_{spine}$. In the neck of the femur, multiple linear regression demonstrated that the factor with the strongest significant association with Z-score$_{n..femur}$ and T-score$_{n.femur}$ was exercising (β=0.26 and β=0.29, respectively), followed by calcium and vitamin D supplements in Z-score$_{n..femur}$ and by BMI in T-score$_{n.femur}$. Concerning BMD$_{n.femur}$, BMI and animal protein consumption were significantly

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associated with this parameter. The association was stronger for BMI than for animal and protein consumption (β=0.346 versus β=0.271, respectively). Different results were found in the spine. For the three parameters, BMI, dairy and milk consumption, and sun exposure were the factors that showed the strongest significant association. The highest β was obtained for dairy and milk consumption (0.38 in Z-score$_{spine}$, 0.37 in T-score$_{spine}$ and 0.30 in BMD$_{spine}$).

Table 3: Z-score, T-score, and BMD (*Mean ± SD*) of the spine and in the neck femur according to lifestyle factors. (*P* value obtained from *t-test* and *ANOVA test*)

Lifestyle factors (n, %)	Z-Score		T-Score		BMD	
	Spine	*Femur*	*Spine*	*Femur*	*Spine*	*Femur*
BMI category**						
Underweight **(14, 13.8)**	-0.74±1.20	-0.64±1.14	-1.04±1.31	-0.70±1.19	1.02±0.23	0.93±0.15
Normal **(69, 68.3)**	-0.61±1.01	-0.63±0.81	-0.88±0.98	-0.77±0.77	1.10±0.19	0.95±0.15
Overweight **(14, 13.8)**	-0.28±0.90	-0.23±0.88	-0.32±0.86	-0.32±0.94	1.12±0.15	1.06±0.20
Obese **(4, 3.9)**	-0.28±1.08	0.35±0.66	0.58±0.81	0.43±0.37	1.36±0.18	1.24±0.28
	p =0.24	***p =0.08***	***p =0.01***	***p =0.02***	***p =0.02***	***p < 0.01***
Smoking*						
No **(93, 92.0)**	-0.53±1.04	-0.50±0.9	-0.75±1.07	-0.6±0.9	1.10±0.20	1.0±0.2
Yes **(8, 8.0)**	-0.68±1.04	-0.50±0.9	-0.76±0.95	-0.6±0.8	1.16±0.23	1.1±0.3
	p = 0.30	***p = 0.80***	***p =0.40***	***p =0.90***	***p =0.30***	***p =0.10***
Dairy and milk consumption**						
Rare (<2 times/week) **(46, 45.5)**	-1.10±0.86	-0.8±0.9	-1.30±0.93	-0.9±0.9	1.02±0.18	1.0±0.2
Moderate (2 times/week) **(46, 45.5)**	-0.13±0.91	-0.3±0.8	-0.38±0.94	-0.4±0.8	1.18±0.19	1.15±0.15
Frequent (3-5times/week) **(9, 8.9)**	0.08±1.17	0.2±0.8	-0.13±1.09	-0.5±0.9	1.15±0.20	0.9±0.17
	p <0.01	***p=0.03***	***p < 0.01***	***p = 0.01***	***p < 0.01***	***p = 0.20***
Sun Exposure*						
No **(60, 59.1)**	-0.79±0.94	-0.62±0.87	-1.03±1.11	-0.77±0.87	1.06±1.07	0.97±0.20
Yes **(41, 40.8)**	-0.15±1.06	-0.32±0.90	-0.34±1.11	-0.45±0.88	1.17±0.22	0.98±0.15
	p < 0.01	***p =0.70***	***p < 0.01***	***p =0.08***	***p = 0.003***	***p = 0.09***
Vit. D and Ca supplement*						
No **(88, 86.8)**	-0.64±0.98	-0.6±0.8	-0.84±1.02	-0.7±0.8	1.09±0.20	1.0±0.2
Yes **(13, 13.3)**	0.06±1.23	-0.1±1.1	-0.28±1.18	-0.1±1.1	1.17±0.21	1.0±0.2
	p = 0.03	**p = 0.01**	***p = 0.07***	***p = 0.01***	***p = 0.10***	***p = 0.90***
Animal protein consumption**						
Rare (<2 times/week) **(27, 27.0)**	-0.66±0.87	-0.62±0.7	-0.92±0.93	-0.84±0.74	1.07±0.18	0.93±0.14
Moderate (2-4 times/week) **(41, 40.0)**	-0.65±0.96	-0.60±0.87	-0.90±1.03	-0.71±0.84	1.09±0.13	0.94±0.18
Frequent (daily) **(33, 33.0)**	-0.28±1.20	-0.25±0.98	-0.45±1.13	-0.37±0.98	1.15±0.27	1.05±0.18
	p = 0.33	***p = 0.33***	***p = 0.17***	***p = 0.08***	***p = 0.20***	***p = 0.01***
Soft drinks consumption**						
Rare (<1 can/day) **(37, 37.0)**	-0.12±0.81	-0.29±0.72	-0.34±0.91	-0.45±0.74	1.15±0.15	0.99±0.18
Moderate (>2 cans/day) **(47, 46.0)**	-0.70±1.06	-0.53±0.92	-0.87±1.16	-0.66±0.92	1.10±0.22	0.99±0.18
Frequent (>3 and large cans/day)**(17, 17.0)**	-1.04±1.04	-0.92±1.04	-1.37±1.04	-1.03±1.02	1.01±0.20	0.87±0.12
	p = 0.05	***p = 0.05***	***p = 0.01***	***p = 0.07***	***p = 0.02***	***p = 0.02***
Exercise*						
No **(62, 61.3)**	-0.66±1.05	-0.68±0.89	-0.91±1.03	-0.83±0.90	1.09±0.23	0.95±0.18
Yes **(39, 38,6)**	-0.35±0.99	-0.23±0.82	-0.54±1.06	-0.36±0.78	1.12±0.15	1.01±0.17
	p = 0.06	***p = 0.01***	***p = 0.04***	***p < 0.01***	***p = 0.20***	***p = 0.08***

**t-test , **ANOVA test*

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Table 4: Correlation coefficients r^2 between Z-score, T-Score and BMD of the spine and in the neck femur and lifestyle factors. *$*p<0.05$, $**p<0.01$, $***p<0.001$*

	Z-Score		T-Score		BMD	
	Spine	***Femur***	***Spine***	***Femur***	***Spine***	***Femur***
BMI (Kg/m²)	0.29**	0.23*	0.38***	0.31**	0.36***	0.33**
Smoking	0.01	0.06	0.04	0.07	0.11	0.01
Milk and dairy products consumption	0.44***	0.21*	0.41***	0.21*	0.33**	0.01
Sun Exposure	0.30**	0.18*	0.32**	0.19*	0.28**	0.04
Calcium & Vitamin D supplements	0.23*	0.24**	0.18*	0.25**	0.12	0.06
Animal protein consumption	0.14	0.16	0.17*	0.21*	0.16	0.27**
Soft drink consumption	-0.30**	-0.21*	-0.31**	-0.18*	-0.22*	-0.17*
Exercise	0.17	0.26**	0.19*	0.27**	0.07	0.19*

Table 5: Multiple linear regression models.

	SPINE			**NECK OF FEMUR**		
	ß	*Partial R^2*	*95.0% CI for B*	*ß*	*Partial R^2*	*95.0% CI for B*
Z-SCORE						
BMI (Kg/m²)	0.21	0.25*	0.01, 0.11	0.15	0.16	-0.01, 0.08
Dairy and milk consumption	0.38	0.41***	0.32, 0.89	0.18	0.12	-0.02, 0.52
Sun Exposure	0.19	0.21*	0.01, 0.78	0.01	0.01	-0.35, 0.39
Calcium & Vitamin D supplements	0.14	0.16	-0.13, 0.95	0.23	0.24*	0.01, 1.12
Soft drinks consumption	-0.14	-0.16	-0.48, 0.06	-0.13	-0.12	-0.41, 0.11
Exercise	---	---	---	0.26	0.27**	0.12, 0.84
T-SCORE						
BMI (Kg/m²)	0.30	0.36***	0.04, 0.13	0.25	0.28*	0.02, 0.10
Dairy and milk consumption	0.37	0.42***	0.32, 0.88	0.19	0.21*	0.00, 0.52
Sun Exposure	0.19	0.22*	0.02, 0.80	0.02	0.02	-0.32, 0.39
Calcium & Vitamin D supplements	0.07	0.1	-0.29, 0.75	0.21	0.23*	0.05, 1.01
Animal protein consumption	0.12	0.15	-0.07, 0.39	0.20	0.22*	0.01, 0.44
Soft drinks consumption	-0.09	-0.11	-0.40, 0.1	-0.03	-0.03	-0.28, 0.21
Exercise	0.16	0.20	-0.02, 0.7	0.29	0.31**	0.18, 0.88
BMD						
BMI (Kg/m²)	0.30	0.33**	0.01, 0.03	0.28	0.3*	0.004, 0.02
Dairy and milk consumption	0.30	0.33**	0.04, 0.15	---	---	---
Sun Exposure	0.23	0.25*	0.02, 0.17	---	---	---
Soft drinks consumption	-0.04	-0.05	-0.07, 0.04	-0.05	-0.0.	-0.060, 0.03
Animal protein consumption	---	---	---	0.28	0.30*	0.022, 0.11
Exercise	---	---	---	0.17	0.18	-0.007, 0.13

Model summaries:

In spine:

Z-score: F=9.59, p<0.01, R^2= 0.35, *SEE*= 0.86

T-score: F=8.95, p<0.01, R^2= 0.49, *SEE*= 0.83

BMD: F= 8.76, p<0.01, R^2= 0.28, *SEE*= 0.17

In the neck of the femur:

Z-score: F= 4.21, p<0.01, R^2= 0.22, *SEE*= 0.82

T-score: F=5.29, p<0.01, R²= 0.29, *SEE*= 0.77

BMD: F=6.21, p<0.01, R^2= 0.25, *SEE*= 0.16

BMD: Bone mineral density. $*p \le 0.05$, $**p \le 0.01$, $***p \le 0.001$

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Discussion

The present results showed that most of the participants had Z-score that matched their age, similar studies were reported by recently published findings by Al Nozha and colleagues [21]. The significant positive correlation between both milk and dairy product consumption and sun exposure with all the evaluated parameters except with BMD $_{femur}$ and the positive correlation between Calcium & Vitamin D supplements with T-score and Z-score at both neck of femur and spine are in agreement with previous studies [22, 23]. This is of importance as previous studies confirmed that women with vitamin D deficiency are known to be at high risk for bone loss, bone fractures and disability [24], in addition to that; calcium malabsorption with resultant secondary hyperparathyroidism was found to cause impairment of skeletal mineralization, rickets development and osteomalacia in children or osteomalacia and osteoporosis in adults [25].

Although the sun exposure duration was not measured in our study, a previous study in the Riyadh area found that sun exposure time for optimum vitamin D3 production is from 9:00 AM and before 10:30 AM and after 2:00 PM until 3:00 PM (local time) during summer time and from 10:00 AM until 2:00 PM (local time) during winter time. These timings are important from a public health perspective, as it's a free and highly efficacious way for the management and the prevention of vitamin D deficiency [26], limited exposure to sunlight was reported as the main contributor to low serum 25(OH)D concentrations in the Saudi Arabian population as hot climate drives individuals to prefer air-conditioned comfort indoors that limit the endogenous production of vitamin D [27]. Other factors that would affect vitamin D production and might be of interest in future studies include; the effect of skin colour, season, altitude, time of the day, and amount of sun exposure within different areas of Saudi Arabia. The positive association between milk intake and BMD$_{spine}$ found in our study agrees with Yoshii and colleagues who suggested that milk consumption is beneficial for the bone health of adult women and high school females if accompanied by exercise [28]. The present study did not examine for the effect of the number of pregnancies nor the area of living on bone status as most of the sample studied were unmarried and lived within the same city (Riyadh) though earlier studies found that; factors like education level, number of pregnancies and area of living could influence the risk for osteopenia and osteoporosis [29]. Osteopenia was more common in unmarried urban women versus rural married ones, and college-educated females had considerable normal bone mass than females with lower than high school education. In the postmenopausal age (PMA) group, urban women were more Osteopenic than rural or industrial women and less than primary educated women were significantly more osteoporotic than college-educated women [29]. The present results reported a significant positive correlation between animal protein consumption and T-Score$_{femur}$ and BMD$_{femur}$ (r^2=0.22 & 0.3 respectively, Table: 5), in contrast to our findings, other studies concluded that in healthy adults, little profits for bone health were found with increasing protein intake, though no detrimental effect was found [30].

The association between other dietary patterns such as high consumption of fish and olive oil and low red meat intake was not investigated in this study, other studies suggested the potential bone-preserving properties of this eating pattern throughout adult life [31]. The significant positive correlation between exercise and both Z-score $_{femur}$, T-score $_{femur}$ in this study is in agreement with findings from a review paper that suggested that walking as an exercise program for postmenopausal women can improve the femoral BMD [32]. Although previous meta-analysis found that bone strength improvements ranged from 0.5% to 2.5% with high exercise compliance in premenopausal women [33], the significantly higher T-score$_{spine}$ in participants who exercised (Table3) suggests the importance of studying the effect of different exercise programs (resistance, aerobic and impact) on both bone and muscle strength. As low bone mineral density is a risk factor for the low quality of life in old age [34], the above findings suggest further research into different lifestyle factors that may affect bone strength. It could provide an approach to health education intervention to improve lifestyle and bone health in the Saudi population. In terms of limitation, the study design was cross-sectional meaning that causality between the different lifestyle factors and BMD could not be determined. In addition, the interpretation of the current findings could not be generalized because of the sample size, however, it could serve as a direction to develop larger research studies among this critical age group and set adequate public health policies in this regard.

Conclusion

Some lifestyle factors were found to be significantly correlated with low BMD in young Saudi females. Significant negative effects of soft drink consumption were found, whereas, milk and dairy products consumption, sun exposure, calcium & Vitamin D supplements and exercising exhibited significant positive effects on some BMD parameters. Understanding lifestyle factors that increase the occurrence of osteopenia and osteoporosis should help in planning preventive measures. Further studies are required to provide in-depth knowledge of the effect of each factor on the development of bones and later the prevention of osteoporosis.

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Conflicts of interest

The authors declare that they have no competing interests

Ethical approval

The study was approved by the Research Ethics Committee of the University (Ethics No. CAMS18/3S36), and was performed according to the principles of the Helsinki Declaration.

Authors contributions

LFH: Conceived and designed the study; collected data; wrote the initial draft and contributed to the final draft.

NB: Performed data analysis tools; contributed to the final draft.

LKJ: contributed to the final draft

AFA: contributed to the final draft

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