

# **The Influence of Body Mass Index, Age, and Gender on the Levels of 25-Hydroxyvitamin D: A Study in the United Arab Emirates**

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## **Abstract**

**Background:** Although many studies have highlighted the association between obesity and vitamin D, the results remain inconsistent. Therefore, we assessed this correlation in association with other parameters. Our objectives in this study were to demonstrate the relationship between gender and vitamin D deficiency, to examine the association of age with vitamin D deficiency and to investigate the correlation between body mass index and vitamin D deficiency. **Methods:** The levels of serum 25-hydroxyvitamin D (25-OH-VitD), age, gender and body mass index (BMI) of the 422 participants were analysed by T- test, ANOVA and multiple regressions using the Statistics Package for Social Sciences.

**Results:** Overall, 84.4 per cent of study participants had either mild or severe vitamin D deficiency using a cut-off level of 25-OH-VitD of  $\leq 30$  ng/ml. The statistical analysis indicated that there was a significant correlation between gender and 25-OH-VitD levels. Conversely, no significant correlations of age and BMI with 25-OH-VitD were recognized. Furthermore, the directions of the correlations of 25-OH-VitD levels with the independent variables were as follows: positive with gender, negative with age and negative with BMI.

**Conclusion:** The levels of 25-OH-VitD were influenced significantly by gender but not by BMI and age. Female patients seem to suffer more from vitamin D deficiency than do males. High BMI decreases the levels of 25-OH-VitD, pushing the body towards vitamin D deficiency. The same effect is reported for the patient age. The effect of gender on the 25-OH-VitD levels is higher than the effects of BMI and age.

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**Keywords:** Vitamin D, body mass index, 25-hydroxyvitamin D, 25-OH-VitD, 1, 25-dihydroxyvitamin D, obesity

## 1 Introduction

As a result of global warming and the increase in the daytime temperatures in the Gulf region, people are avoiding exposure to the sun, which leads to a lack of natural vitamin D synthesis. At present, people consume more unhealthy foods due to their rapid lifestyles and the increase in junk food and artificial food product advertising. Therefore, obesity has become a major problem globally. In this context, vitamin and mineral deficiencies have increased, including vitamin D deficiencies, which cause many health problems. The total 25-hydroxyvitamin D (25-OH-VitD) level, which is the summation of 25-hydroxyvitamin D<sub>2</sub> and 25-hydroxyvitamin D<sub>3</sub>, is the appropriate indicator of vitamin D body stores [1, 2]. The optimal level of serum 25-OH-VitD is 30-40 ng/ml (75-100 nmol/L) [3]. Vitamin D deficiency is defined as serum 25-OH-VitD levels less than 20 ng/ml [4, 5]. Exposure to sunlight, dietary vitamin D intake and vitamin D supplements are the main sources of vitamin D in humans [5].

Furthermore, vitamin D deficiency has become common worldwide, causes devastating consequences at any stage of life and is attributed to many factors such as race, latitude, age, season, time and duration of exposure to sun light and socioeconomic factors [2, 6-12]. It has been reported that vitamin D deficiency is significantly prevalent in the United States, especially among African American (82.1 per cent) and Hispanic (69.2 per cent) individuals with low education levels, obesity, poor health statuses, low high-density lipoprotein cholesterol levels, and no daily milk consumption [13]. Huffman et al. [14] found that African Americans had higher rates of vitamin D insufficiency compared to Cuban Americans.

Moreover, Nesby-O'Dell et al. [15] reported that African American women have suffered from hypovitaminosis D more than white American women. Worldwide, a high prevalence of vitamin D deficiency has been observed among healthy children [16-20] and among healthy adults [21, 22], but this deficiency could be improved by increasing the duration of sunlight exposure and dietary vitamin D intake. The effect of seasonal and latitudinal variations on the level of vitamin D has been assessed in many studies. According to the vitamin D council, more children are born with a low level of vitamin D in the northern mid-latitudes during the spring, especially in March, and this may affect the risk of autism due to brain damage around the sixth month of pregnancy due to restricted sunlight [23, 24]. Arunabh et al. [12] studied the effects of season, dietary vitamin D intake, age and race on the level of serum 25-OH-VitD in healthy women, and they found that race and season had the greatest effects on the levels of 25-OH-VitD compared to the other parameters. Interestingly, in other studies, researchers found a more significant decrease in the vitamin D concentrations in men than in women in the winter, although this difference did not persist in the summer [25-27].

In contrast, Hagenau et al. [28] found that there was no overall association between 25-OH-VitD levels and latitude. However, there was no evidence in the literature addressing the level of sunlight exposure required to maintain serum 25-OH-VitD concentrations [29]. It was stated that sun exposure to the face, arms, legs or back without sunscreen between 10 am and 3 pm at least twice a week is sufficient sunlight exposure [30], while it was reported that every person should be exposed to the sun without

sunscreen and umbrellas three times per week for approximately 15-20 minutes between 11 am and 2 pm [24]. Al Anouti et al. [31] noted that the perfect sun exposure time is between 11 am and 3 pm. In contrast, Hasehmipour et al. [22] revealed that there was no significant statistical association between serum 25-OH-VitD levels and the duration of exposure to sunlight.

Various studies in the literature have described the potential relationship between vitamin D deficiency and a diversity of diseases including type 1 diabetes [32], type 2 diabetes mellitus [14, 33, 34], cancer [11, 24, 35-39], immune diseases [40], osteoporosis [35, 41, 42], cardiovascular disease [24, 43- 45], hypertension [46, 47], chronic headaches [48] and migraines [49]. Due to sedentary lifestyles, individuals of different ages are at risk of obesity and vitamin D deficiency. Kelly et al. [50] reported that being overweight was more common among men worldwide, while obesity was more prevalent among women in 2005. Moreover, it has been estimated that the prevalence of being overweight or obese among the world's adult population will reach 57.8 per cent (3.3 billion people) in 2030 [50].

In the United States, nearly one-third of all adults are obese [51]. Obesity causes many metabolic and endocrine abnormalities [52], such as hyperparathyroidism that lead to hypovitaminosis D [53]. However, the association between obesity and vitamin D status has been investigated by many studies [12, 54].

Some studies have reported that serum concentrations of parathyroid hormone and 1, 25-dihydroxyvitamin D (1, 25(OH)<sub>2</sub>D) increased in obese and overweight individuals, while the concentration of 25-OH-VitD decreased [12, 54-60]. Meanwhile, Konradsen et al. [61] found an inverse relationship between BMI and the levels of both 25-OH-VitD and 1, 25(OH)<sub>2</sub> VitD, which is in contrast to the hypothesis that increasing 1,25(OH)<sub>2</sub> VitD promotes obesity. Moreover, a number of studies have shown a negative correlation between both levels of serum 1, 25- hydroxyvitamin D and serum 25-OH-VitD with BMI [53, 62]. Rodríguez-Rodríguez et al. [63] reported that vitamin D insufficiency in children is influenced by BMI and abdominal obesity. Some studies have correlated vitamin D deficiency with greater weight and high BMI in obese adolescents [64, 65]. Recently, several studies have described an inverse relationship between serum 25-OH-VitD levels and BMI [14, 56, 61, 66, 67], while no association between vitamin status and obesity has been observed in other works [68]. Furthermore, an inverse correlation between obesity and serum 25-OH-VitD levels has been reported in different disease conditions such as epilepsy [69], systemic lupus [70], metabolic syndrome [71], cancer [66] and polycystic ovarian disease [72]. Despite the abundance of sunshine in the Middle East region, a high percentage of the populations in these countries have vitamin D deficiency [20, 73, 74]. Many studies conducted in Iran found a high prevalence of vitamin D deficiency [22, 41, 75].

In the Gulf region, there are evidences of documented vitamin D deficiency among healthy males and females [31, 42, 76-80]. Sadat-Ali et al. [81] indicated that the percentage of vitamin D deficiency among healthy Saudi men was between 28 and 37 per cent. Al-Turki et al. [82] assessed the 25-OH-VitD levels in healthy, young Saudi women and found the percentages of hypovitaminosis D in young age (25-35 years) and postmenopausal age (50 years and older) to be 30 per cent and 55 per cent, respectively. Furthermore, Alsuwaida et al. [83] found that vitamin D deficiency was significantly greater in healthy, adult Saudi females (34.8 per cent) compared to healthy adult Saudi males (13.4 per cent) ( $p < 0.0001$ ) and individuals <45 years old. Correspondingly, it was documented in Qatar that the prevalence of vitamin D deficiency was very high among

health care professionals [79].

In the United Arab Emirates, 78 per cent of the population has vitamin D deficiency, which is especially prevalent in Emirati women [24]. A large study including 2836 patients was conducted in a Dubai hospital between 2008 and 2012. The results indicated that 81 per cent of Dubai residents (Emirati and non- Emirati) had 25-OH-VitD levels of  $< 30$  ng/ml despite the year-round abundance of sunlight [84]. Moreover, the study found a higher prevalence of vitamin D deficiency in Arabs than in the non-Arabic population [84]. Furthermore, Ybanez and Tayah [85] confirmed the findings of previous studies and mentioned that this deficiency was more common among the local and regional populations compared to westerners in Dubai, indicating that there might be inadequate vitamin D in the diet or inadequate sun exposure due to indoor activities. Moreover, this health problem is common in women of childbearing age and in maternal-infant pairs in Arab communities residing in Al Ain, UAE [77, 86].

These studies have prompted us to examine the relationship between different age groups in both genders and 25-OH-VitD levels. Due to the importance of vitamin D to our health and the increasing of obesity worldwide, we conducted this study in an attempt to highlight the correlation between body mass index (BMI) as an indicator of weight and vitamin D deficiency, to examine the association between age with vitamin D deficiency and to demonstrate the relationship between gender and vitamin D deficiency.

## 2 Patients and Methods

This study was carried out in the Canadian specialty hospital in Dubai, which has Joint Commission International Accreditation (JCIA). With the approval of the hospital and patients, the research was conducted on patients who attended the rheumatology clinic at the hospital from October 2013 until April 2014. A total of 500 participants aged 15 to 77 years who suffered from bone pain without any complications, such as osteoporosis, osteopenia and rheumatism, were included in the study. To obtain accurate vitamin D level results, we excluded all patients with other diseases such as diabetes, hypertension, cardiovascular problems, hyperthyroidism, malabsorption, high cholesterol and others. Additionally, we excluded patients who had taken medications or vitamin D supplements, or who had any other factors that might affect the results.

The concentrations of 25-OH-VitD were measured for 500 patients using the Abbott Architect 25-OH vitamin D assay, which is a chemiluminescent microparticle immunoassay (CMIA). The levels of 25-OH vitamin D using this method are categorized as follows: normal 30-80 ng/ml, mild deficiency 10-30 ng/ml and severe deficiency  $< 10$  ng/ml [87]. Among the 500 patients, 422 were diagnosed with vitamin D deficiency. The results indicated that 153 patients had severe vitamin D deficiency, while 269 patients had mild vitamin D deficiency. The body weight of each patient was measured to the nearest 0.1 kg on an electronic beam scale, and height was measured to the nearest 0.5 cm using a stadiometer. The body weight and height of each patient were measured twice at each time point, and the average of the duplicate measures was calculated. The BMI was calculated using the following formula: body weight in kg divided by body height in meters squared. The BMI was categorized by using the World Health Organization (WHO) classifications as follows: underweight BMI corresponds to a body weight of less than  $18.5 \text{ Kg/m}^2$ ; normal weight BMI is body weight of  $18.5\text{-}24.9 \text{ Kg/m}^2$ ; overweight corresponds to a body weight of  $25\text{-}29.9 \text{ kg/m}^2$ ; and obesity BMI corresponds

to a body weight of 30 Kg/m<sup>2</sup> or more [88]. The data were analysed without including the names and personal details of the patients using T- tests, ANOVA and multiple regression models with the Statistics Package for Social Sciences (SPSS program, version 20) to measure the correlation between 25-OH vitamin D levels and the independent variables (gender, age and BMI).

### 3 Results

Of the 500 participants in this study, 422 participants (84.4 per cent) had either mild or severe 25-OH-VitD deficiencies. The participants were aged 15 to 77 years, 28.4 per cent of the participants were males, and 71.56 per cent were females, as described in Table 1.

Table 1: Descriptive table of participant gender

Gender	N	%	Mean	Std. Deviation
Male	120	28.4	2.03	0.157
Female	302	71.6	2.08	0.266
Total	422	100	2.06	0.241

N= Number of participants

Table 2: Independent sample T-tests by gender

		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	99% Confidence Interval of the Difference	
									Lower	Upper
25-OH-VitD	Equal variances assumed	17.035	0.000	-1.976	420	0.049	-0.051	0.026	-0.118	0.016
	Equal variances not assumed			-2.443	360.148	0.015	-0.051	0.021	-0.105	0.003

df= degrees of freedom  
sig. = p-value

Independent sample t-tests were conducted to compare the mean score of the two categories of male and female whether males and females differed significantly in terms of their levels of 25-OH-VitD. The significance level of Levene's test was a cut-off of 0.05, which means that the variances for the two groups (males and females) were not the same. Therefore, the results violate the assumption of equal variance. According to Table 2, the significance value (2- tailed) was less than 0.05 (p-value= .015), so there was a statistically significant difference in the mean scores of the dependent variable (25-OH-VitD) for each of the two groups. As a result, there was a statistically significant difference in the mean scores for males (M= 2.03, SD= 0.157) and females (M=2.08, SD= 0.266); t (420) = 1.976.

Table 3: Descriptive table of participant age

Age categories	N	Mean	Std. Deviation
15-29	53	2.08	0.267
30-44	274	2.06	0.235
45-59	85	2.07	0.258
60-77	10	2.00	0.000
Total	422	2.06	0.241
N= Number of participants			

Table 4: ANOVA test for the influence of age on the 25-OH-VitD levels

	Sum of Squares	df	Mean Square	F	Sig. or p-value
Between Groups	0.058	3	0.019	0.331	0.803
Within Groups	24.340	418	0.058		
Total	24.398	421			
df= degree of freedom					

A one-way between-groups analysis of variance was conducted to investigate the influence of age on 25-OH-VitD levels. Participants were divided into four categories according to their ages (Group 1: 15-29 years; Group 2: 30-44 years; Group 3: 45-59 years and Group 4: 60-77 years) as shown in the descriptive table of participant age, Table 3. As determined by ANOVA; Table 4, there was no statistically significant difference at the  $p < 0.05$  level for these four groups:  $F(3,418) = 0.331$ ,  $P\text{-value} = 0.803$ . However, there was no actual difference in mean scores between the groups as mentioned in Table 3.

Table 5: Descriptive table of participant BMI

BMI Categories	N	Mean	Std. Deviation
18.5-24.9	75	2.04	0.197
25-29.9	186	2.09	0.281
30-50	161	2.04	0.205
Total	422	2.06	0.241

Table 6: ANOVA test for the influence of BMI on the 25-OH-VitD levels

	Sum of Squares	df	Mean Square	F	Sig. or p-value
Between Groups	0.199	2	0.099	1.721	0.180
Within Groups	24.199	419	0.058		
Total	24.398	421			

df= degree of freedom

The participants were divided into three categories according to their BMI; Group 1, normal BMI: 18.5-24.9; Group 2, overweight: 25-29.9; and Group 3, obesity: 30-50. As shown in Table 5, there was no actual difference in the mean scores between the groups; therefore, there was no statistically significant difference at the  $p < 0.05$  level for the BMI categories:  $F(2,419) = 1.721$ ,  $P\text{-value} = 0.180$ , as shown in Table 6. Additionally, correlation analysis was conducted to describe the strength and direction of the linear relationship between the independent variables (age, gender and BMI) jointly and individually with the dependent variable (25-OH-VitD) depending on the Pearson correlation coefficient. Consequently, simple correlation and multiple regressions were investigated in this study.

Table 7: The Pearson correlation between gender and 25-OH-VitD levels

		Gender	25-OH-VitD
Gender	Pearson Correlation	1	0.096*
	Sig. (1-tailed)		0.024
25-OH-VitD	Pearson Correlation	0.096*	1
	Sig. (1-tailed)	0.024	

\* Correlation is significant at the 0.05 level (1-tailed).

As shown in Table 7, there was a significant correlation ( $p = 0.024$ ) between gender and 25-OH-VitD levels, and the Pearson correlation coefficient ( $r$ ) was 0.096, indicating a positive and weak correlation,  $n = 422$ .

Table 8: The Pearson correlation between age and 25-OH-VitD levels

		Age	25-OH-VitD
Age	Pearson Correlation	1	-0.019
	Sig. (1-tailed)		0.352
25-OH-VitD	Pearson Correlation	-0.019	1
	Sig. (1-tailed)	0.352	

In Table 8, there was no significant correlation ( $p = 0.352$ ) between age and 25-OH-VitD, and the Pearson correlation coefficient ( $r$ ) was -0.019, indicating a negative and weak correlation,  $n = 422$ .

Table 9: The Pearson correlation between BMI and 25-OH-VitD levels

		BMI	25-OH-VitD
BMI	Pearson Correlation	1	-0.018
	Sig. (1-tailed)		0.358
25-OH-VitD	Pearson Correlation	-0.018	1
	Sig. (1-tailed)	0.358	

There was no significant correlation ( $p= 0.358$ ) between BMI and 25-OH-VitD, as indicated in Table 9, as the Pearson correlation coefficient ( $r$ ) was  $-0.018$ , indicating a negative and weak correlation,  $n= 422$ . Moreover, the relationship among the group of independent variables jointly (age, gender and BMI) with the dependent variable (25-OH-VitD) was explored as presented in Table 10.

Table 10: The correlation between the independent variables (gender, age and BMI jointly) and 25-OH-VitD levels

Variables		Gender	Age	BMI	25-OH-VitD
Gender	Pearson Correlation	1	$-0.084^*$	0.062	$0.096^*$
	Sig. (1-tailed)		0.042	0.103	0.024
Age	Pearson Correlation	$-0.084^*$	1	$0.147^{**}$	$-0.019$
	Sig. (1-tailed)	0.042		0.001	0.352
BMI	Pearson Correlation	0.062	$0.147^{**}$	1	$-0.018$
	Sig. (1-tailed)	0.103	0.001		0.358
25-OH-VitD	Pearson Correlation	$0.096^*$	$-0.019$	$-0.018$	1
	Sig. (1-tailed)	0.024	0.352	0.358	

\*. Correlation is significant at the 0.05 level (1-tailed).  
\*\*. Correlation is significant at the 0.01 level (1-tailed).

From the output presented in Table 10, there was a significant negative weak correlation between gender and age ( $r = - 0.084$ ), and no significant correlation between gender and BMI ( $r = 0.062$ ); however, the relationship was positive. Moreover, there was a significant positive weak correlation between gender and 25-OH-VitD levels ( $r = 0.096$ ). The correlation between age and BMI was weak, significant and positive ( $r = 0.147$ ), while a negative weak correlation that was not significant was observed between age and 25-OH-VitD levels ( $r = - 0.019$ ). A negative and weak correlation was found between BMI and 25-OH-VitD levels ( $r = - 0.018$ ). Multiple regression analysis and ANOVA were conducted to assess the correlation between the independent variables (age, gender and BMI) and the dependent variable (25-OH-VitD levels) by comparing the contribution of each independent variable to the 25-OH-VitD levels depending on the beta values as illustrated in Table 11.



Table 11: Multiple regression analysis and ANOVA of the independent variables (gender, age and BMI) and the dependent variable (25-OH-VitD)

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.099 <sup>a</sup>	0.010	0.003	0.240

a. Predictors: (Constant), BMI, Gender, Age

Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	Constant	1.996	0.068		29.169	0.000
	Gender	0.052	0.026	0.097	1.976	0.049
	Age	-0.003	0.019	-0.007	-0.144	0.885
	BMI	-0.008	0.016	-0.023	-0.460	0.646

As shown in Table 11, the R-square value in the model summary box measures the strength of the association among the independent variables (age, gender and BMI). This value was 0.01, which means that the model explains 1 per cent of the variance in the 25-OH-VitD levels. As shown in the ANOVA table, no statistical significance was observed ( $p$ -value = 0.248). The beta coefficient values in the output of the coefficient box represent the contributions of each independent variable (gender,  $B = 0.097$ ; age,  $B = 0.007$ ; and BMI,  $B = 0.023$ ). The largest beta coefficient was for gender.

This means that this variable (gender) makes a statistically significant ( $p = 0.049$ ) and the strongest contribution ( $B = 0.097$ ) to the predication of the dependent variable (25-OH-VitD levels). Meanwhile, the beta coefficient value for age was the lowest (0.007), indicating that this variable made the least contribution to the 25-OH-VitD levels. Moreover, the significant values of all independent variables together (gender, age and BMI) were greater than 0.05 ( $p = 0.248$ ), meaning that they did not make significant contributions to the predication of the dependent variable (25-OH-VitD levels).

This result might be due to the overlap of the independent variables in the model; therefore, we assessed three models to minimize these overlaps among the independent variables. The first model was used to assess the correlation between age and BMI together, while the second model studied gender and BMI together. The third model examined age and gender together.

Table 12: Multiple regression analysis and ANOVA of two independent variables (age and BMI) and the dependent variable (25-OH-VitD)

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	0.024 <sup>a</sup>	0.001	-0.004	0.241		
a. Predictors: (Constant), BMI, Age						
ANOVA <sup>a</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig. or p-value
1	Regression	0.014	2	0.007	0.121	0.886 <sup>b</sup>
	Residual	24.384	419	0.058		
	Total	24.398	421			
a. Dependent Variable: 25-OH-VitD						
b. Predictors: (Constant), BMI, Age						
Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	Constant	2.086	0.051		40.903	0.000
	Age	-0.006	0.019	-0.016	-0.331	0.741
	BMI	-0.005	0.016	-0.015	-0.312	0.755

As shown in Table 12, the R-square in the model summary box was 0.001, which means that the model (BMI and age) explains 0.1 per cent of the variance in the 25-OH-VitD levels. From the ANOVA table, the significant values of the two independent variables (age and BMI) were greater than 0.05 (p-value = 0.886). There was no statistical significance, meaning that the variables did not make any significant contributions together to the predication of the dependent variable (25-OH-VitD levels), even after deleting the overlap of gender. The beta coefficient values in the output of the coefficient box represent almost the same contribution as each of the independent variables alone (age, B= 0.016; BMI, B= 0.015), but little was contributed by age.

Table 13: Multiple regression analysis and ANOVA of two independent variables (gender and BMI) and the dependent variable (25-OH-VitD)

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	0.099 <sup>a</sup>	0.010	0.005	0.240		
a. Predictors: (Constant) Gender, BMI						
ANOVA <sup>a</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig. or p-value
1	Regression	0.239	2	0.119	2.068	0.128 <sup>b</sup>
	Residual	24.160	419	0.058		
	Total	24.398	421			
a. Dependent Variable: 25-OH-VitD						
b. Predictors: (Constant), BMI, Gender						
Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	Constant	1.990	0.057		35.125	0.000
	Gender	0.052	0.026	0.097	2.001	0.046
	BMI	-0.008	0.016	-0.024	-0.489	0.625

As indicated in Table 13, the R-square value in the model summary box was 0.010, which means that the model (BMI and gender) explains 1 per cent of the variance of the 25-OH-VitD levels. From the ANOVA table, the significant values of the two independent variables (gender and BMI) were greater than 0.05. There was no statistical significance ( $p$ -value = 0.128), meaning that these variables together did not make a significant contribution to the predication of the dependent variable (25-OH-VitD levels), even after deleting the overlap of gender. However, the beta coefficient value of gender ( $B = 0.097$ ) in the output of the coefficient box was larger than the beta coefficient value of BMI ( $B = -0.024$ ). This means that the variable (gender) makes a statistically significant ( $p = 0.046$ ) and strong contribution to the predication of the dependent variable (25-OH-VitD levels) compared to BMI. However, BMI had greater insignificant contribution to the predication of the dependent variable (25-OH-VitD levels),  $p = 0.625$ . The last model was to assess the contribution of two independent variables together (age

and gender) on the levels of 25-OH-VitD as represented in Table 14.

Table 14: Multiple regression analysis and ANOVA of two independent variables (gender and age) and the dependent variable (25-OH-VitD)

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	0.097 <sup>a</sup>	0.009	0.005	0.240		
a. Predictors: (Constant), Gender, Age						
ANOVA <sup>a</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig. or p-value
1	Regression	0.227	2	0.114	1.972	0.141 <sup>b</sup>
	Residual	24.171	419	0.058		
	Total	24.398	421			
a. Dependent Variable: 25-OH-VitD						
b. Predictors: (Constant), Gender, Age						
Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	Constant	1.983	0.063		31.563	0.000
	Age	-0.004	0.018	-0.011	-0.217	0.828
	Gender	0.051	0.026	0.095	1.949	0.052

As indicated in Table 14, the R-square value in the model summary box was 0.009, which means that the model (age and gender) explains 0.9 per cent of the variance in the 25-OH-VitD levels. There was no statistical significance (p-value = 0.141) in the ANOVA table, meaning that these variables together did not have a significant effect on the predication of the dependent variable (25-OH-VitD levels), despite the deletion of overlapping BMI. In the output of the coefficient box, the beta coefficient value of gender (B= 0.095) was greater than the beta coefficient value of age (B= -0.011). This means that this variable (gender) makes a stronger contribution (B=0.095), although it is not significant (p= 0.052), to the predication of the dependent variable (25-OH-VitD levels) than does age.

#### 4 Discussion

Vitamin D deficiency has become common around the world because of inadequate exposure to the sun and insufficient consumption of food rich in vitamin D. However, there was a discrepancy in the literature about the association between obesity, BMI and serum levels of vitamin D [33, 89]. Therefore, further studies are necessary to verify the relationship between BMI and vitamin D levels.

In our study, we continue these investigations and selected three independent variables (age, gender and BMI) in order to judge their influences and correlations individually and together on 25-OH-VitD levels. We found that 84.4 per cent of the participants in this

study had mild to severe 25-OH-VitD deficiency. As seen from the results in Table 6, there was no statistically significant difference between BMI categories ( $p$ -value = 0.180), but there was a negative and weak correlation between BMI and 25-OH-VitD levels. This result was confirmed when we assessed the correlation individually and jointly with other variables using simple correlation and multiple regression analyses. We found ample studies in the literature that were consistent with our results, which highlighted an elevated risk of vitamin D deficiency in obese subjects [62, 90-92] and demonstrated an inverse correlation between serum concentration of 25-OH-VitD and obesity [12, 91, 93-95].

Likewise, Alfawaz et al. [96] found that vitamin D deficiency was significantly associated with increasing weight. Furthermore, Saneei et al. [89] revealed a significant inverse weak correlation between serum 25-OH-VitD levels and BMI in healthy adults (age > 18 years). Furthermore, an inverse correlation between higher BMI and lower serum vitamin D was reported in type 2 diabetes patients [14]. Likewise, the serum 25-OH-VitD levels assessed in a total of 1,172 healthy Saudi women in pre- and postmenopausal stages who were living in Jeddah; 80.0 per cent of the participants exhibited vitamin D deficiency [97]. Coupled with the previous study, Ardawi et al. [98] mentioned that the prevalence of vitamin D deficiency and insufficiency were 87.8 per cent and 9.7 per cent, respectively, among older and obese Saudi men. These deficiencies have been attributed to many factors such as smoking, age, poor exposure to sunlight, inactive lifestyles that increase obesity, no education, and foods poor in vitamin D [97, 98].

Conversely, Al-Elq et al. [99] found that the levels of 25-OH-VitD in obese Saudi males were lower than in females with the same BMI, which suggests that obesity has a protective effect against vitamin D deficiency in females. However, Nesby-O'Dell et al. [15] found that hypovitaminosis D in African American women was independently associated with low body mass index, which confirms previous findings that obesity has a protective role. On the contrary, other investigations have concluded that there is no correlation between serum vitamin D levels and BMI in a cross-sectional study of a healthy population [22, 100].

Moreover, Baradaran et al. [101] found no significant correlation between 25-OH-VitD levels and BMI among healthy Iranian and no correlation between vitamin D level and the gender of the participants, although a significant correlation between age and vitamin D levels was found ( $r = 0.002$ ). Furthermore, AL Anouti et al. [31] reported no significant association between vitamin D status and BMI among university students in the UAE, which supported our results that no statistically significant association exists between BMI and serum 25-OH-VitD levels.

According to the literature, the declining levels of serum 25-OH-VitD in obese individuals have been attributed to many factors such as negative feedback inhibition on the hepatic synthesis of 25-OH-VitD from high levels of parathyroid hormone and 1, 25-hydroxyvitamin D [102, 103], the storage of high amounts of vitamin D in the adipose tissue and changes in tissue distribution consequential from increasing adipose mass [58, 104]. Arunabh et al. [12] noted that the mechanism of variations in serum 25-OH-VitD levels in both non-obese and obese individuals is related to the percentage of body fat content, which leads to the excessive storage of the precursor of fat tissue. Additionally, Worstman et al. [54] reported that the storage of cutaneous and dietary sources of vitamin D3 in body fat compartments reduce its bioavailability in the circulation of obese individuals. Furthermore, Cheng et al. [105] mentioned that there was a strong association between vitamin D status and its deposition in subcutaneous and visceral adiposity.

Conversely, Abbasi et al. [106] found a negative relationship between serum 25-OH-VitD levels and the magnitude of weight loss in obese patients after surgical treatment. However, some studies stressed the importance of body mass in studying the association between BMI and vitamin D status [107], while another study did not consider adipose mass in a population of 250 overweight and obese adults [108]. Some researchers have attributed the conflicting results of the relationship between obesity and 25-OH-VitD levels to the methods used and the sensitivity of the tests used to measure the serum 25-OH-VitD and 1,25(OH)<sub>2</sub> VitD levels. The older studies that applied radio receptor assays to measure serum vitamin D indicated a positive correlation between vitamin D and obesity, while recent studies using modern radioimmunoassay to measure vitamin D levels found negative associations between vitamin D and obesity [33].

In connection with the objectives of this study, gender was the second variable assessed. There were inconsistent studies of the association between gender and serum 25-OH-Vit D levels. Our results indicated that 71.6 per cent of the participants were female and 28.4 per cent were male, and there was a statistically significant difference between these two groups ( $p$ -value = 0.000), as shown in Table 2. Moreover, there was a significant positive correlation between gender and the levels of 25-OH-Vit D. Our results are consistent with many previous investigations. Several studies have mentioned that women in the Middle East and around the world suffer from vitamin D deficiency [31, 42, 74, 109-112].

Similarly, healthy girls between 10 and 16 years of age have suffered from hypovitaminosis D more than healthy boys of the same age [20]. Alfawaz et al. [96] found that women in Riyadh, Saudi Arabia, had significantly lower 25-OH-VitD levels than men. In contrast, some studies reported that vitamin D deficiency was more predominant in men than women [62, 91]. Johnson, et al. [25] noted that obese men had significantly higher odds of vitamin D deficiency than obese women even after adjusting for other variables such as BMI, the season, age, current smoking and vitamin D supplements. Furthermore, Hagenau et al. [28] studied vitamin D status globally in native individuals and noted that women had borderline significantly higher 25-OH-VitD levels than men. Conversely, Sedrani et al. [76] reported that the concentration of vitamin D in male university students among Saudi Arabian residents was less than 10 ng/ml, despite the abundant year-round sunlight. However, in contrast to the previous findings, there was no association between gender and vitamin D levels [101] and there were no differences in the prevalence of vitamin D deficiency between males and females as reported by Abdelgadir et al. [84].

With respect to the effect of age on the levels of vitamin D, conflicting findings have been reported in previous studies. In our study, we did not observe a statistically significant difference among the age categories, and there was an inverse and weak correlation between age and 25-OH-VitD levels, but this correlation was not significant. This result was confirmed by analysing the data using simple correlation, ANOVA and multiple regressions. Other studies have found that hypovitaminosis D increased with age [96-99, 113]. Moreover, it was observed that the serum 25-OH-VitD concentrations without regular vitamin D intake were lower in elderly individuals compared to younger individuals [114].

Baradaran et al. [101] observed a significant relationship between age and vitamin D levels ( $r = 0.002$ ). Conversely, Sherman et al. [115] found a decline in the serum levels of 25-OH-VitD and 1, 25-(OH)<sub>2</sub>VitD that was not concomitant with aging, regardless of gender, in healthy individuals. Meanwhile, Parikh et al. [53] indicated independent associations between lower 25-OH-Vit D and 1, 25-(OH)<sub>2</sub>VitD concentrations and the age,

sex, or race of obese adults. Conversely, it was stated that serum 25-OH-VitD concentrations were higher in individuals aged greater than 15 years compared to younger individuals [28], and it was documented that serum 25-OH-VitD concentrations increased with increasing age in healthy Saudi adults [83].

In contrast, Masoompour et al. [116] found an independent relationship between 25-OH-VitD concentrations and age. According to the literature, many studies have endeavoured to attribute the reasons for 25-OH-VitD deficiencies in Arabian women and children to their insufficient sunlight exposure and low dietary vitamin D intake [117]. Generally, although there is an abundance of sunshine throughout the year in the Gulf region, people avoid exposure to the sunlight, especially in during the summer, because of the excessive heat [77], thereby minimizing their outdoor activities and spending most of their time indoors [77, 118]. In the UAE, it was recorded that female students avoid sun exposure more than male students, which might explain the lower vitamin D levels among females [31]. Thus, the decline in serum 25-OH-VitD concentrations was higher during the summer ( $20.9 \pm 14.9$  nmol/L) than in the winter ( $31.3 \pm 12.3$  nmol/L) for female Emirati students [31]. Conversely, some studies in the UAE have shown no significant association between vitamin D status and the low dietary intake of foods fortified with vitamin D [31, 42]. However, the optimal health requirement of vitamin D in food to be effective in increasing serum 25-OH-VitD concentrations to 100 nmol/L is approximately 1000-3000 IU/day [119-125].

Some studies have highlighted the cultural and traditional dresses and dress styles of both genders, which cover the body extensively, including the face and hands in women, as another cause vitamin D deficiencies in the Gulf region and Arab countries [74, 76, 77, 80, 83, 86, 118, 126-128]. Furthermore, El-Hajj et al. [20] found that the level of hypovitaminosis D was lowest in girls who followed the dress code of covering their heads, arms, and legs. Overall, the high prevalence of vitamin D deficiency in the UAE is explained as a result of people's lifestyles, indoor work, and clothing habits that limit sunlight exposure [24]. Saadi et al. [42] reported that vitamin D deficiency was more prevalent among Emirati women due to their insufficient exposure to sunlight and their dress style compared with non-Arab Caucasians living in the UAE who dressed in a Western style ( $P < 0.001$ ).

In general, it was not clear whether vitamin D insufficiency causes obesity or if vitamin D deficiency is a consequence of obesity; in another words, obesity may result in vitamin D deficiency or it may be a consequence of vitamin D insufficiency [33]. One hypothesis called the "winter response" explains how vitamin D deficiency is causing obesity. This model clarifies how the body maintains temperature and energy balance in a cold environment. Accordingly, the accumulation of fat tissue in obese individuals decreases heat conductance from the body to the environment [129] and blood circulation to the skin [130] for the synthesis of vitamin D stimulated by the ultraviolet (UV) component of sunlight, which acts as an environmental signal for changing seasons. Therefore, the decrease in vitamin D concentrations in the winter stimulates mechanisms to obtain additional body weight in the hypothalamus. However, vitamin D deficiency due to inadequate sunlight exposure and dietary vitamin D perform in similar ways to the winter situation [131].

Overall, the relatively few male participants compared with female participants could be considered a limitation of our study. The strengths of our study include using different statistical techniques (t-tests, Pearson correlation and multiple regressions) in the SPSS package to analyse the individual and package influences and correlations of the

independent variables BMI, age and gender with low levels of 25-OH-VitD. We eliminated the effect of the normal levels of 25-OH-VitD levels on the results; therefore we considered only 422 samples in the analysis.

## 5 Conclusion and Recommendation

This study suggested that female patients suffer more from vitamin D deficiency compared to males; the reported gender difference was significant. There were no actual differences among the age and BMI categories in association with 25-OH-VitD deficiency. In other words, age and BMI were insignificantly associated with 25-OH-VitD deficiency. The results of the Pearson correlation showed a weak positive significant correlation between gender and levels of 25-OH-VitD. Age and BMI had the same correlation with 25-OH-VitD levels. The correlations of age and BMI with the levels of 25-OH-VitD were insignificantly negative and weak. The inverse relationships of age and BMI with low levels of 5-OH-VitD suggest that more advanced age and higher BMI push the body towards higher degrees of vitamin D deficiency.

Moreover, the results of the multiple regression analysis of all of the variables together found the following results. First, the effect of gender on 25-OH-VitD levels was higher compared to the effects of BMI and age. Second, age had a lower effect on the deficiency of 25-OH-VitD than BMI. Third, all of the independent variables (gender, age and BMI) together did not significantly contribute to the predication of 25-OH-VitD deficiency. Fourth, the strength of the association of the independent variables (age, gender and BMI) together was the same as the strength of the association of the gender and BMI pair, but it was stronger than other pairs of variables (age and BMI, and gender and age). That means that age did not contribute effectively to the predication of 25-OH-VitD deficiency. Finally, reducing the number of measured variables did not affect the significant contribution of the independent variables on 25-OH-VitD. Furthermore, it has been noted that the effect of BMI on 25-OH-VitD was not as strong as gender and that there were weak correlations between gender, age and BMI with the levels of 25-OH-VitD.

In light of the importance of this topic, we recommend further follow up studies, including other variables, in order to explore the proposed similarities between vitamin D levels and unhealthy lifestyles that cause further health complications. Additionally, we recommend more innovative educational approaches that address both the problem of vitamin D deficiency and obesity, which depend on outdoor activities and games at different age levels, in order to enhance public awareness.

### ABBREVIATION

25-OH-VitD: 25-hydroxyvitamin D; BMI: Body mass index; 1,25-(OH)<sub>2</sub>VitD: 1, 25-dihydroxyvitamin D; SPSS: Statistics Package for Social Sciences.

### COMETING OF INTEREST

The authors declare that they have no competing interests.

### AUTHORS' CONTRIBUTION

WAM and AMR constructed and designed the idea of the work; AMR collected the patients' samples, conducted the practical work and diagnosed the participants; EAS analyzed the data statistically by SPSS, WAM collected the literature review, interpreted the results, wrote and prepared the manuscript, reviewed the manuscript format, and



selected the journal for publication. All authors read and approved the final manuscript.

**ACKNOWLEDGEMENTS:** The work was carried out at the in the rheumatology clinic and the laboratory of the Canadian specialty hospital in Dubai, United Arab Emirates.

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