Association Between Vitamin D Status and Body Composition: A Cross-Sectional Study among University Female Students

Nasser Alqahtani[1]*, Wala Alzahrani[1], Mona Abosamrah[1], Waseem Fatima[1], Ansh Garwal[2] and Amer Alanazi[3]

[1]Clinical Nutrition Department, Faculty of Applied Medical Sciences, Northern Border University, Arar, Saudi Arabia.
[2]Faculty of Medicine, Northern Border University, Arar, Saudi Arabia.
[3]Northern Medical Tower, Directorate of Health Affairs in Northern Border Region, Ministry of Health, Arar, Saudi Arabia.

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Vitamin D deficiency is currently recognized as a global epidemic and has been linked to many diseases. According to recent studies in Saudi Arabia showed a high prevalence of Saudi population having vitamin D deficiency. The objective of this project was to find out how common vitamin D grade is and to look at the relationship between body fat proportion and vitamin D status among female university students. University female students were the subject of a cross-sectional study. After obtaining their permission, sample of 300 students were selected to participate. Weight, height and waist circumference were taken. Body composition were analyzed by using bioelectrical impedance analysis (BIA). Bloodspot testing was used to determine 25 hydroxyvitamin D (25(OH) D) level. This research found significant relationship between vitamin D deficiency and the body fat percentage. Overweight and obese people have lower vitamin D levels than slimmer people. The relationship between the two variables is medium strong and inverse meaning that students with high proportion of body fat have decreased levels of vitamin D and vice versa. This finding is supported by the linear regression model between the two variables that reveals that if all factors affecting vitamin D status are held constant, the percentage body fat explains 28.2% of the variability in the vitamin D status. In conclusion, there is a statistically significant connotation between body fat and vitamin D status amongst female students. Further investigation is in need to tackle this health issue.

Keywords: Body Fat; BMI; Overweight; Obesity; Vitamin D status.

Vitamin D insufficiency is now recognized as a worldwide problem[1;2] with approximately over 1 billion people globally have vitamin D deficiency[3;4]. It has been linked with many non-musculoskeletal chronic diseases such as cardiovascular diseases[5;6] and diabetes mellitus[7; 8].

A major cause of vitamin D deficiency is insufficient exposure to sunlight, wearing of covering clothes and using sunscreen[9] and it depends on the activity of the enzymes responsible for its final hydroxylation (10). Some food items naturally contain vitamin D, and fortified food with vitamin D are often insufficient[11;12].

According to a new study, 83.6% of Saudi population having vitamin D deficiency. Comparing to males, females are severely vitamin D deficient [13]. Even the Kingdom of Saudi Arabia (KSA) is considered a sunny country all over,

*Corresponding author E-mail: nalqahtaniphd@gmail.com

except in winter, but they found certain factors as dress styles and regions were associated with the low of vitamin D[13]. Florez et al. (2007)[14] reported that low levels of vitamin D concentrations were among the obese participants. Accordingly, the high frequency of low vitamin D status was associated of overweight and obesity[15]. Together, the high prevalence of obesity and low vitamin D status, have been linked to many chronic illnesses like cancer, type2 diabetes, heart diseases[16.]

As a result, more study is being conducted to better understand the relationship between vitamin D status and obesity [(15)]. Saudi Arabia and other countries in the Middle East have high prevalence of vitamin D deficiency status and obesity [(16); (17)]. Even though, studies in the Middle East investigating the association between vitamin D status and obesity are limited[18;19].

According to Gannage et al. (2010)[20], 25 (OH) D exposed was in reversely associated by means of Body mass index (BMI) ($p < 0.01$) and waist circumference ($p < 0.01$) amongst 381 Lebanese University students.

Nonetheless, Sadiya et al. (2014)[19] disclosed that the incidence of vitamin D < 50 nmol/L was 83.2% amongst obese 309 diabetic adults in United Arab Emirate.

Research objectives

• The purpose of this project is to investigate the low occurrence of vitamin D status among female university students' in KSA.

• To investigate the relationship between percentage of body fat and vitamin D status.

Literature Review

According to Davis and Dwyer (2007)[21,] vitamin D is a critical controller of bone breakdown which plays a vital role in adipogenesis and helps to prevent number of sicknesses such as osteoporosis, cancer, diabetes, and immunological disorders. Furthermore, Kremer et al. (2009)[22] noted that deficiency of vitamin D is regarded as an epidemic problem due to its association with diminished bone mineral density, an amplified fracture risk, and obesity in adults. Obesity and being overweight are serious public health issues. In 2014, the WHO estimated that 39 percent of individuals were overweight, and 13 percent were obese[23].

Al Nozha et al. (2005)[24] stated that the prevalence of overweight and obesity in Saudi Arabia was 36.9% (females 31.8%) and 35.5% (females 44%) respectively.

Vitamin D deficiency can occur mainly because of inadequate exposure to sunlight. Also, the activation of this enzyme depends on the action of the enzymes (25- hydroxylase and 1á- hydroxylase) which are responsible for its final hydroxylation[10]. Moreover, Moreira and Hamadah (2010)[(12)] thought that vitamin D exists naturally in few foods and the content of this vitamin in the fortified foods is often inadequate and this only account for about 30% of vitamin D. Therefore, the rest of vitamin D is obtained through skin exposure to U.V. radiation which is responsible for the activation of this vitamin into 7- dehydrocholesterol leading to formation of pre-vitamin D3.

Albaik and her colleges (2016)[25] found that, compare to normal weight participants, obese cases have been known to have lower vitamin D levels. They investigated the association between serum vitamin D status and BMI among obese women in Saudi Arabia and reported that vitamin D deficiency were common among women in Jeddah, KSA, and that this prevalence is increasing with obesity.

According to Foss YJ. (2009)[26,] vitamin D deficiency can cause of obesity, and that obesity may be corrected by boosting vitamin D status.

Obesity, on the other hand, is a risk aspect for hypovitaminosis D[27,] because obese people often have less exposure to sun light because of their limited mobility and they tend to be less physically active, as well as the possible trapping of vitamin D by the adipocytes. Obesity can contribute to poor vitamin D grade due to the storage of this vitamin in body fat compartments, lowering its bioavailability, and the need for vitamin D to create stronger bones to sustain their increased weight, in addition to clothing preferences.[28]

Adipogenesis can be repressed by 1,25 dihydroxyvitamin D[29.] There is link between the status of vitamin D and body fat, A strong inverse relationship between weight, body mass and vitamin D levels. That s found in young women with decreased vitamin D levels were much heavier and had more body mass compared to women with normal vitamin D levels[22.]

The vitamin D contributes to body mass maintenance because it tends to lower leptin concentrations[30.] The vitamin D status dependence on BMI was studied by Lagunova and her colleagues in 2009 and they concluded that BMI negatively correlated with both serum $25(OH)D_3$ and $1,25(OH)_2D_3$ [(31)]. Also, it was been found that in animal models, body adipose cells can accumulate 10-12% as a supplemented amount of vitamin D[32.]

As a result of the above research, it is possible to conclude that obesity is partially, a direct outcome of vitamin D deficiency and may affect in vitamin D deficiency. Furthermore, it is worth noting that vitamin D deficiency can lead to a variety of disorders such as osteoporosis, cancer, diabetes, and rheumatoid arthritis[33,] and that excess body fat is strongly connected to an increased risk of diabetes and cancer[34.] Consequently, vitamin D deficiency could play a part in the expansion of these diverse clinical diseases, whichever directly or indirectly.

Hypothesis

Our goals are to investigate the relationship anthropometric parameters and status of vitamin D, as well as the relationship between body fat proportion and vitamin D position among university female students in Saudi Arabia.

As a result, we expected that patients with a high total % body fat would have lower serum vitamin D levels.

Research Methodology (Material & Methods)

This is a cross-sectional study was carried out among female students at Northern Border University (NBU) in Arar. After describing the purpose of the study, 300 female students were volunteer to take part in this study

1. Each participant sign a written informed consent form to participate in the study, which was authorized by the Research Ethics Committee at NBU Faculty of Medicine.

Students having history of renal/hepatic disease, malabsorption, gestation, lactation, a family history of rickets, or who are using anti-convulsant or vitamin D supplements will be disqualified.

Anthropometric assessment

Following an overnight fasting, study participants were asked to the nutrition laboratory for anthropometric collection including height, WC, weight, and body composition.

To measure height to the bordering 0.1 cm, the subsequent procedure was used: no wearing of shoes, heels, while head in contact with the horizontally oriented stadiometer's ruler.

An un-stretchable tailor's tape measure was wrapped around the plain abdomen precisely above the hip bone but corresponding to the floor to determine WC.

The InBody720 bioelectrical impedance analyzer (BIA) has been used to determine weight and body composition (Biospace, Seoul, Korea). BIA assesses bodily water before estimating fat and fat free mass. The BIA machine was calibrated before use. After cleaning hands and feet using electrolyte wipes, participants has been requested to stand on the machine barefooted and without any metal/jewelry. BMI is computed as follows: Weight (kg)/ Height (m2). BMI of 18.5 kg/m2 was considered underweight, standard weight of 18.5–24.9 kg/m2, while overweight at 25–29.9 kg/m2, and finally obese at 30 kg/m2 or above.

Vitamin D (25 (OH) D) was measured using vitamin D bloodspot testing

Research Design

Collected data were analyzed using the social sciences statistical tool SPSS.

• Chi-square test data was used to assess cluster differences for categorical variables.

• P value of < 0.05 was used as statistically significant.

The Saudi Ministry of Health discovered a great prevalence of deprived vitamin D status in adult females and males in Saudi Arabia.

Vitamin D insufficiency was thought to be common among female students at NBU.

The significance of this study stems from the fact that it will compare vitamin D status and percent body fat among female students at Northern Border University.

There has been little or no investigation about the relationship between body fat % and vitamin D status amongst university female students in Arar city.

RESULTS

Table 1 above shows the descriptive statistics of vitamin D, fat % and age. The means and median are important measures of central tendency that can be used to determine whether the data follows a normal distribution. From the above table, it is clear that the three variables follow a fairly normal distribution due to the closeness between the values of the mean and median. Fairly normal distribution of the variables is also shown by the values of skewness and kurtosis which are not very far from zero.

Table 2: The correlation coefficients between the variables are shown. The strength of the association between two continuous variables is measured by correlation. The correlation coefficient value goes from -1 to +1 and measures the strength and direction of the link. From the table above, there is a medium strong and inverse relationship between vitamin D and fat %. This means that as fat % increases, vitamin D decreases. As a result of this link between body fat and vitamin D levels, overweight and obese people have lower vitamin D levels than slimmer people. It is crucial to remember, however, that correlation does not indicate causation, which means that being obese does not always and always result in low vitamin D levels.

Table 1. Statistics

		Vitamin D	Fat %	Age
N	Valid	65	65	65
	Missing	0	0	0
Mean		24.743	25.846	22.08
Median		21.000	25.000	22.00
Std. Deviation		9.9709	10.1041	1.190
Skewness		.785	.186	-.841
Std. Error of Skewness		.297	.297	.297
Kurtosis		-.532	-1.527	-.314
Std. Error of Kurtosis		.586	.586	.586
Minimum		9.9	13.0	19
Maximum		45.0	45.0	24

Table 2.

Correlations

		Vitamin D	Fat %	Age
Vitamin D	Pearson Correlation	1	-.531**	0.205
	Sig. (2-tailed)		0.000	0.102
Fat %	Pearson Correlation	-.531**	1	-.293*
	Sig. (2-tailed)	0.000		0.018
Age	Pearson Correlation	0.205	-.293*	1
	Sig. (2-tailed)	0.102	0.018	
	N	65	65	65

Table 3.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.531[a]	0.282	0.270	8.5165

a. Predictors: (Constant), fat %
b. Dependent Variable: vitamin D

Figure 1 above is a scatter plot showing the relationship between vitamin D and fat %. A scatter plot is actually a visual representation of correlation and from the scatter plot above, it is clear that there is a negative / inverse relationship between the two variables. The red line is referred to as a line of best fit and it is a linear fit on the scatter plot. The equation of the line above is y = -0.52x + 38.28 which can be interpreted as follows:
(i) Vitamin D = -0.52*fat % + 38.28. Vitamin D is the dependent or response variable, fat % is the independent or predictor variable, -0.52 is the coefficient of the predictor variable while the value 38.28 is known as the constant.
(ii) The negative value of the coefficient of the predictor reveals the inverse relationship between vitamin D and fat %.

Table 3 above shows the basic statistics after performing a linear regression procedure. R is the coefficient of correlation covered extensively earlier. R square also known as the coefficient of determination is an important measure of goodness of fit of the regression model and it is abbreviated by R^2. The R^2 value is 0.282 and what this means is

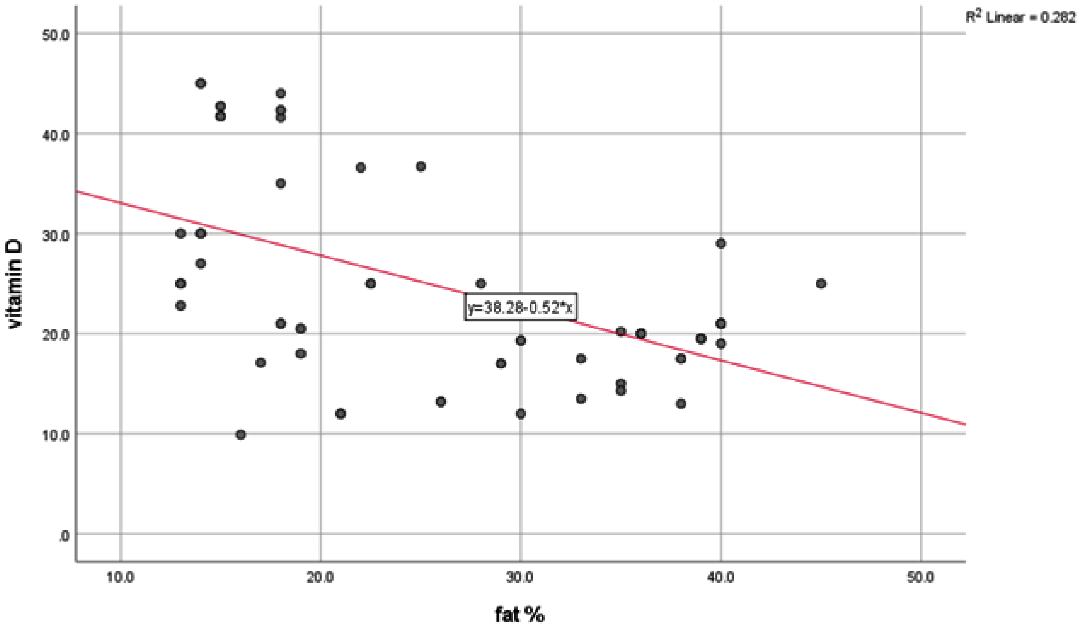

Fig. 1.

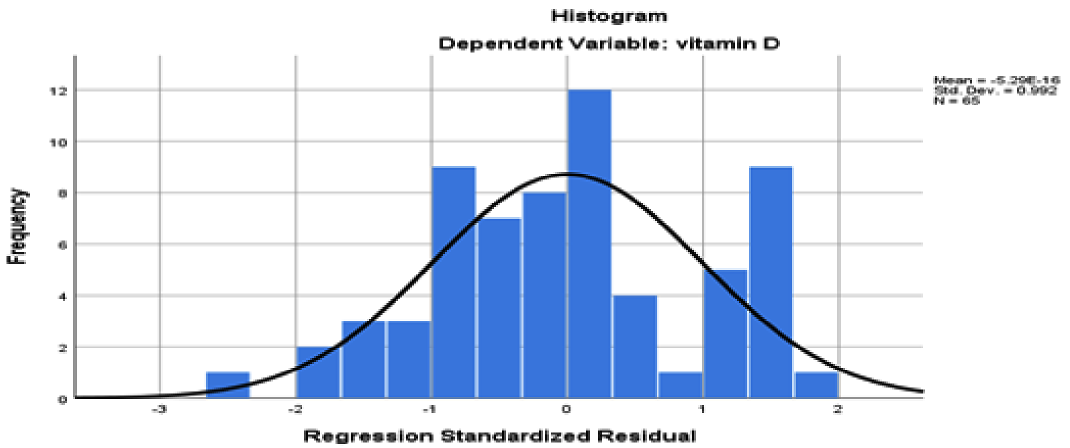

Fig. 2.

that 28.2% of the variability in vitamin D levels is explained by fat % holding other factors constant.

Table 4 is the Analysis of Variance (ANOVA) table and what it basically does in the context of regression is to breakdown the sum of squares, the degrees of freedom, the computed F-statistic, and the p-value. This table is very crucial because it used to determine whether to reject or fail to reject the null hypothesis. The null and alternative hypotheses of linear regression are shown below:

(i) Null hypothesis, H_0: There is no statistically significant linear regression between vitamin D and fat % ($\beta_1 = 0$)

Table 4.

ANOVAa

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1793.412	1	1793.412	24.727	.000b
	Residual	4569.387	63	72.530		
	Total	6362.799	64			

Table 5.

Coefficientsa

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	38.284	2.921		13.107	0.000
fat %	-0.524	0.105	-0.531	-4.973	0.000

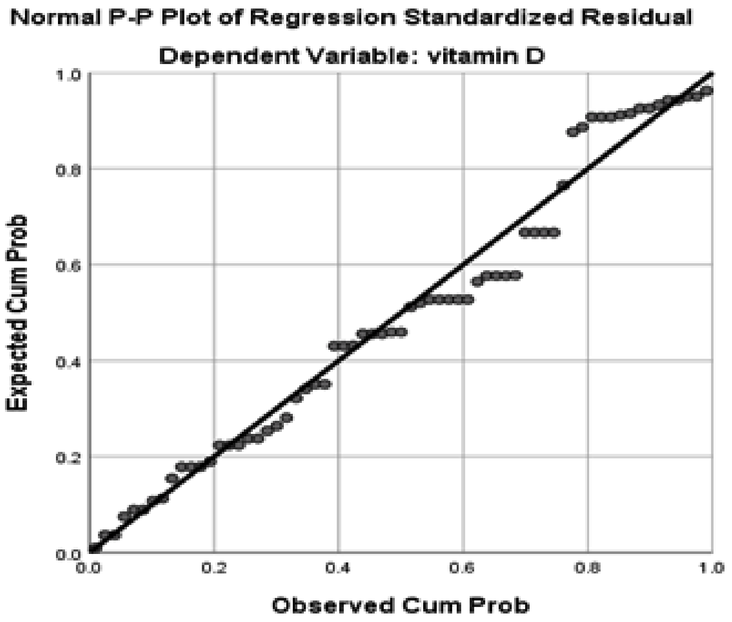

Fig. 3.

(ii) Alternative hypothesis, H_1: There is a statistically significant linear regression between vitamin D and fat % ($\beta_1 \neq 0$)

From table 4 above, the p-value is 0.000 which is less than 0.05 and this leads us to reject the null hypothesis and conclude that there is a statistically significant regression between vitamin D and fat %.

Table 5 above contains the coefficients of regression and in essence the equation of the regression equation. The equation of the linear regression model can be written as:

Vitamin D = -0.524*fat % + 38.284

The regression equation above brings out two vital things;

(i) A unit change in fat % leads to a decrease in vitamin D by 0.524 units.

(ii) When fat % is 0, the value of vitamin D is 38.28

The t-statistic is an important statistic for each regression coefficient and it is computed by dividing the regression coefficients by the standard error of the coefficients.

After a regression analysis, it is important to conduct regression diagnostics to ensure that the regression model does not violate linear regression assumptions. One of the crucial assumptions is that the residuals follow a normal distribution. The residuals or error terms are obtained by getting the difference between the observed and expected values of the dependent variable. From figure 2 above, the histogram shows a fairly normal distribution of the residuals.

Figure 3 above shows a standard P-P plot of the residuals.

A P-P normal plot is a visual check on the normality of the distribution of the error terms around the middle of the line of best fit. The normal P-P plot above shows that the points at the middle are close to the line of best fit which means that the normality assumption has not been violated.

DISCUSSION

The above results show that there is a significant relationship between vitamin D deficiency and the body fat %. The three variables in the data set, vitamin D, fat % and age follow a fairly normal distribution which is demonstrated by the closeness between the values of the mean and median. The fairly normal distribution of the variables is also shown by the values of skewness and kurtosis which are not very far from zero.

There exists a medium strong and inverse connection between vitamin D and fat %. This means that as fat % increases, vitamin D decreases. Therefore, according to this relationship between body fat and vitamin D levels, overweight and obese people have lower levels of vitamin D than slimmer people. Nonetheless, it is important to note that this correlation does not imply causality meaning that being obese does not necessarily and automatically lead to low vitamin D levels.

The coefficient of determination (R^2) of the regression model is 0.282 and what this means is that 28.2% of the variability in vitamin D levels is explained by fat % holding other factors constant.

The null and alternative hypotheses of linear regression are shown below:

(i) Null hypothesis, H_0: There exists no statistically significant linear regression between vitamin D and fat % ($\beta_1 = 0$)

(ii) Alternative hypothesis, H_1: There exists a statistically significant linear regression between vitamin D and fat % ($\beta_1 \neq 0$)

From the linear regression results, the p-value is 0.000 which is less than 0.05. Hence we reject the null hypothesis and established that there is a significant regression between vitamin D and fat %.

The equation of the linear regression model is as follows:

Vitamin D = -0.524*fat % + 38.284

From the regression equation we deduced that:

(i) A unit change in fat % leads to a decrease in vitamin D by 0.524 units.

(ii) When fat % is 0, the value of vitamin D is 38.28

The histogram of the residuals produced as part of post-estimation diagnostic tests shows that the residuals follow a normal distribution and therefore the assumption of normality is satisfied. The normal P-P plot also showed that the normality assumption has not been violated by the regression model between vitamin D and fat percentage.

It is important to mention that vitamin D has strong effectiveness on the epigenome and more than thousand genes inside body cells by activating the VDR. It has been found that the more of gene variants like cholesterol and vitamin

D metabolism, the greater the risk of developing vitamin D deficiency.

CONCLUSION

In conclusion, there is a statistically significant relation between body-fat percentage and vitamin D status amongst female students at NBU in KSA. The relationship between the two variables is medium strong and inverse meaning that students with high proportion of body fat have decreased levels of vitamin D and vice versa. This finding is supported by the linear regression model between the two variables that reveals that if all factors affecting vitamin D status are held constant, the percentage body fat explains 28.2% of the variability in the vitamin D status. These findings corroborate previous studies that have found a link between obesity and low vitamin D levels. Therefore, it is imperative for health officials to generate policies towards reducing the number of overweight and obesity. Further research in order to explore additional factors that affect the vitamin D grade and determine whether there is a causal link between these factors and vitamin D status.

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Conflict of interests

The authors have no conflicts of interest to declare.

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