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Relationship between body mass index and vitamin D status, age, and sex in Saudi Arabia

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Abstract

Obesity and vitamin D deficiency are closely linked issues that have negative health consequences for people of all ages. The objective of this study was to analyze the connotation between body mass index and vitamin D status, age and sex in Saudi Arabia. Most participants (n = 37; 67.27%) were female, and the age of 61.82% of all participants (n = 34) who participated in the study were lesser than 40 years. The BMI of only 21 (38.18%) participants was normal and other participants were either overweight (36.36%) or obese (25.46%). A significant relationship ($p \leq 0.05$) has been found between vitamin D status and BMI for subjects > 40 years. Among females, a significant relationship ($p \leq 0.05$) has been observed between vitamin D status and BMI. A significant ($p \leq 0.01$) positive correlation has been observed between BMI and age in subjects >40 years while a significant ($p \leq 0.05$) negative correlation has been observed between BMI and vitamin D. A significant ($p \leq 0.01$) positive correlation has been observed between age and BMI in females. In summary, this study shows that females had lower vitamin D concentrations than males among the different classes of BMI.

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Introduction

Vitamin D (calciferol) plays a vital role in calcium and phosphorous homeostasis and the mineralization of bones (Weaver, 2007). Vitamin D_2 and vitamin D_3 also known as ergocalciferol and cholecalciferol respectively are vitamin D forms that are synthesized in response to ultraviolet radiation of sterols (CDC, 2012). Human obtains their vitamin D either through diet, mostly fortified foods (exogenous sources) or produced directly in the skin after sunlight exposure (endogenous syntheses) (Holick, 2007; Chiang *et al.*, 2011). Vitamin D_3 is synthesized in mammal's skin while vitamin D_2 is synthesized in yeast, molds and vascular plants (Wagner and Greer, 2008). However, the enzyme cytochrome P450 converts vitamin D2 and D3 in a similar way in the liver to 25-hydroxyvitamin D (Haddad Jr. and Hahn, 1973). Further, 1α-hydroxylase enzyme causes the hydroxylation of 25-hydroxyvitamin D to its active form, i.e. 1, $25(OH)_2D$ (calcitriol) which is accountable for calciotropic and non-calcitropic actions of vitamin D. Vitamin D are found mostly in fatty fish, egg yolk, cod liver oil, liver and fat from aquatic mammals and in vitamin D fortified foods (Misra *et al.*, 2008; Wagner and Greer, 2008).

Its deficiency is associated with a variety of disorders such as cardiovascular disease, kidney disease, multiple sclerosis, cancers and so on (Giovannoni and Ebers, 2007; Chiang *et al.*, 2011; Dusso, 2011; Autier *et al.*, 2014; Larose *et al.*, 2014; Theodoratou *et al.*, 2014), apart from rickets in children and osteomalacia in adults (Holick, 2007;Holick and Chen 2008). Numerous other elements such as increased metabolic demands decreased bioavailability and synthesis, and even cultural norms are responsible for vitamin D deficiency (Sadat *et al.*, 2013; Al Saleh *et al.*, 2015). The increasing rate of obesity has been observed throughout the world and according to WHO reports it has become an epidemiological problem (Avitabile *et al.*, 2004). Vitamin D deficiency and obesity are the concerns that are related and have poor health repercussions for people of all ages (Savastano *et al.*, 2017). Studies have shown that as compared to non-obese people, obese people have lower circulating vitamin D concentrations (Ding *et al.*, 2010; Mai *et al.*, 2012). As a consequence of vitamin D deficiency, secondary hyperparathyroidism is a common finding in people with obesity, and it is often secondary to vitamin D deficiency (Snijder *et al.*, 2005). This study evaluates the connotation between body mass index and vitamin D status, age and sex in Saudi Arabia.

Materials and methods

Research design

In this study, a descriptive cross-sectional approach was used and 55 adults aged between 25-70 years old (37 women and 18 men) were involved. They were recruited from the outpatient clinic of King Abdul Aziz University Hospital and King Khalid University Hospital, Riyadh, Saudi Arabia. The objectives of the study were described to all contributors, and a written approbation was acquired from them. Data were collected by a well-trained researcher and a well-qualified nurse has withdrawn the blood. The subjects were guaranteed that the information provided by them would be used solely for scientific reasons and kept confidential.

Inclusion criteria

Adults aged between 20-70 years who acceded to provide blood samples were involved in this study.

Exclusion criteria

Pregnant and lactating women, subjects having a BMI lower than 18.5 kg/m2, subjects on vitamin D supplementation or osteoporosis therapies, hypolipidemic agents were debarred from the study.

Demographic characteristics

The demographic information was collected through a structured questionnaire. The significance and extensiveness of the study tools were studied by the board of experts.

Anthropometric measurement

Weight: Weight was recorded by the researcher using an electronic balance and was noted in kg to the nearest 0.1kg. The subjects were measured wearing light-weight clothing and barefoot.

Height: Height was recorded using an electronic scale and was mentioned as cm to the nearest 0.1cm.

Body mass index (BMI): The BMI of the subjects was calculated as follows:
BMI=weight (kg)/height^2 (m^2)
Based on BMI the subjects were classified as follows: (1)Underweight= BMI <18.5, (2) Normal= BMI between 18.5 and 24.9, (3) Overweight= BMI between 25 and 29.9 and (4) Obese=BMI >30 (WHO, 2004).

Biochemical measurements

All subjects were requested to fast and not to participate in any high-intensity physical activity 10-12 hours before providing blood samples. The blood was withdrawn by a specialized nurse at King Khalid University Hospital and King Abdul Aziz University Hospital. The serum was obtained by centrifuging the obtained sample at 3,000 rpm for 10 minutes. Vitamin D ($25(OH)_2D_3$ in serum) levels were measured with an immunoassay using a radioactive device (Roche Analyzer Cobas e170 Immunoassay, Roche Diagnostic, USA) (Vieth *et al.*, 2007). Based on the vitamin D levels, the participants were classified as follows: (1) deficient (<50 nmol/L), (2) relative insufficient (between 50 nmol/L and 72 nmol/L) and (3) normal (>72 nmol/L) (Salas-Salvadó *et al.*, 2008).

Statistical analysis

The data were interpreted using Statistical Package for Social Sciences (SPSS), version 21 (IBM Corp., Armonk, NY, USA). The continuous variables are mentioned as the mean ± standard deviation and the frequencies are presented as percentages (%). Pearson's Chi-square test was performed to compare frequencies and to test differences between group proportions for categorical variables.

Results

Participant's characteristics

The participants' characteristics and statuses of vitamin D are shown in Table 1. Most participants (n=37; 67.27%) were female, and the age of 61.82% of all participants (n = 34) who participated in the study were lesser than 40 years. Only 3 participants (5.88%) had a normal level of vitamin D, otherwise, 21 participants (38.18%) had an insufficient level of vitamin D and maximum participants were identified as deficient (n=31; 56.36%). In addition, the body mass index (BMI) of only 21 participants (38.18%) was normal and other participants were either overweight (36.36%) or obese (25.46%).

Table 1. Sociodemographic characteristics and vitamin D status of the participants.

Parameters	Number (n)	Percentage (%)
Age		
< 40 years	34	61.82
> 40 years	21	38.18
Gender		
Male	18	32.73
Female	37	67.27
Vitamin D		
Normal	3	5.88
Insufficient	21	38.18
Deficient	31	56.36
Body Mass Index		
Normal	21	38.18
Overweight	20	36.36
Obese	14	25.46

Relationship between vitamin D status and BMI based on the age groups (< 40 years and > 40 years)

Table 2 represents the connotation between vitamin D status and BMI based on the age groups. In subjects of age group < 40 years, only 3 subjects had normal vitamin D level while others were either had insufficient (n=11) vitamin D level or were deficient (n=20). While in the > 40 years age group none of the members had a normal level of vitamin D. Ten subjects had insufficient vitamin D level while 11 subjects were grouped in the category of deficient. A significant relationship (p ≤0.05) has been observed between vitamin D status and BMI for subjects > 40 years.

Table 2. Relationship between vitamin D status and body mass index (BMI) based on the age groups (< 40 years and > 40 years).

Age group	Body mass index	Vitamin D			*P*-value
		Normal n (%)	Insufficient n (%)	Deficient n (%)	
< 40 years	Normal	2 (66.7)	3 (27.3)	12 (60)	0.096
	Overweight	0 (0)	7 (63.6)	4((20)	
	Obese	1(33.3)	1 (9.1)	4 (20)	
> 40 years	Normal	0 (0)	2 (20)	2 (18.2)	0.027*
	Overweight	0 (0)	7 (70)	2 (18.2)	
	Obese	0 (0)	1 (10)	7 (63.6)	

Where n=number, Model Chi-square tests, *p values ≤0.05 are significant.

Relationship between vitamin D status and BMI based on the gender (males and females)

Table 3 represents the connotation between vitamin D status and BMI based on gender (males and females). None of the males had a normal level of vitamin D while only 3 females had normal vitamin D levels. Thirteen males and 8 females had an insufficient level of vitamin D while 5 males and 26 females were deficient. As compared to males (27.7%), more females (70.27%) were deficient.

Among females, a significant relationship (p ≤0.05) has been observed between vitamin D status and BMI.

Table 2. Relationship between vitamin D status and body mass index (BMI) based on the age groups (< 40 years and > 40 years).

Age group	Body mass index	Vitamin D			*P*-value
		Normal n (%)	Insufficient n (%)	Deficient n (%)	
< 40 years	Normal	2 (66.7)	3 (27.3)	12 (60)	0.096
	Overweight	0 (0)	7 (63.6)	4((20)	
	Obese	1(33.3)	1 (9.1)	4 (20)	
> 40 years	Normal	0 (0)	2 (20)	2 (18.2)	0.027*
	Overweight	0 (0)	7 (70)	2 (18.2)	
	Obese	0 (0)	1 (10)	7 (63.6)	

Where n=number, Model Chi-square tests, *p values ≤0.05 are significant.

Correlations between vitamin D status age and gender of participants

Table 4 represents the correlations between vitamin D status and age of participants presented as either >40 years or <40 years and gender represented as males and females. A significant (p ≤0.01) positive correlation has been observed between BMI and age in subjects >40 years while a significant (p ≤0.05) negative correlation has been observed between BMI and vitamin D. A significant (p ≤0.01) positive correlation has been observed between age and BMI in females.

Discussion

Obesity and overweight is a rapidly developing health issue and is among the most health-threatening diseases. The growth in the occurrence of obesity indicates that this upsurge is not only limited to the developed world but also spreading towards the developing world. According to the data of the World Health Organization from 2016, almost 13% of the world's adult population (females: 15%, males: 11%) was obese (WHO, 2021) and the worldwide occurrence of obesity almost tripled between 1975 and 2016.

Table 3. Relationship between vitamin D status and body mass index (BMI) based on gender (males and females).

Age group	Body mass index	Vitamin D			*P*-value
		Normal n (%)	Insufficient n (%)	Deficient n (%)	
Male	Normal	0 (0)	4 (30.8)	1(20)	0.529
	Overweight	0 (0)	7 (53.8)	2 (40)	
	Obese	0 (0)	2(15.4)	2 (40)	
Female	Normal	2 (66.7)	1(12.5)	13(50)	0.002*
	Overweight	0 (0)	7 (87.5)	4 (15.4)	
	Obese	1 (33.3)	0 (0)	9 (34.6)	

Where n=number, Model chi-square tests, *p values ≤0.05 are significant.

It has been predicted that a majority of the adult population of the world would be either obese or overweight by 2030 (Kelly *et al.*, 2008; Wang *et al.*, 2008; May *et al.*, 2013). Various elements such as metabolic, genetic, behavioral and environmental factors are the contributors to obesity. They are a risk factor for many diseases. In many developing societies, decreased physical activity, high caloric intake, and adoption of western lifestyle are contributing toward the prevalence of obesity (El Nashar *et al.,* 2016) and in the past few years' westernization has augmented in the Kingdom of Saudi Arabia (KSA). Alqarni (2016) in his study has stated that the KSA is the world's 15th most obese country, with an overall obesity rate of 33.7%. Al-Quwaidhi *et al.*, (2014) in their research discussed the existing trends and future projections of the prevalence of adult obesity in KSA and forecasted that the overall obesity will increase to 78% in women and 41% in men by 2022. Vitamin D deficiency is very common in KSA among all ages and genders (Ardawi *et al.*, 2012; Al Alyani *et al.*, 2018). Unlike vitamin D, no other micronutrient has gained as much consideration in the health and biomedical research community (Al-Daghri *et al.*, 2016).

Serum $25(OH)_2D_3$ is used to quantity vitamin D status in clinical practice. In this study lower concentration of vitamin D has been observed in females compared to males. In both sexes, vitamin D concentration was inversely linked to BMI and a significant ($p \leq 0.05$) relationship has been observed between vitamin D status and BMI. Similar results have been reported by Lagunova *et al.* (2009) and Muscogiuri *et al.* (2019).Previous studies in KSA have shown that among the Saudis, vitamin D deficiency and high BMI are interrelated and it increases with age (Ardawi *et al.*, 2012; AlOthma *et al.*, 2012; Al Kadi and Alissa, 2017). Smotkin-Tangorra *et al.* (2007) has revealed that vitamin D insufficiency was related to an upsurge in age, while in disparity to these outcomes, Masoompour *et al.* (2008) found that serum 25-hydroxyvitamin D levels did not decrease with age. Schmitt *et al.* (2018) also stated converse association between vitamin D level and BMI, and they also concluded that females with vitamin D deficiency had a higher risk for metabolic syndrome. Obesity is one of the numerous factors such as gender, physical activity, nationality and lifestyle, etc that might disturb the vitamin D status (Carlin *et al.*, 2006; Al-Daghri, *et al.*, 2012). Hijab (clothes), use of sunblock cream and lesser outdoor activity are the other important contributors responsible for lower vitamin D levels of females (Holick *et al.*, 2011). Generally, men possess 10%–15% less fat in their bodies than women with the same BMI and excess body fat results in increased sequestration and low availability and as a result low serum vitamin D levels (Gurrici, *et al.*, 1998; Gallagher *et al.*, 2000; Wortsman *et al.*, 2000). As compared to that of obese subjects; the normal and even overweight subjects have lesser adipose tissue, so they might show a rise in the availability of vitamin D (Rock *et al.*, 2012) and this is in agreement with the outcomes of this study. Forrest and Stuhldreher, (2011) stated a higher prevalence of vitamin D deficiency in obese subjects.

Table 4. Spearman correlations between vitamin D status and age of participants presented as either >40 years or <40 years.

Age groups	Parameters	Vitamin D	BMI	Age
		Based on age		
Less than 40 years	Vitamin D	1.000	0.070	0.165
	BMI	0.070	1.000	0.570**
	Age	0.165	0.570**	1.000
More than 40 years	Vitamin D	1.000	-0.536*	0.075
	BMI	-0.536*	1.000	-0.270
	Age	0.075	-0.270	1.000
		Based on gender		
Male	Vitamin D	1.000	-0.427	0.043
	BMI	-0.427	1.000	0.221
	Age	0.043	0.221	1.000
Female	Vitamin D	1.000	-0.113	-0.053
	BMI	-0.113	1.000	0.560**
	Age	-0.053	0.560**	1.000

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

In animal models it has previously been demonstrated that body adipose tissue can store 10-12 percent of a vitamin D supplemented dosage. Simultaneously, vitamin D release from fat is exceedingly slow and proportional to the vitamin's content in adipose tissue (Rosenstreich *et al.*, 1971).

Conclusion

In summary, this study shows that females (70.27%) had lower vitamin D concentrations than males among the different classes of BMI. A significant relationship (p ≤0.05) has been perceived between vitamin D status and BMI in females and a significant relationship (p ≤0.05) has also been found between vitamin D status and BMI for subjects > 40 years. A significant (p ≤0.01) positive correlation has been observed between BMI and age in subjects >40 years while a significant (p ≤0.05) negative correlation has been observed between BMI and vitamin D.

A significant (p ≤0.01) positive correlation has been observed between age and BMI in females. Development of local strategies and public health education is required apart from vitamin D supplementation, vitamin D-rich diet and physical exercise to reduce its prevalence of vitamin D deficiency and to maintain a healthy lifestyle.

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