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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Vitamin D Status in Patients with Type 2 Diabetes Mellitus in Makkah Region of Saudi Arabia

I.R. Dabbour[1], A.S. Jazar[2] and F.S. Azzeh[2]
[1]Department of Nutrition and Food Technology, Faculty of Agriculture,
Mutah University, AlKarak, P.O. Box 61710, Jordan
[2]Department of Clinical Nutrition, Faculty of Applied Medical Science,
Umm Al-Qura University, Makkah, Saudi Arabia

Abstract: Deficiency of vitamin D is still a worldwide health problem. Although the sun is replete all over the year in Saudi Arabia, it has been shown that deficiency of vitamin D is an important health problem. The aim of this study was to investigate the association of serum 25-hydroxy vitamin D [25(OH)-D] in type 2 diabetic patients (T2DM) compared to control healthy subjects. A randomized case-control study was conducted and a total of 200 subjects were equally categorized in each group. A detailed basic information questionnaire was used. Serum levels of 25(OH)-D and others related biochemical analysis were also measured. According to our results, there were no significant differences ($p>0.05$) in age, serum 25(OH)-D level, parathyroid hormone (PTH), alkaline phosphatase (ALP) and BMI between case and control groups. On the other hand, there was a significant inverse relationship between age and serum 25(OH)-D level ($r = -0.37$, $p<0.05$), while a significant positive correlation between serum 25(OH)-D and intakes of vitamin D ($r = 0.33$, $p<0.05$) was observed. The mean value of serum 25(OH)-D was significantly higher ($p<0.05$) for the subjects who regularly played outdoor physical activities than those subjects who did not play regularly. Respect of income, the mean value of serum 25(OH)-D for subjects with low income was significantly ($p<0.05$) higher than those subjects with high income. Additionally, the mean value of serum 25(OH)-D for subjects who can write and read was significantly ($p<0.05$) higher than those illiterate subjects and subjects hold a university degree. The mean value of serum 25(OH)-D level for small family size was significantly ($p<0.05$) higher than those with large family size. The subjects in our study were generally deficient in 25(OH)-D irrespective of having T2DM, indicating a greater need for vitamin D supplementation.

Key words: Vitamin D, type 2 diabetes mellitus, parathyroid hormone, physical activity

INTRODUCTION

Vitamin D is a fat-soluble vitamin with hormonal function. Exposure to sunlight, dietary intake and supplementation with vitamin D are the main sources of vitamin D in human (Rolfes *et al*., 2009). In addition to its role in calcium and phosphorus homeostasis, bone metabolism and skeletal growth, the active form of the vitamin, 1,25-dihydroxyvitamin D [1,25$(OH)_2$, D], plays an essential functions in many body organs (Holick, 2004a,b). Consequently, vitamin D deficiency plays an important role in many diseases such as diabetes mellitus, hypertension, immune disorders, osteoporosis, cardiovascular disease (CVD) and cancers (Holick, 2004a,b; Azzeh, 2012; Taheri *et al*., 2012; Azzeh and Kensara, 2015). 25(OH)-D deficiency is still a global health care attention. An increasing number of studies have reported widespread 25(OH)-D deficiency and insufficiency in both obviously healthy populations and patients with various diseases. It has been estimated that billion people worldwide are influenced by various degrees of 25(OH)-D deficiency (Nikooyeh *et al*., 2011). Unfortunately, very few foods naturally contain vitamin D and only a few foods fortified with vitamin D. This is the reason why 25(OH)-D deficiency has become predominant for all age groups in the United States and Europe (Holick, 2004a,b; Taheri *et al*., 2012). Diabetes is considered the most common endocrinological disorder in the world. It is a metabolic disorders characterized by elevated blood glucose concentration resulting from a defects in insulin secretion, insulin action or both (Nikooyeh *et al*., 2011). The World Health Organization (WHO) mentioned that 347 million people worldwide have diabetes. The prevalence of T2DM has increased dramatically in the Arabic-speaking countries over the last three decades (WHO, 2013).

1125(OH)-D deficiency was linked to T2DM in humans many years ago. An increased prevalence of T2DM has been described in 25(OH)-D-deficient individuals and insulin synthesis and secretion have been shown to be impaired beta cells from 25(OH)-D-deficient animals (Mathieu *et al*., 2005). Several studies have indicated a

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Corresponding Author: I.R. Dabbour, Department of Nutrition and Food Technology, Faculty of Agriculture, Mutah University, AlKarak, P.O. Box 61710, Jordan

relationship between vitamin D status and the risk of diabetes or glucose intolerance. Vitamin D has been proposed to play an important role and to be a risk factor in the development of insulin resistance and the pathogenesis of T2DM by affecting either insulin sensitivity or β-cell function, or both (Deleskog *et al.*, 2012).

It has been shown that in the Kingdom of Saudi Arabia (KSA), 25(OH)-D deficiency is an important health problem with different age groups (Alqurashi *et al.*, 2011; Kensarah and Azzeh, 2012; Kensara *et al.*, 2015). There have been rare studies about vitamin D statues in Saudi population in the Western region. Therefore, the purpose of this study is to compare and assess the 25(OH)-D deficiency between patients with T2DM and normal non-T2DM subjects in Makkah Region of Saudi Arabia and find-out the possible effect of life-style factors and dietary intake on vitamin D status between groups.

MATERIALS AND METHODS

Design and selection of the sample: A randomized case-control study was conducted during winter months (January to March) of 2014. A total of 200 subjects were selected randomly with 100 patients in the T2DM group and 100 subjects in the non-T2DM control group. The ethical approval of the study was given by the Research and Ethical committee of Umm Al-Qura University, Makkah, Saudi Arabia. The subjects having hepatic or renal disease, metabolic bone disease, fat malabsorption, T1DM and medications influencing bone metabolism such as antacids, anticonvulsants and anti-rejection medications were excluded from the study. Subjects were also excluded if they had received supplements containing vitamin D before testing.

Data collection: Pre-tested questionnaire (in Arabic language) and anthropometric measurements were used for data collection. The questionnaire was designed to collect the following information: (i) basic information: each one of subjects answered through personal interview a detailed basic information questionnaire that included: personal information, social data (socio demographic factors and life style factors) and health information and use of food supplements, (ii) eating habits: included likes and dislikes of the food groups for each subject, with emphasis on food items known to be rich sources of vitamin D and/or calcium and finally (iii) dietary intake data: by using food frequency tables, subjects were requested to record the intake of 31 selected food items considered sources for vitamin D and/or calcium. To facilitate the estimating of portion size, photographs and standard portion sizes (measuring cups and spoons) were used. After that the intakes of vitamin D and calcium were calculated using a locally prepared computer software analysis program based on food composition tables and available literature (Pellet and Shadarevian, 1970; Misra *et al.*, 2008; NIH, 2008). Based on dietary intake data, nutrient adequacy ratio (NAR) for vitamin D was measured, which represents an index of adequacy for a nutrient based on the corresponding U.S Recommended Dietary Allowance (RDA) for that nutrient (Food and Nutrition Board, 1997). NAR value for vitamin D was calculated by dividing the vitamin D intake by the RDA for vitamin D for specific age group. So, NAR values were compared among the two different vitamin D requirement groups; 31-50 years and 51-70 years.

Anthropometric measurements: Height and weight were measured while subjects wore light clothing and without shoes. Body weight and height were measured to the nearest 0.1 kg and 0.1 cm, respectively, using a digital scale (BA Wang DT 150) and a height board (Seca 200, Germany). The recorded weight (kg) and height (m) were used to calculate BMI by using the following equation:

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}$$

Biochemical analysis: Blood samples were collected from each person using a medicinal syringe and transferred to tubes containing separating gel, centrifuged at 3200 rpm for 15 min to obtain serum. The analysis of serum vitamin D, PTH, glycated hemoglobin (HbA1c) and alkaline phosphatase (ALP) were done in corporation with Elite medical laboratory, Makkah, KSA. COBAS Integra 400 plus analyzer (Roche Diagnostics Gmbh, USA), a clinical chemistry photometric analyzer, was used for the analysis of PTH and HbA1c. While, COBAS e 411 analyzer (Roche Diagnostics Gmbh, USA), an electro immunoassay analyzer, was used for the analysis of vitamin D as 25(OH)D and ALP. Prior to analysis calibration of the analyzer for PTH, HbA1c, ALP and vitamin 25(OH) D were done according to the manufacturer instructions. The analytical procedures were performed using biochemical kits purchased from Roche USA. A quality control was run with the samples in each test.

The subjects were classified into four categories according to their serum 25 (OH)-D concentration. In increasing order of severity, the serum 25 (OH)- D levels were as follows: sever vitamin D deficiency; <7 ng/ml, relative vitamin D deficiency; 7- ≤20 ng/ml, vitamin D insufficiency; more than 20 to 29 ng/ml and normal vitamin D level ≥30 ng/ml. The definition of vitamin D deficiency, insufficiency and normal level were based on data from previous studies (Holick, 2007).

Statistical analysis: Statistical analysis was performed using SPSS software version 20. The results of each variable studied were subjected to analysis of Variance (ANOVA) followed by Least Significant Difference (LSD).

The association between serum 25(OH)-D and other parameters were assessed using Pearson correlation coefficient. Results were expressed as Means±SD and frequency distribution. P-value less than 0.05 was considered significant.

RESULTS

Description of the studied sample: The sample size was further divided into 100 adults suffered from T2DM (case) and 100 normal subjects (control), with equal numbers from both genders (100 males and 100 females). As shown in Table 1, the means age of the case group (males and females) was 49.7 year. Whereas the means age of the control group (males and females) was 44.6 year. In both groups, there were no significant differences ($p>0.05$) in age, BMI, serum 25(OH)-D level, serum PTH, serum ALP, duration of outdoor physical activity, calcium intake and vitamin D intake as shown in Table 1. On the other hand, the mean value of HbA1c was significantly higher ($p<0.05$) in case group than those of control group.

Age and gender groups: The percentage distribution of the study groups according to their vitamin D status are presented in Fig. 1. About 90% of the whole sample having severe vitamin D deficiency and 10% showed relative vitamin D deficiency. No insufficient or normal vitamin D status was observed in recruited subjects. Table 2 shows a significant inverse relationship between age and 25(OH)-D level ($r = -0.37$, $p<0.05$). Regarding gender, there were no significant differences ($p>0.05$) in the means values of serum 25(OH)-D level among gender groups.

Anthropometric indicators: The anthropometric indicators that were measured during the study period were height, weight and BMI. Table 2 shows a non-significant inverse relationship between BMI and serum 25(OH)-D level ($r = -0.09$, $p>0.05$).

Nutrient intake: As shown in Table 3, there were no significant differences ($p>0.05$) in the means values of serum 25(OH)-D for the subjects who took adequate vitamin D and those who did not take adequate vitamin D among both age groups. However, Table 2 shows significant positive correlation between serum 25(OH)-D and intakes of vitamin D ($r = 0.33$, $p<0.05$).

Life-style characteristics: Figure 2 shows that, the mean value of serum 25(OH)-D was significantly higher ($p<0.05$) for the subjects who regularly played outdoor physical activities than those subjects who did not play regularly. Moreover, duration of outdoor physical activity showed a positive correlation with serum 25(OH)-D level ($r = 0.34$, $p<0.05$) as shown in Table 2.

Socioeconomic characteristics: The distribution of the study groups according to their socioeconomic characteristics is given in Table 4. The mean value of serum 25(OH)-D for subjects with income below 5000 SR was significantly higher than those subjects with income above 5000 SR. Furthermore, Table 2 shows a significant ($p<0.05$) inverse relationship between income and serum 25(OH)-D level ($r = -0.51$). Educational level of the subjects was analyzed as categorical variable. The mean value of serum 25(OH)-D for subjects who can write and read was significantly higher than those illiterate subjects and subjects hold a university degree (Table 4). The family size was analyzed as categorical variables according to the average family size in Makkah (Central Department of Statistics and Information, 2012). Table 4 shows that the mean value of serum 25(OH)-D level for small family size was significantly higher than those with large family size ($p<0.05$).

DISCUSSION

Vitamin D deficiency has strong argument in its effect on pathogenicity and development of T2DM. Therefore, we tried in this study to determine the effect of life-style factors and dietary intake on vitamin D status in diabetic volunteers with comparing the results with healthy subjects.

Serum 25(OH)-D level: First of all, serum 25(OH)-D deficiency or insufficiency is now recognized as a worldwide problem for both children and adults regardless they are healthy or suffering from diseases (Holick, 2006; Vimaleswaran *et al*., 2013). According to several studies, 40 to 100% of US and European elderly men and women still living in the community are deficient in 25(OH)-D (Nesby *et al*., 2002). In Saudi Arabia, 25(OH)-D deficiency has been reported previously but our study shows a very significant deficiency in 25 (OH) D levels in study population. In this study, we could not find any significant difference in 25(OH)-D status between our patients with T2DM and those without the disease (Table 1). The mean serum 25(OH)-D levels in the T2DM group were 6.17±2.47 ng/ml which are considered low. But surprisingly the mean 25(OH)-D levels in the non-T2DM group were even lower, 5.26±2.59 ng/ml, than diabetic group with no statistical significance (p-value >0.05). Not all studies showed lower 25(OH)-D levels in persons with T2DM compared with the control group. Serum samples from 110 subjects with T1DM and 153 control subjects were cross-sectionally analyzed and the 25(OH)D levels were similar among the 2 groups (Bierschenk *et al*., 2009). Our results are compatible with a recent study conducted in Southern Region of Saudi Arabia, which indicates that the population in this region was generally insufficient in 25(OH)-D irrespective of presence of

Table 1: Characteristic of study group

Variable	Case	Control
Number	100	100
Age (year)	49.7 ± 8.31	44.60 ± 10.74
BMI	31.74 ± 6.79	28.40 ± 5.81
25(OH)-D level (ng/ml)	6.17 ± 2.47	5.26 ± 2.59
PTH level (pg/ml)	57.62 ± 23.25	57.49 ± 22.29
Alkaline phosphate (U/L)	87.70 ± 29.88	67.71 ± 17.16
Duration of outdoor physical activity (minute/day)	12.00 ± 5.49	22.00 ± 12.87
Calcium intake (mg)	459.22 ± 225.29	476.80 ± 252.06
Vitamin D intake (IU)	319.21 ± 201.43	281.07 ± 188.47
HbA1c	8.93 ± 3.40^a	5.75 ± 2.41^b

1: Each value is represented as mean±SD.

2: Means with different superscripts within the same row are significantly different ($p<0.05$).

Table 2: Correlation between selected independent variable of serum 25 (OH)-D levels (Irrespective of the presences of T2DM) (n = 200)

Independent variable	Serum 25(OH)-D level
Age	r = -0.37 ($p<0.05$)
Vitamin D intake	r = 0.33 ($p<0.05$)
BMI	r = -0.09 ($p>0.05$)
PTH	r = -0.24 ($p>0.05$)
ALP	r = 0.09 ($p>0.05$)
Duration of outdoor physical activity	r = 0.34 ($p<0.05$)
Monthly frequency of outdoor physical activity	r = 0.31 ($p<0.05$)
Level of education	r = -0.26 ($p>0.05$)
Income	r = -0.51 ($p<0.05$)

T2DM (Alhumaidi *et al*., 2013). They found that the mean serum 25(OH)-D levels in the T2DM (172 patients) were 15.7±7.5 ng/ml as compared healthy non-T2DM group (173 patients) having 11.1±5.9 ng/ml and a total of 340 patients (98.5%) from both groups were found to be deficient in 25(OH)-D which is the highest reported till now in Saudi Arabia (Alhumaidi *et al*., 2013). On the other hand, several studies have shown defect in calcium, phosphate and vitamin D metabolism in diabetic patients. Those studies have found a significant decrease in 25(OH)-D levels in T2DM patients than in control group, while there were no difference in 25(OH)-D levels between T1DM patients and control group (Pietschmann *et al*., 1988; Hypponen and Power, 2007; Vimaleswaran *et al*., 2013).

Age and gender groups: Regarding gender, we found that there was no significant difference ($p>0.05$) in the mean values of serum 25(OH)-D among gender groups in our study population which is compatible with previous studies from Saudi Arabia (Ardawi *et al*., 2010, 2012). These studies have shown that 25(OH)-D deficiency is highly prevalent among healthy Saudi women as well as men and largely referred to obesity, poor exposure to sunlight, poor dietary vitamin D supplementation, sedentary lifestyle, lack of education and older age; which in turn affects bone mass density and bone turnover markers (Ardawi *et al*., 2010, 2012). Regardless of the presence of diabetes or not. There are also other studies conducted in Saudi Arabia contrary to our findings; these studies indicated that there are a much higher degree of 25(OH)-D deficiency in females in comparison to males. One of these studies pointed out that 25(OH)-D deficiency among healthy young Saudi women of age 30 to 55 years was 30 and 55% in women of 50 years or more, indicating that it is common in young and postmenopausal women (Al-Turki *et al*., 2008). In another study on male population from Saudi Arabia, the prevalence of 25(OH)-D deficiency was found to between 28 and 37% (Sadat-Ali *et al*., 2009).

When we take into consideration the age as a factor in this study irrespective of the presence of diabetes, we found that there was a significant and inverse relationship between age and serum 25(OH)-D level for all subjects (r = -0.37; $p<0.05$) (Table 2). This result is in line with Nesby *et al*. (2002) study that showed 40 to 100% of US and European elderly men and women still living in the community (not in nursing homes) are deficient in 25(OH)-D.

Anthropometric indicators: BMI is the commonly accepted index for classifying adiposity in adults and it is recommended for use with children and adolescent (Snijder *et al*., 2005; Hypponen and Power, 2007; Brock *et al*., 2010). Many studies have investigated the prevalence of 25(OH)-D deficiency among overweight and obese people, suggesting that the higher percent of body fat in the obese peoples isolate vitamin D which is highly related to BMI >30 kg/m^2 (Snijder *et al*., 2005;

Table 3: Serum 25(OH)-D levels according to nutrient adequacy ratio (NAR)* for vitamin D^1 (Irrespective of the presences of T2DM)

Age group	NAR	No. of subject	Serum 25(OH)-D levels (ng/ml)	p-value
31-50 years	Adequate vitamin D	60 (30%)	5.42±2.47	>0.05
	Inadequate vitamin D	40 (20%)	3.09±0.18	>0.05
51-70 years	Adequate vitamin D	20 (10%)	4.74±3.87	>0.05
	Inadequate vitamin D	80 (40%)	3.01±0.11	>0.05

*NAR: Nutrient adequacy ratio = nutrient intake/Recommended Dietary Allowance (RDA) based on Food and Nutrition Board (1997).

1: Each value is represented as means±SD

Table 4: 25(OH)-D levels of the study groups according to socioeconomic characteristics (Irrespective of the presences of T2DM)

Independent variable	Frequencies n (%)	Serum 25(OH)-D level (ng/ml)	p-value
Income (SR)			
<5000	30 (15)	6.91±3.40^a	<0.05
5000-10000	60 (30)	3.06±0.14^b	<0.05
10000-20000	70 (35)	3.27±0.71^b	<0.05
>20000	40 (20)	3.10±0.21^b	<0.05
Level of education			
Illiterate	30 (15)	3.00±0.90^b	<0.05
Write and read	50 (25)	6.02±3.30^a	<0.05
University degree	120 (60)	3.19±0.54^b	<0.05
Family size			
≤5	90 (45)	4.55±2.52^a	<0.05
>6	110 (55)	3.03±0.12^b	<0.05

1: Each value is represented as mean±SD. 2: Means with different superscripts within the same row are significantly different (p<0.05)

Hypponen and Power, 2007). Moreover, each 1 kg/m^2 higher BMI was associated with 1.15% lowers 25 (OH)-D (Vimaleswaran *et al*., 2013). Another study showed that the total body fat is inversely associated with 25-OH-D levels and is positively associated with PTH levels (Snijder *et al*., 2005; Hypponen and Power, 2007; Brock *et al*., 2010).

In the present study, we expected to find statistically significant difference in 25 (OH)-D levels between normal, overweight and obese groups. However, we could not be able to find any differences in 25(OH)-D levels in our patients according to their BMI's, as well as there was a clear not-significant inverse relationship between BMI (r = -0.09, p>0.05) and serum 25(OH)-D level (Table 2). Relatively small study sample of our groups might be one of the reasons. It may also be said that when 25(OH)-D levels were very low; obesity markers may not be affected. Hypponen and Power (2007) showed that serum 25(OH)-D levels decreased with increasing BMI. Al-Daghri *et al*. (2010) also determined that BMI was a significant predictor of 25(OH)-D. Barchetta *et al*. (2011) when classified their patients according to serum 25(OH)-D quartiles; found an increasing BMI and waist circumference, in accordance with decreasing 25(OH)-D levels. Gordon *et al*. (2004) and Catherine *et al*. (2004) showed an inverse correlation between BMI and serum 25(OH)-D concentrations in adolescent subjects aged 11-18 years. Kamycheva (2003) also found significant inverse associations between BMI and vitamin D intake in men and women aged more than 24 years.

Nutrient intake: Very few foods in nature contain vitamin D. Oily fish (such as salmon, mackerel and sardines), cod liver oil and liver are among the best sources. Small amounts of vitamin D are found in cheese and egg yolks (Holick, 2007). Therefore, many foods, especially infants and children foods, are usually fortified with vitamin D. Food that were fortified with vitamin D on the market in Saudi Arabia includes only some types of milk especially milk powder, some types of cheese, some types of yoghurt and some types of ready to eat cereals. Table 3 demonstrates that there were no significant differences (p>0.05) in the means values of serum 25(OH)-D for the subjects who took adequate vitamin D and those who did not take adequate vitamin D among both age groups, while there is a clear trend showing that whenever there is an adequacy of vitamin D intake for the subjects there is an increase in serum 25(OH)-D levels. However, Table 2 shows significant positive correlation between serum 25(OH)-D and intakes of vitamin D (r = 0.33, p<0.05). These results are in agreement with the results of the study conducted by Fuleihan *et al*. (2001) who found that vitamin D intake was significantly correlated with serum 25(OH)-D levels. Also, Nicolaidou *et al*. (2006) reported that the serum 25(OH)-D was affected by dietary vitamin D intake. Furthermore, Scragg and Camargo (2008) showed that serum 25(OH)-D levels were positively associated with milk intake, but not with cereal intake.

Life-style characteristics: The important findings of this study reveal that 25(OH)-D deficiency in subjects is very common in Saudi Arabia as noted previously and elsewhere in the Middle East and is associated with lack of physical activity and sun exposure (Al-Daghri *et al*., 2010; Racinais *et al*., 2010). Daytime outdoor physical activity may act as an alternative indicator for sun

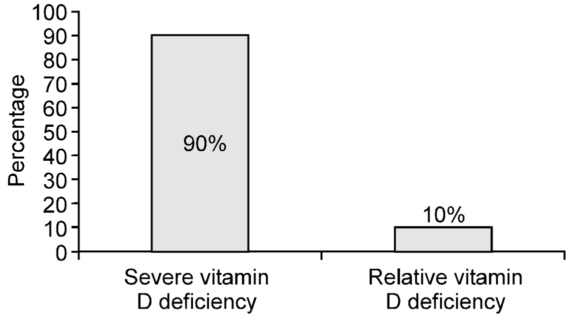

Fig. 1: Distribution of the study groups according to vitamin D status (Irrespective of the presences of T2DM)

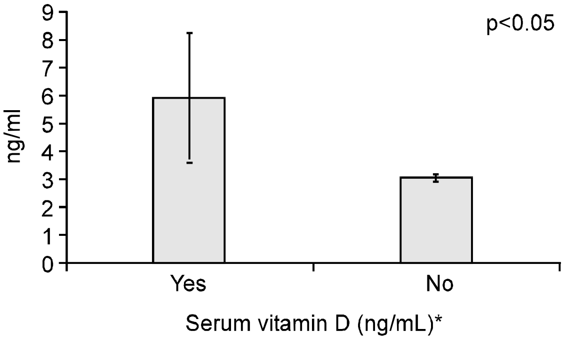

Fig. 2: Serum 25(OH)-D according to regular played outdoor physical activities (Irrespective of the presences of T2DM). *Each value is represented as Means±SEM

exposure; however, exercise in itself may contribute to the maintenance of vitamin D status, other than merely by increasing exposure of skin to sunlight (Scragg *et al.*, 1995). Moreover, the current study showed a significant difference ($p<0.05$) and a positive correlation ($r = 0.34$) between duration of outdoor physical activity and serum 25(OH)-D level. This result is consistent with the result obtained by Scragg and Camargo (2008) as they found that the mean of serum 25(OH)-D concentrations were lowest in the participants who had no outdoor physical activity during the previous month, compared with those who were physically active and increased in a stepwise manner with increasing frequency of outdoor activity. Also, Nicolaidou *et al.* (2006) reported that the subjects with high outdoor activities had higher 25(OH)-D levels than subjects with little of moderate outdoor activities. Brock *et al.* (2010) demonstrate that low vitamin D status related to physical inactivity.

Socioeconomic characteristics: In our study, we found that 15% of the sample comes from families with an income below the average income in Saudi Arabia, while 85% of the sample comes from families with an income above the average, which indicate that the study groups represent a high socioeconomic status. Fuleihan *et al.* (2001) showed that the subjects of higher socioeconomic status had higher 25(OH)-D levels than those subjects of middle or low socioeconomic status. While in the current study, the mean values of serum 25(OH)-D of low income subjects were significantly high and inversely related to 25(OH)-D levels of high income subjects (>5000 RS) ($r = -0.51$, $p<0.05$). On the contrary, another study conducted by Baroncelli *et al.* (2008) found that there were no significant differences between healthy and rachitic children according to the family income. The explanation for this result is that vitamin D can be obtained from sunlight exposure which might be available for all.

From Table 4, it can be noticed that 60% of subjects had university or college education. This indicates that the study groups represent a group with a high educational level in the Saudi Arabian community. An interesting result in this study that the mean value of serum 25(OH)-D for subjects who can write and read was significantly higher ($p<0.05$) than those illiterate subjects and subjects holding a university degree. This result is partially similar to the study conducted by Baroncelli *et al.* (2008) in Turkey in which there were significant differences between healthy and rachitic children according to the parents' educational levels. A striking observation was that although this study group (parents' education) was moderately educated, their nutritional knowledge about vitamin D was low. The present study demonstrates that the mean levels of serum 25(OH)-D of all subjects for small family size were significantly different ($p<0.05$) than those with large family size. This result is not in agreement with the results of the study conducted by Baroncelli *et al.* (2008) who found that there were no significant differences between healthy and rachitic children according to family size. Our interpretation for the socioeconomic status results is that the low income subjects who mostly read and write (with no higher education) were found to have the high significant levels of serum 25(OH)-D compared to other subjects probably due to the nature of their work which is often outside the offices and thus leading for more sun exposure for long periods. For this reason we see that there is a consensus among these factors and the high level of 25(OH)-D in serum.

Finally, we must mention that there were some limitations faced while conducting this study including: (i) we carried out our study in winter between January and March and because the primary source of this vitamin is skin production and seasonal variations in vitamin D status is well known; we recommend to perform similar studies in summer, (ii) data on which body parts were exposed to sun and the exact duration and time of sun exposure were not provided, which might affect the results and (iii) the small study sample size.

Conclusions: Under the conditions of this study, we conclude that the prevalence of hypovitaminosis D was high in adult and older Saudi men and women in Makkah region regardless of the presence of T2DM. But we cannot generalize this result to all the Makkah population because there are some limitations to this study that have been mentioned above, but is considered a general indication of this deficiency.

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