Is there a relationship between body mass index and serum vitamin D levels?

Abdulmohsen H. Al-Elq, ABIM, FACE, *Mir Sadat-Ali,* FRCS, FICS, *Haifa A. Al-Turki,* SSOG, ABOG, *Fathma A. Al-Mulhim,* MBBS, KFR, *Amein K. Al-Ali,* MS, PhD.

ABSTRACT

الأهداف: تقييم العلاقة بين مستوى فيتامين (د) ومؤشر كثافة الجسم (BMI) لدى شريحة من المجتمع السعودي.

الطريقة: أجريت هذه الدراسة المقطعية على 400 شخص سليم (200 ذكر و200 أنثى) في عمر 25 عام فما فوق. حيث تم عمل فحص إكلينيكي مع حساب مؤشر كثافة الجسم (BMI). كما تم قياس مستوى 25 هيدروكسي فيتامين (د) (25OHD)، هرمون جار الدرقية ومستوى الكالسيوم لدى كل الأفراد المشمولين في الدراسة. شملت الدراسة الأفراد خلال الفترة مابين 1 فبراير 2008 حتى 31 مايو 2008 من الموظفين العاملين بمستشفى جامعة الملك فهد – الخبر – المملكة العربية السعودية و المرضى المراجعين لعيادات الغدد الصماء، و العظام، و العقم في المستشفى نفسه. تم حساب مؤشر كثافة الجسم و إجراء التقييم السريري. تم قياس مستوى هيدروكسي فيتامين (د) (25OHD) و مستويات هرمون الغدة الدرقية و الكالسيوم لجميع الأفراد.

النتائج: كان معدل العمر 46.5±14.6 عام لدى الذكور و 42.6±5.9 لدى الإناث (p=0.01). وكان مؤشر كثافة الجسم (BMI) متساوي لدى الجنسين. أما الاختلاف في مستوى 25 هيدروكسي فيتامين (د) (25OHD) بين الجنسين فكان ذات دلالة إحصائية هامة (p=0.04). وكان الرجال الذين لديهم نقص في مستوى فيتامين (د) أكبر سناً (p=0.03) ومؤشر كثافة الجسم لديهم كانت أعلى (p=0.01) من الذكور الذين لديهم مستوى فيتامين (د) طبيعي. وبالرغم من أن النساء اللاتي لديهن نقص في مستوى فيتامين (د) كن أكبر سناً (p=0.01) إلا أن مؤشر كثافة الجسم لديهن كان أقل من النساء اللاتي لديهن مستوى طبيعي من فيتامين (د) وكان ذلك بدلالة إحصائية هامة (p=0.001).

خاتمة: بينت هذه الدراسة أن الذكور المصابين بالسمنة لديهم قابلية خطر الإصابة بنقص مستوى هيدروكسي فيتامين (د) (25OHD) في الدم وبالعكس من ذلك فإن النساء المصابات بالسمنة لديهن حماية من الإصابة بنقص فيتامين (د) لدى العينة التي تم دراستها. ونحن نعتقد بأهمية تقييم وعلاج حالات نقص فيتامين (د) لدى الذكور المصابين بالسمنة والنساء النحيفات.

Objectives: To evaluate the relationship between vitamin D level and body mass index (BMI) among Saudi Arabian citizens.

Methods: Four hundred healthy individuals aged ≥25 years (200 males and 200 females) were included in this cross-sectional study. Subjects were recruited in the period between 1st February 2008 and 31st May 2008 from the medical staff and employees of King Fahd Hospital of the University, Al-Khobar, Kingdom of Saudi Arabia, and from patients attending the endocrinology, orthopedic, and infertility clinics at the same hospital. Clinical evaluation was carried out, and BMI was calculated. Serum 25 hydroxy vitamin D (25OHD), in addition to serum parathyroid hormone levels and calcium chemistry were measured for all subjects.

Results: The mean age was 46.5 ± 14.6 years for males, and 42.6 ± 15.9 years for females (p=0.01). Mean BMI was similar in both genders, and the difference in the level of serum 25OHD just reached statistical significance (p=0.04). Male subjects with vitamin D deficiency were found to be older (p=0.03), and with higher BMI (p=0.01) compared to males with normal 25OHD. Although female subjects with hypovitaminosis D were also older than subjects with normal vitamin D level (p=0.01), BMI was significantly lower in females with vitamin D deficiency (p=0.001).

Conclusion: Obese males are at higher risk of having low 25OHD levels, while obesity in females appears to be protective against vitamin D deficiency in the population studied. We believe that obese male and thin female patients should be appropriately investigated, and treated for vitamin D deficiency.

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From the Departments of Orthopedic Surgery (Sadat-Ali), Internal Medicine (Al-Elq), Obstetrics and Gynecology (Al-Turki), Radiology (Al-Mulhim), and Biochemistry (Al-Ali), College of Medicine, King Faisal University, Dammam, and King Fahd Hospital of the University, Al-Khobar, Kingdom of Saudi Arabia.

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Address correspondence and reprint request to: Professor Mir Sadat-Ali, Department of Orthopedic Surgery, King Fahd University Hospital, PO Box 40071, Al-Khobar 31952, Kingdom of Saudi Arabia. Tel. +966 505848281. Fax. +966 (3) 8820807. E-mail: drsadat@hotmail.com

Vitamin D concentration is largely determined through vitamin D intake as ergocalciferol (vitaminD_2) from plant sources, and as cholecalciferol (vitamin D_3) from animal sources, and through ultraviolet reduction of 7-dehydrocholesterol in the skin with subsequent formation of cholecalciferol.[1] While it was agreed that the best marker of total body vitamin D status is the serum level of 25 hydroxy vitamin D (25OHD), different recommendations for the definition of hypovitaminosis D have been used. A recent consensus statement for vitamin D nutritional guidelines suggested that serum 25OHD ≥75 nmol/l (≥30 ng/ml) concentration is the minimum acceptable level for the maintenance of bone health, and health in general. There is also a general agreement between the experts that serum concentration of 25OHD should not be <50 nmol/l (<20 ng/ml [to be considered as deficiency).[2-4] Vitamin D deficiency is recognized lately to be a world wide health problem affecting different populations at different ages.[5] A healthy Saudi Arabian population is known to have low vitamin D levels, this was reported as early as 1982,[6] and confirmed later by different studies.[7,8] Low serum 25OHD, and the subsequent hyperparathyroidism are among the endocrine derangements of obesity.[9] Obese individuals have been shown to have vitamin D deficiency.[10-13] The causes of such a deficiency are still being debated. One possible explanation is that low vitamin D in obesity results from the sequestrating effect of high quantity of subcutaneous fat on circulating vitamin D.[12,14] Another possible explanation is the fact that obese individuals due to cosmetic reasons, and lower mobility are less exposed to sunlight, and this could be a major contributing factor.[15] During the last 30 years, the dietary habit of the children and adults in the Kingdom of Saudi Arabia has changed tremendously, and the body mass index (BMI) appears to be on the rise among the Saudi population. Al-Hazzaa[16] reported an increase in the proportion of obese Saudi schoolboys from 3.4% in 1988 to 24.5% in 2005. Our review of the literature did not reveal any studies that investigated the correlation between serum 25OHD levels and BMI among Saudi Arabian men and women. This study was conducted to find whether any relationship exist between serum 25OHD levels and BMI among Saudi Arabian males and females.

Methods. This is a cross-sectional study using an available convenient sample, which included 400 Saudi Arabian nationals from the eastern province of Saudi Arabia, with an altitude of approximately 18^0. The study sample consisted of 200 males and 200 females, aged 25 years and older. Subjects were recruited in the period between 1st February 2008 and 31st May 2008 from the medical staff and employees of King Fahd Hospital of the University, Al-Khobar, Kingdom of Saudi Arabia, and from patients attending the endocrinology, orthopedic and infertility clinics at the same hospital. The study was approved by the Ethical and Research committee of King Fahd Hospital of the University, Al-Khobar and King Faisal University, Dammam. An informed verbal consent was obtained. History was taken from all the subjects and physical examination was carried out for patients recruited from the above-mentioned clinics to rule out any well-known cause of vitamin D deficiency. Patients were excluded in case of the presence of organ dysfunction that affects vitamin D status such as malabsorption, chronic liver disease, renal impairment, or nephritic syndrome, in case of vitamin D supplement use, or drugs that can affect vitamin D metabolism, and in case of positive family history of hypocalcemia, or vitamin D disorders. Females who were pregnant, lactating, or postpartum were also excluded. Height and weight were measured using a Detecto scale to the nearest 0.5 cm, and 0.1 kg. The BMI was defined as the weight in kilograms divided by the square of the height in meters. Blood was drawn in the morning in a fasting state for serum calcium, serum phosphorous, serum albumin, alkaline phosphatase, serum parathyroid hormone (PTH), and serum 25OHD. Serum calcium, serum phosphorous, serum albumin, and alkaline phosphatase were determined according to the standard laboratory procedures. Intact PTH was determined by immunoradiometric assay. Serum levels of 25OHD was measured by radioimmunoassay using Wallac1470 Gamma Counter (Wallac Inc., Gaithersburg, MD, USA). The 25OHD was considered in this study to be normal if the level is ≥30 ng/ml (≥75 nmol/l), insufficient if the level is between 20-30 ng/ml (50-75 nmol/l), and deficient if the level is <20 ng/ml (<50 nmol/l). Subjects were divided into 3 groups, based on the 25OHD level (group one - with vitamin D sufficiency, group 2 - with vitamin D insufficiency, and group 3 - with vitamin D deficiency). Overweight and obesity was defined according to the definitions used by the Department of Health and Human Resources Center for Disease Control.[17] None of the participants received any form of remuneration for participation in this study.

The data were entered in the database and analyzed using the t-test to compare means between different groups. All tests were performed using the Statistical Package for Social Sciences version 14.0 (SPSS Inc.,

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Chicago, Illinois, USA). Statistical significance of $p<0.05$ with 95% confidence interval (CI) was used during the analysis.

Results. The mean age for males was 46.5 ± 14.6 years, and 42.6 ± 15.9 years for females ($p=0.01$). Mean BMI was 23.4 ± 4.3 kg/m^2 in males versus 23.96 ± 4.1 kg/m^2 in females, with no significant statistical difference. The difference in the level of serum 25OHD between males and females reached statistical significance (**Table 1**).

Table 1 - Characteristics of the study population.

Parameter	Male	Female	*P*-value
Number screened	200	200	
Age	46.43 ± 14.5	42.5 ± 15.9	0.01
BMI kg/m^2	23.4 ± 4.3	23.96 ± 4.1	0.1
25OHD ng/ml	31.1 ± 10.7	28.9 ± 10.7	0.04

BMI - body mass index, 25OHD - 25 hydroxy vitamin D

Clinical and biochemical characteristics for the male group is summarized in **Table 2**. Males subjects (67.5%) have normal vitamin D level, while 21.5% had vitamin D insufficiency, and 11% had deficiency (hypovitaminosis D present in 32.5%). The mean vitamin D level was significantly lower in groups 2 and 3, compared to group one ($p=0.01$ for both). Males with vitamin D deficiency were significantly older than males with normal vitamin D level ($p=0.03$). The BMI was significantly higher in males with vitamin D insufficiency and deficiency. Although serum calcium and phosphorus levels were similar among males in the 3 groups, alkaline phosphatase was significantly higher in groups 2 and 3 compared to subjects in group one, while PTH was significantly higher in males with 25OHD deficiency ($p=0.01$).

Table 3 summarizes the clinical and biochemical data of the female group. It comprises 57.5% of female having normal vitamin D level, 27.5% having vitamin D insufficiency, and 15% having vitamin D deficiency

Table 2 - Relationship between body mass index (BMI) and 25 hydroxy vitamin D (25OHD) in males.

Parameters	All patients	Group 1	Group 2	Group 3	*P*-value Groups 1 and 2	*P*-value Groups 1 and 3
Number of patients	200	135	43	22		
Age, years	43.23 ± 14.5	42.30 ± 16.5	42.8 ± 16.6	50.2 ± 21.8	0.2	0.03
BMI, kg/m^2	24.08 ± 4.3	23.6 ± 3.85	25.54 ± 3.75	25.01 ± 2.6	0.004	0.03
Serum calcium level, mg/dl (normal range; 8.5-10.5)	9.25 ± 0.22	9.6 ± 0.1	9.5 ± 1.1	9.2 ± 1.8	0.2	0.2
Phosphorus, mg/dl (normal range; 2.5-4.9)	3.81 ± 0.5	3.7 ± 0.3	3.6 ± 0.7	3.52 ± 0.9	0.3	0.2
Alkaline phosphatase, U/l (normal range; 43-277)	86.17 ± 23.5	87.6 ± 0.7	97.2 ± 1.3	97.8 ± 2.2	0.01	0.01
Parathyroid hormone, pmol/l (normal range; 1.3-7.6)	5.5 ± 0.8	5.3 ± 0.9	5.4 ± 1.2	5.76 ± 0.9	0.3	0.01
25OHD, ng/ml	36.25 ± 10.7	41.9 ± 6.5	25.3 ± 2.9	16.9 ± 2.6	0.001	0.001

Table 3 - Relationship between body mass index (BMI) and 25 hydroxy vitamin D (25OHD) in females.

Parameter	All patients	Group 1	Group 2	Group 3	*P*-value Groups 1 and 2	*P*-value Groups 1 and 3
Number of patients	200	115	55	30		
Age, years	42.5 ±15.9	40.25 ± 13.6	46.36 ± 14.5	46.9 ± 12.6	0.01	0.01
BMI, kg/m^2	23.9 ± 4.1	23.7 ± 3.4	22.55 ± 3.3	20.67 ± 3.8	0.03	0.001
Serum calcium level, mg/dl (normal range; 8.5-10.5)	9.07 ± 0.51	9.2 ± 0.6	9.1 ± 0.6	9.08 ± 0.9	0.3	0.2
Phosphorus, mg/dl (normal range; 2.5-4.9)	3.85 ± 0.52	3.87 ± 0.7	3.82 ± 0.6	3.87 ± 0.2	0.1	0.1
Alkaline phosphatase, U/l (normal range; 43-277)	88.30 ± 21.5	87.9 ± 1.6	90.26 ± 16.7	105.7 ± 52.7	0.2	0.5
Parathyroid hormone, pmol/l (normal range; 1.3-7.6)	7.75 ± 3.2	7.6 ± 3.1	7.14 ± 2.8	9.4 ± 7.6	0.1	0.2
25OHD, ng/ml	30.9 ± 10.7	38.28 ± 6.8	25.5 ± 2.4	13.03 ± 2.12	0.01	0.001

(42.5% with hypovitaminosis D). The 25OHD was significantly lower in females of groups 2 (p=0.01) and 3 (p=0.001) compared to females of group one. As in males, females with vitamin D deficiency were older than patients with normal vitamin D (p=0.01). Interestingly, the relation between vitamin D level and BMI is contrary to what was found in males were BMI was significantly lower in groups 2 (p=0.03) and 3 (p=0.001), compared to group one. Serum calcium, phosphorus, alkaline phosphatase, and PTH were similar among the 3 female groups.

Discussion. It has been known for a long time that vitamin D is vital to bone health.[18,19] Lately, vitamin D was also recognized to be important for non-skeletal health.[20] Among those non-skeletal conditions, which were found to be related to vitamin D is the association between low vitamin D level, metabolic syndrome,[15,21] and adiposity.[22] The link between vitamin D deficiency and secondary hyperparathyroidism in obese patients has been reported before, and after bariatric surgery. Goldner et al[23] evaluated 25OHD in 41 patients undergoing gastric bypass, and compared them to healthy non-obese controls. They found that 90% of their obese patients have vitamin D insufficiency versus 32% in controls. This deficiency was also found to be unchanged after bariatric surgery.[24]

Our study included somewhat younger individuals with a mean age of 46.5 ± 14.6 years for males, and 42.6 ± 15.9 years for females. The mean BMI for male and female group was lower than expected, if we keep in mind the prevalence of overweight and obesity in Saudi population as reported by Al-Nozha et al,[25] Al-Othaimeen et al,[26] and the recently reported prevalence of overweight and obesity from the eastern province of Saudi Arabia.[27] This can be explained partly by the fact that this study is hospital based, rather than community based. The prevalence of vitamin D deficiency found in our females was lower than reported from several European, Middle East, and Asian countries using a cutoff level of <25 nmol/l 25OHD (<10 ng/ml).[28] This may be related to the difference in the population studied, different cutoff level of serum 25OHD that was applied, and the seasonal effect. In both male and female groups, hypovitaminosis D prevalence increased with age, and this is consistent with what was reported in the literature.[29] An important and interesting finding that came out from this study is the observed discrepancy in the relation between BMI and 25OHD levels among males and females. The BMI was significantly higher in males with both vitamin D insufficiency and vitamin D deficiency, while it was significantly lower in females with hypovitaminosis D.

In fact, there are conflicting reports regarding the effect of obesity on vitamin D level. Some studies found no relationship between obesity and levels of vitamin D,[30,31] while other studies found a strong relation between high BMI and hypovitaminosis D.[10-13] Gender effect was not evaluated in most of the studies on the relationship between obesity and vitamin D level. Both males and females are usually included in the same analysis. Vilarrasa et al[10] studied only Caucasian females, and found vitamin D level to be low in obese women, compared to women with normal BMI. Another study[32] included mainly females (200 females and 43 males), and found an inverse relation between serum vitamin D level and BMI. Konradsen et al[33] studied the effect of gender among 2187 individuals, and found a uniformly low level of 25OHD and 1,25 OHD in obese males and females. The above finding does not concur with what we found among our female subjects, while in the male group, our finding is consistent with what was documented in the literature. We have no specific explanation for our result in the female group, however, racial difference and the difference in life styles can be contributing factors. Also, there is no specific explanation for the discrepancy between male and female groups, regarding BMI and 25OHD level, however, the significantly higher PTH level among males with vitamin D deficiency possibly contributed to their higher BMI.[34] This can also be an incidental finding that needs to be tested by a larger and community based study.

The limitation of this study is that it was hospital based, apart from BMI, no other anthropometric parameters were studied, and the fact that no multivariate analysis was carried out to study the effect of other confounding factors such as the PTH level. Another limitation is the relatively low mean BMI in both male and female groups that may lead to the underestimation of the effect of obesity on the 25OHD level. In spite of the above limitations, an important and interesting observation that came out from this study is the discrepancy in the relationship between BMI and 25OHD level among males and females. This observation needs to be re evaluated in a larger community based study.

In conclusion, this study partly supports the recent view of the inverse relationship between BMI and vitamin D levels. Vitamin D level was found to be inversely related to the BMI in the male group, and positively related to the BMI in the female group. We believe that obese males, thin females, and possibly obese females should be routinely screened for vitamin D deficiency, and treated appropriately in order to avoid its deleterious effect on both the skeletal and non-skeletal heath.

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