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Endocrinol Nutr. 2011;**58(6):**267–273

ENDOCRINOLOGÍA Y NUTRICIÓN

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ORIGINAL ARTICLE

High prevalence of hypovitaminosis D in Medical Students in Gran Canaria. Canary Islands (Spain)

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Received 3 August 2010; accepted 9 March 2011

KEYWORDS
Vitamin D;
Deficiency;
Insufficiency;
Students;
Sun exposure;
Canary Islands

Abstract
Background: Vitamin D deficiency has been reported in many diseases and in the general population. However, few reports have been published in young, healthy people. Vitamin D deficiency should not be found in medical students of the Canary Islands, because they have all the resources to avoid it.
Objective: To estimate the prevalence of vitamin D deficiency in a population of medical students of both genders from the University of Las Palmas de Gran Canaria.
Methods: 103 medical students of both genders from the University of Las Palmas de Gran Canaria were studied. They completed a questionnaire and a physical examination. Vitamin D (25- hydroxycholecalciferol [25-HCC]), parathyroid hormone, and biochemical markers of bone remodeling were measured, and a general biochemical study was performed. Bone mineral density was assessed by dual energy X-ray absorptiometry at the lumbar spine and the proximal femur. Quantitative ultrasound parameters were measured at the calcaneus.
Results: Only 38.8% of medical students (42.1% of males and 44.9% of females) had 25-HCC values higher than 30 ng/dL as currently recommended. Vitamin D deficiency (< 20 ng/mL) was found in 32.6% and vitamin D insufficiency (< 30 ng/mL) in 28.6% of medical students in Las Palmas de Gran Canaria.

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Conclusion: Although they enjoy optimal conditions for having high vitamin D levels, almost two thirds of medical students in the Canary Islands have low vitamin D levels.
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PALABRAS CLAVE
Vitamina D;
Deficiencia;
Insuficiencia;
Estudiantes;
Exposición solar;
Islas Canarias

Elevada prevalencia de hipovitaminosis D en los estudiantes de Medicina de Gran Canaria, Islas Canarias

Resumen
Fundamento: Se ha descrito la existencia de deficiencia de vitamina D tanto en la población general como en un gran número de enfermedades. Sin embargo, se han publicado pocos estudios realizados en población joven y sana en España. Teóricamente no debería encontrarse deficiencia de vitamina D entre los estudiantes de Medicina de la Universidad de Las Palmas de Gran Canaria, porque disponen de todos los medios para evitarla.
Objetivo: Estimar la prevalencia de deficiencia de vitamina D en una población de estudiantes de Medicina de ambos sexos de la Universidad de Las Palmas de Gran Canaria.
Método: Se estudiaron 103 alumnos de Medicina de ambos sexos de la Universidad de Las Palmas de Gran Canaria. A todos se les realizó un cuestionario y una exploración física. Se determinó la vitamina D 25-hidroxicolecalciferol (25-HCC), la hormona paratiroidea, varios marcadores bioquímicos de remodelado óseo y un estudio bioquímico general. Se estimó la densidad mineral ósea por absorciometría radiológica dual en la columna lumbar y en la extremidad proximal del fémur. Asimismo, se midieron los parámetros ultrasonográficos en el calcáneo.
Resultados: Sólo el 38,8% de los estudiantes de Medicina (el 42,1% de los varones y el 44,9% de las mujeres) presentaron niveles de 25-HCC superiores a 30 ng/dl tal y como se recomienda en la actualidad. Se observó deficiencia de vitamina D (menos de 20 ng/ml) en el 32,6% de los alumnos e insuficiencia (menos de 30 ng/ml) en el 28,6% de los estudiantes de Medicina de la Universidad de Las Palmas de Gran Canaria.
Conclusiones: Aunque los estudiantes de Medicina de las Isla Canarias disponen de las condiciones ideales para tener unos niveles óptimos de vitamina D, casi dos tercios de ellos tienen valores de 25-HCC inferiores a 30 ng/ml.
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Introduction

Vitamin D is no longer considered to be an essential micronutrient, but is currently considered to be a hormone involved in a complex endocrine system that regulates mineral homeostasis, protects skeletal integrity, and modulates cell growth and differentiation in a wide variety of tissues[1]. Vitamin D deficiency has been reported in many diseases[2,3] and has been proposed as a risk factor for osteoporosis[4,5], fragility fractures[6,7], and falls[8,9]. Since vitamin D is mainly synthesized at the skin upon exposure to sunlight and this capacity decreases with age[10], vitamin D has usually been reported in elderly people, although there are some reports of this deficiency in healthy populations with little exposure to sunlight[3,11].

Hypovitaminosis D should not be prevalent among medical students from the University of Las Palmas de Gran Canaria because 1) they are a young, healthy population, 2) are aware of the physiology and daily requirements of vitamin D, and 3) the sunny climate of Gran Canaria guarantees many hours of sunshine and low rainfall throughout the year. However, students spend a good number of hours every day inside buildings, either in hospitals or classrooms. It was previously reported that 32% of medical students and resident and staff physicians from a Boston hospital had vitamin D deficiency, despite the fact that they drank at least one glass of milk every day, took multitivamin tablets daily, and ate salmon at least once weekly[12].

A study was therefore conducted in a population of medical students from the University of Las Palmas de Gran Canaria to estimate the potential prevalence of hypovitaminosis D in this group.

Patients and methods

One hundred and three medical students of both genders from the University of Las Palmas de Gran Canaria with a mean age of 23 years were enrolled into this study. They all were white and had been born and raised in Gran Canaria. All of them gave their informed consent to participate in the study after receiving information about the study objectives.

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General osteoporosis questionnaire. All the students participating in the study were administered a questionnaire to collect information about their state of health, lifestyles, nutritional habits, drug use, and reproductive history related to osteoporosis[13].

Specific questionnaire. In addition to the above questionnaire, the students completed a 28-item questionnaire aimed at recording factors with a potential influence on vitamin D levels such as general health status, daily activity, weekly exercise, and weekly sunlight exposure.

The questionnaire also included questions about daily, weekly, or monthly consumption of vitamin D-containing foods such as dairy products, fortified orange juice, cereals, fish, eggs, and cod liver oil, as well as nutritional and multivitamin supplements.

They were also asked about the number of hours per week they spent outdoors with no sun protection factor, the number of body parts exposed to sunlight, outdoor sport activities practiced, and weekly hours spent on the beach. All subjects were asked about their use of sunlight protection during these activities.

A complete physical examination was performed on all students. Height and weight were measured and used to calculate the body mass index (BMI) of each subject. Blood was collected after a 12-hour fast and was immediately frozen at –80ºC. Biochemical parameters were measured using standardized tests.

Serum vitamin D levels were measured by immunochemiluminescence using the Nichols method (Nichols Institute Diagnostics, San Clemente, CA). This method has intra-assay and inter-assay coefficients of variation of 3.0%-4.5% and 7.1%-10.0% respectively. Normal laboratory values range from 10 to 68 ng/mL.

Serum intact parathormone (PTH) levels were measured by immunochemiluminescence using the Nichols Advantage method. Normal PTH levels range from 6 to 40 pg/mL, with an inter-assay coefficient of variation of 7.0%-9.2%. Amino-terminal propeptides of type I collagen and beta crosslaps in blood were measured using previously reported procedures[14,15]. All other biochemical parameters were measured using colorimetric procedures.

Bone mineral density

Bone mass was measured by dual X-ray absorptiometry (DXA) in both the lumbar spine (L2-L4) and the proximal femur with a Hologic Discovery densitometer (Hologic Inc. Waltham, USA). Precision was 0.75%-0.16%. Measurements were done by the same technician, and there was therefore no interobserver variation. Z and T-score values were calculated from normal values reported for the Canarian population[16].

Calcaneal ultrasound parameters

A calcaneal ultrasound examination was performed on all study participants. A Sahara ultrasound densitometer (Hologic®, Bedford, MA) was used. This system consists of two transducers coaxially mounted on a monitor. One transducer acts as a transmitter, and the other as a receptor. Transducers were adjusted to the calcaneus using pads on which an oily gel was applied. The ultrasonographic parameters measured by the Sahara device are broadband ultrasound attenuation (BUA) and speed of sound (SOS). The combination of BUA and SOS makes it possible to obtain a new parameter, called the consistency index or the quantitative ultrasound index (QUI), using the formula: QUI = 0.41*(BUA + SOS) – 571. Z and T-score values were calculated from normal values previously reported for the Spanish population[17].

Statistical analysis

Categorical variables were summarized as percentages and continuous variables as mean and standard deviation when data were normally distributed, or as medians with their interquartile ranges for non-normally distributed data. Percentages were compared using a Chi-square test, means using a Student's t test, and medians by a Wilcoxon test.

Results

Table 1 shows the baseline characteristics of the study population. Seventy percent of students were females. Mean age was similar in both groups. Height and weight values were higher in males, and BMI was therefore greater in them.

Table 2 shows the distribution of some lifestyles and risk factors for osteoporosis, as well as medical history data. 10.7% of students were left-handed, 6.5% of males and 12.5% of females, with no statistically significant difference in prevalence. Most students lived in urban areas, with no statistically significant difference between areas. Most students did not smoke (p = 0.901). Alcohol consumption was reported by 26.2% of all students, 35.5% of males, and 22.2% of females. A majority of students drinking coffee were females, with the difference being statistically significant.

Table 3 shows the results for lipids, kidney and liver function, TSH, and some other biochemical parameters. All of these parameters were within the normal range.

Table 4 shows the laboratory parameters related to mineral metabolism PTH, 25-hydroxyvitamin D, and biochemical markers of bone remodeling. Mean 25-HCC values were 27.9 ± 12.4 ng/mL (26.5 ± 10.1 ng/mL in males and 28.5 ± 13.3 ng/mL in females, p = 0.478). The values of all other parameters measured were within the normal range reported by our laboratory.

Table 5 shows BMD values measured in both the lumbar spine (L2-L4) and the proximal femur. No statistically significant differences were seen between males and females in the lumbar spine, but males showed significantly higher densitometric values in all anatomical sites of the proximal end of the femur.

Table 6 shows ultrasonographic parameters measured in calcaneus. There were no statistically significant differences between both sexes in any of the parameters tested: BUA, SOS, and QUI.

Finally, Table 7 shows the prevalence of vitamin D insufficiency and deficiency in the study population. 25-HCC levels were lower than 30 ng/mL in 48.3% of males and 26.1% of females, and lower than 20 ng/mL in 27.6% of

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Table 1 Baseline characteristics of the study population, mean ± standard deviation.

	All students	Male	Female	p value
Number (%)	103 ± 100	31 ± 30	72 ± 7	–
Age (years)	22.3 ± 3.5	22 ± 3.6	22.5 ± 3.4	0.477
Height (cm)	167.2 ± 8.1	174.8 ± 6.5	164 ± 6.4	0.001
Weight (kg)	64 ± 11	73.8 ± 10.7	58.7 ± 8	0.001
BMI (kg/m^2)	22 ± 2.6	23.5 ± 2.9	21.4 ± 2.2	0.001
Arm reach (cm)	166.4 ± 10.8	176.9 ± 7.3	161.6 ± 8.5	0.001

Table 2 Distribution of some lifestyles, risk factors for osteoporosis, and personal and family history.

	All students (%)	Male (%)	Female (%)	p value
Left-handed	10.7	6.5	12.5	0.317
Urban area	80.2	83.9	79.2	0.580
Smokers	2.9	3.2	2.8	0.901
Alcohol users[a]	26.2	35.5	22.2	0.160
Coffee drinkers	54.4	38.7	61.1	0.03
History of hip fracture in grandmother	12.6	16.1	11.1	0.482
Maternal history of hip fracture	0	0	0	NA
History of fracture in other relatives	5.8	0	8.3	NA
Personal history of fracture	22.3	22.6	22.2	0.968
Use of any drug	20.4	12.9	23.6	0.216

NA: not analyzed.
[a]All alcohol users only recognized drinking at weekends.

Table 3 Values of biochemical parameters, lipids, kidney and liver function, and TSH.

	All students	Male	Female	p value
Glucose (mg/(dL)	86.2 ± 5.7	87 ± 6	85.1 ± 5.7	0.136
Cholesterol (mg/(dL)	177.7 ± 35.4	163.1 ± 31.4	183.8 ± 35.4	0.006
HDL cholesterol (mg/(dL)	56.3 ± 13	46.7 ± 7.5	60.4 ± 12.7	0.001
LDL cholesterol (mg/(dL)	104.6 ± 27.1	99.7 ± 27.3	106.7 ± 23	0.241
Triglycerides (mg/(dL)	83.7 ± 37.6	85.2 ± 39	83 ± 37.2	0.792
Urea (mg/(dL)	26.6 ± 7.8	30.7 ± 9.7	24.9 ± 6.1	0.001
Creatinine (mg/(dL)	0.9 ± 0.1	1.1 ± 0.1	0.9 ± 0.1	0.001
Uric acid (mg/(dL)	4.4 ± 1.2	5.6 ± 1	3.9 ± 0.9	0.001
GOT (IU/L)	22.8 ± 7.7	20.8 ± 9.8	16.1 ± 6.4	0.006
GPT (IU/L)	17.5 ± 7.8	26 ± 9.8	21.4 ± 6.1	0.005
GGT (IU/L)	16.5 ± 6.3	20.7 ± 7.4	14.7 ± 4.8	0.001
TSH (IU/L)	1.8 ± 0.7	1.8 ± 0.8	1.8 ± 0.7	0.689

Table 4 Parameters of mineral metabolism and bone remodeling.

	All students	Male	Female	p value
Serum calcium (mg/dL)	10.1 ± 0.3	10.4 ± 0.3	10 ± 0.3	0.001
Serum phosphate (mg/dL)	3.6 ± 0.3	3.5 ± 0.3	3.7 ± 0.3	0.045
Total protein (g/L)	7.5 ± 0.5	7.6 ± 0.3	7.4 ± 0.6	0.03
PTH (pg/mL)	27.4 ± 10.8	24.2 ± 7.6	28.8 ± 11.6	0.049
25-HCC (ng/mL)	27.9 ± 12.4	26.5 ± 10.1	28.5 ± 13.3	0.478
Osteocalcin (ng/mL)	26 ± 8.7	29.2 ± 9.6	24.6 ± 7.9	0.015
PINP (g/L)	58.5 ± 23.2	65.5 ± 23.7	54.7 ± 22.1	0.011
TRAP (IU/L)	2.1 ± 0.3	2.2 ± 0.4	2 ± 0.3	0.048
Beta-crosslaps (ng/mL)	0.4 ± 0.2	0.6 ± 0.2	0.4 ± 0.1	0.001

25-HCC: 25-hydroxyvitamin D; TRAP: tartrate-resistant acid phosphatase; PINP: amino-terminal propeptide of type I collagen.

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Table 5 Values of bone mineral density measured in the lumbar spine (L2-L4) and the proximal femur.

DXA	All students (103)	Male (31)	Female (72)	p value
Lumbar spine (L2-L4) (g/cm^2)	1.026 ± 0.116	1.025 ± 0.999	1.026 ± 0.124	0.968
T-score		–0.1 ± 0.8	-0.1 ± 1.2	0.935
Femoral neck (g/cm^2)	0.886 ± 0.127	0.936 ± 0.124	0.863 ± 0.122	0.007
T-score		0.1 ± 1.1	0.2 ± 1.1	0.557
Total hip (g/cm^2)	0.988 ± 0.126	1.053 ± 0.115	0.959 ± 0.121	0.001
T-score		0.2 ± 0.8	0.4 ± 1.2	0.223
Trochanteric (g/cm^2)	0.743 ± 0.104	0.789 ± 0.960	0.722 ± 0.101	0.003
T-score		0.1 ± 0.8	0.4 ± 1.2	0.189
Intertrochanteric (g/cm^2)	1.138 ± 0.151	1.213 ± 0.134	1.104 ± 0.147	0.001
T-score		0.1 ± 0.8	0.4 ± 1.3	0.218

Table 6 Calcaneal ultrasound measurements.

QUS	All students	Male	Female	p value
BUA (dB/MHz)	76.8 (13.7)	80.3 (12.8)	75.1 (14)	0.084
T-score		–0.2 ± 0.7	–0.2 ± 0.9	0.733
SOS (m/s)	1.561.8 (24.5)	1.560.4 (25.7)	1.562.5 (24.1)	0.692
T-score		–0.2 ± 0.8	–0.1 ± 0.8	0.529
QUI	102.7 (18)	102.8 (15.7)	102.6 (19.1)	0.960
T-score		–0.1 ± 0.8	–0.1 ± 1	0.514

Table 7 Prevalence of vitamin D insufficiency and deficiency (%).

	All students	Male	Female	p value
Deficiency (25-HCC < 30 ng/dL)	32.6	48.3	26.1	0.048
Insufficiency (25-HCC < 20 ng/dL)	28.6	27.6	29	0.927
Combined deficiency and insufficiency	61.2	75.9	55.1	0.081
Optimum values (> 30 ng/mL)	38.8	24.1	44.9	0.081

males and 29% of females. Overall, 75.9% of males and 55.1% of females had vitamin D insufficiency or deficiency, i.e. only 24.1% of males and 44.9% of females had 25-HCC values higher than 30 ng/mL.

Discussion

Under normal conditions, vitamin D is synthesized in the skin, which converts 7-dihydrocholesterol into previtamin D3, which is rapidly converted into vitamin D3. Vitamin D from skin and diet is metabolized in the liver to 25-HCC, which is the metabolite used to assess vitamin D status in the body[18,19].

Although no agreement exists as to the optimum levels of 25-HCC, it is currently accepted that vitamin D deficiency exists when 25-HCC levels are less than 20 mg/mL[20], while 25-HCC levels less than 30 ng/mL are considered indicative of vitamin D insufficiency[3,21].

People living near the equator exposed to sunlight without protection usually have high 25-HCC levels, greater than 30 ng/mL[3]. However, even in sunnier areas, vitamin D deficiency is a common finding, because skin exposure to sunlight is usually avoided. Studies conducted in Saudi Arabia, the United Arab Emirates, Australia, India, and Lebanon found that 30%-50% of children and adults have 25-HCC levels lower than 20 ng/mL[22-25].

Vitamin D deficiency is considered as a true pandemic. Its main cause is unawareness that exposure to sunlight is the main source of vitamin D for most human beings[11]. The main consequences of vitamin D deficiency include osteoporosis, osteomalacia, some autoimmune diseases, cardiovascular diseases, infectious diseases, and some cancers[3,4,11].

Surprisingly, vitamin D deficiency is usually found in countries with plenty of sunshine, such as India or the United Arab Emirates. This paradox may be explained by little outdoor activity in urban areas[26], dark skin, the wearing of clothes limiting skin exposure to sunlight[27], a calcium-poor diet that would lead to a secondary calcium deficiency[27,28], or environmental contamination[29].

This same phenomenon occurs in Spain, a country with many hours of sunshine throughout the year, but in which

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high rates of hypovitaminosis D are found both in the healthy population[30] and in patients with different diseases[31,32].

The Canary Islands are geographically located near Africa, between 27° 37' and 29° 25' North latitude and between 13° 20' and 18° 10' West longitude, and are the southernmost part of Spanish territory. This study was conducted on young, healthy medical students who understand vitamin D physiology and the need for sunlight exposure for its synthesis.

Few studies have been published about vitamin D levels in the Canary Islands. A study conducted on institutionalized elderly patients reported 25-HCC levels of 20 ng/mL[33]. Our results were compared to those reported by studies in populations of potentially similar characteristics (young, healthy people), such as a study of young surfers conducted in Hawaii which showed a high prevalence of vitamin D insufficiency. Mean 25-HCC level was 31.6 ng/mL, but if the cut-off point was set at 309 ng/mL, up to 51% of this population had low vitamin D levels[34], a proportion similar to that found in our study.

Some studies conducted on physicians and medical students were found in the literature. Thus, 25-HCC levels were tested in a group of 116 Spanish resident intern physicians (RIPs) in the physical examination performed at the start of their residency period. Mean 25-HCC levels were 24.5 ± 6.9 ng/mL, and up to 83.6% of these physicians had values lower than 30 ng/mL[35]. In another study conducted on 35 internal medicine RIPs, 51.4% showed 25-HCC levels lower than 20 ng/mL[35]. In our study, 28.6% of students had 25-HCC levels under 20 ng/mL, the cut-off value for vitamin D deficiency, and 32.6% showed values lower than 30 ng/mL, which is the limit for vitamin D insufficiency. No statistically significant gender differences were found regarding vitamin D levels or the prevalence of vitamin D insufficiency and deficiency.

A comparison of the results given in Table 1 showed higher height and weight values, and thus greater BMI, in males as compared to females of a similar age. This was to be expected, and requires no further comment. No statistically significant differences were seen either in the distribution of lifestyles, risk factors for osteoporosis, and personal and family history, as shown in Table 2, except for a greater coffee consumption by female students. While some studies suggest a negative correlation between caffeine consumption and BMD values[36], we think that no such relationship exists with regard to vitamin D levels. The study population was homogeneous as regards the distribution of lifestyles. Results given in Table 3 and Table 4 for general biochemical parameters (kidney and liver function, lipids, glucose, etc.), biochemical markers of bone remodeling, and calciotropic hormones (PTH, osteocalcin, TRAP, PINP, and beta-crosslaps) show statistically significant differences. These differences were not clinically relevant, because the values recorded in both groups were within the normal range for each of the laboratory parameters. It could therefore be inferred that the study population was normal and had no pathology that could interfere in any way with the results. In our view, the BMD values obtained by both DXA and ultrasound examination and shown in Table 5 and Table 6 should be similarly interpreted.

In conclusion, this study reports a high prevalence of hypovitaminosis D among medical students despite their understanding of vitamin D physiology and requirements and the fact that they live in an area with plenty of hours of sunshine. This leads us to ask three questions: first, what is the use of having adequate hours of sunshine for synthesizing vitamin D if no advantage is taken of them? Second, given our current lifestyles, with long periods inside buildings and wearing our Western clothes, can we synthesize all the vitamin D we need? Finally, based on the foregoing, should we not consider supplementing some foods with vitamin D? Further studies in this field are needed to answer these questions.

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