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Levels of Vitamin D and the Association with Body Composition in Adolescents

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Abstract

Objective: To determine the levels of vitamin D in adolescents and its association with body composition.

Methods: We assessed 198 adolescents (53% girls) between 12 to 17 years-old. Evaluations were performed in autumn; at 25°25′S 49°15′W. Vitamin D was measured by ECLIA for the determination of 25-hydroxyvitamin D3. Anthropometrics measures were obtained BMI, waist circumference and percentage of body fat by skin folds.

Results: 70.9% of the adolescents were vitamin D-deficient and 24.5% were vitamin D-insufficient. Patients with severe vitamin D-deficient (<10 ng/ml) had significantly higher BMI and body fat. Vitamin D deficiency was associated with an increased risk of BMI>25 kg/m^2 (OR 10.9) and high body fat (OR 11.9).

Conclusion: Only 5% of our healthy adolescents had normal levels of vitamin D. Individuals with lower serum 25-hydroxyvitamin D3 showed higher values of BMI and body fat. We suggest a focus on replacement of vitamin D in healthy adolescents.

Keywords: Vitamin D; Prevalence; Adolescent body composition

Introduction

Vitamin D is a steroid hormone, essential for calcium and bone mineral metabolism. The main source of vitamin D is the epidermis, where 7-dehidrocholesterol is converted to cholecalciferol by ultraviolet B rays. In the liver, cholecalciferol is metabolized into 25-hydroxyvitamin D. The metabolically active form, 1.25 dihydroxyvitamin D, is synthesized in the kidneys. Food intake is a poor source of vitamin D, except for selected sources, such as oily fish, egg yolk and shiitake mushrooms [1].

Due to sedentary lifestyles, children and adolescents are at risk for presenting vitamin D deficiency. In this population, low levels of vitamin D are a risk factor for delayed growth and development [2]. Amongst Hispanic and African-American teenagers from Boston, approximately 52% have vitamin D levels lower than 20 ng/ml [3]. Similar results were seen in Caucasian girls, with a 48% prevalence of vitamin D insufficiency [4].

Sun exposure varies according to the season and latitude. Populations who live near the Equator line are generally more exposed to the sun, and present vitamin D levels higher than 30 ng/ml [5]. However, vitamin D deficiency can be also observed in those areas, with prevalences ranging between 30 to 50% in children and young adults from Saudi Arabia, Lebanon, Arab Emirates and India [6,7].

Since cholecalciferol is stored in the adipose tissue and is recruited during periods of low sun exposure, excess body fat may play a positive role on the regulation of vitamin D levels. However, the recruitment of cholecalciferol into the active form of vitamin D is impaired in severe obesity [1], as observed in a study that showed that obese individuals have 50% less active vitamin D, as compared to their lean counterparts [8].

Taking into account the concomitantly high prevalences of vitamin D deficiency and obesity worldwide, we aimed in this study at determining the vitamin D levels in adolescents, and at correlating those levels with their nutritional status.

Material and Methods

Patients

This is an observational, cross-sectional study evaluating adolescents from a public school in Curitiba, Brazil (25°25′S 49°15′W). In 2008, 834 students were enrolled at that school, of which 202 were recruited to the study aleatore (CI 95%, type I error 15%, 20% addition to account for possible losses to follow-up) [9]. Were excluded from the study participants with pre-existing diseases such as diabetes mellitus, rheumatologycal diseases, hyperthyroidism, malignancies, asthma, chronic diarrhea and osteo-metabolic diseases. Four students decided not participate in the study, and a total of 198 adolescents (53% females, 47% males) were included in the final analysis.

Informed consent was obtained from all patients and their parents. This study was approved by the Hospital de Clinicas – Universidade Federal do Parana, Curitiba, Brazil.

Methods

Assessments were conducted on the same morning, during the month of April (autumn). General data on the participants' lifestyle was obtained, and arterial blood pressure was measured after 15 minutes at a sitting position. Body anthropometrics were obtained from all participants, consisting of weight, height, Body Mass Index

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	Height (cm)	Weight (kg)	BMI (kg/m²)	WC (cm)	Body fat (%)
Girls	1.57±0.8	52.71±12.87	21.16±4.41	66.36± 8.50	30.39±10.07
Boys	1.62±0.12	53.93±13.38	20.28±3.55	68.98± 9.58	21.64±7.49

Table 1: Body anthropometrics variables in among boys and girls.

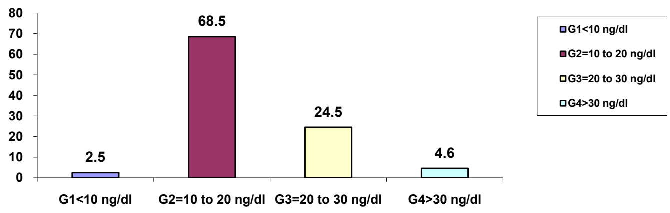

Figure 1: Distribution of vitamin D levels according to Holick et al (2007).

(BMI), Waist Circumference (WC, measured at the midpoint between the upper iliac crest and the lower rib), total fat mass and total lean mass (by measuring the skin folds at the trycipital and at the medial leg areas, and by using the Slaughter equation). [10,11]. According to the measured BMI, and based on age and gender-matched reference tables [12], patients were categorized as eutrophyc (BMI ≥ 5th and < 85th percentile), overweight (BMI ≥ 85th).

Blood was drawn while fasting and stored at -20ºCelsius for batch analysis of 25-hydroxyvitamin D3 (25OHD, ECLIA immunoassay, coefficient of variation 4.9%). Participants were categorized into 4 groups, according to their vitamin D levels. [13] Group 1: severe vitamin D deficiency (< 10 ng/dl); Group 2: vitamin D deficiency (10 – 20 ng/dl); Group 3: vitamin D insufficiency (20 to 30 ng/dl); and vitamin D sufficiency (> 30 ng/dl).

Statistical analysis

Statistical analyses were performed with the SPSS 13.0 software (Chicago, USA). Data were presented as frequency and mean ± standard deviation. Group comparisons were undertaken by one-way ANOVA and Tukey test. Correlation analyses were performed by Pearson correlation test and logistical regression analysis, with 95% of confidence interval. Significance level was set at 0.05.

Results

Data regarding body anthropometrics variables are presented in Table 1.

Low levels of vitamin D were observed in 95.4% of the participants. Among those, 70.9% were vitamin D-deficient and 24.5% were vitamin D-insufficient. One percent of the boys and 4% of the girls had vitamin D deficiency. Only 4.6% of the subjects had normal levels of vitamin D (Figure 1).

The mean level of vitamin D was 18.16±6.66 ng/dl. Table 2 illustrates the median and range values in each vitamin D group.

No differences were observed among the groups, regarding age and WC. Participants with severe vitamin D deficiency presented higher BMI and total body fat (Table 3).

Participants with greater BMI and total body fat were at a 11-fold higher risk of having severe vitamin D deficiency (Table 4).

Discussion

Ricketts and osteomalacia were practicaly eradicated in the 19th century due to early diagnosis and vitamin D replacement. However, hypovitaminosis D has been increasingly reported in several populations. In this study, we report a high prevalence – 70.9% - of vitamin D deficiency among healthy adolescents in a subtropical region of the Southern hemisphere (25°S). This high prevalence is similar to that of new-borns evaluated during winter and exclusively breast-fed [14], and of a German young population from 6 to 21 years-old, among which 61.8% of the boys and 63.4% of the girls were vitamin D deficient [15]. A lower prevalence of vitamin D deficiency was reported among an American population (26%) [16].

In addition to a high prevalence of vitamin D deficiency, approximately 25% of the participants were vitamin D insufficient. Only 4.6% of the participants had normal levels of vitamin D, a consistently lower prevalence in comparison to the 10.8% prevalence reported in children and adolescents from Iran [17].

Vitamin D is endogenously produced in the epidermis and stored in the adipose tissue for long periods. The daily requirements of vitamin D are determined by the calcium and phosphorus intake, age, sex, skin pigmentation and sun exposure [18]. Our participants are from Curitiba, located at 25°S. This might lead to low sun exposure, explaining the low levels of vitamin. This hypothesis is strengthened by the evidence that children and adolescents living in regions closer to the Equator do not suffer from vitamin D deficiency [19].

Although sun exposure plays a major role in the regulation of the homeostasis of vitamin D, food intake may also provide up to 20% of the daily requirements of vitamin D. Food intake can become the main source of vitamin D for patients with low sun exposure [20,21]. The western diet is generally a poor source of vitamin D, particularly in countries where vitamin D supplementation is not customary, such as Brazil. Therefore, we believe that the low levels of vitamin D in our study are attributed to a combination of both low sun exposure and low intake of vitamin D. However, we did not evaluate food intake in this study [22].

Obesity is associated with low levels of 25OHD in adults [23], as well as in children and adolescents [24]. In our study, we observed that

Group	Vitamin D (ng/ml)
G1 < 10 ng/dl - severe deficiency	9.12 (7.70 – 9.80)
G2 = 10 to 20 ng/dl – deficiency	15.10 (10.10 – 19.80)
G3 = 20 to 30 ng/dl – insufficiency	23.72 (20.20 - 30)
G4 = > 30 ng/dl – sufficiency	38.90 (30.80 – 51.30)

Data are presented as median (minimum – maximum)

Table 2: Vitamin D levels within each group according to Holick et al (2007).

	G1(n=5)	G2 (n= 134)	G3 (n=48)	G4 (n=9)
Age (years)	13.51±3.19	14.27±2.25	14.48±2.25	14.65±1.79
BMI (kg/m²)	26.36±5.25*	20.56±4.07	20.51±3.67	21.61±2.87
WC (cm)	76.04±14.59	67.63±9.45	66.46±7.76	68.58±4.81
Body fat (%)	40.82±14.59*	25.84±9.68	26.35±9.29	23.43±9.47

* p<0.05 (ANOVA)

Table 3: Body mass index, waist circumference and total body fat among the groups.

	Severe vitamin D deficiency
BMI eutrophic	1
BMI (overweight)	11.92 (1.30 – 109.24)
Body fat (< 30%)	1
Body fat (> 30%)	10.98 (1.19 –100.59)

Odds ratio (CI - 95%)

Table 4: Association between vitamin D deficiency and body composition.

participants with sever vitamin D deficiency presented significantly higher BMI, in concordance with studies showing that overweight and obese children and adolescents have lower levels of 25OHD [25,26]. Another study showed that a 1-percent increase in body fat is associated with a mean decrease of 0.46 ng/ml in 25OHD [27]. If we extrapolate that finding to our study, we observe that in group 1, the 15-percent higher amount of body fat may represent a 6.9 ng/ml decrease in vitamin D. This may be explained by the fact that a higher amount of body fat impairs the recruitment of stored cholecalciferol. In addition, overweight and obese individuals may be subject to less sun exposure and, consequently, low levels of vitamin D [16].

Future studies must evaluate the associations between vitamin D and body composition in children and adolescents, as well as analyze the effects of other factors, such as age, race, physical activity and dietary intake. Low levels of vitamin D may impair growth and predispose to diseases such as cancer, diabetes and immune defects [28,29].

In conclusion, we found low levels of vitamin D in 95% of the evaluated adolescents. Patients with the lowest levels of vitamin D presented higher BMI and body fat. The implementation of dietary supplementation, nutritional intervention and the promotion of outdoor physical activities are essential for maintaining a healthy weight and for avoiding vitamin D deficiency in this population.

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