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ORIGINAL ARTICLE

Correlation between vitamin D serum levels and BMI of children and adolescents seen at a university outpatient clinic

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Vitamin D,
Obesity,
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Abstract

Objective: To evaluate the correlation between BMI indices and serum vitamin D levels in children and adolescents. **Methods:** Survey of BMI values and serum vitamin D levels of patients aged between one and 16 years, from April 2017 to November 2020, treated at a university hospital. **Results:** The statistical association between BMI classification and serum vitamin D level by Fishers exact test was p= 0,053, a value very close to the limit of significance. Thus, there was a borderline correlation between obesity and hypovitaminosis D. **Conclusions:** The causal relationship between excess fat and low seeric vitamin D is still not well understood. It is questioned whether reduced serum vitamin D levels function as a direct or indirect cause or consequence of increased BMI. Routine screening of levels of this vitamin in patients with excess body fat is considered relevant, due to its multisystemic and multifunctional role, in addition to the important need for supplementation in patients with its deficiency.

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INTRODUCTION

Vitamin D is a fat-soluble pro-hormone with functions extending beyond those of vitamins. It has a role in calcium homeostasis, phosphorus metabolism, immune response, insulin secretion, skeletal muscle function, adipocytes, neoplastic processes, and cardiovascular disease. Vitamin D insufficiency has been related to the development of Type 1 Diabetes, hypertension, multiple sclerosis, rheumatoid arthritis and other autoimmune diseases, and breast, colon and prostate cancer[1-4].

Such variety of functions means vitamin D levels must remain within physiological levels so that it can contribute to healthy growth, development, and metabolism[5]. Vitamin D is found in the body in two forms: ergocalciferol or vitamin D2, and cholecalciferol or vitamin D3[2,3]. It is synthesized from extrinsic and intrinsic biologically equivalent factors[6].

The intrinsic production of vitamin D starts in the epidermis with the activation of the compound 7-dehydrocholesterol by ultraviolet B rays, converting it to cholecalciferol. Cholecalciferol produced in the skin is absorbed by capillary vessels in the dermis and reaches the bloodstream[2]. This synthesis pathway accounts for 80 to 90% of all vitamin D in the body[4]. If there is excessive exposure to sunlight, 7-dehydrocholesterol is converted into inactive metabolites, which prevent vitamin D toxicity[2].

Diet and supplementation are considered extrinsic factors in vitamin D intake[5]. Dietary sources of cholecalciferol include fatty fish such as tuna, sardines, dogfish, and salmon, and other foods including egg yolks, and cod liver oil. However, the main source of ergosterol is edible fungi, which are absorbed in the duodenum and jejunum. Cholecalciferol and ergosterol are transported in the bloodstream by vitamin D-binding protein. Hydroxylation of carbon 25 in vitamins D2 and D3 occurs in the liver, and calcifediol (25-OH-vitamin D) is formed. DBP-bound calcifediol is transported primarily to the kidneys, where 1-α-hydroxylation into the active form of vitamin D, known as calcitriol (1,25-dihydroxycholecalciferol), takes place[2,3,7]. Although calcitriol is the active form of vitamin D, calcifediol is the predominant circulating form of the vitamin and deemed the best indicator of its serum levels in an individual[8].

An estimated one billion people worldwide have vitamin D deficiency, making it a major public health issue[9,10]. Vitamin D deficiency has been linked to factors such as insufficient exposure to sunlight, prolonged use of clothing covering the whole body, excessive use of sunscreen, age (infants between 0 and 12 months and adolescents between 9 and 18 years), and low intake of foods containing ergocalciferol[11].

This study assessed the correlation between BMI and vitamin D serum levels in children and adolescents seen at a university hospital in the city of Uberaba-MG, Brazil.

METHODS

The electronic medical records of patients aged one to 16 years seen at the pediatrics and nutritional disorder clinics of the hospital of the Federal University of Triângulo Mineiro between April 2017 and November 2020 were analyzed for BMI and serum vitamin D levels.

Levels of 25-hydroxyvitamin D were described as sufficient when between 30 and 100 ng/mL, insufficient when between 20 and 30 ng/mL, deficient when below 20 ng/mL, and toxic when greater than 100 ng/mL[12]. BMI values were described according to the z-score, as recommended by the Ministry of Health and the Brazilian Society of Pediatrics.

Fisher's exact test was used to evaluate the potential associations between gender and serum vitamin D levels, gender and BMI, and BMI and serum vitamin D levels. Significance was attributed to associations with a p-value <0.05.

RESULTS

The Research Ethics Committee of the Federal University of Triângulo Mineiro approved the study and granted it certificate no. 3.324.906. The medical records of 216 patients were reviewed in this study. Of these, 104 belonged to females (48.1%) and 112 to males (51.9%). In terms of the BMI, 41 individuals were eutrophic (19%), four were at risk of becoming overweight (1.9%), 22 were overweight (10.2%), 87 were obese (40.3%), and 62 were severely obese (28.7%) (figure 1).

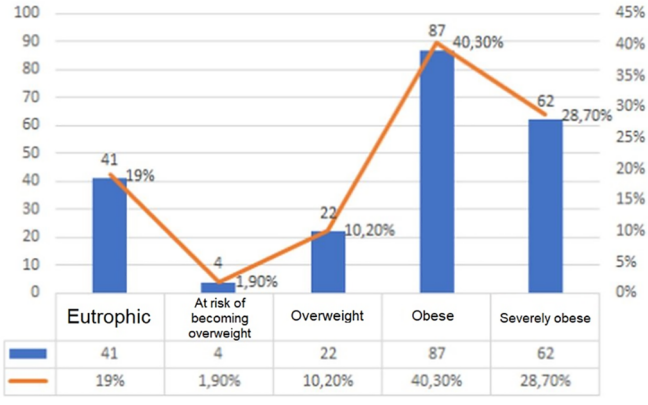


Figure 1. BMI categories of the study population.

Evaluation of serum vitamin D levels found that 20 had hypovitaminosis D (9.3%), 86 had insufficient vitamin D levels (39.8%), and 110 had sufficient vitamin D levels (50.9%) (figure 2).

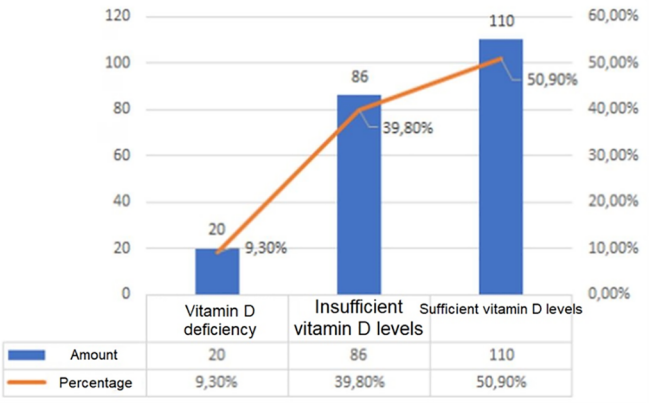


Figure 2. Vitamin D levels of the study population.

The analysis of the correlation between sex and serum vitamin D levels yielded a p-value of 0.76 based on Fisher's exact test. Considering that a significant association occurs when $p<0.05$, one may infer that the sex of the individuals in this age group did not affect vitamin D levels (table 1).

Table 1. Diagnosis X Sex.

		Female	Male	Total
Vitamin D diagnosis	Vitamin D deficiency	8	12	20
	Vitamin D insufficiency	42	44	86
	Sufficient	54	56	110
Total		104	112	210

No correlation was found between BMI and sex. A p-value of 0.35 was calculated with Fisher's exact tes (table 2) .

Table 2. BMI x Sex.

		Female	Male	Total
BMI	Eutrophic	22	19	41
	At risk of becoming overweight	2	2	4
	Overweight	12	10	22
	Obesity	45	42	87
	Severely obese	23	39	62
Total		104	112	216

A borderline significant association ($p=0.053$) was observed in the analysis of the two key variables considered in this study, the BMI and vitamin D levels.

DISCUSSION

Prophylactic vitamin D is currently recommended from the first week of life until two years of age, since individuals within this age range are at increased risk of vitamin D deficiency due to accelerated skeletal growth. Therefore, supplementation with 400 IU/day is recommended for infants under one year of age, and 600 IU/day for children aged between one and two years and individuals at risk of developing vitamin D deficiency[2].

Research based on epidemiological, genetic and metabolic data has shown that vitamin D correlates with obesity [13], with obese individuals presenting lower serum levels of vitamin D compared to eutrophic individuals[12]. The normal range for vitamin D levels include cholecalciferol above 30 ng/ml and levels associated with increased intestinal calcium absorption between 45 and 60%. Vitamin D insufficiency lies in the range between 20 and 29.9 ng/ml; deficiency includes levels below 20 ng/ml[1,15].

Obese individuals have lower serum vitamin D levels compared to eutrophic ones[12,16]. Proportions of vitamin D deficiency in eutrophic, overweight, obese, and severely obese individuals were 21%, 29%, 34%, and 49%, respectively[16].

A study including 1,480 Danish children and adolescents found vitamin D deficiency in 16.5% of obese individuals, in 7.7% of overweight subjects, and in 4.8% of eutrophic ones.[6] In another study enrolling 205 Korean children aged between seven and nine years, vitamin D levels were inversely correlated with the BMI[17]. The prevalence of vitamin D insufficiency in children and adolescents in the United States is estimated to be 78.4%, versus 96% in Germany and 92% in Russia[4].

The relationship between vitamin D deficiency and obesity has been widely studied. Different explanations have been proposed for the correlation between vitamin D deficiency and different levels of overweight and obesity. Adipocytes act as a depot for the storage and release of vitamin D, which is soluble in fat. They accumulate vitamin D proportionally to their concentration in serum and release it much more slowly when they are present in larger amounts. Vitamin D is retained in adipocytes, impairing its bioavailability and biological activity[18].

Some have considered a possible relationship between low calcium intake and obesity due to increased serum calcitriol levels stimulating calcium flow from adipocytes through vitamin D membrane receptors. This increase in intracellular calcium inhibits the expression of hormone-sensitive lipase, resulting in lipogenesis and inhibition of lipolysis and a consequent accumulation of body fat. Calcitriol also inhibits the expression of uncoupling protein-2, involved in the regulation of metabolism, food thermogenesis, and body weight control via vitamin D receptors in adipose tissue[19].

A study including 796 children under 10 years of age described an association between weight gain and the FTO gene, postulating that vitamin D modifies the effects of this gene, by mechanisms not yet clarified[20].

Obese patients who exercise outdoors are apparently at lower risk of developing vitamin D deficiency, which supports the idea that increased exposure to sunlight improves the endogenous synthesis of vitamin D[16,21].

Table 3. Vitamin D levels vs. BMI categories.

Vitamin D levels	BMI			Total
	Eutrophic	Risk of becoming overweight	Obese Severely obese	
Deficient	0	0 2	13 5	20
Insufficient	12	1 11	36 26	86
Sufficient	29	3 9	38 31	110
Total	41	4 22	87 62	216

The correlation between vitamin D deficiency and different levels of overweight and obesity among children and adolescents is still not well defined. Several authors have demonstrated an inverse correlation between the two, as well as an increased risk for deficiency among obese versus non-obese individuals. Several hypotheses have been proposed, but none establish a clear causal link between the mechanisms involved in the correlation.

It has been inferred that the low levels of vitamin D seen in the patients included in our study may be related to sedentarism and inadequate eating habits. Sedentary individuals have a predilection for indoor activities, such as using computers and playing video games, with little involvement with sports and outdoor activities with exposure to sunlight, which hinders the endogenous synthesis of vitamin D.

In addition to having a sedentary lifestyle and spending most of the time indoors, some overweight individuals tend to develop poor eating habits in terms of the quantity and quality of the foods they eat, not to sit at the table during meals, and not to chew food properly. They tend to eat larger amounts of fast, ready-made, processed, ultra-processed, and industrialized foods rich in carbohydrates, hydrogenated fats, and sugar, and poor in macro and micronutrients. Thus, they are more prone to gaining weight and developing excess adipose tissue. The literature lacks studies about the adequate levels of vitamin D intake needed to prevent non-communicable chronic diseases, including obesity.

The present study did not consider the season of the year in the evaluation of vitamin D serum levels, since the population lived in a tropical region, where UVB levels are high and exposure to sunlight occurs all year round.

Considering the significance level of $p<0.05$, a borderline correlation was observed between obesity and hypovitaminosis D. Low vitamin D levels may impair weight control and the metabolism of obese individuals. A causal link between overweight and vitamin D deficiency or insufficiency has not been clearly established, leaving doubt as to whether low vitamin D serum levels are a direct or indirect cause or consequence of BMI increases.

This study did not find a relationship between obesity and hypovitaminosis D, but since the results were very close to a significant correlation based on Fisher's exact test, we believe it is important to routinely screen overweight patients for vitamin D levels, in order to identify individuals who might need early treatment to safeguard the diverse roles vitamin D has in the homeostasis of the human body.

The data from this study should be extrapolated to the general population and analyzed with a larger population, since the statistical result may have been influenced by the limited size of the study's population. Further studies must be carried out in order to better understand this relationship, the main factors involved, and daily vitamin D needs met through diet and supplementation.

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