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## Short Communication

# Sedentary behavior is associated with lower serum concentrations of vitamin D in Brazilian children



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## ARTICLE INFO

## Article history:

Received 11 January 2017

Received in revised form

12 July 2017

Accepted 23 July 2017

Available online 29 August 2017

## Keywords:

Vitamin D

25(OH)D

Child

Sedentary lifestyle

## Introduction

Vitamin D is treated as a hormone responsible for the homeostasis of calcium and phosphorus, contributing to adequate bone formation.<sup>1</sup> Currently, vitamin D deficiency has been considered as a worldwide public health problem and is related to decreased dietary calcium absorption directly influencing bone mineralization and, more recently, to extraskeletal diseases such as some types of cancer, type 2 diabetes mellitus, autoimmune diseases, metabolic syndrome, hypertension, and infectious diseases.<sup>1,2</sup>

The major source of vitamin D is the endogenous cutaneous synthesis from sunlight, around 90%, but it can also be obtained from dietary sources such as cod liver oil and fatty fish (salmon, tuna, sardines, mackerel), fortified foods, and in small quantity in milk and eggs.<sup>2</sup>

In countries located between the tropics, such as Brazil, where there is a greater incidence of sunlight, a lower prevalence of hypovitaminosis D is expected. However, studies have found a high prevalence of vitamin D insufficiency in the Brazilian population.<sup>3</sup>

Developed and developing countries are currently facing an unrecognized and untreated public health problem of vitamin D deficiency.<sup>4,5</sup> Several studies have reported a high prevalence of vitamin D deficiency in healthy children associated with the lowest socio-economic status, younger age group, female sex, limited sunshine exposure, and no vitamin D supplementation; on the other hand, opposite results found no relationship between vitamin D and sex, sunshine exposure, or nutritional status.<sup>5–7</sup> Studies assessing the serum concentration of vitamin D in prepubertal children and its relationship with behavioral and sociodemographic factors are scarce in Brazil. In view of its potential impact on children's growth and adverse health conditions, it is important to identify modifiable risk factors associated with this deficiency in order to promote greater surveillance of professionals in prevention and treatment. Given the above, this study aimed to assess serum concentrations of vitamin D and behavioral and sociodemographic factors associated in Brazilian prepubertal children. This would enable the identification of

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<http://dx.doi.org/10.1016/j.puhe.2017.07.021>

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barriers to guide future campaigns for the prevention of hypovitaminosis D.

Participants in this study were from the Educational Health Assessment Research, a representative study, with children aged between 8 and 9 years enrolled in urban schools in Viçosa, Minas Gerais, Brazil. In 2015, the city had 24 urban schools (17 public and 7 private) that served children aged between 8 and 9 years old, totaling 1464 children. The sample calculation was performed using the software Epi Info 7.2.1 considering the analysis of multiple outcomes with prevalence of 50%, tolerated error of 5%, 95% of confidence interval, significance level of 5%, and estimated loss and confounder factors of 20%, resulting in the calculation of 366 children. Children were included by random selection. This study was approved by the Ethics Committee on Human Research of the Federal University of Viçosa (protocol number 663171/2014).

A semistructured questionnaire was applied to parents or guardians to assess the socio-economic and demographic variables such as sex, skin color, maternal education, total and per capita income.

Based on the child's life habits, physical exercise was considered as regular physical activity when outside of school and at least once a week and sedentary behavior was defined as activities that do not increase energy expenditure substantially above rest, such as sitting, watching television, or engaging in other forms of screen-based entertainment.<sup>8</sup>

With the help of the parents, the average time of daily sun exposure was assessed including outdoor leisure time and walking in the sun in addition to the habit of using sunscreen by children.

Dietary intake was assessed by three 24-hour recalls, obtained in non-consecutive days with one on the weekend, which were quantified in software Diet Pro 5i.

Measurement of calcidiol [25(OH)D] (Architect®) and parathyroid hormone (Access® Intact) was performed by chemiluminescence. 25(OH)D was determined by the Architect® 25-OH vitamin D assay which was developed to have correlation coefficient  $\geq 0.80$  for serum samples when compared with LIAISON® DiaSorin 25-OH vitamin D total

assay. The Architect 25-OH vitamin D assay has been developed to have an imprecision of  $\leq 10\%$  within laboratory total CV. Serum vitamin D levels were classified as deficient calcidiol ( $<20$  ng/mL), insufficiency ( $20\text{--}29$  ng/mL), and sufficiency ( $\geq 30$  ng/mL).<sup>9</sup>

Multiple linear regression analysis was performed to assess the effect of independent variables in serum concentration of vitamin D. The criteria defined for the inclusion of variables in multiple linear regression was the association with the dependent variable in simple linear regression analysis, considering a value of  $P < 0.20$ . The final model was adjusted by intake of vitamin D, sex, and parathyroid hormone.

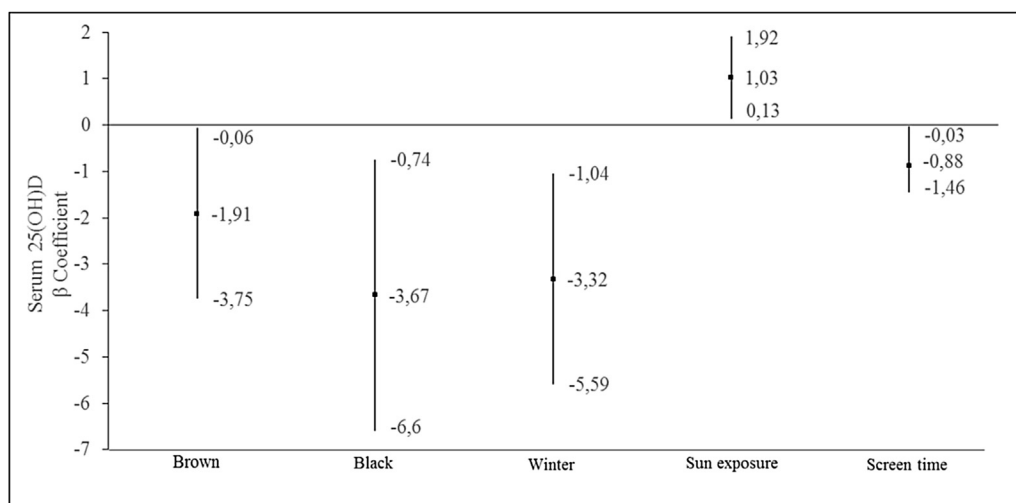
### Factors associated with vitamin D concentration

More than half of the Brazilian children had insufficiency/deficiency of vitamin D (56.3%). The mean serum concentration of vitamin D in children was classified as insufficient (29.3 ng/mL), with 12.8% deficient and 43.5% insufficient. The prevalence of insufficiency/deficiency was 52.2% in boys and 62.2% in girls ( $P = 0.05$ ).

The boys had a higher frequency of regular physical activity ( $P = 0.011$ ) and screen time higher than 2 hours/day ( $P = 0.026$ ). Girls had higher frequency of low sun exposure ( $\leq 30$  minutes/day) ( $P = 0.012$ ). There was no difference between the sexes regarding the habit of using sunscreen. The girls had higher serum concentrations of parathyroid hormone ( $P = 0.008$ ), and there was no difference in serum vitamin D concentration between the sexes ( $P = 0.131$ ).

After adjusting for confounders in the multiple regression analysis, low sun exposure, darker skin color, the season (winter), and the highest screen time have been associated with lower vitamin D serum concentrations (Fig. 1).

Exposure of the skin to sunlight is an important source of vitamin D that is influenced by the seasons which cause fluctuations in the incidence of ultraviolet B (UVB) radiation, needed to skin synthesis of vitamin D.<sup>10</sup> Amount of UVB



**Fig. 1** – Multiple linear regression model for predictors of serum concentration 25(OH)D in children in Viçosa, Minas Gerais, Brazil, 2015 Model adjusted by vitamin D intake, sex, and parathyroid hormone.

radiation also varies depending on the latitude and time of day, with significant variation in the incidence of UVB radiation in middle latitudes according to the season.<sup>11</sup>

Additionally, skin pigmentation can also modify the synthesis of vitamin D, so that the dark-skinned children usually require more sun exposure compared with the white skin ones to produce the same amount of vitamin D.<sup>10</sup> This is due to melanin, greater in black race, which competes for the UVB radiation needed to fragmentation of the 7-dehydrocholesterol, precursor of 25(OH)D, decreasing the availability of photons to this reaction. It is important to highlight that all ethnic groups have the same capacity for synthesis of 25(OH)D, whereas individuals with darker skin need more sun exposure time for this synthesis.<sup>10</sup>

The highest screen time and shortest time of sun exposure were the behavioral factors associated with lower serum concentrations of vitamin D. The current behavioral, social, and cultural changes favor sedentary behavior, limiting physical activity especially outdoors and consequently to sun exposure. Recommendations for the promotion of cardiovascular health in children and adolescents include active play and limiting the screen time of children seeking to reduce sedentary behavior.<sup>12</sup> In this study, most of the children (66.1%) did not practice any type of regular physical activity, which contributes to a sedentary behavior and consequently to lower sun exposure.

It is noteworthy that no child has reached the recommended vitamin D intake. Vitamin D dietary intake becomes essential when sun exposure is insufficient to achieve the requirement, which has become common, especially among people living in urban centers exposed to suboptimal levels of sunlight due to the current sedentary lifestyle along with sun protection recommendations to reduce the incidence of skin problems such as cancer.<sup>13</sup>

Rigorous photoprotective behaviors such as minimal sun exposure, use of long sleeves, and hat may contribute to a lower serum concentration of 25(OH)D. Monitoring of serum vitamin D levels in subjects at risk for hypovitaminosis in combination with regular sun exposure and increased vitamin D intake is an important approach to achieve optimal levels of serum vitamin D.

This is one of the few studies in developing countries that investigated the association between serum concentrations of vitamin D and behavioral and sociodemographic factors in childhood, being the first Brazilian study with children with this approach. These findings are consistent with other studies, suggesting that vitamin D insufficiency has become a worldwide public health problem, even in tropical countries such as Brazil.

This study is one of the few that evaluated the serum concentration of vitamin D and associated behavioral and sociodemographic factors in children of developing countries. We concluded that the modifiable behavioral factors associated with the lowest serum concentration of vitamin D were the highest screen time and less sun exposure. Moreover, darker skin color and season (winter) also contributed to reduce serum concentrations of vitamin D. The high prevalence of vitamin D deficiency/insufficiency is very concerning since the higher screen time and lower physical activity are behaviors frequently more common in the pediatric public.

Encouraging children to adapt healthier behaviors such as play and physical activity outdoors at appropriate times of sun exposure should be done by parents, teachers, and health professionals, even in tropical countries such as Brazil. In addition, activities of food and nutritional education in schools and health centers are important since no child has reached the recommended vitamin D intake.

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## Author statements

### Acknowledgments

The authors are grateful to the National Council for Scientific and Technological Development (CNPq) for financial support (grant number 478910/2013-4) and to Coordination for the Improvement of Higher Education Personnel (CAPES) for the granting of a master's scholarship.

### Ethical approval

This study was approved by the Ethics Committee on Human Research of the Federal University of Viçosa (protocol number 663171/2014).

### Funding

This work was supported by National Council for Scientific and Technological Development (CNPq) (grant number 478910/2013-4).

### Competing interests

None declared.

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