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Vitamin D deficiency and associated factors among pregnant women of a sunny city in Northeast of Brazil

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SUMMARY

Objective: We analyzed the serum vitamin D concentrations and identified the factors associated with vitamin D deficiency in Brazilian pregnant women, in a city with a high solar exposure.
Methods: Cross-sectional study with a sample of 190 pregnant women in a municipality in the Brazilian state of Bahia. Socio-environmental information, regarding the lifestyle and biological factors of participants, was collected and recorded in a questionnaire, and serum concentrations of 25(OH)D was determined (PR).
Results: The deficient and insufficient vitamin D concentrations were found in 14.21% and 44.74% of the pregnant women, respectively. Vitamin D deficiency was associated with commuting to work via motor vehicles (PR: 2.79; 95% CI: 1.06–7.31), with winter (prevalence ratio – PR: 1.54; 95% CI: 1.01–2.35), exposure to the sun only on the face and hands (PR: 2.99; 95% CI: 1.35–6.63) and single pregnant women (PR: 2.53; 95% CI: 1.01–6.35).
Conclusions: We detected a high proportion of pregnant women with vitamin deficient and insufficient vitamin D levels among pregnant women of a sunny city. These data suggest the necessity to monitor serum vitamin D levels during pregnancy and the adequate orientation in prenatal care to adoption healthy lifestyle for the prevention of vitamin D deficiency in this population.

1. Introduction

Pregnancy is a phase of life that is susceptible to vitamin D deficiency, since the demand for this nutrient increases; not only to meet the needs of the pregnant and maintain their own reserves, but also to meet the demands of the fetus [1].

Vitamin D performs functions in the regulating of cell differentiation and in the development of the immune system and brain [2], in addition to consist in placental calcium transport and acting in its homeostasis; thereby regulating the fetal osteogenesis process. In this sense, the deficiency of this vitamin during pregnancy may affect the development and growth of the fetus [3].

Vitamin D deficiency is associated with adverse health problems in pregnancy such as the occurrence of preeclampsia, genitourinary infections, and gestational diabetes, as well as the risk of a caesarean section [2,3]. Moreover, inadequate vitamin D concentrations during pregnancy may increase the risk of health problems to newborns, including low weight, small birth size for the gestational age [3–5] and in later life could result in the risk of food allergies [6], asthma, rickets [7] and endocrine metabolic diseases [8].

Thus, scientific effort has been undertaken to identify factors associated with vitamin D deficiency in pregnant women, with special attention paid to the environmental and individual factors. Among the environmental factors, there are high air pollution, high latitude, the period of winter and the duration of sun exposure [9]. In regards to the individual factors, studies identify obesity [10,11], black skin color [9] and metabolic disorders, as in the example of primary hyperparathyroidism and renal or hepatic insufficiency, as

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important risk factors of vitamin D deficiency [8,9], as well as the low education level [12] and low income of the mother [13,14].

In reference to the bioavailability of vitamin D, it is estimated that 80–90% of the 25(OH)D circulating in the human body is derived from sun exposure and the remainder is provided by food, with the most significant sources being butter, cheese, eggs and fish oil [15].

Thus, in regions with low latitude, it is possible to photosynthesize this vitamin in adequate concentrations during all seasons of the year, due to the availability of UV rays – UVB [16]. Paradoxically, studies of the populations of countries with tropical climate, such as Brazil, record a high prevalence of vitamin D deficiency among different age groups [17,18]. However, it was not identified in the literature study on the prevalence and determinants of vitamin D deficiency in pregnant Brazilian women. In addition, most of the available research on this group is carried out in countries with low solar presence [19]. Thus, the aim of this study is to analyze the serum concentrations of vitamin D and identify the factors associated with vitamin D deficiency among pregnant Brazilian woman in a city with high sun exposure.

2. Materials and methods

2.1. Population and sample

A cross-sectional study nestled to one cohort of pregnant women "Factors of nutritional and genetic risk during pregnancy associated with low birth weight/prematurity – NISAMI Study", conducted in Santo Antonio de Jesus a municipality of Northeast of Brazil, with a land area of 261 km^2, lying 187 km from the city of Salvador, the capital of the state of Bahia. It is located at 12°58′S, 36°16 W, with a tropical climate (annual average of 23.0 °C), with a high solar radiation daily average (11.8 MJ/m^2, maximum of 22 in January MJ/m^2 and minimum of 12 MJ/m^2 in June) and annual average of daily isolation of 7 h [20,21]. Seasons of the year were defined as summer (December–January–February), fall (March–April–May), winter (June–July–August) and Spring (September–October–November).

To identify factors associated with vitamin D concentrations, a sample of 161 with a women was calculated, using the prevalence of 73.5% of hypovitaminosis D [25(OH)D < 80 nmol/L] in normal weight pregnant women [11],with an estimated variation of 10% in these concentrations, depending on the geographic location of the municipality in question. A type I error (α) was adopted of 5%, and to the power of 80%. However, for this study, effectively 190 pregnant women were investigated.

This study was approved by the ethics committee of the School of Nutrition, Federal University of Bahia (UFBA).

2.2. Eligibility criteria and data collection

Clinically healthy women with 18 years or more of age, resident and domiciled in the urban area Northeast of Brazil were included in this study. The eligibility criteria to participate were a gestational age of less than 32 weeks at the time of first contact and attending the service of prenatal care of the public health system (SUS). Women with multiple pregnancies, preeclampsia, kidney problems, HIV and women who had not fasted for the blood collection were excluded. However, these conditions were not identified among the selected pregnant women.

Trained interviewers collected the data and information relating to the socioeconomic and demographic conditions, lifestyle and sun exposure habits were recorded in a standardized questionnaire.

The pre-pregnancy weight collected from the health card of the pregnant woman and, if not available, the reported weight was used. Height was measured in the health unit, by the health service team, according to Lohman et al.'s [22] recommendations. The gestational age at the time of blood collection was calculated based on the last menstrual period available on the card of the pregnant woman or by recording the gestational age at the time of the first ultrasound performed until the end of the first trimester.

2.3. Serum 25-hydroxyvitamin D measurement

The blood collection was performed in the morning, between 7:00 am and 9:00 am, adopting a fasting period of at least 8 h. On the day before blood collection, the pregnant woman was reminded by telephone about the date and time and the guidance on the blood collection. At the laboratory, the trained technician performed the collection of 6 ml of blood with a vacuum tube, brand BD Vacutainer®, for determination of 25(OH)D, total calcium and blood count.

After collection, the blood was centrifuged for 15 min at 2000 rpm, in an environment with low light for serum separation. The serum samples were identified by codes and stored at −32 °C in a freezer, until the time of measurement of 25(OH)D. For this, we used the quantitative determination method, based on the principle of chemiluminescence (CLIA). The dosage kit of 25(OH)D (DiaSorin®) was used; with a intra-assay coefficient of variation (CV) of 8.4%–12.5% and an inter-assay CV of 8.6%–11.0%.

The blood count was performed with the equipment Sismex XT 1800i® and the total calcium was measured by the chemical analysis Vitros (Johnson & Johnson®).

2.4. Response variables and exposure

The serum concentration of 25(OH)D was defined as the response variable and classified as low (<50 nmol/L), insufficient (≥50 nmol/L and 75 nmol/L) and sufficient (≥75 nmol/L) [23]. In the multivariate analysis, the concentrations of 25(OH)D were categorized as deficient (<50 nmol/L) and not deficient (≥50 nmol/L).

The exposure variables are represented by sociodemographic, biological and health care conditions; including maternal age [18–29 years (0), ≥30 (1)], family income [0–3 minimum wages per month (0), ≥4 minimum wages per month (1)], maternal education (<11 years of schooling (1), ≥11 years of schooling (0)], skin color [no black–black (2)], marital status [married/partner) (0); unmarried, single (1)].

Among those biological, gestational age at blood collection [6–13 weeks (0); ≥13–26 weeks (1)] were selected. Variables related to the habits and lifestyle were also adopted: number of times exposed to the sun per week [≥4–6 times a week (0), <4 times a week (1)], the body part that is exposed to the sun [Arms and legs (0), face and hands (1)], and the use of sunscreen [no (0) yes (1)].

2.5. Statistical analysis

The prevalence was adopted to describe the categorical variables, and for the continuous variables we adopted the average and standard deviation. The comparison of the mean concentrations of 25(OH)D, in accordance with the exposure variables, was performed using a student's T-test for equal variances. The comparison between the prevalence of categorical variables of interest and vitamin D concentrations was performed using the chi-squared test. The variables that integrated the multivariate *Poisson* model were selected based on the backward technique [24], which consists of including all the variables in the model and selecting those that presented $p \leq 0.20$ and, in the final model the associations were accepted with a value $p < 0.05$. The prevalence ratio (PR) was used as a measure of association, and the value p (<0.05) and the confidence interval were used to evaluate the magnitude of the association found. The analyses were performed using the Stata/IC program for Mac (Stata Corp, College Station), version 12.0].

2.6. Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

3. Results

The description of the characteristics of the 190 pregnant women sampled in this study is presented in Table 1. The predominant age was of 18–29 years (63%) among those interviewed; low-income (65%) and a level of education more or equal to 11 years of schooling (73%). It was also observed that 43% of the group presented a pre-pregnancy BMI classified as overweight, anemia and hypocalcaemia reached 22% and 13% of the pregnant women, respectively.

The frequency of exposure to the sun of 4–6 times a week was identified in 39% (74) of the women, the habit of daily self exposure for up to 45 min to the sun was reported by 45.0% of them and the use of clothing that allowed the exposure of the upper limbs to the sun was reported by 73% (134) of the pregnant women. However, sunscreen was used daily by 51% (97) of them, being mostly (32%) and only 5% (9) were using a food supplement source of vitamin D (data not present in the table). The average of concentrations of 25(OH)D was 79 (SD = 32) nmol/L. The deficient and insufficient vitamin D concentrations were found in 14.2% and 44.7% of the pregnant women, respectively. The highest concentrations of this vitamin were observed during spring/summer (90, SD = 36 nmol/L) and the lowest in winter (66, SD: 26 nmol/L) (Fig. 1). During this season, the prevalence of vitamin D deficiency was 57% (43), while in spring and summer, the prevalence was 34% (28) (data not shown). It was observed that 54% (102) of the women had some form of employment and 52% (99) went to work on foot.

It was observed that pregnant women with a low concentration of vitamin D had a higher family income, a higher educational level, 2nd trimester, part of the body exposed to the sun, method of

Table 1
Sociodemographic characteristics of the pregnant women, Santo Antônio de Jesus, Bahia, Brazil, 2013–2014.

Variable	N (%)	Mean (SD)	p Value[a]	Deficient = 27 (14)	Insufficient N = 85 (45)	Sufficient N = 78 (41)	p Value[b]
Age (years)							
18–29 years	120 (63.16)	81 (34)		16 (13)	50 (42)	54 (45)	
30–45 years	70 (37)	75 (28)	0.19	11 (16)	29 (41)	30 (43)	0.89
Skin color							
Black	62 (33)	79 (34)		6 (10)	27 (44)	28 (46)	
Others	128 (68)	78 (32)	0.87	21 (16)	52 (41)	55 (43)	0.48
Income							
0–3 MS	122 (65)	83 (34)		13 (11)	50 (41)	59 (48)	
≥4 MS	66 (35)	72 (26)	0.02	24 (36)	13 (20)	29 (44)	0.13
Level of maternal education							
<11 years of study	52 (27)	91 (38)		22 (16)	63 (46)	53 (39)	
≥11 years of study	138 (73)	74 (28)	0.00	5 (10)	16 (31)	31 (60)	0.03
Marital status							
Married/in a relationship	159 (84)	79 (33)		20 (13)	67 (42)	72 (45)	
Single	31 (16)	75 (30)	0.49	7 (23)	12 9 (39)	12 (39)	0.34
Pre pregnancy BMI − 187							
<30	162 (87)	77 (31)		22 (14)	72 (44)	68 (42)	
≥30	25 (13)	81 (3)	0.59	5 (20.00)	7 (28)	13 (52)	0.28
Gestational age							
6–13 weeks	75 (40)	71 (27)		17 (23)	32 (43)	26 (35)	
≥13–32 weeks	115 (60)	88 (34)	0.01	10 (9)	47 (41)	58 (50)	0.01
Anemia − 183							
Yes	41 (22)	80 (33)		20 (14)	57 (40)	65 (46)	
No	142 (78)	73 (28)	0.20	7 (17)	19 (46)	15 (37)	0.57
Hypocalcemia − 182							
Yes	23 (13)	82 (32)		4 (18)	9 (39)	10 (43)	
No	159 (87)	78 (33)	0.64	23 (14)	67 (42)	69 (43)	0.92
Weekly sun exposure							
≥4–6 times	74 (39)	81 (33)		7 (9)	34 (46)	33 (45)	
<4 times	116 (61)	77 (32)	0.48	20 (17)	45 (39)	51 (44)	0.28
Part of the body exposed to the sun N = 183							
Upper/lower body members	134 (73)	82.12 (34)		13 (10)	45 (60)	61 (46)	
Face and hands	49 (27)	69.23 (27)	0.01	13 (27)	17 (35)	19 (39)	0.01
Use of sunscreen − 188							
Yes	97 (51)	82 (33)		13 (14)	34 (37)	46 (49)	
No	93 (49)	75 (30)	0.10	14 (14)	45 (46)	38 (39)	0.32
Method of commuting							
Motor vehicles	99 (52)	74 (31)		21 (21)	40 (40)	38 (3)	
On foot	91 (48)	84 (32)	0.03	6 (7)	39 (43)	46 (51)	0.01
Season							
Fall, spring and summer	115 (60)	87 (33)		9 (8)	38 (33)	68 (59)	
Winter	75 (39)	66 (26)	0.00	18 (24)	41 (55)	16 (21)	0.00

[a] Student's t-test.
[b] Chi-squared test.

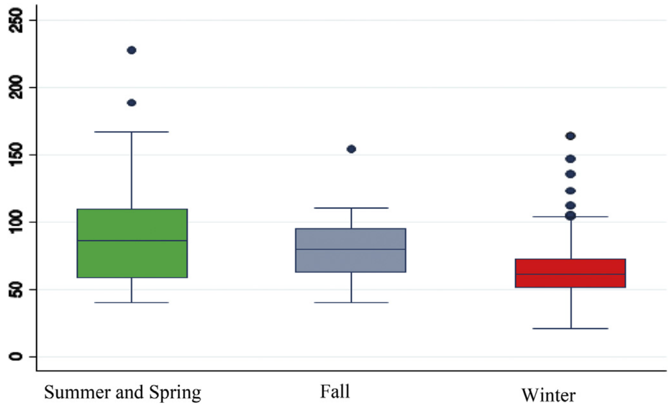

Fig. 1. Concentrations of 25(OH)D in pregnant women according to the seasons of the year, Santo Antônio de Jesus, Bahia, Brazil, 2013–14.

commuting and season ($p < 0.05$). There were no statistically significant differences between deficient and not deficient average concentrations of 25(OH)D for the age of the pregnant women, pre-pregnancy BMI, serum hemoglobin and calcium concentration, exposure to the sun and use of Sunscreen (Table 1).

The results of the *Poisson* regression for the association between the selected determinants and deficient concentrations of 25(OH)D are shown in Table 2. It was found that vitamin D deficiency during pregnancy was associated with the marital status corresponding to pregnant women (PR: 2.5; 95% CI: 1.01–6.35), sun exposure to only the hands and face (PR: 2.9; 95% CI: 1.3–6.6), use of motor vehicles for commuting to work (PR: 2.8; 95% CI 1.1–7.4) and winter (PR: 2.6; 95% CI: 1.1–7.3).

4. Discussion

The high prevalence of vitamin D insufficiency (45%) and deficiency (14%) among pregnant women living in a sunny geographical area in northeastern Brazil in this study follows the same trend, this observed in countries with a low exposure of sunlight. A similar result was recorded in pregnant women in Norway, 16.8% of disability and 34.0% and insufficiency of vitamin D [25]. Prevalence of lightly higher (27.4% deficiency and insufficiency in 35.3% of pregnant women) were recorded in northern Spain [26]; and among pregnant women from Belgium, it was observed higher prevalence of 74% failure and 44.6% of vitamin D deficiency compared to our studies [27].

These are higher prevalence than in pregnant women with HIV residing in different countries in Latin America (30.5% deficient and insufficient 35.2%) [28]. In the city of Porto Alegre, Southern Brazil higher prevalences of vitamin D deficiency was diagnosed in 53.3% of the sample, and insufficiency was found in 33.2% of the pregnant women with diabetes [29].

On the other hand, we identify few studies in the literature reports regarding the vitamin D concentrations in Brazilian pregnant women, the studies carried out with adults, children and the elderly in different regions in Brazil report a high prevalence of vitamin D deficiency [17,18,30]. Based on these records, it can be suggested that the high prevalence of vitamin D deficiency can be influenced by the lifestyle of these population groups and the environment in which they live.

Among the factors associated with lifestyle, it was observed that the highest prevalence of vitamin D deficiency was observed among single mothers, when compared with those who were living with a partner. These results were also recorded in previous population-based studies in which the highest concentration of vitamin D in serum was observed among married women or those who had partners (married or cohabiting), which can be understood by the fact that married people could possibly spend more time outdoors and have a more balanced diet than singles [14,31].

In addition, the habit of exposing only the faces and hands to the sun was associated with vitamin D deficiency in pregnant women when compared to those who exposed the arms and legs to the sun. Accordingly, it is recognized that the use of long garments decreases the areas of skin exposed to sun rays, thus contributing to a lower level of synthesis of vitamin D.

Although some reported association between black skin color and lower serum concentrations of vitamin D [9,32] in our study this relationship was not observed. It is possible that in an area of low socioeconomic insertion black and white live under similar living conditions, which do not favor distinctions among the determinants of deficiency of this vitamin.

Furthermore, another point to add is that, when the dietary intake of vitamin D is low, a major source of this vitamin is exposure to sunlight. In Brazil, the intake of vitamin D is low and the small quantities available in fortified foods are insufficient to meet the physiological needs of vitamin D in the human body [33]. Moreover, exposure to sunlight without sunscreen use has been strongly discouraged by dermatologists [33], this practice may contribute to the occurrence of vitamin D deficiency.

A possible explanation for the relationship between vitamin D deficiency and commuting to work by motor vehicle is the ability of decreasing the opportunity for the pregnant woman's exposure to sunlight. Another hypothesis is that women with a lower socioeconomic level, who usually walk to work, perform longer walks while exposed to the sun. This condition may favor the photoproduction of vitamin D and the prevention of the deficiency of this vitamin.

In regards to the environmental factors, it was observed in this study that in winter the women had a higher prevalence of vitamin D deficiency and higher concentrations of this vitamin during the summer and fall. In such seasons, the activation of the 7-dehydrocholesterol in the skin, the initial precursor of vitamin D, is sharper, due to the increasing availability of sunlight and the intensity of the ultraviolet rays.

Thus, low-latitude regions, such as the town in Bahia (latitude 12° and longitude 39°) present a higher availability of sunlight and thus a higher incidence of UV radiation, which can promote the cutaneous of vitamin D. However, reduced serum concentrations of vitamin D among pregnant women were found in fall. This trend of

Table 2
Vitamin D deficiency in pregnant women and associated factors, Santo Antônio de Jesus, Bahia, Brazil, 2013–2014.[a]

Variables	Unadjusted RP,[b] 95% CI	Adjusted RP, 95% CI
Marital status		
Married/in a relationship	1	
Single	1.80 (0.75–4.24)	2.53 (1.01–6.35)
Gestational age		
6–13 weeks	1	
≥13–32	0.38 (0.17; 0.83)	0.50 (0.21–1.18)
Weekly sun exposure		
≥4–6 times	1	
<4 times	1.82 (0.77–4.31)	1.25 (0.50–3.13)
Part of the body exposed to the sun		
Upper/lower body members	1	
Face and hands	2.73 (1.26–5.89)	2.99 (1.35–6.63)
Method of commuting		
On foot	1	1
Transport	3.21 (1.29–7.97)	2.79 (1.06–7.31)
Season		
Summer, Spring, Fall	1	1
Winter	1.75 (1.17–2.61)	1.54 (1.01–2.35)

[a] *Poisson* regression.
[b] Prevalence ratio (PR).

a high prevalence of vitamin D deficiency is found in a study conducted in Spain [26]. These results identified in previous studies may suggest that inadequate concentrations are also influenced by factors of a socioeconomic and cultural nature.

On the other hand, one should consider that winter *per se* is a major risk factor for vitamin D deficiency. Research conducted with adults in São Paulo [18], after winter, reported an average concentration of 25(OH)D_3 of 21.4 ng/ml and 77.4% of the individuals had presented serum 25 vitamin D < 30 ng/ml. In that study, 209 volunteers were submitted, during the summer, to a second assessment of serum concentrations of vitamin D, identifying an average increase of 10.6 ng/ml (3.7–19.3) in the concentration of 25(OH)D and a significant reduction in the prevalence of 25 vitamin D < 30 ng/ml [18].

This study is one of the first to analyze the vitamin D concetrations in healthy pregnant women in Brazil, using as scenario a city with a high solar incidence. We found that vitamin D deficiency was associated with unmarried marital status, exposure of only the face and hands to the sun, the winter season and commuting to work by motor vehicles. We recommend the development of longitudinal studies based on representative samples of the population, involving participants with different sociodemographic and cultural conditions, in order to identify the variation in vitamin D concentrations among pregnant women according to different epidemiological contexts of the country. In addition, the need for nutritional guidelines on the consumption of foods rich in vitamin D and lifestyle habits that enable increased sun exposure during pregnancy is highlighted. However, the monitoring of vitamin D levels during pregnancy is necessary, especially in winter and in pregnant women with higher socioeconomic conditions, in order to contribute to the correction of deficiencies and negative implications for maternal-infant health.

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