Vitamin D status in a sunny country: Where has the sun gone?
Original Article

Vitamin D status in a sunny country: Where has the sun gone?

Marianna D. Unger a, Lilian Cuppari b, Silvia M. Titan a, Maria Cláudia T. Magalhães c, Ana L. Sassaki c, Luciene M. dos Reis a, Vanda Jorgetti a, Rosa Maria Affonso Moysés a, *

a Nephrology Department, Universidade de São Paulo, São Paulo, Brazil
b Nephrology Department, Universidade Federal de São Paulo, São Paulo, Brazil
c Universitary Hospital, Universidade de São Paulo, São Paulo, Brazil

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Summary

Background & aims: Hypovitaminosis D [serum 25 vitamin D < 30 ng/ml] is related to the development of metabolic bone disease and greater risk of chronic illnesses. However, it is frequently under-diagnosed, mainly in countries where UV radiation is abundant. We prospectively determined the prevalence and the predictors of serum 25 vitamin D (s25(OH)D) in a healthy Brazilian population after the winter and after the summer.

Methods: 603 (118M and 485F) healthy Brazilian volunteers aged 18–90 years from a universitary hospital were selected after the winter of 2006. From the initial sample, 209 volunteers (31M and 178F) accepted to participate in a second health check after the subsequent summer.

Results: After the winter, median s25(OH)D was 21.4 ng/mL and 77.4% of the population presented hypovitaminosis D. s25(OH)D was significantly related to age, BMI, PTH and race. In multivariate linear regression analysis, s25(OH)D was significantly and independently dependent on age, glycemia and skin color. Significant increase in s25(OH)D was verified after summer [10.6 (3.7–19.3 ng/ml); p < 0.001] and this improvement was dependent on age. We also observed a significant decrease in hyperparathyroidism prevalence (20.8% vs. 4.9%; P < 0.0001).

Conclusion: In São Paulo, at the end of winter, we observed a high prevalence of hypovitaminosis D and secondary hyperparathyroidism in healthy adults. s25(OH)D was dependent on age and skin color. After summer, we observed a decrease in the prevalence of hypovitaminosis D. This unexpected finding emphasizes the need for a strong recommendation to monitor s25(OH)D, even in a sunny country such as Brazil.

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1. Introduction

Hypovitaminosis D (s25(OH)D < 30 ng/ml)], even subclinical, is now recognized as one of the more important factors influencing skeletal integrity and some chronic illnesses.1 The main source of 25 vitamin D [25(OH)D] is sun exposure, but other individual factors, such as age, fat mass, skin color, gender and life style are also relevant.2

Several epidemiological studies have shown a high prevalence of hypovitaminosis D in different regions of the world, including Latin America.3 However, Brazilian studies have been cross-sectional, and only evaluated specific populations narrow age ranges such as children,4 adolescents,5 healthy young6 and elderly people7 from different regions of the country. There is no prospective data regarding seasonal effects of UV exposure on s25(OH)D.

São Paulo is the largest city in Brazil and the world’s 7th largest metropolitan area, with almost 20,000,000 residents, comprising more than 10% of the entire Brazilian population. It is located at 23°34’S, with a subtropical climate, and with a considerable sun radiation across the year (from 11.7 MJ/m² in June to 20.2 MJ/m² in December).8 However, air pollution, which has been previously linked to hypovitaminosis D in other countries,9 is highly prevalent in this city, as is a sedentary life style.10

Therefore, the objective of our study was to determine the prevalence of hypovitaminosis D in a sample of a normal Brazilian population after the winter and after the summer. We also evaluated which factors could be linked to baseline winter s25(OH)D, as well as to the variation observed after summertime. Since hypovitaminosis D is recognized as one of the major causes of secondary hyperparathyroidism (SHPT), we measured serum parathormone...
(PTH) after both seasons, in order to confirm if the variation observed in s25(OH)D would be associated with any change in SHPT prevalence.

2. Subjects and methods

Study recruitment took place between September 1st and October 31st of 2006, at the end of winter. Briefly, according to Brazilian laws, students and employees from the Sao Paulo University are evaluated yearly by a clinician in the Universitary Hospital. At the time of his (her) consultation, the subject was invited to participate in the study. Patients who were already regularly followed in the outpatient clinic in this hospital and were also an employee or student from the Sao Paulo University were also asked to participate. This study was approved by the local ethics committee (CAPPesq) and was registered on the Brazilian official trial registry (SISNEP-CAAE-0660.0.015.000-06). Informed consent was obtained from all volunteers.

Inclusion criteria were age between 18 and 80 years and permanent residence in Sao Paulo. Exclusion criteria were chronic disease conditions such as serum creatinine >1.2 mg/dL, serum glucose >200 mg/dL or serum albumin <3.5 g/L or the current use of any drug that could interfere with mineral metabolism, such as calcium supplements, bisphosphonates, steroids or vitamin D.

In this first phase, 118M and 485F volunteers agreed to participate in the study. Data on clinical history was obtained by the investigator (MDU) on the same day of recruitment acceptance. Self-reported skin color, height and weight information were also collected. Presence of arterial hypertension was confirmed if the volunteer confirmed the use of any antihypertensive drug.

Subsequently, an overnight fasting blood sample was obtained. After blood centrifugation, serum samples were harvested and frozen (−80°C) until analysis for serum albumine, total calcium, ionized calcium, phosphate, creatinine, alkaline phosphatase, and glucose. Intact parathormone (PTH) was measured using Immulite analyzer (Diagnostic Products Corporation, Los Angeles, CA, USA, reference range 10−87 pg/ml). s25(OH)D was measured using a chemoluminescent assay (Dia-Sorin Inc., Stillwater, MN, USA, detection limit = 2 ng/ml; inter-assay CV <20%).

Vitamin D insufficiency, deficiency and hypovitaminosis have been defined as s25(OH)D <30 ng/ml and >20 ng/ml, <20 ng/ml and <30 ng/ml respectively. Subsequently, Body Mass Index (BMI) was calculated using the anthropometric data.

A second health questionnaire and blood collection were performed after six months, by the end of the summer (between February 28th and April 1st, 2007). All volunteers were recruited and, from the original population, 209 were available for follow-up. The same biochemical analyses were done, using the same commercial kits.

Scatter plots were built and Pearson’s correlation coefficients were calculated for s25(OH)D and various clinical and laboratorial variables. In the descriptive analyses, chi-square test was used for categorical data, Student t test for gaussian continuous variables and Mann–Whitney test for non-gaussian variables. Univariate and multivariate linear regression models were performed using vitamin D as the dependent variable. For the follow-up data, paired-samples T test was used to compare differences on variables between winter and summer. Next, we wanted to analyze predictor and associated variables of the s25(OH)D variation between winter and summer. Therefore, univariate and multivariate linear regression models were built on the unstandardized residuals of the regression of winter s25(OH)D on summer s25(OH)D. All tests were two-sided and a p value <0.05 was considered as significant. Statistical analysis was done using SPSS for Windows 13.0.

3. Results

3.1. First collection (end of winter): prevalence of hypovitaminosis D and predictors of s25(OH)D status

Of the 603 participants, mean age was 47.8 ± 13.4 years, 67.2% were White, and 80.4% were female, with a menopause prevalence of 42.1%. Diabetes mellitus and arterial hypertension were present in 9.6% and 27.7% of the subjects, respectively. Surprisingly, median s25(OH)D was 21.4 ng/ml, with 77.4% of our sample presenting hypovitaminosis D.

We observed a negative correlation between s25(OH)D and PTH (r = −0.20, p < 0.0001), BMI (r = −0.09, p = 0.03) and age (r = −0.11, p = 0.009), as shown in Fig. 1. There was also a trend for a correlation between s25(OH)D and serum glucose (r = −0.07, p = 0.07) and with serum phosphate (r = 0.08, p = 0.06). Table 1 shows that BMI, PTH and hypertension were significantly related to categories of s25(OH)D (<30 ng/ml), whereas a trend for an association was seen for age, phosphorus and skin color but not sex and BMI. Next, univariate linear regression models identified age, BMI, glycemia, PTH and skin color as significant variables related to s25(OH)D (Table 2). In the multivariate models, we first analyzed which factors could be considered as predictors of s25(OH)D, based on a biological plausibility (models 1 and 2). In model 1, we observed that s25(OH)D was dependent on age and skin color. In model 2, glycemia was included and we found that s25(OH)D was dependent on age, skin color and glycemia. In Model 3, we included all parameters associated with s25(OH)D and we found that skin color, glycemia and PTH remained independently related to s25(OH)D (Table 3). Age was no longer significantly associated with s25(OH)D in this last model probably because we included many variables and there might be a significant co-linearity among them. The same results were obtained in a stepwise linear regression model (data not shown).

3.2. Second collection (end of summer): predictors of s25(OH)D status improvement

At the end of the summer, 209 volunteers were submitted to a second exam and blood collection. This group was representative of the original population, since we could not find any significant differences between participants on the first and second health checks (data not shown). We could observe a significant increase in s25(OH)D, with a median increase of 10.6 ng/mL (3.7–19.3) and a significant decrease in the prevalence of hypovitaminosis D, as shown in Table 4. Importantly, the prevalence of hyperparathyroidism decreased significantly, from 20.6% at the end of the winter to 4.9% at the end of summer; (p < 0.0001). It is important to notice that 12.7% of the volunteers who presented a satisfactory 25(OH) D status at the end of the winter (≥30 ng/ml) were not able to keep this condition after the summer, making clear that there are several factors that could modulate s25(OH)D.

Table 5 shows univariate and multivariate linear regression models on the unstandardized residual of the regression of winter s25(OH)D on summer s25(OH)D. Since winter s25(OH)D is a very important determinant of summer s25(OH)D, residual analysis are interesting in this context because it allows the exploration of the effects of other variables on the variation of vitamin D behavior between winter and summer. In the univariate models, age, BMI and menopause were inversely related to s25(OH)D variation between winter and summer. However, in the multivariate model, only age remained negatively related to the seasonal variation of s25(OH)D.
4. Discussion

This study showed that in São Paulo, Brazil, at the end of the winter, mean s25(OH)D is below the reference range in almost 80% of the normal adult population. Other studies have shown a significant prevalence of hypovitaminosis D in Brazilian volunteers, but they evaluated only selected groups. Our data confirms that, at least in São Paulo urban area, low s25(OH)D is highly prevalent and not restricted to children or the elderly. In our study, the volunteers aged 18—80 years presented median s25(OH)D of 21.4 ng/ml, and 77.4% of them had 25 vitamin D insufficiency. Therefore, we must be aware that living in a sunny place does not assure a normal s25(OH)D, even in a healthy population.

In Brazil, dietary intake of vitamin D is low, as is the use of vitamin D supplements. The major source of s25(OH)D is casual exposure to sunlight, and the current belief is that this natural source provides adequate serum levels of this hormone for most Brazilians. Since sunlight is abundant even in the winter months, our unexpected finding might be explained by cultural habits, lifestyle, air pollution or the high percentage of women in our sample. Regarding cultural habits, Gannage-Yared and cols. found a similar prevalence of hypovitaminosis D at the end of the winter.

Table 1

<table>
<thead>
<tr>
<th>Category</th>
<th>s25(OH)D &lt; 30 ng/mL</th>
<th>s25(OH)D ≥ 30 ng/mL</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years, mean/standard)</td>
<td>48.3</td>
<td>13.1</td>
<td>0.08</td>
</tr>
<tr>
<td>Sex (female, n%)</td>
<td>384</td>
<td>81.2</td>
<td>0.22</td>
</tr>
<tr>
<td>Total calcium (mg/dL, mean/standard)</td>
<td>9.6</td>
<td>0.5</td>
<td>0.86</td>
</tr>
<tr>
<td>Ionized calcium (mg/dL, mean/standard)</td>
<td>5.0</td>
<td>0.2</td>
<td>0.52</td>
</tr>
<tr>
<td>Phosphorus (mg/dL, mean/standard)</td>
<td>3.8</td>
<td>0.7</td>
<td>0.07</td>
</tr>
<tr>
<td>Serum creatinine (mg/dL, mean/standard)</td>
<td>0.8</td>
<td>0.1</td>
<td>0.10</td>
</tr>
<tr>
<td>Creatinine clearance (Cr, ml/min/1.73 m²)</td>
<td>102.3</td>
<td>24.4</td>
<td>0.51</td>
</tr>
<tr>
<td>Albumin (mg/dL, mean/standard)</td>
<td>4.5</td>
<td>0.3</td>
<td>0.68</td>
</tr>
<tr>
<td>Glycemia (mg/dL, mean/standard)</td>
<td>87.1</td>
<td>23.9</td>
<td>0.28</td>
</tr>
<tr>
<td>BMI (mean/standard)</td>
<td>27.2</td>
<td>5.0</td>
<td>0.02</td>
</tr>
<tr>
<td>Intact PTH unit (pg/mL, median/IQR)</td>
<td>65.0</td>
<td>53—83</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Alkaline phosphatase (U/L)</td>
<td>72.3</td>
<td>25.3</td>
<td>0.53</td>
</tr>
<tr>
<td>Hypertension (n%)</td>
<td>139</td>
<td>30.0</td>
<td>0.01</td>
</tr>
<tr>
<td>Diabetes mellitus (n%)</td>
<td>48</td>
<td>10.3</td>
<td>0.17</td>
</tr>
<tr>
<td>Menopausal status (yes, n%)</td>
<td>157</td>
<td>42.0</td>
<td>0.65</td>
</tr>
<tr>
<td>Skin color (white, n%)</td>
<td>303</td>
<td>65.6</td>
<td>0.11</td>
</tr>
</tbody>
</table>

* CG, Cockcroft-Gault formula; BMI, body mass index; IQR, inter-quartile range.

| p value for Mann-Whitney test.
in Beirut, Lebanon. However, differently from their study, our population does not have a conservative clothing style due to religious habits. Nevertheless, in São Paulo, people do not expose themselves frequently to the sun (even during weekends) and in the majority of the cases, they work indoors. Another possible cause of low 25 vitamin D synthesis is the current concept of avoiding any sun exposure by using sun protection, which is strongly recommended in our country by many dermatologists. We can also consider that during the winter people use more clothes and do not spend much time outdoors. Another potential factor that could relate to hypovitaminosis D is the air pollution, as previously shown by Agarwal et al.\textsuperscript{13}. Indeed, São Paulo still presents high concentrations of ozone and other air pollutants.\textsuperscript{14} Unfortunately, we could not evaluate the effects of air pollution in our sample because this would require a control group located in another city in similar latitude, but with a clean air. Other potential factors of s25(OH)D are Sun exposure and fat mass,\textsuperscript{19} and the negative confounding factor would be the higher percentage of females in our sample. Some studies describe higher s25(OH)D in men,\textsuperscript{14} which could be explained by a higher sun exposure and hormonal factors in men or by pregnancy and breast-feeding in women. However, we could not find significant differences in s25(OH)D between men and women, making this hypothesis less plausible. On the other hand, we could confirm that age, color of the skin, BMI and glycemia influence s25(OH)D in our volunteers.

A negative correlation between s25(OH)D and age was found and the serum levels of this hormone were dependent on age in regression models. Furthermore, the improvement in 25(OH)D status at the end of summer was also dependent on age. In summary, older people present lower s25(OH)D at the winter and have a lower probability of correcting their vitamin D status after the summer. A decreased capacity to produce vitamin D\textsubscript{3} occurs in the elderly, due to a decline in cutaneous levels of 7-dehydrocholesterol.\textsuperscript{1,16} Indeed, this could have occurred with our older volunteers. However, it is important to emphasize that the median age of our sample was 47.8 years, and that 11.9% of the volunteers were below 30 years. Therefore, we can consider that this problem is not restricted to the high-risk population, at least during a significant part of the year.

We also found that s25(OH)D was dependent on skin color, confirming several other studies.\textsuperscript{1,16} Brazilian population is extremely mixed, making it difficult to identify someone as Caucasian or as Afro–American. However, since it is melanin content of the skin, and not the ethnicity that will determine the amount of 25(OH)D synthesized, we classified our volunteers simply as white and non-white. Since non-white individuals comprise approximately half of our population,\textsuperscript{15} this is very relevant information.

We also found in univariate analysis, a negative association between BMI and s25(OH)D. The median values for BMI in our population were 27.3 kg/m\textsuperscript{2}, and we should classify our sample as an overweight population. In fact, currently, obesity is also a health problem in Brazil.\textsuperscript{18} According to Bolland, two major determinants of s25(OH)D are Sun exposure and fat mass,\textsuperscript{10} and the negative association between s25(OH)D and fat mass should be attributed to the sequestration into adipocytes of fat-soluble vitamin D generated in the skin or orally ingested, before it can be transported to the liver and converted to 25(OH)D. Other possible explanations would be that overweight persons have less sun because of their choice of clothing or because they spend less time exercising outdoors and are less mobile. These authors also found that fat mass was associated with a blunted increase in seasonal s25(OH)D. We also found a trend towards an association between decreased

### Table 2

<table>
<thead>
<tr>
<th></th>
<th>β coefficient</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>−0.11</td>
<td>−0.14</td>
<td>−0.02</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>−0.05</td>
<td>−3.45</td>
<td>0.65</td>
</tr>
<tr>
<td>Glycemia (mg/dL)</td>
<td>−0.07</td>
<td>−0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>BMI</td>
<td>−0.09</td>
<td>−0.35</td>
<td>−0.02</td>
</tr>
<tr>
<td>Race (white)</td>
<td>0.10</td>
<td>3.85</td>
<td>0.02</td>
</tr>
<tr>
<td>Intact PTH (pg/mL)</td>
<td>−0.20</td>
<td>−1.11</td>
<td>0.05</td>
</tr>
<tr>
<td>Phosphorus (mg/dL)</td>
<td>0.08</td>
<td>2.26</td>
<td>0.06</td>
</tr>
<tr>
<td>Calcium (mg/dL)</td>
<td>0.06</td>
<td>−0.34</td>
<td>2.76</td>
</tr>
<tr>
<td>Hypertension</td>
<td>−0.07</td>
<td>−3.50</td>
<td>0.17</td>
</tr>
</tbody>
</table>

### Table 3

**Multivariate linear regression models on s25(OH)D.**

<table>
<thead>
<tr>
<th></th>
<th>β coefficient</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>−0.13</td>
<td>−0.17</td>
<td>−0.03</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>−0.04</td>
<td>−3.30</td>
<td>1.03</td>
</tr>
<tr>
<td>BMI</td>
<td>−0.07</td>
<td>−0.32</td>
<td>0.03</td>
</tr>
<tr>
<td>Skin color (white)</td>
<td>0.10</td>
<td>0.35</td>
<td>4.04</td>
</tr>
<tr>
<td><strong>Model 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>−0.09</td>
<td>−0.14</td>
<td>−0.002</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>−0.05</td>
<td>−3.34</td>
<td>1.00</td>
</tr>
<tr>
<td>BMI</td>
<td>−0.05</td>
<td>−0.27</td>
<td>0.08</td>
</tr>
<tr>
<td>Skin color (white)</td>
<td>0.10</td>
<td>0.31</td>
<td>4.01</td>
</tr>
<tr>
<td>Glycemia (mg/dL)</td>
<td>−0.09</td>
<td>−0.08</td>
<td>−0.001</td>
</tr>
<tr>
<td><strong>Model 3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>−0.03</td>
<td>−0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>−0.08</td>
<td>−4.21</td>
<td>0.27</td>
</tr>
<tr>
<td>BMI</td>
<td>−0.01</td>
<td>−0.20</td>
<td>0.16</td>
</tr>
<tr>
<td>Skin color (white)</td>
<td>0.12</td>
<td>0.54</td>
<td>4.36</td>
</tr>
<tr>
<td>Glycemia (mg/dL)</td>
<td>−0.11</td>
<td>−0.09</td>
<td>−0.01</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.00</td>
<td>−2.11</td>
<td>2.26</td>
</tr>
<tr>
<td>Phosphorus (mg/dL)</td>
<td>0.09</td>
<td>2.47</td>
<td>0.05</td>
</tr>
<tr>
<td>Intact PTH (pg/mL)</td>
<td>−0.19</td>
<td>−0.11</td>
<td>−0.04</td>
</tr>
</tbody>
</table>

### Table 4

#### Univariate and multivariate linear regression models on the unstandardized residuals of the regression of winter vitamin D on summer vitamin D.

<table>
<thead>
<tr>
<th></th>
<th>β coefficient</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multivariate model</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>−0.15</td>
<td>−0.28</td>
<td>−0.02</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>−0.03</td>
<td>−5.31</td>
<td>3.38</td>
</tr>
<tr>
<td>Winter Cr Cl (mg/dL)</td>
<td>−0.09</td>
<td>−0.12</td>
<td>0.03</td>
</tr>
<tr>
<td>Winter BMI</td>
<td>−0.14</td>
<td>−0.62</td>
<td>−0.01</td>
</tr>
<tr>
<td>Winter glycemia (mg/dL)</td>
<td>0.03</td>
<td>8.06</td>
<td>0.09</td>
</tr>
<tr>
<td>Menopause</td>
<td>−0.15</td>
<td>−6.64</td>
<td>−0.13</td>
</tr>
<tr>
<td>Skin color (white)</td>
<td>−0.02</td>
<td>−3.87</td>
<td>3.02</td>
</tr>
</tbody>
</table>

### Table 5

#### Seasonal variation on s25(OH)D and PTH and prevalence of hypovitaminosis D and hyperparathyroidism.

<table>
<thead>
<tr>
<th></th>
<th>Winter</th>
<th>Summer</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTH (pg/mL)</td>
<td>64.0</td>
<td>48.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>s25(OH)D (ng/ml)</td>
<td>22.0</td>
<td>34.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>s25(OH)D &lt; 15 ng/ml (n%)</td>
<td>29.13</td>
<td>8.38</td>
<td>&lt;0.0004</td>
</tr>
<tr>
<td>s25(OH)D &lt; 30 ng/ml (n%)</td>
<td>160.76</td>
<td>78.37</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>s25(OH)D &lt; 40 ng/ml (n%)</td>
<td>193.92</td>
<td>133.63</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>PTH &lt; 87 pg/ml (n%)</td>
<td>42.264</td>
<td>9.49</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Values are expressed as median/inter-quartile range or n/%. *PTH values were available for 159 subjects after the winter and for 184 subjects after the summer.

Cr Cl – creatinine clearance.

* corrected by Sex, Cr Cl and winter glycemia.
which presented a strong and negative correlation with s25(OH)D. At the same time, we recognize that the higher the glycemia, the lower the s25(OH)D levels predict cardiovascular mortality in the elderly men, even in individuals with PTH within the normal range, giving us another reason to aggressively search for and treat hypovitaminosis D.

As expected, we also found a seasonal periodicity in serum SHPT, which presented a strong and negative correlation with s25(OH)D. At the end of the summer, when the majority of our volunteers presented an adequate 25(OH)D status, the prevalence of SHPT decreased significantly. Previous studies have already shown this association and many authors consider high serum PTH levels as one of the markers of 25(OH)D insufficiency. The question that arises is what would be the consequences of having high serum PTH half of the year. One hypothesis is that this seasonal variation in s25(OH)D and PTH is a normal response phenomenon. Another more intriguing hypothesis is that, in a long-term analysis, this intermittent SHPT would lead more frequently to osteoporosis and bone fractures. Indeed, Pasco has shown a seasonal periodicity in s25(OH)D and PTH, associated with increased risk of fractures. According to the authors, “during winter, the relatively low s25(OH)D induces a higher serum PTH, which in turn increases bone remodeling rate and bone fragility”. If this hypothesis holds true, strong efforts should be made in order to avoid this temporary increase in serum PTH. In addition, it has already been shown that plasma PTH levels predict cardiovascular mortality in the elderly men, even in individuals with PTH within the normal range, giving us another reason to aggressively search for and treat hypovitaminosis D.

Our study presents some limitations. We did not evaluate the oral intake of vitamin D. In Brazilian adolescents, a low intake of vitamin D was associated with low s25(OH)D, mainly because few almonds are vitamin D-fortified. Thus, it seems reasonable to assume that low ingestion is one of the causes of our high prevalence of hypovitaminosis D. Neither did we quantify the sun exposure or the air pollution. However, this was beyond the scope of our study.

In conclusion, after winter, we observed a high prevalence of 25(OH)D insufficiency and SHPT in healthy adults in São Paulo, Brazil. s25(OH)D was associated with age, skin color, BMI and serum glucose levels. After summer, we observed a decrease in the prevalence of 25(OH)D insufficiency. However, almost 40% of our volunteers still presented inappropriate s25(OH)D. This unexpected finding emphasizes the need for a strong recommendation regarding the monitoring of s25(OH)D, even in a sunny country such as Brazil.

Conflict of Interest

The authors have no conflicts of interest to declare.

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MDU recruited the volunteers, collected the data, carried out the literature review, interpreted the results, and drafted the manuscript. LC contributed to the design of the analysis and interpreted the results. ST conducted the analyses and interpreted the results. MCTM, ALS and LMR recruited the volunteers and collected the data. VJ contributed to the design of the analysis, the interpretation of results, and revised the manuscript. RMA designed and conducted the analyses, interpreted the results, revised the paper and had final responsibility to submit for publication. All authors gave their final approval of this version of the manuscript. The authors have no conflicts of interest to declare.

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