

Vitamin D Deficiency in Risk Groups Living in Tropical Curaçao

TJM Leenders¹, FHA van Eijndhoven², E van der Veer¹, FAJ Muskiet¹

ABSTRACT

Objective: Curaçao (12 degrees 10N, 69 degrees 0W) is characterized by whole year abundant sunshine (8–10 hours/day). We challenged the automatic assumption that people living in tropical countries do not have a high risk of vitamin D deficiency, and investigated the vitamin D status in a tropical environment.

Methods: For this, we selected fifty-two elderly people with little or no exposure to direct sunlight [median 84 (60–96) years; 34 females, 18 males] and who were cared for by community nurses or lived in retirement or nursing homes. Furthermore, six rehabilitating orthopaedic patients [median 72 (38–90) years; one female, five males] were included. Serum 25(OH)D, calcium, phosphate, parathyroid hormone (PTH) and creatinine were measured. Those exhibiting elevated creatinine, PTH or both had their 1,25-dihydroxyvitamin D [1,25(OH)₂D] examined.

Results: Serum levels of 25(OH)D below 25, 50 and 75 nmol/L were detected in, respectively, seven (12%), 22 (38%) and 48 (83%) of the fifty-eight persons. Four persons had combined high creatinine and PTH, and low 1,25(OH)₂D, which was not known by their caregivers.

Conclusion: Abundant sunshine outdoors is no guarantee for vitamin D sufficiency. More attention is needed for vitamin D deficiency in risk groups living in tropical areas and elderly persons with poor kidney function.

Keywords: 25(OH)D, deficiency, tropics, Vitamin D

Deficiencia de Vitamina D en los Grupos de Riesgo de Curacao Tropical

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RESUMEN

Objetivo: Curacao (12 grados 10N, 69 grados 0W) se caracteriza por su abundante luz solar durante todo el año (8–10 horas/día). Ponemos en duda la suposición automática de que los habitantes de países tropicales no poseen un alto riesgo de deficiencia de vitamina D, e investigamos los niveles de vitamina D en un ambiente tropical.

Métodos: Para ello, seleccionamos a cincuenta y dos personas de avanzada edad [mediana 84 (60–96) años; 34 mujeres, 18 hombres] con poca o ninguna exposición directa a la luz solar; cuidados por enfermeras comunitarias o que vivían en hogares de ancianos o casas de retiro. Además, se incluyeron seis pacientes bajo rehabilitación ortopédica [mediana 72 (38–90) años; una mujer, cinco hombres]. Se les realizaron las siguientes mediciones: 25(OH)D en suero, calcio, fosfato, hormona paratiroidea (HPT), y creatinina. A todos aquellos que mostraron niveles elevados de creatinina, de HPT, o de ambas, se les realizó un examen de 1,25-dihidroxivitamina D [1,25(OH)₂D].

Resultados: Se detectaron niveles séricos de 25(OH)D por debajo de 25, 50 y 75 nmol/L en siete (12%), 22 (38%) y 48 (83%) de las cincuenta y ocho personas, respectivamente. Cuatro personas presentaron una combinación de elevada creatinina y HPT, y bajo 1,25(OH)₂D, datos desconocidos para sus cuidadores.

Conclusión: La abundancia de luz solar exterior no es garantía de suficiencia de vitamina D. Se necesita prestar mayor atención a la deficiencia de vitamina D en los grupos de riesgo que viven en áreas tropicales, así como a las personas de edad avanzada con pobre función renal.

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Palabras claves: 25(OH)D, deficiencia, trópicos, vitamina D

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INTRODUCTION

Vitamin D status is strongly dependent on the direct exposure of the skin to ultraviolet B radiation (UVB; wavelength 290–315 nm). The second most important determinant is its uptake from the diet, in which (fatty) fish, eggs and fortified food products are amongst the richest sources (1). Vitamin D can be viewed as a pro-hormone. In the liver, it becomes converted into 25-hydroxyvitamin D [25(OH)D] which is substrate for the formation of active 1,25-dihydroxyvitamin D [1,25(OH)₂D]. The serum 25(OH)D concentration represents the individual's vitamin D status (2). The amount of vitamin D needed to support health is controversial. There is general agreement that serum 25(OH)D levels below 25 nmol/L indicates vitamin D deficiency. It seems also clear that levels up to 200–250 nmol/L are safe (3, 4), moreover, sunlight exposure is unable to cause vitamin D toxicity. Lifeguards typically have serum 25(OH)D levels of 250–312.5 nmol/L (2). There is much less agreement on optimal levels. Based on many arguments, such as the relation with parathyroid hormone [PTH] (5), many investigators consider 75–80 nmol/L 25(OH)D as optimal. Levels up to 100 nmol/L may be necessary for optimal insulin secretion by the pancreas (6).

The occurrence of vitamin D deficiency in tropical areas might not be expected, because of the year round abundant (UVB-rich) sunlight. A recent study showed that traditionally-living people in Tanzania have a mean vitamin D status of 115 nmol/L 25(OH)D (7). Low vitamin D status has, however, been reported in several tropical regions (8–11), presumably because people tend to reside increasingly behind (UVB-absorbing) glass, a natural tendency to avoid sunlight exposure in tropical areas, the lower rate of vitamin D synthesis in dark skin (12, 13), and the fear of skin cancer. Given vitamin D's calcaemic and many non-calcaemic functions, it might, however, be of importance to find a balance in the exposure to direct sunlight, since a 75–80 nmol/L 25(OH)D status cannot be reached by vitamin D intake from the usual diet (14). This seems especially important for groups that are at risk of low vitamin D status, such as the (frail) elderly and others who voluntarily or involuntarily avoid direct sunlight exposure. The aim of our study was to measure the vitamin D status in persons belonging to such risk groups living in the tropical island of Curaçao (12 degrees 10N, 69 degrees 0W).

SUBJECTS AND METHODS

Study design

The study was conducted from February to June 2008 and aimed at the establishment of the vitamin D status of persons at increased risk of low vitamin D, notably those reha-

bilitating from hip fractures (referred to as 'orthopaedic patients'), and elderly living in a nursing home, three retirement homes and those supported by healthcare professionals in a home care setting. Persons were eligible to participate if their caretakers reported an estimated lack of direct and indirect sunlight exposure for two months or more. Those suffering from cancer were excluded. All participants provided us with informed consent. The study protocol was approved by the Medical Ethical Committee of the St Elisabeth Hospital in Curaçao and the Medical Ethical Committee of the Betèsda Nursery home, and was in agreement with the Helsinki Declaration on Human Rights (15).

Data collection

All participants were physically examined and completed an assisted questionnaire. The latter included questions about medicine use, medical history, diet, supplement usage, physical activity and sunlight exposure. These questions were answered using the interview and the medical records. Data on height and weight were collected when they were available. Mid-upper arm circumference (MUAC) of the non-dominant upper arm was measured in centimetres (16) for the calculation of body mass index (BMI, in kg/m²) using BMI = (1.06 × MUAC) – 5.8. Skin colour was assessed by comparison with Fitzpatrick skin type scale, class I–VI (17).

Laboratory measurements

Non-fasting venous blood samples were collected into a tube containing lithium-heparin for the preparation of plasma and two gel tubes for the preparation of serum. Lithium-heparin plasma and serum were prepared by centrifugation and stored at -70 °C within four hours of collection. Samples were transported to the University Medical Centre Groningen in Netherlands in dry ice. Serum 25(OH)D was measured with the ¹²⁵I RIA KIT (DiaSorin, Stillwater, USA), PTH with the Immulite 2500 (Siemens, Breda, Netherlands) and creatinine, calcium and phosphate with the RocheModular (Mannheim, Germany). If creatinine exceeded the upper limits of the local reference ranges (> 90 mmol/L for women, > 110 mmol/L for men) or the PTH proved elevated (> 8 pmol/L), we also measured serum 1,25(OH)₂D with a ¹²⁵I RIA kit (Immunodiagnosicsystems, Boldon, UK).

Statistics

Statistical analyses were performed with SPSS 14.0. Pearson or Spearman correlations were used to test for associations between PTH, creatinine, 25(OH)D, 1,25(OH)₂D, phosphate and calcium. Between-group comparisons of 25(OH)D were performed with an independent samples *t*-test. *P*-values < 0.05 were considered significant.

RESULTS

Study group and anthropometrics

Fifty-eight persons, 23 males and 35 females, were recruited from retirement homes ($n = 18$), a nursing home ($n = 12$), *via* home care health professionals ($n = 22$) and a rehabilitation clinic ($n = 6$). The latter were recovering from orthopaedic operations. The mean \pm SD age of the total group was 81 ± 11 (38–96) years and the majority of the participants had dark skin (Fitzpatrick scale $> III$). Twenty-eight per cent had a BMI (MUAC) between 25 and 30 kg/m^2 and 24% had a BMI (MUAC) above 30 kg/m^2 . The mean BMI (MUAC) was 26.1 ± 5.7 (13.3–38.7) kg/m^2 . The characteristics of the persons are depicted in Table 1. All mobile participants en-

rehabilitation clinic. Of the total group, 12% had 25(OH)D levels below 25 nmol/L, 26% levels between 25 and 50 nmol/L, 45% levels between 50 and 75 nmol/L, and 17% had 75 nmol/L 25(OH)D or more (Fig. 1). The 17 vitamin D supplemented participants had similar 25(OH)D compared with the 41 unsupplemented counterparts (62 ± 23 vs 54 ± 22 nmol/L, respectively; $p = 0.21$). Median (range) PTH level in the total group was 5.4 (1.9–42.1) pmol/L. The median creatinine for the total study group was 79 (31–729) mmol/L. For men, this was 91 (52–729) mmol/L and for women 75 (31–464) mmol/L. In the nursing home, 7/22 participants had low calcium levels, the lowest level in this group was

Table 1: Clinical characteristics

| | Retirement homes | Nursing home | Home care | Rehabilitation clinic |
|--|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Number | 18 | 12 | 22 | 6 |
| Gender (male/female) | 3/15 | 4/8 | 11/11 | 5/1 |
| Age (years) | 82 ± 8 (68 – 94) | 83 ± 9 (69 – 95) | 80 ± 10 (60 – 96) | 73 ± 19 (38 – 90) |
| Skin colour $> III^a$ | 13 (72%) | 9 (75%) | 10 (45%) | 2 (33%) |
| BMI (MUAC) kg/m^2 ^b | 25.7 ± 5.7 (14.9 – 35.5) | 22.1 ± 3.9 (13.3 – 28.1) | 28.3 ± 5.3 (20.2 – 37.1) | 26.0 ± 6.7 (19.1 – 38.7) |
| Mobile ^c | 14 (78%) | 0 (0%) | 9 (41%) | 0 (0%) |
| Vitamin D supplement user ^d | 3 (17%) | 5 (42%) | 9 (41%) | 0 (0%) |
| Smoking | 0 (0%) | 0 (0%) | 2 (9%) | 1 (17%) |
| Diabetes mellitus (I or II) | 3 (17%) | 5 (42%) | 8 (36%) | 0 (0%) |
| Hypertension ^e | 6 (33%) | 5 (42%) | 10 (46%) | 3 (50%) |
| Ever broken a bone | 3 (17%) | 2 (17%) | 7 (32%) | 6 (100%) |
| Other diseases ^f | 6 (33%) | 2 (17%) | 5 (23%) | 2 (33%) |
| Medication use ^g | 16 (89%) | 12 (100%) | 20 (91%) | 6 (100%) |

Values expressed as mean \pm SD (range) or number (%)

a Fitzpatrick scale

b Body mass index (BMI) or mid-upper arm circumference (MUAC), measured in cm ($= (1.06 \times \text{MUAC}) - 5.8$)

c Engaged in daily activities including walking

d Through enriched milk ($n = 7$) and through vitamin supplements ($n = 11$)

e From medical records

f Parkinson, arthritis, hypothyroidism *etc*

g Oral anticoagulants, diuretics, glucose lowering medication, proton pump inhibitors, laxatives *etc*

gaged in daily activities including walking. Of the 35 immobile participants, seven were temporarily immobile, because of a hip fracture, hip replacement or operation. None of the rehabilitation patients was supplemented with vitamin D. Within the other groups, 17 were supplemented: seven through enriched milk products and 11 through vitamin supplements (one person used both). Three participants smoked and almost all used some kind of medication, mostly oral anticoagulants, diuretics, glucose lowering medication, proton pump inhibitors and laxatives.

Parameters of calcium homeostasis

Parameters of calcium homeostasis are depicted in Table 2. The 25(OH)D level of the total group was 57 ± 22 (7–106) nmol/L. Lowest 25(OH)D levels were encountered in the

1.95 nmol/L. In the rehabilitation clinic, 4/5 participants had calcium levels below reference values, the lowest level was 1.79 nmol/L. Low levels of phosphate was detected in 3.4% of the participants (these were all homecare participants) and 5.2% had high phosphate levels.

Patients exhibiting increased creatinine, PTH, or both

Levels above reference range of PTH and/or creatinine were detected in 25/58 participants and consequently 1,25(OH)₂D was measured (Table 2, Fig. 2, one missing). Seven persons had 1,25(OH)₂D levels below the cut-off value of 40 pmol/L. Two lived in home care, four in a retirement home and one was in the rehabilitation clinic. Four patients had the combination of high PTH and creatinine, and low 1,25(OH)₂D.

Table 2: Parameters of calcium homeostasis

| | Units and criteria | Retirement homes | Nursing home | Home care | Rehabilitation clinic |
|--------------------------|--------------------|------------------|--------------|--------------|-----------------------|
| Number | | 18 | 12 | 22 | 6 |
| 25(OH)D | nmol/L | 50 ± 21 | 58 ± 24 | 66 ± 21 | 43 ± 18 |
| | range | (7–85) | (23–106) | (26–103) | (19–66) |
| | < 25 nmol/L | 3 (17%) | 2 (17%) | 0 (0%) | 2 (25%) |
| | < 50 nmol/L | 9 (50%) | 3 (25%) | 6 (27%) | 4 (67%) |
| | < 75 nmol/L | 16 (89%) | 11 (92%) | 15 (68%) | 6 (100%) |
| 1,25(OH) ₂ D* | pmol/L | 37 | 63 | 111 | 34 |
| | range | (21 – 113) | (63 – 63) | (13 – 195) | (15 – 53) |
| PTH | pmol/L | 5.1 | 4.2 | 7.9 | 4.1 |
| | range | (1.9 – 11.5) | (2.1 – 11.3) | (2.4 – 42.1) | (2.9 – 31.7)** |
| | >8 pmol/L | 3 (17%) | 1 (8%) | 11 (50%) | 1 (20%)** |
| Creatinine | umol/L | 87 | 64 | 84 | 65 |
| | range | (54 – 471) | (31 – 103) | (46 – 729) | (53 – 355)** |
| | > ref range*** | 6 (33%) | 1 (8%) | 10 (45%) | 2 (40%)** |
| Calcium | mmol/L | 2.29 ± 0.12 | 2.17 ± 0.10 | 2.31 ± 0.15 | 2.00 ± 0.16 |
| | range | (2.17–2.51) | (1.95–2.35) | (2.09–2.66) | (1.79-2.20)** |
| Phosphate | mmol/L | 1.10 ± 0.25 | 1.15 ± 0.35 | 1.14 ± 0.46 | 1.08 ± 0.25 |
| | range | (0.81–1.38) | (0.90–2.16) | (0.50–2.95) | (0.81–1.38)** |

Values are either mean ± SD (range), median (range), or number (%)
 25(OH)D, parathyroid hormone (PTH) and 1,25(OH)₂D were measured in serum; creatinine, calcium and phosphate were measured in plasma
 * Measured if serum creatinine was above the reference value or PTH was > 8 pmol/L or both: retirement homes n = 7; nursing home n = 1; home care n = 14; rehabilitation clinic n = 2
 ** n = 5
 *** reference range is > 90 umol/L for women and > 110 umol/L for men

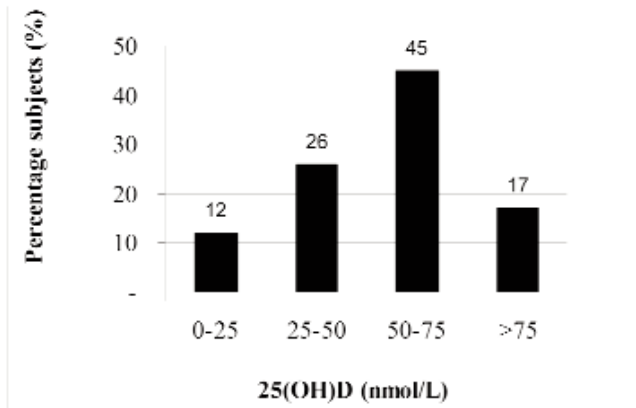


Fig. 1: Distribution of serum 25(OH)D levels.

Correlations

Parathyroid hormone (n = 57) correlated positively with creatinine ($r_s = 0.476, p < 0.001$), and calcium ($r_s = 0.345, p = 0.009$). 1,25(OH)₂D (n = 24) correlated negatively with phosphate ($r_s = -0.805, p < 0.001$) and creatinine ($r_s = -0.710, p < 0.001$). Creatinine (n = 57) also correlated positively with phosphate ($r_s = 0.434, p = 0.001$).

DISCUSSION

Living in Curaçao, with sunshine year round, does not forestall vitamin D deficiency; 12% of the selected

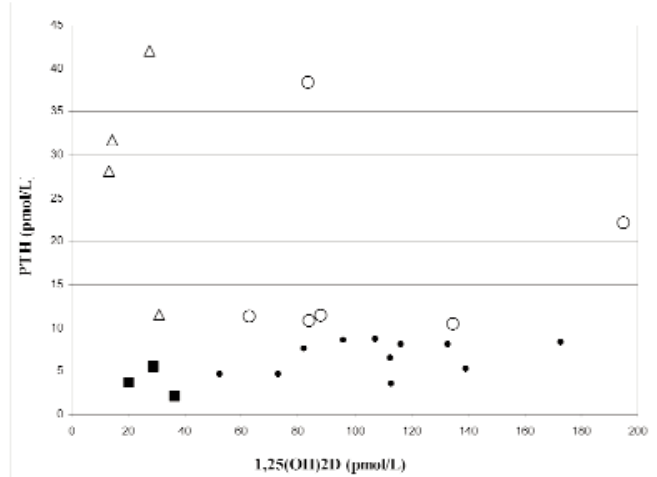


Fig. 2: Relation between 1,25(OH)₂D and parathyroid hormone (PTH) in the 24 participants with increased PTH and/or, serum creatinine levels.
 ● = normal 1,25(OH)₂D + normal PTH (n = 11); ○ = normal 1,25(OH)₂D + high PTH (n = 6); Δ = low 1,25(OH)₂D + high PTH (n = 4); ■ = low 1,25(OH)₂D + normal PTH (n = 3).
 Abnormal levels are defined as: PTH > 8 pmol/L, creatinine > 90 umol/L in women and > 110 umol/L in men, 1,25(OH)₂D < 40 pmol/L

participants had 25(OH)D levels < 25 nmol/L and 26% had levels between 25 and 50 nmol/L, using the recent cut-off value of the Institute of Medicine [IOM] (18). The percentage of participants with insufficient vitamin D status rose to

83% if the more widely employed cut-off value of 75 nmol/L (19) was used.

The mean level of 57 nmol/L contrasts with 85 nmol/L 25(OH)D level encountered in pre- and postmenopausal women living in Curaçao (20) and can be explained by our focus on a group with low sunshine exposure. Although we could not demonstrate a negative correlation between 25(OH)D and PTH in this small group, as reported in other studies (21, 22), three persons exhibited increased PTH with low 25(OH)D and normal 1,25(OH)₂D. This combination suggests secondary hyperparathyroidism due to vitamin D deficiency and might easily become corrected by vitamin D supplementation or moderate exposure to direct sunlight. Also rehabilitating orthopaedic patients deserve special attention with respect to their vitamin D status. Vitamin D deficiency is strongly associated with muscle weakness and falls (23, 24), which is likely to retard the rehabilitation process. Somewhat unexpectedly, we encountered four participants with a combination of high PTH, high creatinine and low 1,25(OH)₂D, suggesting secondary hyperparathyroidism is due to impaired kidney function. This might easily become underdiagnosed in tropical countries with abundant sunshine, where clinical chemical laboratories usually have less access to 25(OH)D and 1,25(OH)₂D measurements because of the widespread notion that vitamin D deficiency does not occur. More attention is warranted, since correction of 1,25(OH)₂D levels by treatment with vitamin D or alfacalcidol (1-hydroxy-cholecalciferol) necessitates careful monitoring of the PTH, together with the 25(OH)D and 1,25(OH)₂D if necessary.

The present outcome is in line with other studies showing low vitamin D status in certain groups living in a tropical or subtropical area. Low 25(OH)D status was also encountered in elderly men and women living in subtropical Sao Paulo (Brazil). In this study, the mean 25(OH)D level was 49.5 nmol/l. Vitamin D deficiency was found in 15.4% of subjects, while 41.9% showed levels between 25 and 50 nmol/L (10). Low 25(OH)D levels were also found in a mixed group of patients attending an internal medicine department of a hospital in tropical South Florida. In the 'winter' period, 39% had 25(OH)D levels below 50 nmol/L, while 9% had levels below 30 nmol/L (9). Also, young people living in tropical areas may have low vitamin D status when insufficiently exposed to sunlight. A study among female garment workers in Bangladesh yielded 16% vitamin D deficiency (< 25 nmol/L) and 88.5% vitamin D insufficiency (8). A large study on the population vitamin D status was conducted among healthy men and women living in rural and urban areas in South India. The overall vitamin D deficiency was 18% and 70% for the cut-off levels of 25 and 50 nmol/L 25(OH)D, with women having lower vitamin D status than men (11).

All of these studies, including the present one, show that vitamin D deficiency and insufficiency is also a common observation in tropical and subtropical areas. Particularly,

groups that are at risk are elderly people living in nursing homes. A limitation of the current study is its small group size and its questionable representativeness. It should be viewed upon as a pilot that might be followed by systematic screening in high risk groups that are characterized by limited exposure to direct sunlight.

We conclude that living in a country with year-long abundant sunlight does not guarantee a sufficient vitamin D status. Elderly living in nursing and retirement homes, those with home care, and orthopaedic patients with long term rehabilitation programmes are among the risk groups. Measurements of 25(OH)D for vitamin D status assessment and of 1,25(OH)₂D and PTH for patients with poor renal function are also needed in the tropics.

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