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Functionality and 25-hydroxyvitamin D levels in institutionalized older adults

Funcionalidade e níveis de 25-hidroxivitamina D em idosos institucionalizados

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Abstract

Objectives: To evaluate the frequency of hypovitaminosis D among older adults and its association with the level of functionality.

Methods: This cross-sectional observational study of older adults residing in a non-profit long-term care facility assessed functionality with the Katz Index of Independence in Activities of Daily Living. Vitamin D levels were classified as: deficient (< 20 ng/mL), insufficient (21–29 ng/mL), or normal (≥ 30 ng/mL). We used the chi-square test and Student's *t*-test to compare dichotomous and continuous variables, respectively. Analysis of variance with Tukey's post hoc test was used to assess differences between groups.

Results: The sample consisted of 63 individuals whose mean age was 81 (61–113) years: 36 (55.4%) women and 27 (44.6%) men. The mean vitamin D level was 18.6 ng/mL, being < 30 ng/mL in 84.1%. The level was normal in 10 (15.9%), insufficient in 17 (27%), and deficient in 36 (57.1%). Vitamin D deficiency was present in 76.5% of those with total functional dependence (Katz = 5–6).

Conclusions: We observed a high frequency of hypovitaminosis D, especially vitamin D deficiency, which was very common among those with significant functional dependence.

Keywords: older adult; long-term care facility; vitamin D; functional status.

Resumo

Objetivos: Avaliar a frequência de hipovitaminose D em idosos de uma instituição filantrópica de longa permanência e sua associação com grau de funcionalidade.

Metodologia: Estudo transversal, observacional e analítico de idosos de uma instituição filantrópica de longa permanência. A funcionalidade foi avaliada pela Escala de Katz. Os níveis de vitamina D foram classificados em: deficiência (valores menores que 20 ng/mL); insuficiência (valores entre 21 – 29 ng/mL) e normais (valores igual ou superior a 30 ng/mL). Empregamos teste qui-quadrado e *t de student*, para compararmos variáveis dicotômicas e contínuas, respectivamente; e análise de variância (ANOVA) com teste *post hoc* de Tukey, para avaliarmos as diferenças entre os grupos.

Resultados: Sessenta e três indivíduos foram analisados com média de idade de 81 anos (61 – 113), sendo 36 (55,4%) mulheres e 27 (44,6%) homens. A média de vitamina D foi 18,6 ng/mL, 84,1% com níveis menores que 30 ng/mL; dez apresentaram níveis normais (15,9%), 17 com insuficiência (27%) e 36 com deficiência (57,1%); ainda, 76,5% dos portadores de dependência funcional total (Katz = 5 – 6) apresentam deficiência de vitamina D.

Conclusões: Observamos uma alta frequência de hipovitaminose D, especialmente deficiência, muito frequentes naqueles com dependência funcional importante.

Palavras-chave: pessoa idosa; instituição de longa permanência para idosos; vitamina D; estado funcional.

INTRODUCTION

Vitamin D is a hormone produced mainly in the skin. In response to ultraviolet light, keratinocytes in the epidermis convert 7-dehydrocholesterol (an immediate precursor to cholesterol) into vitamin D3. Production of vitamin D3 in the skin is affected by a variety of factors; aging also reduces the skin's ability to synthesize vitamin D.¹

Vitamin D3 produced in the skin is biologically inert and must be hydroxylated in successive steps to become active. The main function of 25-hydroxyvitamin D, the active form of vitamin D, is to maintain the concentration of circulating calcium by stimulating absorption in enterocytes and increasing bone resorption.¹

Vitamin D deficiency, classically defined as values < 20 ng/mL, is very common in older adults, especially those who have been institutionalized. This arises from low sun exposure, low concentrations of 7-dehydrocholesterol in the skin² and insufficient dietary intake of vitamin D.³

Studies on the association between vitamin D levels and functionality are limited by the fact that vitamin D deficiency is common among older adults (the prevalence is approximately 90%).^{4,5} The Longitudinal Aging Study Amsterdam, which included 1237 older adults (65–88 years), found an association between vitamin D deprivation and functional limitation.⁶

Thus, the objective of this study was to determine the frequency of hypovitaminosis D and its association with functionality among residents of a non-profit long-term care facility.

METHODS

This was a cross-sectional observational study of older adults from a long-term care facility in Cariacica, Espírito Santo,

Brazil. The dichotomous variables were: arterial hypertension (blood pressure $\geq 150/90$ mmHg or regular use of antihypertensives), diabetes mellitus (fasting blood glucose > 126 mg/dL or use of oral hypoglycemic agents or insulin), and dementia (diagnosed according to DSM-IV or National Institute of Neurological and Communicative Diseases and Stroke/Alzheimer's Disease and Related Disorders Association criteria).⁷ No participant had impaired kidney function. Functionality was assessed using the Katz Index of Independence in Activities of Daily Living, which assesses self-care in 6 domains: independent dressing, moving in and out of bed, using the toilet, washing, eating, and controlling urine and fecal continence. Each domain was assigned 1 or 0 points if the participant was dependent or independent, respectively. Thus, total scores ranged from 0 to 6 points⁸ and were classified as complete independence (Katz = 0), mild dependence (Katz = 1–2), moderate dependence (Katz = 3–4) or total dependence (Katz = 5–6).

Serum levels of 25-hydroxyvitamin D were collected, in addition to total cholesterol, glucose, glycated hemoglobin, creatinine, sodium, hemoglobin and hepatic transaminases (see Table 1). These examinations were performed between July and August. Levels of 25-hydroxyvitamin D were classified as: deficient (< 20 ng/mL), insufficient (21–29 ng/mL) or normal (≥ 30 ng/mL: competition-type electrochemiluminescent immunoassay).⁹ Residents who were taking vitamin D2/D3 supplements or multivitamins were excluded. All individuals (or their legal guardians) who agreed to participate in the study and provided written informed consent were included.

Categorical variables were represented as percentages, and continuous variables were represented as mean (SD).

TABLE 1. Demographic and laboratory profile of the participants.

Characteristics	Women (36)	Men (27)	p-value*	Mean
Age (years) (min–max)	83 $\pm$ 10	78 $\pm$ 7	0.02*	81 $\pm$ 9 (61–113)
25-OH vitamin D3 (ng/mL)	17.20 $\pm$ 9.10	20.40 $\pm$ 9.80	0.18	18 $\pm$ 9.50
Total cholesterol (mg/dL)	179 $\pm$ 37	163 $\pm$ 3.10	0.08	172 $\pm$ 35
Glucose (mg/dL)	93 $\pm$ 13	97 $\pm$ 24	0.45	95 $\pm$ 18
Hemoglobin glycosylated (HbA1c)%	5.90 $\pm$ 0.50	6.0 $\pm$ 0.60	0.58	6.03 $\pm$ 0.56
Creatinine (mg/dL)	0.80 $\pm$ 0.17	1.07 $\pm$ 0.29	0.001	0.92 $\pm$ 0.26
Sodium (mEq/L)	139 $\pm$ 2	137 $\pm$ 2	0.07	138 $\pm$ 2.30
Hemoglobin (g/dL)	13 $\pm$ 1.40	14 $\pm$ 1.80	0.02*	13 $\pm$ 1.60
GOT (units/L)	18 $\pm$ 7	21 $\pm$ 20	0.50	15 $\pm$ 2
GTP (units/L)	13 $\pm$ 15	18 $\pm$ 26	0.37	19 $\pm$ 14

*t-test for independent samples ($p \leq 0.05$). GOT: serum glutamic-oxaloacetic transaminase; GTP: serum glutamic-pyruvic transaminase.

The association between the dependent variable (vitamin D) and the independent variables was analyzed using the chi-square test. Student's *t*-test for independent samples was used to compare continuous variables. One-way analysis of variance with Tukey's post hoc test was used to compare variables between groups with normal, insufficient, and deficient vitamin D levels.

The data were analyzed in IBM SPSS Statistics 25.0 (IBM, Armonk, NY, USA). We considered *p*-values < 0.05 significant. This research project was approved by the Escola Superior de Ciências da Santa Casa de Misericórdia de Vitória research ethics committee (number 29112914.9.0000.5065).

RESULTS

We analyzed 63 older adults: 36 women (55.4%) and 27 men (44.6%) with a mean age of 81 (61–113) years, distributed in the following age groups: 61–74 years (*n* = 15; 23.8%), 75–84 years (*n* = 23; 36.5%), and > 85 years (*n* = 25; 39.7%). The mean vitamin D level was 18.695 ng/mL, being insufficient in 17 (27%) residents, deficient in 36 (57.1%), and normal in 10 (15.9%). Individuals with normal vitamin D levels were younger, with a mean age of 77 (SD, 6) years. The mean age in the insufficient and deficient groups was 80 (SD, 7) and 82 (SD, 1) years, respectively (*p* = 0.26). We found no association between vitamin D level and dementia (*p* = 0.48), high blood pressure (*p* = 0.59), or diabetes mellitus (*p* = 0.50).

The participants had been institutionalized for 1–8 (mean 4.46) years. The mean residence time was 2 (1–5) years in the normal vitamin D group, 6.53 (1–18) years in the insufficient group, and 4.23 (1–17) years in the deficient group (*p* = 0.02). A *post hoc* analysis of variance test revealed a significant difference (*p* = 0.02) in residence time between the normal and insufficient groups.

A total of 24 participants (40%) were completely independent in activities of daily living (Katz = 0), 16 (24.6%)

were mildly dependent (Katz = 1–2), 6 (9.3%) were moderately dependent (Katz = 3–4), and 17 (26.1%) were totally dependent (Katz = 5–6). The distribution of groups according to functional dependence and hypovitaminosis D is shown in Table 2.

When correlating functional dependence with 25-hydroxyvitamin D levels in analysis of variance with Tukey's post hoc test, the mean vitamin D level was 19.78 ng/mL in independent individuals, 22.10 ng/mL in mildly dependent individuals, 19.49 ng/mL in moderately dependent individuals, and 13.51 ng/mL in totally dependent individuals (*p* = 0.02). There was a significant difference (*p* = 0.02) between the totally and mildly dependent groups in the post hoc analysis. A high (23.8%; 15 individuals) but non-significant (*p* = 0.23) percentage of participants had severe vitamin D deficiency (< 10 ng/mL).

DISCUSSION

The frequency of older adults with abnormal vitamin D levels was 84.1% (mean level 18 ng/mL), with 57.1% classified as deficient (< 20 ng/mL). Similar results have been observed in other studies, ie, a significant portion of institutionalized older adults have deficient vitamin D levels.^{10,11}

A total of 23.8% of the institution's residents had severe vitamin D deficiency (< 10 ng/mL), which corresponded to 46.7% of those with high functional dependence. Functional dependence was thus an important determinant of vitamin D deficiency. This finding is corroborated by other studies, such as Alekena et al.,¹² who found an association between vitamin D deficiency and dependence in activities of daily living.

In a 2007 study of 117 institutionalized older Brazilians, Saraiva et al.¹³ observed that vitamin D levels were deficient in 40.7% and insufficient in 30.5%. Among outpatients, vitamin D levels were deficient in 15.8% and insufficient in 40.0%. Institutionalization had the greatest influence on the results of

TABLE 2. The relationship between functionality and vitamin D levels.

ADL	Vitamin D			n
	Normal (≥ 30 ng/mL) n (%)	Insufficient (21 – 29 ng/mL) n (%)	Deficient (≤ 20 ng/mL) n (%)	
Independent	4 (16.70)	7 (29.20)	13 (54.20)	24
Mild dependence	5 (31.20)	4 (25.00)	7 (43.80)	16
Moderate dependence	1 (16.70)	2 (33.30)	3 (50.00)	6
Total dependence	0 (0.00)	4 (23.50)	13 (76.50)	17
Total (individuals)	10 (15.87)	17 (57.14)	36 (26.98)	63 (100.00)

χ^2 test (*p* = 0.31). ADL: Activities of daily living (Katz Index).

the multivariable analysis. Therefore, it appears that individuals with more pronounced functional dependence have a higher frequency of vitamin D deficiency due to reduced sun exposure.¹⁴

Studies have demonstrated an association between vitamin D deficiency and decreased insulin secretion, insulin resistance, type 2 diabetes mellitus, and metabolic syndrome. However, the mechanisms that justify such findings are still poorly understood.^{15,16} Recent evidence has shown that vitamin D is a neurosteroid that is important in aging and age-associated cognitive decline. Thus, hypovitaminosis D has been associated with a risk of dementia and Alzheimer's disease.¹⁷ However, in the present study we found no association between vitamin D levels and dementia, high blood pressure, or diabetes mellitus.

Those with normal vitamin D levels were younger and had been institutionalized for less time, but these differences were not significant. Due to low sun exposure, poorer nutritional status, and a high prevalence of frailty, long-term care facility residents are at high risk for vitamin D deficiency, as shown by Gau et al.¹⁸

Our study was limited by its sample size and by sampling a single long-term care facility. The fact that the facility was for at-risk individuals could have affected the low dietary intake of vitamin D. The scarcity of recent literature on this theme limited comparison with other studies. Due to the study design, causal links between the variables could not be determined.

The high frequency of vitamin D deficiency in the present study leads us to recommend monthly supplementation with 50,000 IU vitamin D, which is a safe and effective dose for older adults.¹⁹

CONCLUSION

We observed a high frequency of hypovitaminosis D, especially vitamin D deficiency, among institutionalized older adults who are functionally dependent in activities of daily living.

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Conflict of interests

The authors declare no conflicts of interest.

Author contributions

RLM: study design and planning, data curation, formal analysis. RLM, SJF, MMHB, IAC, CDN, WBW: writing – original draft, writing – review & editing.

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