

The Association Between Hypovitaminosis D Status with Muscle Strength and Functional Capacity in a Brazilian Community-Dwelling Elderly Population: A Cross- Sectional Study

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Abstract

Background: Although there have been studies on the association between hypovitaminosis D status with muscle strength and functional capacity, there were few studies on Brazilian community-dwelling elderly population. Therefore, this study aims to assess the association of hypovitaminosis D with muscle strength and functional capacity in a sample Brazilian community-dwelling elderly population.

Methods: An analytical, cross-sectional observational study with a convenience sample was conducted. The 25(OH)D levels were assessed using an enzyme-linked fluorescent assay and classified according to the standardization of the Brazilian Society of Clinical Pathology/Laboratory Medicine. Hand grip strength (HGS) and isometric quadriceps strength (IQS) were measured using manual Jamar[®] and Lafayette[®] 01165 dynamometers, respectively. Functional capacity was evaluated using the Short Physical Performance Battery (SPPB). Multiple linear regression models were used to assess the association of hypovitaminosis D with the HGS, IQS, and SPPB score via the Enter method. The models were adjusted for age, sex, presence of pain, level of physical activity, and use of vitamin D supplementation.

Results: A total of 150 elderly individuals (age: 67.18±5.33 years) were included. According to the 25(OH)D levels, 60.7% had hypovitaminosis D (insufficient: 48%, deficient: 12.7%), and 39.3% had sufficient levels. No associations were found between hypovitaminosis D and the HGS ($p=0.84$), LogIQS ($p=0.462$), and SPPB score ($p=0.617$). In the regression model, the influence of the vitamin D levels on functional capacity was not significant, demonstrating no association between them.

Conclusion: Hypovitaminosis D was not associated with decreased muscle strength and functional capacity in the sample Brazilian community-dwelling elderly population. Longitudinal studies with measurement of the time of use and levels of vitamin D are encouraged.

Background

Hypovitaminosis D is a frequent finding in older populations. Approximately 1 billion individuals have low vitamin D levels, regardless of ethnicity, age group, and geographic location [1, 2]. Depending on the population studied, the prevalence can reach up to 90%, being considered by many researchers as a public health problem. Approximately 50–70% of European older individuals, 20–100% of Americans, and one third of Taiwanese and Japanese older individuals had vitamin D levels lower than 20 ng/mL, indicating a deficiency [3, 4]. In Brazil, despite being a country with a tropical climate, hypovitaminosis D occurs in several age groups mainly owing to a diet low in vitamin D, and affected individuals are rarely offered multivitamin supplementation [5]. In a recent systematic review with meta-analysis involving 340,476 Brazilians of different age groups, the mean level of vitamin D was 27.06 ng/mL, with the highest prevalence of deficiency among the older people group, which corresponded to 41.53% of the total population with vitamin D insufficiency [6].

This high prevalence in older people populations occurs owing to several factors, including decreased sun exposure, altered ability to synthesize this vitamin in the skin, impaired bowel absorption, poor dietary intake, and emergence of renal and gastrointestinal diseases [7]. Vitamin D receptors (VDRs) are present in more

than 250 body sites, including muscle tissue. Inconclusive evidence shows that vitamin D is directly related to the metabolism of muscle energy and regulation of consumption and dynamics of mitochondrial oxygen, besides playing an important role in the regulation of muscle tone and contraction [8].

Taken together, changes in the vitamin D levels may contribute to the deterioration of various systems; however, the relationship of hypovitaminosis D with muscle strength and functional capacity in older people populations has been a subject of conflicting results [9–12]. Given the tropical climate of Brazil and the peculiarities inherent to the senescence of older people individuals living in a country with socio-economic and cultural inequities, we hypothesized that hypovitaminosis D would negatively influence the muscle strength and functional capacity of older people individuals. Thus, the aim of this study was to examine the association of hypovitaminosis D (insufficiency and deficiency) with muscle strength and functional capacity in a sample Brazilian community-dwelling older people population.

Methods

Study design and participants

This study was an analytical observational study with a cross-sectional design. A convenience sample of 150 Brazilian community-dwelling older people individuals of both sexes, aged 60 years or older, and recruited from August 2019 to February 2020 participated in the study. The exclusion criteria were as follows: cognitive decline detectable on the Mini-Mental State Examination [13], neurological sequelae, acute diseases, neoplasms, gastrectomy, use of prosthesis, use of drugs that interfere with the vitamin D levels, sequelae of diseases that could cause decreased muscle strength of the hands and lower limbs, severe sequelae of fracture, and previous orthopedic surgeries.

Measurements

Sociodemographic and clinical variables

To characterize the sample, we asked all participants to answer a clinical-sociodemographic questionnaire with items on age, sex, race, origin, marital status, schooling, profession, main diagnosis, presence of comorbidities, use of medications and supplements, and anthropometric data.

Laboratory measurements

The levels of 25(OH)D were measured using an enzyme-linked fluorescent assay. The tests were conducted in the laboratory of SARAH Network of Rehabilitation Hospitals. The reference levels were determined according to the standardization of the Brazilian Society of Clinical Pathology/Laboratory Medicine (SBPC/ML) for individuals aged 60 years or older: 30–100 ng/mL, indicating vitamin D sufficiency; 20–29.9 ng/mL, indicating insufficiency; and below 20 ng/mL, indicating deficiency [5].

Muscle strength

Muscle strength was evaluated on the basis of hand grip strength (HGS) and isometric quadriceps strength (IQS). The Jamar[®] dynamometer was used to assess the HGS, as recommended by the American Society of Hand Therapist (ASHT) [14]. The Lafayette[®] model 01165 manual dynamometer was used to assess the IQS, following the recommendations standardized by Bohannon (2012) [15]. In both parameter evaluations, three repetitions were performed with the dominant limb, with a 1-minute rest interval between each measurement; subsequently, the arithmetic mean was calculated [16,17].

Functional capacity

Functional capacity was measured using the Short Physical Performance Battery (SPPB) adapted and validated for Brazilian older people individuals [18].

Statistical analysis

The Shapiro–Wilk test was used to evaluate the normality of the data. The quantitative descriptive data of the sample were summarized by measures of central tendency (medians and interquartile interval dispersions). The categorical variables of the study were described as absolute frequencies and percentages and the quantitative variables as medians (first quartile; third quartile) because the variables did not have a normal distribution as verified in the normality test.

As this study was an exploratory study conducted with a convenience sample, we initially tested the effect of the use of vitamin D and use of supplements on the study-dependent variables (HGS, IQS, and SPPB score) and vitamin D status to assess whether these variables influenced the outcome variables. The tests used were the Mann–Whitney (HGS and IQS), Pearson's exact chi-square (SPPB score), and asymptotic Pearson's chi-square tests (vitamin D status).

Multiple linear regression models were used to assess the association of the vitamin D levels with muscle strength (HGS and IQS) and functional capacity through the Enter method. The models were adjusted for age, sex, presence of pain, level of physical activity, and use of vitamin D supplementation. Since the IQS did not present a normal distribution, we decided to use the logarithm of the IQS (LogIQS).

The coefficient of multiple determination (R^2) was used to quantify the strength of the association between muscle strength and the independent variables. The F-test was used to determine the statistical significance at p-values of <0.05. Regarding the assumptions of the model, the presence of multicollinearity was taken into account when the variance inflation factor was >10, and the tolerance was <0.2; homoscedasticity was verified by observing the graph of the predicted values and observed values and the normality of the non-standardized residue. For all analyses, the SPSS version 23.0 software for Windows was used.

For all analyses, the significance level was set at 0.05, and the SPSS version 20.0 software (SPSS Inc., Chicago, IL, USA) was used.

Results

The prevalence of hypovitaminosis D in the sample studied was 60.7%. All 150 older people participants were classified as follows: 48% as having insufficient vitamin D levels ($n = 72$, median: 25.40 (range: 23.20–27.90 ng/mL); 39.3%, normal vitamin D levels ($n = 59$, median: 33.60 (range: 31.77–38.10 ng/mL); and 12.7%, deficient vitamin D levels ($n = 19$, median: 18.30 (range: 14.70–19.00 ng/mL). The descriptive analysis of the sociodemographic and clinical characteristics of the participants is presented in Table 1.

Interestingly, the participants who were using supplements ($p < 0.0001$) and vitamin D ($p < 0.013$) presented significantly lower HGS values in both analyses. Meanwhile, there was no significant difference in the IQS and SPPB score between the participants who used and who did not use supplements and vitamin D ($p \geq 0.05$) (Table 2).

The multiple regression analysis showed that the vitamin D levels were not associated with the HGS and IQS. The influence of the vitamin D levels on the HGS and LogIQS lost its significance after the inclusion of the adjustment variables age, sex, presence of pain, level of physical activity, and use of supplements (Tables 3 and 4).

Regarding functional capacity, 2% had an SPPB score of ≤ 6 , 15.3% between 7 and 9, and 82.7% between 10 and 12 (good). In the regression model, the influence of the vitamin D level on functional capacity was not significant.

Discussion

This study conducted in a sample of 150 Brazilian community-dwelling older people individuals showed that the prevalence of hypovitaminosis D was high (60.7%); in contrast, there was no association of hypovitaminosis D with muscle strength and functional capacity. This finding may be attributed to the fact that the sample included older people individuals with lower active age groups and few comorbidities, and the majority was practicing physical activity.

The high prevalence of hypovitaminosis D in this sample corroborates previously reported findings. Recently, a systematic review and meta-analysis of 72 studies on the prevalence of hypovitaminosis D in Brazil reported a rate of insufficiency of 45.85% and a rate of deficiency of 41.53%. The study mentioned included all age groups; however, it highlighted a greater presence of hypovitaminosis D among the older people group [6].

In recent decades, research has confirmed the important role of vitamin D in several outcomes, especially after the discovery of its activity on various organs and tissues [7]. Its relationship with the muscular system was more noticeable after the discovery of the VDRs in muscle tissue in the 1980s [19]. However, to date, the evidence on the influence of vitamin D deficiency on the muscle strength and functional capacity of older people individuals is still inconclusive. Aspell *et al.* (2019) evaluated 4,157 individuals with a mean age of 69.8 ± 6.9 years and reported that vitamin D deficiency was associated with decreased muscle strength among English community-dwelling older people individuals [20]. The value adopted to verify the vitamin deficiency used in this study was 30 nmol/L, which corresponds to 12 ng/mL. In our study, the recommendations of the SBPC/ML established levels below 30 ng/mL to indicate insufficiency and below 20

ng/mL to indicate deficiency. The absence of an international standardization for the classification of vitamin D deficiency hampers a comparative analysis between the two studies [21].

In 2018, Mendes *et al.* evaluated 1,425 older people individuals (mean age: 75.4 ± 7.5 years in women and 74.2 ± 6.7 years in men) and found a significant association between vitamin D deficiency and decreased gait speed and HGS, especially in men (41.5% of the total sample) [22]. Of the participants of our study, only 28% were men, with a much smaller age group (67.18 ± 5.33 years), which could explain, at least in part, the conflicting results. It is already established that men have greater muscle strength than women in all age groups and that the higher the age group, the lower the muscle strength and functional capacity [23]. Verlaan *et al.* (2018) conducted a multicenter study of 380 community-dwelling older people individuals aged over 65 years from 6 European countries (Belgium, Germany, Ireland, Italy, Sweden, and the United Kingdom) [24]. They found that older people individuals with vitamin D deficiency also presented decreased muscle mass (on DXA), strength (HGS), and functional performance in the SPPB (4–9 points). In our study, despite low schooling and living in a developing country, such as Brazil, 82.7% of the older people participants displayed good functional performance; further, 50.6% practiced regular physical activity, with few comorbidities, and were often exposed to sunlight. This differentiated profile of the Brazilian older people individuals may have contributed to the results found.

Notably, some studies have demonstrated similar results: not finding an association between hypovitaminosis D and decreased muscle strength and functional capacity. Mathei *et al.* (2013) assessed the relationship between the levels of 25(OH)D, HGS, and gait speed and balance test findings in 367 octogenarians. In this sample, only 12.8% presented vitamin D levels of 30 ng/mL or more [11]. Interestingly, there was no association found between hypovitaminosis D and the variables studied, although it was expected that the older age group would present worse results, which did not occur. Verreault *et al.* (2002) followed a cohort of 628 women (age: ≤ 65 years) for 3 years, performing evaluations every 6 months. The sample was divided into three groups according to the levels of vitamin D (≤ 10 ng/mL, 10–20 ng/mL, and ≥ 21 ng/mL) at baseline. Their analysis showed that the decline in strength (HGS) and muscle function (SPPB score) was similar in the three groups, regardless of the initial level of vitamin D [25]. Annweiler *et al.* (2009) evaluated the HGS, IQS, renal function, and parathyroid hormone (PTH) and calcium levels in 440 older people women with a mean age of 80.1 ± 3.5 years [26]. No association was found between vitamin D deficiency and decreased muscle strength. Advanced age and a higher number of chronic degenerative diseases were associated with greater decreases in muscle strength. The association of muscle weakness with increasing age is already well established in the literature and was one of the findings.

A possible physiological explanation for the lack of association of vitamin D deficiency with muscle strength and functional capacity in the older people population found in this study could be the decrease in the number of VDRs in the muscle tissue. Currently, the exact mechanism of the relationship between receptors and vitamin D deficiency is not yet established, that is, whether this reduction is caused by vitamin D deficiency itself (negative regulation of the receptor) or if by another factor inherent to aging [27].

The complex interaction between muscle strength and vitamin D, especially in older people individuals, is still contradictory. The existence of possible confounding factors, such as the level of PTH, presence of kidney diseases, comorbidities, use of medications or supplements, and practice of physical activity, is not always

controlled in studies, which may have contributed to the reporting of divergent results. Further, the large methodological variability, especially between the forms of measurement and classification of 25(OH)D, and diversity of assessments for muscle strength and functional capacity limit the comparison of data and may explain, at least in part, the large disparity of the findings. Conversely, the heterogeneity of the aging process, senility, clinical and socio-cultural factors, and life habits could also interfere in muscle and functional performance and should also then be considered.

In this study, sex (female), increased age, presence of pain, and use of supplements were more related to decreased HGS than the serum level of 25(OH)D. Both sex and age are factors that explain the decrease in muscle strength, that is, men have higher HGS than women, and muscle strength decreases with age [23].

Our study had an exploratory design; however, it is important to highlight that we analyzed not only the serum levels of vitamin D and the functionalities but also the use of vitamin supplements. Herein, we found that the older people participants who were using some type of supplementation had lower HGS, which may suggest that they were experiencing functional decline and thus had the need for supplementation.

There was no association between hypovitaminosis D and the IQS; increased age, sex, presence of pain, and physical activity were most related to this variable. The participants of this study were healthy community-dwelling older people individuals, of whom 50.6% practiced regular physical activity, and 82.7% had a good functional status. The performance of physical activity is considered a premise to reduce the physiological losses inherent to aging; it is widely studied and has been proven to be efficient in maintaining functional capacity and muscle strength [28]. The presence of pain could be a source of bias for the performance of muscle contraction required in the IQS assessment. In our sample, the older people participants who complained of pain in some joint presented lower quadriceps strength. In a systematic review with meta-analysis, Latey *et al.* (2017) reported that the intensity, frequency, and duration of pain are associated with muscle weakness [29].

Our study used the SPPB for the evaluation of functional capacity. Most of the older people participants presented good performance in the SPPB, which resulted in a low variability in this variable. Previous studies have reported that life habits, such as the practice of physical activity and good diet, can influence the functional performance of older people individuals; however, the influence of the vitamin D levels on these outcomes needs further investigation in future studies [24, 26].

This study has several limitations. First, as a cross-sectional study, which has an inherent limitation of not allowing the establishment of a cause-effect relationship. Therefore, the findings must be analyzed with caution. Second, the medications and supplements taken by the participants were not qualitatively assessed. Last, we did not evaluate the diet or time of sun exposure, which are factors that may influence the level of vitamin D.

Conclusions

In conclusion, among the healthy Brazilian community-dwelling older people participants with good functional performance, there was no association found between hypovitaminosis D and the HGS, IQS, and

SPPB score. The better muscle and functional performance observed may be attributed to the fact that the sample had a lower age and was practicing physical activity and living in a tropical country. Future studies should be conducted to achieve a better understanding of the influence of vitamin D level alterations on the muscle strength and functional capacity of older people individuals, especially in the Brazilian population wherein we perceive a scarcity of this information.

Abbreviations

25(OH)D: 25-hydroxivitamina D; HGS: hand grip strength; IQS: isometric quadriceps strength; SPPB: Short Physical Performance Battery; PTH: parathyroid hormone.

Declarations

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Authors' contributions:

Pelizari, A.A.C: Conceptualization; Investigation; Writing; Pereira, D.A.G.: Formal analysis; Writing - Review & Editing; Pereira, D.S.: Formal analysis; Writing - Review & Editing; Parentoni, A.N.: Writing - Review & Editing; Pereira, L.S.M.: Methodology; Writing - Review & Editing; Supervision; Project administration. All authors read and approved the final manuscript.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Ethics approval and consent to participate

All the experimete protocol for involving humans was in accordance to guidelines of national, international, institutional, and Declaration of Helsinki in the manuscript. All participants provided written informed consent. The study was approved by the Ethics Committees of the SARAH Network of Rehabilitation Hospitals and the Federal University of Minas Gerais, under the CAAE numbers 06716919.5.0000.0022 and 06716919.5.3001.5149, respectively. Data were anonymized and de-identifiable with no personal information, with careful protection on confidentiality.

Consent for publication

Not applicable.

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Tables

Table 1

Sociodemographic and clinical characteristics of the participants.

Characteristics	n = (150)	N = (%)
Gender		
Female	108	72
Male	42	28
Age (years)		
60 – 69 years	105	70
70 – 79 years	41	27,3
80 > years	4	2,7
Ethnicity		
White	77	51,3
Half-breed	62	41,3
Asian	2	1,3
Black	9	6,0
Education (years)		
unlettered	7	4,7
< 5 years	63	42,0
6 a 10 years	23	15,3
11 a 15 years	33	22,00
16 years >	24	16,0
SAH [†]		
No	57	38,0
Yes	93	62,0
DM [‡]		
No	104	69,3
Yes	46	30,7
Other comorbidities		
No	120	80
Yes	30	20
Use of drugs		
No	28	18,7

Yes	122	81,3
Use of supplements		
No	90	90
Yes	60	60
Physical activity		
No	74	49,3
Yes	76	50,7

[†]Systemic Arterial Hypertension; [‡]Diabetes Mellitus

Table 2

Comparison of the variables HGS, IQS, SPPB and vitamin D status in relation to the use of supplements and use of vitamin D.

P-value	Use of supplements		P-value	Use of vitamin D		
	Yes n=47	No n= 103		Yes n=37	No n= 113	
HGS	23,3	29,3 (24,0;36,7)	<0,0001 ¹	24,0	29,0	0,013 ¹
Median (Q1;Q3)	(18,7;28,7)			(20,7; 29,7)	(23,5 ; 35,3)	
QIS	200,1 (167,7;230,8)	201,2 (168,6;256,4)	0,403 ¹	199,4 (162,4;251,0)	201,2 (168,9;251,4)	0,624 ¹
Median (Q1;Q3)						
SPPB	11,0 (10,0;12,0)	11,0	0,384 ¹	11,0 (10,0;11,0)	11,0 (10,0;12,0)	0,153 ¹
Median(Q1;Q3)		(9,0; 12,0)				
SPPB						
0 a 6	2 (66,7)	1 (33,3)	0,142 ²	2 (66,7)	1 (33,3)	0,251 ²
7 a 9	10 (43,5)	13 (56,5)		6 (26,1)	17 (73,9)	
10 a 12	35 (28,2)	89 (71,8)		29 (23,4)	95 (76,6)	
Vitamin D status						
Sufficiency	17 (28,8)	42 (71,2)	0,592 ³	18 (30,5)	41 (69,5)	0,181 ³
Hypovitaminosis D	30 (33,0)	61 (67,0)		19 (20,9)	72 (79,1)	

1 Mann Whitney Test; 2 Pearson's exact chi-square test; 3 Asymptotic Pearson's Chi-square test.

Table 3

Results of the selection of variables in the multivariate HGS model

Variable	p model 1	p model 2	p model 3	p model 4	Beta	IC 95% Beta
Vitamin D						
Yes	0,788	0,794	0,813	-	-	-
No						
Age						
<70 years	0,005	0,004	0,004	0,004	3,32	-0,16 ; -2,94
≥70 years						
Gender						
1-Female	<0,0001	<0,0001	<0,0001	<0,0001	14,33	0,67 ; 11,74
2-Male						
Pain						
	0,007	0,007	0,006	0,006	-0,51	-0,15 ; -2,77
BMI [†]						
	0,899	-	-	-	-	-
Supplement						
Yes	0,057	0,056	0,055	0,048	-2,33	-0,11 ; -1,99
No						
Vitamin D status						
Sufficiency	0,834	0,841	-	-	-	-
Hypovitaminosis D						
R2 adjusted	0,574	0,577	0,580	0,582	-	-

[†]Body mass index

Table 4

Results of the logFIQ multivariate linear regression analysis.

Variable	p model 1	p model 2	p model 3	Beta	IC95% Beta
Age					
<70 years	0,006	0,005	0,005	-0,07	-0,12 ; -0,02
≥70 years					
Gender					
1-Female	<0,0001	<0,0001	<0,0001	0,12	0,07 ; 0,17
2-Male					
Pain	0,002	0,002	0,001	-0,01	-0,02 ; -0,01
Number of comorbidities	0,607	0,596	-	-	-
Physical activity					
Yes	0,004	0,004	0,003	0,07	0,02 ; 0,11
No					
Supplement	0,884	-	-	-	-
R2 adjusted	0,247	0,252	0,255	-	-