Association between vitamin D deficiency and heart failure risk in the elderly

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Abstract

Aims The aim of this study was to evaluate the association between vitamin D deficiency and risk of heart failure in elderly patients of cardiology outpatient clinics.

Methods and results A cross-sectional study with an analytical approach was employed. Clinical data were collected from the elderly from August 2015 to February 2016. The dependent variable was the risk of heart failure; the independent variable was vitamin D deficiency; and intervening factors were age, gender, education, ethnicity, hypertension, diabetes mellitus, hypothyroidism, renal failure, dementia, stroke, dyslipidaemia, depression, smoking, alcoholism, obesity, andropause, and cardiac arrhythmia. To analyse the association between vitamin D deficiency and risk of heart failure, we used the bivariate logistic analysis, followed by analysis through the multivariate logistic regression model. Of the 137 elderly, the study found the following: women (75.9%); overweight (48.2%); obese (30.6%); increase in the index waist/hip (88.3%); dyslipidaemia (94.2%); and hypertension (91.2%); coronary artery disease (35.0%); and 27.7% with cardiac arrhythmia or left ventricular hypertrophy. Sixty-five per cent of the elderly were deficient in vitamin D. The risk of heart failure was significantly associated with vitamin D deficiency [odds ratio (OR): 12.19; 95% confidence interval (CI) = 4.23–35.16; P = 0.000], male gender (OR: 15.32; 95% CI = 3.39–69.20; P = 0.000), obesity (OR: 4.17; 95% CI = 1.36–12.81; P = 0.012), and cardiac arrhythmia (OR: 3.69; 95% CI = 1.23–11.11; P = 0.020).

Conclusions There was a high prevalence of vitamin D deficiency in the elderly, and the evidence shows a strong association between vitamin D deficiency and increased risk of heart failure in this population.

Keywords Vitamin D; Heart failure; Risk; Elderly

Received: 26 January 2017; Revised: 22 May 2017; Accepted: 21 June 2017

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Introduction

With the improvement of care in the prevention of high blood pressure (hypertension), smoking, and dyslipidaemia, coupled with technological advances in the diagnosis and treatment of cardiovascular diseases (CVDs), there was a decline in the mortality rate due to CVD in the elderly; however, CVD is the leading cause of morbidity and mortality in the world and the most chronic disability.2

From the point of view of cardiovascular risk, epidemiological studies have demonstrated an association between chronic and degenerative diseases such as diabetes, CVDs, and environmental (epigenetic) conditions in the embryonic or foetal phase.5–7 From the epidemiological studies conducted in England and Wales by Barker et al., The Foetal Programming Hypothesis or ‘Baker’s Hypothesis’, finally, important review addressed the various environmental, hereditary, and genetic factors involving the interaction between the parents, placenta, and embryo in the genesis of diseases of adult life, citing epigenetic factors such as nutritional deficiencies and vitamins.8

Among the unfavourable epigenetic factors in pregnant women and related to CVDs, vitamin D deficiency is an important modifiable factor with the treatment, as demonstrated...
in a German study, where low levels of 25-hydroxyvitamin D were related to low birth weight, prematurity, increased perinatal mortality, and decreased glucose tolerance leading to unfavourable renal and cardiovascular outcomes in adulthood.9

Nevertheless, this fact is still relevant because the common end stage of most heart diseases is heart failure (HF), which continues to have a high prevalence, represents an important public health problem and is the biggest cause of hospitalization among the elderly, hence the importance of finding new factors and risk scores for such a condition.10

Among the independent risk factors associated with HF are advanced age, the male gender, diabetes mellitus, pulse pressure, and acute myocardial infarction, found by Chen et al., 11 who evaluated 1749 elderly in a cohort study entitled ‘Established Populations for Epidemiologic Studies of the Elderly’. Data from the Multi-Ethnic Study of Atherosclerosis study showed that diabetes and hypertension are the risk factors responsible for the higher incidence of HF among African-Americans. In this same study, interleukin-6 and C-reactive protein, as well as macroalbuminuria, were independent predictors of the HF development.12

With the progress of age, the myocardium undergoes alterations in the extracellular matrix, with increased collagen (with a higher proportion of type I collagen in relation to type III), reduced elastin content, and increased fibronectin. The balance between production and degradation of the extracellular matrix by the matrix metalloproteinases (MMPs), and by tissue inhibitors of metalloproteinases, is altered, leading to increased activity of MMPs, which degrade extracellular matrix molecules such as collagen, fibronectin, and laminin.13

The myocardial alterations described in the elderly make the ventricular relaxation slower through increased left parietal rigidity, requiring more energy for relaxation, and causing a reduction of ventricular filling speed, which prolongs left ventricular filling. This characterizes a diastolic dysfunction, which is very prevalent and an important cause of HF in the elderly, usually preceding systolic dysfunction and left ventricular hypertrophy.14

Accumulated evidence states that studies on subclinical HF in the elderly are scarce and contain methodological errors, making it impossible to use the results in early diagnosis of this population. These studies also include patients that were selected from a population with its own peculiar characteristics, which cannot be generalized, and they investigate the prevalence of individual risk factors; however, they do not develop a score for evaluating cardiovascular risk.15

The Health Aging and Body Composition (ABC) HF enables to quantify the risk of HF in the elderly through clinical, laboratory, and demographic means and is of important relevance for the development of cardiovascular prevention strategies.15 The Health ABC HF score was tested in a 5-year cohort study including 5335 patients with mean age of 72.6 ± 5.4 years and no history of coronary artery disease and maintained independence in performing activities of daily living. The model predicted HF in 364 of the 400 patients who developed the disease over the 5-year period and is considered a useful tool for preventing HF.16,17

There is strong evidence in the literature relating the functions of vitamin D and cardiovascular metabolism and in this way we investigated the association between vitamin D deficiency and risk of heart failure.18

**Method**

This is an analytical cross-sectional epidemiological study that was carried out in the Care Center for the Elderly and the outpatient clinic of cardiology of the Hospital das Clínicas, both of the Federal University of Pernambuco (UFPE).

The population included in this study was selected from an analysis of medical records of people of 60 years of age and over who were assisted by one of these services in the period between August 2015 and February 2016.

With a prevalence of 80% vitamin D deficiency among the elderly, the sample size was of 137 medical records, corresponding to a power of test of 95%.

The study included elderly patients with medical records who were present for routine cardiological evaluations, were attended by the researcher in the cardiology clinic—by referral or spontaneous demand, regardless of gender and motor restrictions—and were willing to undergo additional tests for primary prevention of aging.

The exclusion criterion was the absence of registration of all the parameters of interest in the medical record of the elderly. If the individual was considered to be in a severe state with hospitalization indication, he or she was excluded from the study.

The variables of this study: independent variable - Vitamin D deficiency, qualitative, ordinal, dichotomous, corresponding to the record in a serum concentration of 25-hydroxyvitamin D lower than 30 ng/mL and absent ≥30 ng/mL.19 The analysis of the total concentration of 25-hydroxyvitamin D serum was performed by the chemiluminescence method by the Architect Abbott®; intervening variables are present in Figure 1, and dependent variable the risk of HF assessed by the Health ABC HF score is shown in Figure 2.

The instruments used for data collection were the copy of the cardiological research protocol used in the cardiology outpatient clinic of the study sites, the Mini-Mental State Examination, the Geriatric Depression Scale, and the Health ABC scale, to calculate risk of HF.
The Health ABC HF was constructed to assess the risk of HF. According to many studies, deficiency of 25-hydroxyvitamin D levels lower than 30 ng/mL was considered as a risk factor for HF. Other studies have classified severity based on the 25-hydroxyvitamin D levels as follows: severe deficiency below 25 nmol/L, moderate deficiency of 25 to 49.9 nmol/L, and insufficiency of 51 to 75 nmol/L. In this study, deficiency/insufficiency of vitamin D or vitamin D deficiency was considered, as well as the presence of levels of 25-hydroxyvitamin D below 30 ng/mL.

The database using the Epi7 program, version 7.1.5.2, was developed by the World Health Organization. The data were analysed with the IBM/SPSS Statistical Package for Social Sciences, version 20.0. To calculate the risk of HF, we conducted the assessment by using the ABC HF and then proceeded to scoring the risk factors of each elderly, as shown in Figure 2.
were carried out, as shown in Figure 2. For bivariate and multivariate analyses, risk was considered normal when <5% and high when greater than or equal to 5%, thus encompassing the classifications corresponding to medium, high, and very high risk.

In the bivariate analysis, to test the association among the variables, Pearson’s chi-square test and Fisher’s exact test were used when necessary. As a criterion of entry of the independent and intervening variables in the multivariate logistic analysis, the cut-off point was $P$-value ≤0.20, provided by the bivariate logistic analysis. The logistic regression model used the stepwise method to select, from all independent and intervening variables, those which had significant influence on the risk of HF. In this method, the significance analysis of the variables in the model was carried out using the Wald test. All conclusions were made using the significance level of 5%.

This research study followed the determinations of Resolution 466 of 2012 from the National Council of Health, which regulates research involving human subjects and was approved by the Ethics Committee of the UFPE under CAAE, number 47317715.6.0000.5208. Data collection was authorized through consent letters from the Care Center for the Elderly and the Direction of the Hospital das Clínicas, UFPE.

Results

The sociodemographic characteristics of 137 elderly are shown in Table 1, while the clinical characteristics are shown in Table 2.

In relation to metabolic changes, most seniors in this study were overweight or obese, as well as presenting with waist–hip ratio above normal, high prevalence of dyslipidaemia, and hypertension, characterizing metabolic syndrome. Among the elderly men, prevalence of andropause was 72.7%.

As for the assessment of mental status, with regard to cognitive assessment, 22.6% of seniors had test score of the Mini-Mental State Examination compatible with dementia, and 31.4% were in the range of depression degree with moderate or severe.

For the cardiovascular evaluation, we identified 91.2% as hypertensive, 35% with definite or possible coronary artery
disease, and 27.7% with cardiac arrhythmia; the same percentages have been found for left ventricular hypertrophy (Table 2).

Figure 3 presents the frequency distribution of the vitamin D status of the participants, observing also 65% of individuals with hypovitaminosis. The graph considered the presence of vitamin deficiency or vitamin insufficiency, emphasizing that among these individuals, 62% have vitamin D deficiency.

The results of the analysis of associations between intervening variables, as well as the independent variable, and the risk of HF are presented in Table 3. In the multivariate analysis, this risk can be explained by variables vitamin D, gender, obesity, and cardiac arrhythmia, which are considered explanatory variables.

In this study, 78.7% of the vitamin D-deficient elderly had increased risk of HF. In the multivariate analysis, the chance
of having vitamin D deficiency for those who have risk of increased HF is 12.2 times higher than that who have normal levels of vitamin D.

In the multivariate analysis, the chance of increased risk for HF in the men of this group is 15.3 higher than that in women. The chances of HF for obese individuals present in this multivariate analysis are four times of those who are not obese. Those who have heart arrhythmia have a 3.6 higher chance of HF than those who never had such a condition.

### Discussion

Although vitamin D deficiency is well documented in the elderly living in northern countries, a high percentage (65%)
of vitamin D-deficient elderly investigated in this study was identified. It is worth noting that this study, conducted in Recife, northeastern Brazil, where the tropical climate predominates most of the time, showed a prevalence of vitamin D deficiency in the elderly similar to the data from the third National Health and Nutrition Examination Survey.\textsuperscript{20} The prevalence of hypovitaminosis D in the present study was also lower than that reported for the French population, mainly for those above 60 years of age (80.3%),\textsuperscript{21} as well as for populations in northern India, near the Himalayas, where the prevalence of vitamin D deficiency was 83% and is associated with chronic stable angina.\textsuperscript{22} Consideration was given to the greater latitude of these countries, where winters are longer and people use clothes that cover almost the entire body, in contrast to the regions close to the equator, where there is predominantly sunny weather the entire year.

Important studies have addressed vitamin D deficiency associated with HF, such as the prospective study LURIC conducted on 3299 patients with CVD and which found high prevalence of myocardial dysfunction identified by the coronary angiography and ventriculography. These changes were associated with severe deficiency of vitamin D with risk of death three to five times higher than that with HF and sudden death over a period of 7 years. Calcidiol and calcitriol were both ($P < 0.001$) inversely related to deficit of left ventricular function, and also low calcidiol and calcitriol levels were associated with higher New York Heart Association class.\textsuperscript{23}

The increased risk of HF in this study was present in more than half of the elderly and was significantly associated with vitamin D deficiency (increasing by 12.2 times the risk of HF) and may be due to inflammatory mechanisms, aside from the mechanisms already mentioned in this study regarding left ventricular hypertrophy. However, adequate concentrations

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**Table 1:** Distribution of sociodemographic characteristics of the elderly—NAI (Núcleo de Atenção ao Idoso), Hospital das Clínicas, Recife, 2015–16

| Sociodemographic characteristics | Categories | Frequency | Percentage |
|----------------------------------|------------|-----------|------------|
| Sex                              | Male       | 33        | 24.1       |
|                                  | Female     | 104       | 75.9       |
| Self-referred skin colour        | White      | 50        | 36.5       |
|                                  | Mixed colour | 69       | 50.4       |
|                                  | Black      | 18        | 13.1       |
| Marital status                   | Single     | 10        | 7.3        |
|                                  | Married or stable union | 85 | 62.0 |
|                                  | Widow/er   | 37        | 27.0       |
|                                  | Divorced or separated | 5 | 3.6 |
| Education of the elder           | Illiterate | 11        | 8.0        |
|                                  | Basic I    | 39        | 28.5       |
|                                  | Basic II   | 41        | 29.9       |
|                                  | High school | 30  | 21.9       |
|                                  | Higher education | 16 | 11.7 |
| Age classes (years)              | 60–69      | 64        | 46.7       |
|                                  | 70–79      | 60        | 43.8       |
|                                  | 80+        | 13        | 9.5        |
| Economic class, Brazil           | A          | 2         | 1.5        |
|                                  | B1         | 2         | 1.5        |
|                                  | B2         | 14        | 10.2       |
|                                  | C1         | 34        | 24.8       |
|                                  | C2         | 61        | 44.5       |
|                                  | D and E    | 24        | 17.5       |

**Parameters** | **Condition** | **Point** |
|----------------|---------------|-----------|
|                | 170 – 179     | 3         |
|                | 180 – 194     | 4         |
|                | 195 – 200     | 5         |
|                | ≥ 201         | 6         |

**Punctuation** | **Classification of risk** | **Percentage of risk** |
|----------------|---------------------------|------------------------|
| ≤ 2            | Low                       | < 5                    |
| 3 – 5          | Medium                    | 5- 10                  |
| 6 – 9          | High                      | 10- 20                 |
| ≥ 10           | Very high                 | > 20                   |
Table 2 Frequency distribution of risk factors for cardiovascular disease and previous diseases of the elderly—NAI (Núcleo de Atenção ao Idoso), Hospital das Clínicas, Recife, 2015–16

| Risk factors and previous diseases | Categories | Frequency | Percentage |
|-----------------------------------|------------|-----------|------------|
| Smoking                           | Never      | 89        | 65.0       |
|                                    | Passed     | 44        | 32.1       |
|                                    | Current    | 4         | 2.9        |
| Risk of alcoholism (CAGE)         | Yes        | 4         | 2.9        |
|                                    | No         | 133       | 97.1       |
| Hormonal and metabolic measures   |            |           |            |
| Obesity                           | Normal weight | 29  | 21.2       |
|                                    | Overweight | 66        | 48.2       |
|                                    | Obese      | 42        | 30.6       |
| Waist–hip ratio                   | Normal     | 16        | 11.7       |
|                                    | Absent     | 121       | 88.3       |
| Dyslipidaemia                      | Present    | 129       | 94.2       |
|                                    | Absent     | 8         | 5.8        |
| Andropause                        | Present    | 24        | 72.7       |
|                                    | Absent     | 9         | 27.3       |
| Diabetes mellitus                 | Present    | 52        | 38.0       |
|                                    | Absent     | 85        | 62.0       |
| Hypothyroidism                    | Present    | 8         | 5.8        |
|                                    | Absent     | 129       | 94.2       |
| Mental state                      | Present    | 31        | 22.6       |
|                                    | Absent     | 106       | 77.4       |
| Depression                        | Normal     | 94        | 68.6       |
|                                    | Moderate   | 41        | 29.9       |
|                                    | Grave      | 2         | 1.5        |
| Diagnosed conditions              | Present    | 125       | 91.2       |
| Systemic hypertension             | Absent     | 12        | 8.8        |
| Chronic renal failure             | Present    | 4         | 2.9        |
|                                    | Absent     | 133       | 97.1       |
| Previous stroke                   | Present    | 9         | 6.6        |
|                                    | Absent     | 128       | 93.4       |
| Cardiac arrhythmia                | Present    | 38        | 27.7       |
|                                    | Absent     | 99        | 72.3       |
| Left ventricle hypertrophy or reduction of the fraction of left ventricular ejection | Present | 38 | 27.7 |
| Coronary artery disease           | Absent     | 99        | 72.3       |
|                                    | Possible/defined | 48 | 35.0 |

*Calculated percentage based on 33 male elders.

of vitamin D can suppress the inflammatory response through inhibition of the prostaglandin and cyclooxygenase, overstimulation of anti-inflammatory cytokines, reduction of cytokines induced by expression of adhesion molecules, reduction of extracellular matrix metalloproteinases, and inhibition of the release of the pro-inflammatory factor NF-kappa beta, which is associated with endothelial dysfunction. Calcitriol stimulates the tissue inhibitors of metalloproteinases, preventing excessive degradation of the extracellular matrix through the MMPs, particularly MMP-2 and MMP-9, which consequently lead to ventricular progressive remodelling, dilatation, and HF. Another inflammatory mechanism through which vitamin D deficiency acts, by increasing the risk of HF, is through the decrease of Treg cells and the increase of Th17, as well as through their polymorphisms VDR-type BSMI receiver, which were related to left ventricular hypertrophy.

In multivariate analysis, in addition to vitamin D deficiency, the risk of HF was only associated with male gender, obesity, and cardiac arrhythmias.

The high risk of HF presented by men in this work, which was confirmed after multivariate analysis, is consistent with the literature, also noting that this variable was significantly associated with vitamin D deficiency in relation to women. Of equal importance in this context of higher risk of HF in men is the strong association of andropause with vitamin D deficiency, which can justify this high risk, considering the positive relationship between vitamin D and testosterone levels, as reported in the literature. Especially important is the protective effect that testosterone plays on the myocardium, reducing the risk of heart disease and mortality. Thus, male seniors in this study are significantly at increased risk of vitamin D deficiency, HF, and higher prevalence of andropause.

In the evaluation of the elderly in this study, the association between HF and obesity proved to be significant in both bivariate and multivariate analyses, revealing concordance with literature data, with obesity being considered a risk factor for HF, as well as significantly associated with vitamin D deficiency, which also increased the risk for HF. However, studies have shown that although obesity increases the risk for HF, it does not confer increased risk of mortality in patients already with HF, yet it may provide a better prognosis, thus characterizing the obesity paradox.

With reference to the analysis of the association between cardiac arrhythmia and increased risk of HF in the elderly, the present study showed a strong association in both bivariate and multivariate analyses, findings that they reported in the literature, where supraventricular tachyarrhythmia has a high prevalence in HF, especially Atrial Fibrillation (AF), which is the most common treatable arrhythmia, worsening the long-term prognosis and characterized by the highest prevalence with aging and increasing the risk of HF and mortality.

Regarding ventricular arrhythmias, considered independent markers of sudden cardiac death, they are associated with the degree of left ventricular dysfunction. They are also independent predictive factors, along with HF, of higher hospital mortality in octogenarian elderly submitted to percutaneous coronary intervention after suffering acute myocardial infarction.

The results presented in this study show that in older people, disabilities/vitamin D insufficiency was strongly associated with increased risk of HF.

In the analysis of the results, only four patients were considered to have chronic kidney disease (CKD), with a glomerular filtration rate below 60 mL/min/1.73 m², estimated by the CKD Epidemiology Collaboration equation, as well as with markers of kidney damage, with albuminuria.
Vitamin D deficiency and heart failure risk

Figure 3  Distribution of vitamin D concentration classes for the elderly. The frequency distribution of the vitamin D condition of the participants is shown, with a percentage of 65% of these individuals with hypovitaminosis, considered as the presence of vitamin deficiency or insufficiency, among which 62% have vitamin D deficiency – NAI (Núcleo de Atenção ao Idoso), Hospital das Clínicas, Recife 2015-16.

Table 3  Association of sociodemographic, clinical and laboratory variables with the risk of heart failure – NAI (Núcleo de Atenção ao Idoso), Hospital das Clínicas, Recife -2015-16

| Variables                  | Categories          | Heart failure risk | Bivariate analysis | Multivariate analysis |
|----------------------------|---------------------|--------------------|--------------------|-----------------------|
|                            | Extended            | Normal             | Relative risk (IC 95%) | $P$-value (Fisher’s exact test) | Relative risk (95% CI) | $P$-value (Wald test) |
|                            | N | % | N | % | Relative risk | $P$-value | N | % | N | % | Relative risk | $P$-value |
| Vitamin D                  | Poor / Insufficient | 70 | 89.7 | 19 | 32.2 | 18.42 | 0.00 | 12.19 | 0.00 |
|                            | Enough              | 8  | 10.3 | 40 | 67.8 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
| Sex                        | Male                | 30 | 38.5 | 3  | 5.1 | (3.35 – 40.63) | 2.28 | 0.03 | 0.98 - 4.17 | 0.07 |
|                            | Female              | 48 | 61.5 | 56 | 94.9 | (1.11 – 4.71) | 2.01 | 0.07 | 1.39 | 0.38 |
| Education                  | Average / Superior  | 58 | 74.4 | 33 | 55.9 | 2.28 | 0.03 | 0.98 - 4.17 | 0.07 |
|                            | Illiterate / Elementary | 20 | 25.6 | 26 | 44.1 | (0.98 - 4.17) | 2.01 | 0.07 | 1.39 | 0.38 |
| Marital status             | Others              | 35 | 44.9 | 17 | 28.8 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Married / Stable Union | 43 | 55.1 | 42 | 71.2 | (4.23 – 35.16) | 4.23 | 0.00 | 15.32 | 0.00 |
| Ethnicity                  | White               | 31 | 39.7 | 19 | 32.2 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Nonwhite            | 47 | 60.3 | 40 | 67.8 | (4.23 – 35.16) | 4.23 | 0.00 | 15.32 | 0.00 |
| Age Group                  | 70 +                | 49 | 62.8 | 24 | 40.7 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | 60 - 69             | 29 | 37.2 | 35 | 59.3 | (4.23 – 35.16) | 4.23 | 0.00 | 15.32 | 0.00 |
| Class of Income Brazil     | A e B               | 12 | 15.4 | 6  | 10.2 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | C, D e E            | 66 | 84.6 | 53 | 89.8 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
| Hypothyroidism             | Present             | 6  | 7.7  | 2  | 3.4 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Absent              | 72 | 92.3 | 57 | 96.6 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
| Renal insufficiency        | Present             | 4  | 5.1  | 0  | 0.0 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Absent              | 74 | 94.9 | 59 | 100.0 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
| Insanity                   | Present             | 25 | 32.1 | 6  | 10.2 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Absent              | 53 | 67.9 | 53 | 89.8 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
| AVC                        | Present             | 8  | 10.3 | 1  | 1.7 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Absent              | 70 | 89.7 | 58 | 98.3 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
| Depression                 | Moderate / Severe   | 29 | 37.2 | 14 | 23.7 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Normal              | 49 | 62.8 | 45 | 76.3 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
| Alcohol consumption        | Present             | 3  | 3.8  | 1  | 1.7 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Absent              | 75 | 96.2 | 58 | 98.3 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
| Obesity                    | Normal/overweight   | 35 | 44.9 | 7  | 11.9 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Obese               | 43 | 55.1 | 52 | 88.1 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
| Waist-hip ratio            | Extended            | 47 | 60.3 | 36 | 61.0 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Normal              | 31 | 39.7 | 23 | 39.0 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
| Andropausa                 | Present             | 22 | 26.7 | 1  | 1.7 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Absent              | 8  | 26.7 | 1  | 1.7 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
| Arrhythmia heart           | Present             | 29 | 37.2 | 9  | 15.3 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |
|                            | Absent              | 49 | 62.8 | 50 | 84.7 | (7.39 – 45.89) | 11.67 | 0.00 | 15.32 | 0.00 |

ESC Heart Failure (2017)  
DOI: 10.1002/ehf2.12198
(measured by urine albumin to creatinine ≥ 3 mg/mmol) present in more than 3 months,\textsuperscript{38} all included in the high-risk group of HF. CKD, considered a risk factor for the development of vitamin D deficiency/insufficiency, is associated with increased morbimortality, mainly for CVDs, which are more prevalent in chronic kidney patients than in patients with normal renal function.\textsuperscript{39} In patients with HF, there was a prevalence of CKD of up to 29.6%,\textsuperscript{40} and renal insufficiency was considered a poor prognostic factor in these patients.\textsuperscript{41} it was higher in patients with HF with reduced ejection fraction.\textsuperscript{42} From a pioneering study by Dong et al.,\textsuperscript{43} it was reported that the expression of cyclooxygenase-2 in the renal artery is elevated in oophorectomy-induced oestrogen-deficient rats, which in turn results in increased thromboxane-prostanoid receptor expression, which reduces bioavailability of nitric oxide, leading to compromised endothelium-dependent renovascular relaxation. Thus, chronic administration of calcitriol restores vascular function by normalizing the endothelial expression of cyclooxygenase-2 and thromboxane-prostanoid receptors, thus avoiding the reduction of nitric oxide production, which is induced by the activation of the thromboxane-prostanoid receptor.

Hocher et al.,\textsuperscript{44} reviewing the effect of vitamin D on cardiovascular risk in post-menopausal women, report that double-blind randomized clinical trials with placebo are needed in order to provide definitive proof of the effects of vitamin D supplementation on cardiovascular risk in this population, emphasizing that these should answer the following questions: What is the ideal dose of calcitriol to reduce cardiovascular risk, taking into account the concentration–mortality curve of vitamin D in the form of U, according to meta-analyses of association?\textsuperscript{45}\textsuperscript{46}\textsuperscript{47}\textsuperscript{48}\textsuperscript{49} If native vitamin D has the same effect as calcitriol, what consequences in the long run will interfere with renal and cardiovascular functions and mortality?

In secondary hyperparathyroidism, parathyroid hormone (PTH) is one of several ‘uremic factors’ implicated in the pathogenesis of cardiac abnormalities present in patients with chronic renal disease.\textsuperscript{46} PTH receptors are present in cardiomyocytes and endothelial cells, and PTH probably plays a role in cardiac remodelling, and therefore on the morphology and function of this organ. Left ventricular hypertrophy, dilatation, and dysfunction are common in patients with CKD, and about 50% and 70% of them present this alteration before and during dialysis, respectively.\textsuperscript{47} Loncar et al. evaluated secondary hyperparathyroidism and its prognostic impact in all-cause mortality in elderly patients with HF, finding that hyperparathyroidism was highly prevalent in elderly men with this syndrome and was associated with lower survival. Patients with insufficiency cardiac and secondary hyperparathyroidism had more severe myocardial dysfunction compared with those with normal serum PTH, and determination of serum PTH levels provided additional value to NT-proBNP for risk stratification in these patients.\textsuperscript{48} In a recent prospective study, correcting vitamin D deficiency in HD patients in associated with better secondary hyperparathyroidism control with lower doses of vitamin D analogues, as well as an improvement in inflammatory status.\textsuperscript{49} All patients in this study underwent a Doppler echocardiography; and left ventricular hypertrophy changes and reduced left ventricular function seen by this method were associated with vitamin D deficiency, demonstrating the importance of this examination, because the changes of the structure and cardiac function in elderly are usually subclinical, and these often precede the development of HF.\textsuperscript{17}

Based on the evidence presented in this study, which is supported by the literature, the high percentage of elderly individuals with vitamin D deficiency and its consequences for increased risk of HF suggest a need of dosage recommendations for this vitamin, especially in primary healthcare services. The facility of quantifying vitamin D, the low cost of its supplementation, and the possibility of preventing and treating CVDs point to the need for more studies on the supplementation with vitamin D in prospective cohort, so that the conduct of supplementation is implanted with a solid base of evidence.

Among the limitations of this study, it is important to highlight its transversal nature, which prevents the establishment of causal relationships.

### Conclusions

The risk of HF was present in more than half of the elderly and was strongly associated with vitamin D deficiency, with male gender and obesity characterized as risk factors for developing HF and cardiac arrhythmia, conferring a worse prognosis in failure heart, as well as being an independent marker of sudden cardiac death and being associated with more severe left ventricular dysfunction.

This research study proved that there is association between vitamin D deficiency and increased risk of HF in the elderly assisted in the UFPE cardiology clinics.

### Conflict of interest

None declared.

### Author contributions

Catarina Porto: Author and researcher of the master’s degree in gerontology, responsible for data collection, interpretation of results, conclusion, and literature review.

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DOI: 10.1002/ehf2.12198
Vanessa de Lima Silva: Co-supervisor of the master’s degree. Responsible for the methodology of the study.

Brivaldo Markman Filho: Responsible for the interpretation of data and results.

Vera Magalhães da Silveira: Responsible for the interpretation of the results.

João Soares Brito da Luz: Responsible for blood sample collection and performing the laboratory tests.

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