Original Article (short paper)

Sedentary behavior is associated with physical activity, functional capacity, and a history of stroke in patients with heart failure. A cross-sectional study

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Abstract — Aims: Sedentary behavior (SB) has emerged as an important risk factor for poor health. Evidence showed that patients with heart failure (HF) exhibit high levels of SB, and that high SB increases mortality among such patients. We aimed to identify factors associated with SB in HF patients. **Methods:** A cross-sectional study was carried out with adults with HF and categorized under New York Heart Association (NYHA) functional class I–III. Sociodemographic, clinical, and health information were gathered. Evaluation of SB (by sitting time) and moderate-to-vigorous physical activity (MVPA) was performed by self-reported measures. Functional capacity was assessed using the Duke Activity Status Index. Simple and multivariate linear regression analyses were performed to identify the most suitable predictive model. **Results:** The sample (n = 80) comprised predominantly of patients in functional class I, men, and with an average age of 50.8 years. Time spent on SB totaled to 7.69 ± 2.35 h/day. Weekly volume of MVPA, functional capacity, and previous stroke were predictors of higher SB. Using simple linear regression analysis, the variables body mass index, quality of life, NYHA functional class, total comorbidities, dyslipidemia, MVPA in the leisure domain, and the use of diuretics, statins, and sildenafil were shown to have a statistically significant association with SB. **Conclusion:** In patients with HF, a longer time spent in SB was associated with low volumes of MVPA, low functional capacity, and history of stroke. More studies are needed to corroborate these findings.

Keywords: sedentary time, physical activity, health behavior, cardiovascular diseases, nonexercising, aging.

Introduction

Heart failure (HF) is a debilitating, progressive, and high-mortality clinical syndrome [1]. Patients with HF feature reduced physical capacity, which can lead to reduction in their daily activities, decrease in the level of physical activity, and increased periods of sedentary behavior (SB), resulting in adverse health consequences [2-5].

A growing number of studies suggest that high SB results in deleterious metabolic and cardiovascular effects [6-10]. In addition, high SB is importantly associated with early mortality [7, 11, 12]. SB is defined as the time spent in activities of low energy expenditure (≤1.5 METs - Metabolic Equivalent of Task), performed in the sitting, reclining, or lying position during the waking period [13-15]. Thus, sitting time, the generic denomination for SB [13], has been utilized to evaluate SB of individuals in the domestic environment, at work, or during leisure, such as watching TV.

Patients with HF exhibit high SB (~10 h/day)[16-18]. Doukky et al.[19] observed that with increasing sedentary time, risk of all-cause mortality and cardiac causes gradually increases in patients with HF. These patients generally do not meet the recommendations of moderate-to-vigorous physical activity (MVPA) [3, 4, 18, 20] of at least 30 min/day; this insufficient activity may be an aggravating factor given that SB is especially detrimental in individuals who perform low physical activity levels [21, 22]. Thus, a common phenotype is observed in HF patients: high SB (i.e., sitting time) along with low physical activity (i.e., no MVPA).

Although an association exists between SB and increased risk of morbidity and mortality among patients with HF, the factors associated with high prevalence of SB in this population remain unknown. Thus, identifying factors associated with SB in patients with HF can guide clinical management of these patients with regard to non-pharmacological strategies. This study aims to analyze the association between sociodemographic, clinical, and health characteristics and SB in patients with HF.

Methods

Study design and participants

This research is a cross-sectional study carried out between February 2015 and April 2016 in an outpatient clinic specializing in treatment of HF in northeastern Brazil (Federal University of Rio Grande do Norte). The study was approved by the research ethics committee of the institution (number 660.366 HUOL/UFRN), and all participants signed a free and informed consent form in accordance with the Helsinki Declaration. Inclusion criteria were as follows: patients diagnosed with HF, as determined by the Framingham criteria along with the support of diagnostic tests, more than 18 years old, classified under functional class I to III of New York Heart Association (NYHA), and clinically stable for at least three months. Exclusion criteria were as follows: patients using wheelchair or unable to move independently or who were cognitively unable to respond to the questionnaires. Patients who did not have time for answering the questionnaires

(physical activity and functional capacity), which depended on a single evaluator, were also excluded. All patients were evaluated by the same medical staff and received regular medical therapy [23].

Procedures

The study participants were selected according to the order of completion of clinical consultations, which were conducted once a week during afternoons. After the medical consultation, the patients who fulfilled the criteria for participation in the study were referred to the responsible researcher who then invited them to participate in the study. Sociodemographic information was obtained directly from each participant, and clinical and health information were provided by the ambulatory medical team or collected through consultation from patients' medical records. Quality of life (QoL) score was collected through a questionnaire, which was administered by face-to-face interviews accomplished within the same month of collection of other information by two trained applicators who were not part of the research. MVPA and functional capacity were measured using specific questionnaires that were administered through an interview conducted by a trained applicator after the patient's medical consultation. SB was also evaluated through an interview conducted by the same applicator on the same day of the application of the physical activity and functional capacity questionnaires.

Measures

Sociodemographic, clinical, and health characteristics

We collected data on sex, age, schooling (years of study), and occupation (yes / no); functional class according to NYHA; left ventricular ejection fraction determined by echocardiography; body mass index (BMI– Kg/m^2) obtained by objective measurement of weight and height of participants; etiology of the disease (ischemic/nonischemic); medications in use; and comorbidities (total number of comorbidities, systemic arterial hypertension, type 2 diabetes mellitus, dyslipidemia, chronic obstructive pulmonary disease, atrial fibrillation, acute myocardial infarction, coronary artery disease, and stroke).

QoL and functional capacity

QoL was determined by the Minnesota Living with Heart Failure Questionnaire (MLHFQ) [24]. MLHFQ is a questionnaire composed of 21 items measuring physical, psychological, and socioeconomic dimensions. The scores range from 0 to 105. Higher scores indicate worse QoL. Functional capacity was measured using the Duke Activity Status Index (DASI) [25], a questionnaire developed to evaluate perceived functional capacity of individuals with cardiovascular disease. DASI is a simple, short, and quick application questionnaire. The scores range from 0 to 58.2. Higher scores imply increased functional capacity [26]. The questionnaire showed good reproducibility in patients with HF (an intraclass correlation coefficient of 0.95; $p<0.0001$) [27]. A strong correlation ($r = 0,81$; $p<0,01$) was also observed between DASI and VO2peak (peak oxygen uptake) [26].

SB

SB was evaluated for total time (hours) spent in activities performed in the sitting, reclining, or lying down position during periods of awakeness in the day. To facilitate the accounting of the daily hours spent in sedentary activities [28], patients were asked to describe their daily routines involving such activities, with consideration of the domains in the domestic environment, at work, at leisure, and during transportation, keeping in mind a usual day of the week. Patients who reported sleeping during the day were requested to also account for this time. Postures of sitting, reclining, and lying down were recently established as indicators of SB [15], and the evaluation of total daily SB while considering the domains in which it occurs (composite measure) can provide a more precise measure when compared with assessment by a single-item [29].

MVPA

To evaluate weekly volume of MVPA, the International Physical Activity Questionnaire (IPAQ)[30] long form was used. This questionnaire is used to determine the level of physical activity in adult populations. In the Brazilian population, IPAQ showed good reliability and acceptable validity when compared with objective measures of physical activity [31]. This questionnaire measured MVPA in four specific domains: at work, in the domestic environment, during leisure and exercise, and in active transportation.

Continuous score (MET-min/week) was used to quantify the total volume of weekly physical activity, which was later categorized based on the recommendations of physical activity for this population 5 of at least 30 min of MVPA on most days of the week corresponding to approximately 600 MET-min/week. This variable was then dichotomized at <600 MET-min/week and ≥ 600 MET-min/week. To evaluate the impact of regular exercise on SB, ie., non-incidental physical activity [32], the MVPA in the leisure and exercise domain was included in analysis (as categorical variable: yes or no).

Statistical analysis

Data analysis was performed using Stata 11 software (Stata Corporation, College Station, TX, USA). Data are presented descriptively by mean and standard deviation or by absolute

and relative frequencies. A simple linear regression analysis was conducted to evaluate the relationship between sociodemographic, clinical, and health variables and SB to identify variables of statistical significance to construct the multiple linear regression model. Variables with $p \leq 0.10$ were included in the multivariate model, and regression was performed through step-by-step retrograde method. Statistical significance considered for the model was set at 5% ($p < 0.05$). The covariates included in the multivariate model were BMI, MLHFQ, DASI, NYHA functional class, DM2, DLP, stroke, total comorbidities, diuretics, statins, sildenafil, weekly volume of MVPA, and MVPA in the domain of leisure and exercise. Existence of multicollinearity among independent variables was tested through tolerance, and homoscedasticity was verified by residue chart. A sample size of 80 patients would allow the identification of associations with a Pearson's correlation coefficient greater than 0.30 with 80% power [33]. The following formula was used for calculation:

$$n = \left[\frac{(Z\alpha + Z\beta)}{0.5 \times \ln [(1+r))/((1-r)} \right]^2 + 3$$

Results

The study population consisted of 80 patients. Table 1 summarizes the sociodemographic, clinical, health characteristics, and SB and MVPA of the patients. Participants reported an average of 7.69 ± 2.35 h of SB a day, and more than half did not meet the recommendations of MVPA [5]. Patients who performed MVPA volumes ≥ 600 METs-min/week (n = 37; 46%) presented an average weekly volume of 1287.4 ± 681.8 METs-min. The same proportion was observed for those performing MVPA in the leisure and exercise domain. In this specific domain, a mean volume of 662.4 ± 355.1 METs-min/week was observed.

Table 1. Characterization of the sample according to sociodemographic, clinical and health characteristics, and sedentary behavior and physical activity n = 80

Sociodemographic characteristics	
Male	47 (58.8)
Age	50.79 ± 14.43
Schooling – years of study	6.6 ± 4.3
Individuals with occupation	19 (23.8)
Clinical and health characteristics	
BMI	27.64 ± 6.08
MLHFQ	28.5 ± 23.20*
DASI – Mets	34.8 ± 13.7
% Left Ventricular Ejection Fraction	39.03 ± 13.89*
Etiology ischemic	17 (21.3)*
NYHA functional class	
I	42 (52.5)
II	29 (36.3)
III	9 (11.3)
Comorbidities	
Systemic arterial hypertension	46 (57.5)
Diabetes mellitus – type 2	25 (31.3)*
Dyslipidemia	17 (21.3)*
Coronary Artery Disease	15 (18.8)
Acute Myocardial Infarction	14 (17.5)*
Stroke	6 (7.5)
Chronic Obstructive Pulmonary Disease	4 (5)
Atrial Fibrillation	4 (5)*
Total number of comorbidities	1.85 ± 1.37
Medications in use	
ACE inhibitor or ARB	77 (96.3)
Beta bloquers	77 (96.3)
Diuretics	54 (67.5)
Spironolactone	44 (64.7)
Statin	37 (46.3)
Digoxin	27 (33.8)
Amlodipine	9 (11.3)
Hydralazine	8 (10)
Warfarin	7 (8.8)
Ivabradine	5 (6.3)
Sildenafil	3 (3.8)
Sedentary behavior and Physical activity	
SB – hours/day	7.69 ± 2.35
MVPA ≥ 600 METs-min/week	37 (46.3)
Weekly volume -METs-min	1287.4 ± 681.8
MVPA Leisure and exercise domain (yes)	37 (46.3)
Weekly volume –METs-min	662.4 ± 355.1

Note: Values are expressed as mean ± SD or n (%). BMI – Body Mass Index; NYHA - New York Heart Association; MLHFQ - Minnesota Living with Heart Failure Questionnaire; DASI - Duke Activity Status Index; MVPA -Moderate to vigorous physical activity; ACE - Angiotensin-converting enzyme; ARB Angiotensin-II receptor blocker.
*missing data - LVEF: 1; MLHFQ: 5; etiology ischemic: 2; DM2, DLP, IAM e FA: 1

In univariate analysis (Table 2), BMI, MLHFQ score, NYHA functional class, total comorbidities, DLP, stroke, and the use of diuretics and statins showed a significant positive association with SB. MVPA ≥ 600 METs-min/week, MVPA in the leisure and exercise domain, functional capacity, and the use of sildenafil were negatively associated with SB. In the multivariate regression model (Table 2), SB remained significantly associated with MVPA ≥ 600 METs-min/week, functional capacity, and stroke. Age, a potential confounding variable, was included in the final model.

After adjusting for age, weekly volume of MVPA presented strong evidence of negative association with SB. Patients who exhibited

MVPA volumes ≥ 600 METs-min/week presented approximately 2 h and 27 min less of daily time in SB (95% confidence interval: −3.33 to −1.58 h). The observed correlation between functional capacity and SB demonstrated a reduction of 2.8 min in SB at each point of increase in DASI score. Lastly, the patients suffering from stroke presented 1 h and 35 min more SB per day. The final model, composed by covariates MVPA ≥ 600 METs-min/week, DASI, stroke, and age, explains 52.3% of the variability in SB of these patients.

Table 2. Bivariate and multivariate associations of sedentary behavior and the covariates of the study.

SB (hours/day)								
	Univariate analysis				Multivariate analysis			
Covariates	Coefficient	CI 95%		p	Coefficient	CI 95%		p
Gender (male)	0.654	-0.403	1.712	0.222				
Age	0.016	-0.020	0.053	0.372	- 0.013	- 0.043	- 0.016	0.370
BMI	0.098	0.014	0.182	0.023				
Schooling	-0.014	-0.137	0.108	0.815				
Occupation	-0.971	-2.187	0.245	0.116				
MLHFQ	0.033	0.011	0.055	0.004				
DASI	**-0.082**	**-0.116**	**-0.048**	**< 0.001**	**- 0.047**	**- 0.081**	**- 0.012**	**0.008**
LVEF	-0.005	-0.043	0.034	0.805				
Etiology ischemic	0.860	0.293	2.524	0.784				
Functional class								
NYHA 2	1.204	0.108	2.301	0.041				
NYHA 3	1.595	-0.073	3.264					
Comorbidities								
SAH	-0.075	-1.155	1.005	0.890				
DM 2	1.048	-0.072	2.168	0.066				
DLP	1.651	0.380	2.922	0.012				
Stroke	**2.326**	**0.387**	**4.266**	**0.019**	**1.593**	**0.113**	**3.073**	**0.035**
COPD	0.070	-2.359	2.499	0.954				
AF	1.913	-0.477	4.303	0.115				
AMI	0.732	-0.653	2.117	0.296				
CAD	-0.108	-1.454	1.239	0.874				
Total of comorbidities	0.391	0.010	0.773	0.044				
Use of medication								
ACE inhibitor	-0.073	-1.159	1.013	0.893				
ARB	-0.087	-1.199	1.024	0.876				
Beta bloquers	-0.325	-3.091	2.442	0.816				
Diuretics	1.303	0.220	2.387	0.019				
Spironolactone	0.508	-0.588	1.605	0.359				
Statin	1.084	0.058	2.110	0.039				
Digoxin	0.304	-0.806	1.414	0.587				
Amlodipine	-0.023	-1.687	1.640	0.978				
Hydralazine	-0.069	-1.822	1.683	0.937				
Warfarin	0.342	-1.517	2.202	0.715				
Ivabradine	-0.520	-2.689	1.649	0.634				
Sildenafil	-2.792	-5.487	-0.097	0.042				
MVPA ≥ 600 METs	**-3.140**	**-3.921**	**-2.358**	**< 0.001**	**-2.457**	**-3.334**	**-1.580**	**<0.001**
Leisure/exercise domain	-1.961	-2.917	-1.006	< 0.001				

Note: CI – confidence interval; BMI - Body Mass Index; NYHA - New York Heart Association; MLHFQ - Minnesota Living with Heart Failure Questionnaire; DASI - Duke Activity Status Index; LVEF – Left Ventricular Ejection Fraction; SAH - Systemic Arterial Hypertension; DM2 - type 2 Diabetes Mellitus; DLP - Dislipidemia; CAD - Coronary Artery Disease; AMI - Acute Myocardial Infarction; COPD - Chronic Obstructive Pulmonary Disease; AF - Atrial Fibrillation; ACE - Angiotensin-converting enzyme; ARB - Angiotensin-II receptor blocker.; MVPA – Moderate to vigorous physical activity.

Discussion

The results of this study showed that the characteristics indicative of or related to physical condition of patients with HF are associated with their SB. Low weekly volumes of MVPA, low functional capacity, and history of stroke were significantly associated with a longer time spent in SB in these patients. To our knowledge, this study was the first to investigate the factors associated with SB in patients with HF.

The mean SB observed in our sample was relatively lower than that observed in other studies, which used objective measures [16, 18]. However, the value corroborates with the mean observed in the study by Borland, Rosenkvist, Cider[17], who also used self-reported measures. The time spent on SB was significantly low among patients who complied with weekly MVPA recommendations. MVPA performed only in leisure and exercise domain exerted no influence on SB pattern. However, a relatively low mean weekly volume was observed among patients who performed MVPA in this specific domain. Indeed, HF patients spent an average of 2.1 h/week in MVPA in the leisure and exercise domain [18]. This result suggests that for these patients, engagement in incidental MVPA (such as domestic activities, at work, and during transportation) [32] can be important for both reduction of their SB and achievement of satisfactory levels of MVPA according to recommendations of health guidelines [5].

To date, literature presents no consensus with respect to the relationship between MVPA and SB, and little available data support the results obtained in this study, particularly in the HF population. A systematic review of cross-sectional and prospective design studies in the adult population revealed nine articles that assessed SB based on the total sitting time and moderate physical activity. Among these studies, only three showed a negative relationship with physical activity, whereas the others presented no relation [34].

Considering that patients with HF already feature reduced physical capacity [2], the negative association between MVPA and SB observed in this study can be explained by the better physical capacity of patients who performed MVPA volumes ≥ 600 METs-min/week given that adequate volumes of MVPA contribute to the maintenance of physical capacity of these patients [4, 5], thus favoring a more active daily routine. Garet et al.[35] observed that physical capacity, measured objectively ($VO_{2\ peak}$), was highly correlated with daily energy expenditure of HF patients, suggesting that low physical capacity contributes to a pattern of low daily energy expenditure, that is, more time spent in SB. This finding is corroborated by those of Toth, Gottlieb, Fisher, Poehlman[36], who, using objective measures of energy expenditure, also identified a positive relationship between daily energy expenditure and VO_2peak in these patients. Both studies also observed an inverse relationship between daily energy expenditure and NYHA functional class, suggesting that worse functional status/higher severity of the disease may increase the time spent in SB. In our sample, NYHA functional class was also positively associated with SB. However, this association was not observed in the final model. The low number of NYHA class III participants may have influenced this result.

In this study, the functional capacity evaluated by DASI showed a negative association with SB in the final model. This result reinforces our hypothesis to explain the negative association found between MVPA and SB. As discussed previously, in HF patients, a better physical capacity contributes to more independence in performing daily activities (light intensity) [2, 5], which can consequently lead to a reduction in the time spent in SB [6]. Epidemiological evidence has suggested an inverse relationship between sedentary time and light-intensity physical activity [13].

An intervention study with HF patients observed a reduction in sitting time with increased physical capacity after participating in an exercise program [17]. Interestingly, the authors also observed a significant increase in self-reported physical activity in domains not captured by a pedometer, suggesting that patients became more active in their daily activities. This phenomenon should be further investigated in future studies given that the reduction of SB through light-intensity activities may be especially important for HF patients because not all of them can achieve adequate levels of weekly MVPA [18, 20].

The positive association observed between stroke and SB is possibly related to greater physical disability, slow walking speed of stroke patients, and less time spent in MVPA [37]. Although DLP and DM2 comorbidities have not shown statistically significant association with SB in the final model, both are metabolic diseases closely related to deleterious effects of SB [6, 9, 10]. We reasonably believe that an increase in our sample could lead to a significant result of these variables in the final model.

The relationship between SB and QoL among HF patients was recently investigated by Edwards and Loprinzi[38]. The authors observed that SB was significantly associated with worsening of health-related QoL, and that such association was independent of moderate physical activity. Our findings partially converge with their results. Univariate analysis revealed that longer time spent in SB was associated to worse QoL. However, such an association was not independent of MVPA. In our sample, the association observed between QoL and SB was no longer associated in the multivariate model, which was composed by the covariates MVPA, DASI, stroke, and age. When we adjusted the model by MVPA only, the association between QoL and SB was also not statistically significant ($p = 0.30$ data not shown), suggesting that the association between QoL and SB depends on MVPA. This divergence between the findings may be related to differences in the volumes of physical activity observed in each case. In the study by Edwards and Loprinzi[38], the mean of moderate physical activity was significantly lower than that observed in our sample. The authors acknowledge that the volume of moderate physical activity found in their research was consistently below recommendations of physical activity, and these conditions may have influenced their results.

Finally, literature has pointed out a strong and consistent correlation between age and SB [39]. In our sample, we observed no evidence of the association between age and SB. However, the sample consisted of relatively young patients. Future studies with larger and more heterogeneous samples can better investigate this relationship in populations of patients with HF. Regardless, we have opted to include age in the final model as this variable is a biologically plausible confounder in this association and also contributed to better adjustment of the model.

This study features some limitations that must be considered. All exposures (MVPA, SB, and functional capacity) were assessed using self-reported measures, which have been shown to underestimate such behavior. To minimize such measurement bias, the interview for SB assessment, our major exposure of interest, was conducted with consideration for various dimensions of SB [28, 29]. Administration of MVPA, functional capacity, and SB questionnaires was performed by an interviewer who was not blinded to the study objectives and thus may be subject to information bias. A further limitation of this study is related to our decision of measuring SB taking into account only a usual day of the week. It is probable that the amount of time spent in SB varies between weekdays and weekends, and consequently, the total time spent in SB may have been underestimated in our study. Additionally, the findings described in this study should be interpreted considering the intrinsic limitations of the cross-sectional design employed, which prevented us from establishing causal relationships. For example, results cannot possibly determine whether lower functional capacity led to prolonged sitting time, or whether prolonged sitting time led to lower physical capacity in these patients. Lastly, generalization of our results may be limited considering the sample of a single outpatient clinic. Despite these limitations, the study contributes to the scarce literature dealing with the topic of SB in the context of HF.

Conclusion

Findings from the present study suggest that longer time spent in SB of patients with HF is associated with low volumes of weekly MVPA, low functional capacity, and previous stroke. More studies are needed to corroborate these findings. Studies using larger samples and analyzing additional factors, such as psychological and environmental variables, which can be potentially associated with SB in these patients can better explain this behavior in this population.

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