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Association of sedentary behavior and physical activity with occurrence of signs and symptoms in participants of a cardiac rehabilitation program

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Sedentary behavior (SB) is associated with health impairments, while physical activity (PA) has been a protective factor. It is unclear whether SB and PA are associated with occurrence of signs and/or symptoms (SS) during cardiac rehabilitation program (CRP) exercise sessions. The objective was to evaluate the association between SB and PA with occurrence of SS. Was included 48 patients from a CRP program (64.7 ± 10.4 years-old). Daily time and % of time of SB and weekly time in moderate-to-vigorous-intensity [MVPA], % of MVPA time, steps/day, and steps/minute were accelerometer-measured. Patients were followed-up during 24 CRP sessions, for accompaniment of SS. Age, sex, and comorbidities (hypertension, diabetes, dyslipidemia, obesity) were covariates. Log-transformed values of SB, MVPA and steps/day were also analyzed. As results, 43.7% ($n = 21$) of participants presented occurrence of signs, 62.5% ($n = 30$) presented occurrence of symptoms, and 81.2% ($n = 39$) present occurrence of SS. In fully adjusted model, % of time in MVPA (β: −0.449, $p = 0.045$) and steps/minute (β: −0.244, $p = 0.026$) were inversely associated with occurrence of symptoms. No association was observed between SB and PA and occurrence of signs. The occurrence of symptoms and SS among CRP participants was directly associated with SB and inversely associated with variables of PA.

Keywords Cardiac Rehabilitation, Cardiovascular diseases, Exercise, Sedentary behavior, Signs and symptoms

Sedentary behavior (SB) is characterized by activities with an energy expenditure ≤ 1.5 METS[1], such as watching TV, studying, and using a computer[2]. SB can promote several negative repercussions on health, such as reduction of endothelial function and cardiorespiratory fitness, and increase in body mass index, blood pressure values, insulin resistance and blood lipids[3]. Furthermore, SB is also associated with increased all-cause mortality rate[4] and is considered one of the risk factors for the development of cardiovascular diseases[5].

On the other hand, physical activity (PA) at all levels can contribute to the prevention of cardiovascular diseases (CVD)[6]. Hamer et al.[6] highlighted that PA was associated with a decreased risk of seven of the leading causes of death from CVD[6]. Furthermore, Aune et al.[7] suggested that high levels of leisure-time, occupational, vigorous-intensity, and total activity are related to a lower risk of developing heart failure[7].

Cardiac rehabilitation programs (CRP) are widely recommended to help reduce SB and increase PA levels in individuals with cardiovascular diseases and promote several benefits for this population's health[8]. However,

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during physical exercise in CRPs, due to a series of changes in the body caused by increased metabolic demand, there is a greater possibility of signs and symptoms (SS) occurring[9]. SS are events of lesser complexity (e.g., abnormal increase in blood pressure, changes in pulse rate, angina, among others)[10] which may precede major complications, such as complex arrhythmias, cardiac arrest, and sudden death[11]. Therefore, there is a need of identifying variables that might be associated with the occurrence of SS in CRP. This would help anticipate risk and increase safety of patients participating in these programs.

Studies investigating SB and PA in CRP should be encouraged[12,13] to understand how each patient's daily routine can influence the rehabilitation process. Furthermore, and it is unknown if these behaviors (SB and PA) are related to the occurrence of SS in an exercise-based CRP, in which the physical stress tends to be higher. This information may help in the identification of patients with a greater possibility of present SS in CRP and increase the number of clinical and behavioral variables to be used for cardiovascular risk stratification, physical exercise prescription, and supervision of patients. In addition, it will also contribute to the development of educational interventions that indicate the importance of reducing SB and increasing PA. It may consequently improve the overall clinical condition of these patients.

Therefore, the present study analyzed the association of SB and PA parameters with the occurrence of SS during an extent of 24 exercise-based CRP sessions. We hypothesized that the occurrence of SS would be directly associated with SB (daily time and percentage of time) and inversely associated with PA parameters [weekly time and percentage of time in moderate to vigorous intensity activities (MVPA), steps per day, and steps per minute].

Methods

Study design and participants

This is an observational longitudinal prospective cohort study that was developed between February and March 2019. It is described according to the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) recommendations[14]. A total of 65 individuals were recruited for this study. It included those who were participating in an exercise-based CRP conducted in a Brazilian University for at least three months, had a clinical diagnosis of cardiovascular diseases and/or risk factors for cardiovascular diseases, and those who agreed to participate in the study. The recruitment was conducted by a researcher who was not part of the clinical care and had no conflict of interest.

Patients who presented errors in the evaluation of the SB and PA, assessed by an accelerometer, (i.e., did not wear the accelerometer for at least 10 h during 4 days) were excluded from the analyses.

The individuals were informed about the objectives and procedures of the study and provided written informed consent. All procedures used in this study were approved by the Ethical Research Committee of São Paulo State University Campus of Presidente Prudente, São Paulo, Brazil (CAAE: 79213417.0.0000.5402) and all procedures carried out in the study are in accordance with the Declaration of Helsinki, as well as with research regulatory organizations in Brazil.

Sample size

The sample size was determined using the results obtained in a pilot study previously conducted. Data from 10 individuals were considered for analysis. It was based on an estimated correlation of 0.429, alpha risk of 5%, and beta risk of 80%, which resulted in a minimum sample size of 40 individuals. Considering possible sample losses, 10% was added to the sample, which resulted in 44 individuals. The sample size calculation was performed using MedCalc Software bvba - version 19.2.6 (Oostende, Belgium) [https://www.medcalc.org].

Experimental procedure

The study data collection was performed from March to December 2019, in the afternoon (13:30 to 17:30), and occurred in two moments. In the first moment, data for sample characterization were extracted from the patients' medical records, and anthropometric data (body mass and height) were measured for further body mass index calculation and obesity definition. Subsequently, the SB and PA was assessed using an accelerometer[15].

In the second moment, all participants were followed up for 24 exercise sessions of a CRP for the identification and recording of the occurrence of SS. All the assessments were facilitated by a researcher who was not part of the clinical care and had no conflict of interest.

Characterization and assessment of the individuals

The following information was extracted from the patients' medical records: sex, age, main clinical diagnosis. The ACSM recommendations[16] were considered for the analysis of risk factors for cardiovascular diseases, and the presence of hypertension, diabetes mellitus, dyslipidemia, and obesity were assessed from the patients' medical records.

For the assessment of body mass, a digital scale was used (Balmak, Premium Bk – 200Fa, Brazil). Height was measured in an orthostatic position using a stadiometer (Sanny, ES 2020, Brazil). Body mass index was obtained by the formula: body mass (kg)/height^2 (m)[17].

Cardiac rehabilitation program

The exercise sessions of the CRP occurred at a frequency of three times a week, on alternate days, and had a duration period of 60 min divided into 4 phases: (1) resting phase: initial evaluation [blood pressure, heart rate and SS]; (2) warm-up phase: global stretching, active exercises of lower limbs, upper limbs and combined; with an average duration of 15 min; (3) resistance phase: individualized aerobic protocol performed for 30 min (15 min using a treadmill and 15 min using a stationary bike) and with intensity prescribed according to heart rate reserve values; (4) relaxation phase: cardiovascular deceleration and heart rate monitoring, and if necessary

blood pressure monitoring[18]. The sessions were performed and supervised by previously trained therapists, with a maximum ratio of 1:2 patients[18].

Identification of signs and symptoms

The identification of the occurrence of SS was performed for 24 exercise sessions of a CRP. Signs were identified by previously trained professionals, and symptoms were reported by the patients at the end of each phase of the session.

SS that are more frequently observed in CRP were assessed[10]: (a) Signs: Systolic blood pressure with an abnormal increase during exercise (higher than 200 mmHg), diastolic blood pressure with an abnormal increase during exercise (higher than 120 mmHg), changes in pulse rate, pallor and tachypnea; (b) Symptoms: dizziness, angina, cramps, muscle pain, fatigue, and nausea[10].

The calculation of the occurrence of SS was relative to each session, regardless of the number of times that the same sign and/or symptom occurred during a session. Thus, if the patient presented the same sign and/or symptom in all of 24 sessions, it was calculated as 24 times. More information regarding the assessment and the definition of SS is described in the protocol previously published by Vanzella et al.[18].

Assessment of sedentary behavior and physical activity

The Actigraph GT3X-BT triaxial accelerometer (ActiGraph, LLC, Pensacola, FL, USA) calibrated with a frequency of 30 Hz was used for the objective assessment of SB and PA[15]. Patients were previously instructed on how to wear the Actigraph (on the hip - dominant side), and to remove the equipment only while sleeping and performing activities that involves water.

Patients wore the Actigraph for seven consecutive days. The wearing of the device for at least 10 h was defined as a valid day. Data from patients that wore the device for least 4 valid days were considered for analysis[15]. After seven days of use, the data were downloaded from the Actigraph and the activity in counts was analyzed considering an epoch of 60 s[19]. The ActiLife Software - version 6.11.8 (ActiGraph, LLC, Pensacola, FL, USA) [https://theactigraph.com/academic-research#actilife] was used for analysis. To determine the valid periods, the non-valid periods of 24 h were subtracted, defined as intervals of at least 60 consecutive minutes of zero activity[20]. These data provided information about individuals SB, characterized by the time in which the patient performed activities at less than 100 counts per minute[21], and PA, considering MVPA (more than 2020 counts per minute) and total number of steps[20]. Thus, the following outcomes were used: indicators of SB (daily SB time and % of SB total time) and PA (weekly time in MVPA, % of MVPA total time, steps/day, and steps/minute).

Data analysis

Accelerometer data was presented in median and interquartile range for sample characterization, while categorical information was presented in absolute and relative frequency. The SB and PA parameters were compared according to the occurrence of SS and according to each assessed sign/symptom by Mann-Whitney U test. Proportions of categorical variables were compared by chi-square test. Linear regression models were used do analyze the association between SB and PA parameters with SS occurrence in crude and adjusted models for age, sex, and comorbidities. Due to skewness of SB and PA parameters, these variables were transformed in natural logarithm for standardization and robustness of linear models. The first-order autocorrelation in multivariate model was analyzed by the Durbin-Watson test, whereas the Variance Inflation Factor (VIF) was analyzed in order to check whether covariates did not increase the regression coefficient due to multicollinearity. Statistical significance level was set at 5%. Data analysis was performed using the Statistical Packages for the Social Sciences (SPSS) – version 22.0 (SPSS Inc., Chicago, IL, USA) [https://www.ibm.com/mysupport/s/topic/0TO500000001yjtGAA/spss-statistics].

Results

A total of 65 patients enrolled in a CRP program were recruited to participate in the study. Of these, 5 declined to participate, and 60 patients were assessed. The final analyses included data of 48 patients who correctly used the accelerometer device (Fig. 1). A total of 43.7% ($n=21$) of participants presented occurrence of signs, 62.5% ($n=30$) presented occurrence of symptoms, and 81.2% ($n=39$) present occurrence of SS.

Table 1 shows descriptive characteristics of sample. The most frequent medical diagnosis for CRP recommendation was coronary artery disease [$n=33$ (68.8%); $n=27$ (56.2%) stent placement; $n=13$ (27.1%) myocardial revascularization; $n=10$ (20.8%) associated acute myocardial infarction], and hypertension was the most frequent comorbidity in the sample ($n=40$, 83.3%), being marginally different according to sex (males 92.6% vs. females 71.4%, $p=0.051$ for comparison of proportion). The SB and PA parameters did not present significant difference according to sex ($p>0.05$ for median comparison). It was not observed significant difference in occurrence of SS according to sex ($p>0.05$ for comparison of proportion).

The Fig. 2 presents the comparison of SB and PA parameters according to the occurrence of signs or symptoms. Participants without occurrence of symptoms during the CRP sessions had higher minutes per week in MVPA (median 22.0 [IQR: 8.5–36.3] vs. 9.0 [IQR: 5.4–24.2] and higher steps/minute (median 5.1 [IQR: 2.9–8.5] vs. 4.2 [IQR: 2.8–6.8]) than participants with occurrence of symptoms ($p<0.05$). The muscle pain was the unique symptom which presented significant difference in PA parameters, where participants without occurrence of muscle pain showed higher % of time in MVPA when compared to participants with occurrence of muscle pain during CRP exercise sessions (median 1.8 [IQR: 0.6–3.6] vs. 0.7 [IQR: 0.5–1.8], $p=0.048$).

The simple linear regression models of association between SB and PA parameters with occurrence of signs, symptoms and SS is presented in Table 2. The occurrence of symptoms was associated with higher SB (β: 0.002, $p=0.039$ for sedentary time; β: 1.444, $p=0.043$ for log-transformed sedentary time). Regarding PA parameters, the occurrence of symptoms was negatively associated with MVPA (β: −0.039, $p=0.021$ for weekly MVPA

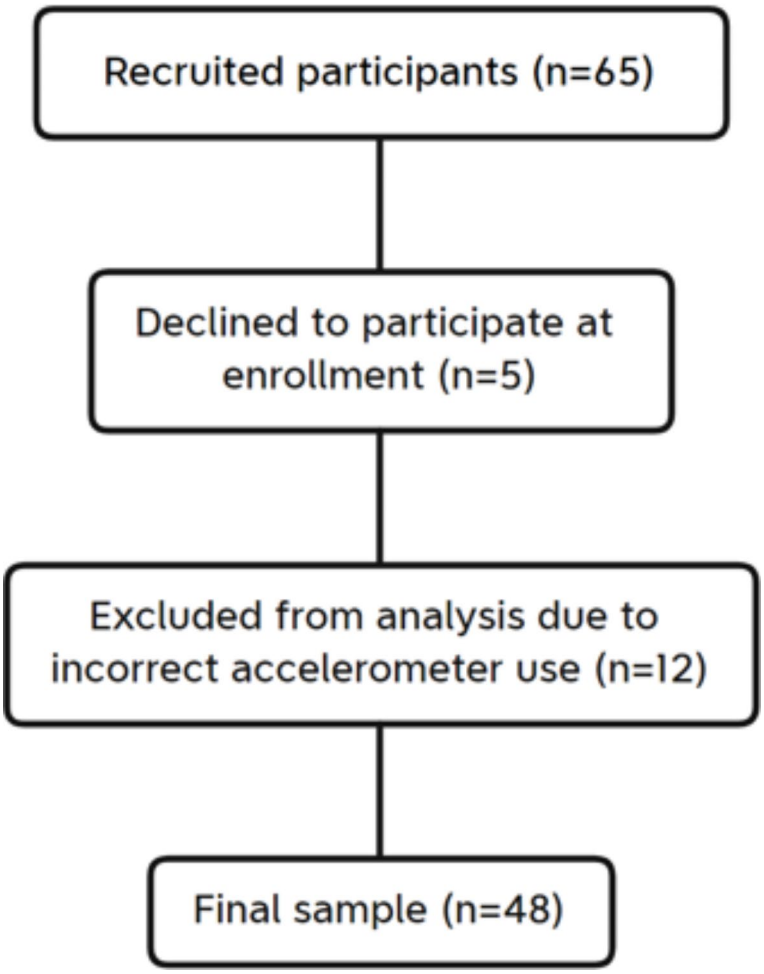

Fig. 1. Sampling flowchart.

time; β: −0.483, $p=0.007$ for % of time in MVPA), steps per day (β: −1.111, $p=0.041$ for log-transformed steps per day), and steps per minute (β: −0.249, $p=0.005$). When signs and symptoms were considered together, a positive association was observed only for the % of time in SB (β: 0.160; $p=0.036$) and a negative association with MVPA (β: −0.103, $p=0.040$ for weekly MVPA time; β: −1.213, $p=0.023$ for % of time in MVPA), steps per day (β: −0.001, $p=0.044$ for total steps per day; β: −3.510, $p=0.029$ for log-transformed steps per day), and steps per minute (β: −0.606, $p=0.022$). No association was observed between SB and PA parameters with occurrence of signs.

The association between SB and PA parameters with occurrence of signs, symptoms and SS considering age and sex as covariates are shown in Table 3. This multiples models showed that association of SB parameters with occurrence of signs, symptoms or SS became non-significant, while PA parameters remained inversely associated with occurrence of symptoms: MVPA (β: −0.043, $p=0.024$); % of time in MVPA (β: −0.583, $p=0.005$); steps per day (β: 0.000, $p=0.017$); log-transformed steps per day (β: −1.413, $p=0.037$); and steps per minute (β: −0.311, $p=0.003$).

The Table 4 presents the association between SB and PA parameters with occurrence of signs, symptoms and SS also considering the presence of comorbidities as covariates (hypertension, diabetes, dyslipidemia, and obesity), besides age and sex. In this fully adjusted model, only the % of time in MVPA (β: −0.449, $p=0.045$) and steps per minute (β: −0.244, $p=0.026$) remained negatively associated with occurrence of symptoms among CRP patients.

Discussion

We observed that occurrence of signs and symptoms reached respectively 43.7% and 62.5% of CRP participants during the extent of 24 exercise sessions. Participants with symptoms occurrence presented lower MVPA and steps per minute than those without occurrence, mainly regarding muscle pain. The main study findings showed that occurrence of symptoms and SS was associated with SB and inversely associated with PA parameters in CRP participants. Although the association between SB and occurrence of symptoms and SS was mitigated by age and sex. PA parameters remained inversely associated with symptoms occurrence even after considering age, sex, and comorbidities of the sample.

Variables	
Age (years), mean (SD)	64.7 (10.4)
Female sex, n (%)	21 (43.8)
Medical diagnosis for enrollment in CRP	
Coronary artery disease, n (%)	33 (68.8)
Other cardiovascular disease*, n (%)	8 (16.7)
Prevention**, n (%)	7 (14.6)
Comorbidities	
Hypertension, n (%)	40 (83.3)
Dyslipidemia, n (%)	32 (66.7)
Diabetes, n (%)	16 (33.3)
Obesity, n (%)	14 (29.2)
Accelerometer outcomes	
Sedentary time (min/day), median (IQR)	804.9 (513.9–1108.8)
Percent in sedentary time[a], median (IQR)	72.7 (60.9–80.5)
MVPA (min/week), median (IQR)	11.8 (6.3–27.3)
Percent in MVPA[a], median (IQR)	1.1 (0.5–3.1)
Steps per day, median (IQR)	5822.6 (3943.7–8013.8)
Steps per minute, median (IQR)	5.1 (2.9–8.5)
Occurrence of signs during CRP sessions per participant	
Arrhythmia, mean (min.– max.)	2.3 (0–24)
Increased SBP during exercise, mean (min. – max.)	0.3 (0–5)
Occurrence of symptoms during CRP sessions per participant	
Angina, mean (min.– max.)	0.3 (0–4)
Muscle pain, mean (min.– max.)	0.7 (0–5)
Fatigue, mean (min.– max.)	0.3 (0–3)

Table 1. Characteristics of sample ($n = 48$). IQR = Interquartile range; SD = Standard deviation; MVPA = Moderate-to-vigorous physical activity; CRP = Cardiac rehabilitation program; min.= minimum value; max.= maximum value; SBP = Systolic blood pressure; *Other cardiovascular disease = Heart failure; Dilated cardiomyopathy; Atrial fibrillation; **Prevention = Comorbidities; a = Percent of accelerometer wear time.

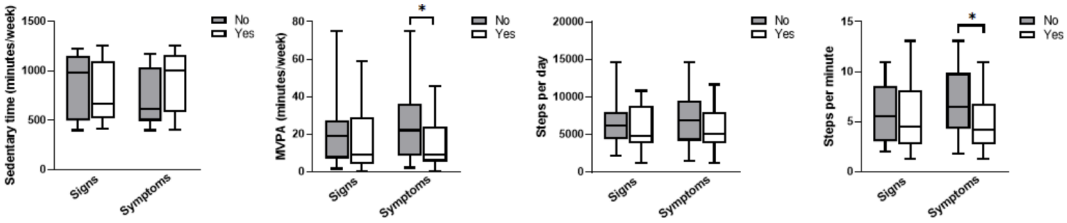

Fig. 2. Comparison of sedentary behavior and physical activity parameters according to occurrence of signs or symptoms in participants of cardiac rehabilitation program ($n = 48$). *Statistical difference at $p < 0.05$ level.

Previous studies related to SB have focused on its influence on the development of diseases[22] and mortality rates[23]. In a population-based study, Vasankari et al.[22] have observed that the accumulated time in SB is associated with greater cardiovascular diseases risk, which highlights the importance of preventive actions to reduce SB[22] in individual participating in CRP. In addition, Wu Z et al.[23] have observed that patients after myocardial infarction with greater SB levels had greater risk of mortality (62%) compared to patients with those with lower SB levels[23]. The results of this study demonstrate that SB is also associated with occurrence of symptoms and SS.

SB is promoting negative changes in the body that may explain its association with the ocurrence of symptoms and SS during the exercise practice in CRP. Several deleterious effects induced by SB on the cardiovascular health were observed in the literature[24]. SB can promote the reduction of peripheral vascular function[3], mediated by reductions in blood flow and shear tension. It increases the production of vasoconstrictors and reduces the availability of nitric oxide[25]. The vasoconstriction action of the norepinephrine on the total peripheral resistance increases the blood pressure[26]. An increase in the inflammatory markers that impairs vascular function[27], and reduction in the aerobic capacity[28] are also observed. Putting together, those factors may increase the chances of the occurrence of symptoms and SS during the exercise practice, which would potentially explain the findings.

	Signs	Symptoms	Signs + Symptoms
	β (95% CI), *p*-value	β (95% CI), *p*-value	β (95% CI), *p*-value
Sedentary time (minutes/day)	0.003 (−0.003; 0.008), $p=0.301$	**0.002 (0.001; 0.004),p = 0.039**	0.005 (−0.001; 0.010), $p=0.095$
Sedentary time (log-transformed)	1.986 (−2.019; 5.991), $p=0.323$	**1.444 (0.049; 2.838),p = 0.043**	3.430 (−0.768; 7.628), $p=0.107$
Percent of time in sedentary behavior[a]	0.110 (−0.033; 0.253), $p=0.127$	0.050 (−0.001; 0.101), $p=0.053$	**0.160 (0.011; 0.309),p = 0.036**
MVPA (minutes/week)	−0.065 (−0.159; 0.030), $p=0.177$	**−0.039 (−0.072; −0.006),p = 0.021**	**−0.103 (−0.202; −0.005),p = 0.040**
MVPA (log-transformed)	−0.673 (−2.099; 0.754), $p=0.348$	−0.450 (−0.952; 0.051), $p=0.077$	−1.123 (−2.624; 0.378), $p=0.139$
Percent of time in MVPA[a]	−0.731 (−1.740; 0.279), $p=0.152$	**−0.483 (−0.826; −0.139),p = 0.007**	**−1.213 (−2.255; −0.172),p = 0.023**
Steps per day	0.000 (−0.001; 0.000), $p=0.201$	**0.001 (0.001; 0.001),p = 0.017**	**−0.001 (−0.001; 0.000),p = 0.044**
Steps per day (log-transformed)	−2.399 (−5.412; 0.614), $p=0.116$	**−1.111 (−2.177; −0.045),p = 0.041**	**−3.510 (−6.645; −0.375),p = 0.029**
Steps per minute	−0.357 (−0.858; 0.145), $p=0.159$	**−0.249 (−0.419; −0.080),p = 0.005**	**−0.606 (−1.122; −0.090),p = 0.022**

Table 2. Simple linear regression between device-measured sedentary time and physical activity with the frequency of occurrence of signs, symptoms and signs and symptoms among participants from cardiac rehabilitation program ($n=48$). CI = Confidence interval; MVPA = Moderate-to-vigorous physical activity; a = Percent of accelerometer wear time. Significant values are in bold.

	Signs	Symptoms	Signs + Symptoms
	β (95% CI), *p*-value	β (95% CI), *p*-value	β (95% CI), *p*-value
Sedentary time (minutes/day)	0.001 (−0.004; 0.007), $p=0.578$	0.002 (0.000; 0.004), $p=0.053$	0.003 (−0.002; 0.009), $p=0.228$
Sedentary time (log-transformed)	0.926 (−3.159; 5.011), $p=0.650$	1.437 (−0.047; 2.920), $p=0.057$	2.363 (−1.933; 6.658), $p=0.274$
Percent of time in sedentary behavior[a]	0.051 (−0.112; 0.214), $p=0.531$	0.056 (−0.003; 0.116), $p=0.062$	0.108 (−0.064; 0.279), $p=0.212$
MVPA (minutes/week)	−0.036 (−0.139; 0.067), $p=0.482$	**−0.043 (−0.080; −0.006),p = 0.024**	−0.079 (−0.187; 0.028), $p=0.145$
MVPA (log-transformed)	−0.265 (−1.857; 1.327), $p=0.739$	−0.520 (−1.101; 0.061), $p=0.078$	−0.784 (−2.463; 0.894), $p=0.351$
Percent of time in MVPA[a]	−0.391 (−1.545; 0.763), $p=0.498$	**−0.583 (−0.984; −0.183),p = 0.005**	−0.974 (−2.172; 0.223), $p=0.108$
Steps per day	0.000 (−0.001; 0.001), $p=0.679$	**0.000 (−0.001; 0.000),p = 0.017**	0.000 (−0.001; 0.000), $p=0.223$
Steps per day (log-transformed)	−1.209 (−4.866; 2.449), $p=0.509$	**−1.413 (−2.733; −0.093),p = 0.037**	−2.622 (−6.449; 1.206), $p=0.174$
Steps per minute	−0.137 (−0.724; 0.450), $p=0.640$	**−0.311 (−0.512; −0.110),p = 0.003**	−0.448 (−1.059; 0.163), $p=0.147$

Table 3. Multiple linear regression between device-measured sedentary time and physical activity with the frequency of occurrence of signs, symptoms and signs and symptoms among participants from cardiac rehabilitation program, considering age and sex as covariates ($n=48$). CI = Confidence interval; MVPA = Moderate-to-vigorous physical activity; a = Percent of accelerometer wear time. Significant values are in bold.

The associations of SB with symptoms and SS were attenuated when age and sex were considered as confounding variables, suggesting that these are variables that may also be related to the occurrence of symptoms and SS. Regarding age, the participants analyzed can be characterized as elderly (64.70 ± 10.40 years) and the aging process, as well as SB, can generate unfavorable changes for the individual's body, such as mitochondrial dysfunction, alteration in myogenic capacity and reduction of cardiorespiratory and muscular function[29], which favor the occurrence of symptoms and SS.

Regarding sex, the literature describes that the relationships between SB and cardiometabolic biomarkers are stronger for women[30] and that the hormonal profile is different between men and women[31]. These are aspects that may, at least in part, be related to the attenuation of the associations found. Women compared to men have lower aerobic capacity, increased attenuated ejection fraction, higher levels of respiratory fatigue, greater hypertensive, and heart rate response, among others[32]. Furthermore, estrogen has a cardioprotective effect in women, via the mechanism of reducing oxidative stress on the cardiovascular system[31], and its decrease due to the menopause process[33] may contribute to the emergence of conditions such as changes in pulse rate[34]. Considering these aspects, these particularities of the female sex may have exerted influences on the occurrence of symptoms and SS. However, for a better understanding of this influence, more research is needed.

Regarding PA, participants who had symptoms had MVPA and steps per minute lower than those without symptoms, especially concerning muscle pain. Moreover, a negative association was observed between MVPA and number of steps with the occurrence of symptoms and SS during the PRC sessions. These findings corroborate those found in the literature, which demonstrated positive results of PA with health status[35–37]. Kulinski et al.[35] showed that increased PA time is favorably associated with cardiorespiratory fitness in the general population[35]. Mora et al.[36] highlighted that moderate PA levels are associated with a lower risk of clinically relevant cardiovascular events, such as acute myocardial infarction and stroke[36], and that this association is mostly mediated by factors related to blood pressure and inflammatory profile[36].

	Signs	Symptoms	Signs + Symptoms
	β (95% CI), *p*-value	β (95% CI), *p*-value	β (95% CI), *p*-value
Sedentary time (minutes/day)	0.002 (−0.003; 0.008), $p=0.418$	0.001 (−0.001; 0.003), $p=0.222$	0.003 (−0.002; 0.009), $p=0.246$
Sedentary time (log-transformed)	1.471 (−2.769; 5.711), $p=0.487$	0.907 (−0.558; 2.373), $p=0.218$	2.378 (−2.118; 6.875), $p=0.291$
Percent of time in sedentary behavior[a]	0.071 (−0.097; 0.239), $p=0.400$	0.033 (−0.025; 0.092), $p=0.253$	0.104 (−0.074; 0.282), $p=0.244$
MVPA (minutes/week)	−0.061 (−0.174; 0.052), $p=0.282$	−0.026 (−0.066; 0.013), $p=0.181$	−0.087 (−0.207; 0.032), $p=0.147$
MVPA (log-transformed)	−0.695 (−2.336; 0.947), $p=0.397$	−0.422 (−0.986; 0.142), $p=0.139$	−1.117 (−2.851; 0.618), $p=0.201$
Percent of time in MVPA[a]	−0.702 (−1.998; 0.595), $p=0.281$	**−0.449 (−0.886; −0.011), p = 0.045**	−1.150 (−2.508; 0.207), $p=0.094$
Steps per day	0.000 (−0.001; 0.000), $p=0.603$	0.000 (0.000; 0.000), $p=0.091$	0.000 (−0.001; 0.000), $p=0.300$
Steps per day (log-transformed)	−1.130 (−4.943; 2.683), $p=0.553$	−1.039 (−2.339; 0.260), $p=0.114$	−2.169 (−6.205; 1.866), $p=0.284$
Steps per minute	−0.208 (−0.852; 0.435), $p=0.517$	**−0.244 (−0.457; −0.031), p = 0.026**	−0.453 (−1.129; 0.224), $p=0.184$

Table 4. Multiple linear regression between device-measured sedentary time and physical activity with the frequency of occurrence of signs, symptoms and signs and symptoms among participants from cardiac rehabilitation program, considering age, sex and comorbidities as covariates ($n=48$). CI = Confidence interval; MVPA = Moderate-to-vigorous physical activity; a = Percent of accelerometer wear time. Comorbidities were hypertension, diabetes, dyslipidemia and obesity. Durbin-Watson test for first-order autocorrelation = 1.326. Variance Inflation Factor (VIF) for multicollinearity was VIF = 1.157 for sex; VIF = 1.104 for age; VIF = 1.233 for hypertension; VIF = 1.484 for dyslipidemia; VIF = 1.346 for diabetes, and VIF = 1.071 for obesity. Significant values are in bold.

Beneficial associations between step counts and CVD risk markers (glycated hemoglobin, high-density lipoprotein cholesterol, triglycerides, and C-reactive protein) in middle-aged adults have also been described[37]. It is also noteworthy that there are associations between PA and lower chances of musculoskeletal pain[38], which can be justified by the modulation of physiological changes via the central nervous system promoted by PA on pain intensity[39]. It is important to note that the inverse associations between MVPA and steps per minute with the occurrence of symptoms were maintained after adjusting for age, sex, and comorbidities, which demonstrates the relevance of habitual PA for individuals with CVD.

Some limitations should be mentioned. It was not possible to monitor hemodynamic parameters during the warm-up phase of exercise practice in CRP, which limited the analysis of the occurrence of some SS. Nevertheless, the intensity of exercises is lower than other phases of CRP and we considered a very low probability of hemodynamic changes during the warm-up phase. Furthermore, the cutoff points used to determine SB and MVPA are not specific to the population with heart disease, however, we selected these because they are widely mentioned in the literature for the general population, including the elderly[40,41], a characteristic profile of our sample.

The limitation regarding the use of an accelerometer to assess SB can also be mentioned. This instrument provides an estimate of SB and does not distinguish posture from behavior, unlike the inclinometer, which allows direct detection of the current posture and transitions between postures, which denotes it as a more specific method for analyzing SB[42]. Another limitation of this study was the restricted sample size, which precludes further sensitivity analysis according to sex and age groups, although the minimum sample size has been reached.

As practical applications of the present study, our findings suggest that health professionals involved with CRP need to monitor the habitual SB and PA levels of patients already enrolled in exercise-based programs, aiming to identify those at potential risk of SS during exercise sessions. This demonstrates the validity and promising nature of using behavioral variables from the entire daily routine (PA and SB) and their association with greater safety and better patient supervision. It is important to emphasize the notoriety of these findings, since the occurrence of SS may precede major adverse events[11]. This indicates the need for caution in prescribing and monitoring exercises for patients at higher risk of developing SS, to avoid the occurrence of more complex events.

Furthermore, based on the fact that improving lifestyle could be a protective factor against the occurrence of SS in CRP patients, we also recommend that, through health education, these individuals be encouraged to increase their PA level (habitual MVPA and number of steps) in their routine activities outside the clinical environment where the program is carried out, and not consider only the exercise sessions performed during the week as sufficient. We highlight this point because the literature shows that regular participants in exercise-based programs have a notable amount of sedentary time[43], a fact that may be related to the lower feeling of guilt when adopting these behaviors during daily life, since they consider themselves "regularly active"[28].

In conclusion, the occurrence of symptoms and SS among CRP participants was directly associated with SB and inversely associated with variables of PA, indicating that lifestyle improvement would be a protective factor against SS occurrence in CRP patients. PA parameters remained inversely associated with symptoms occurrence even after considering age, sex, and comorbidities of the sample.

Data availability

All the data collected for the research in question are not published in any other media or data dissemination tool, nor are they stored in specific repositories. However, upon request, the data may be made available at any time. To request access to the data, contact the corresponding author (email address: jplucas_silva@hotmail.com).

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Declarations

Competing interests
The authors declare no competing interests.

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