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FACTORS ASSOCIATED WITH SEDENTARY BEHAVIOR IN PATIENTS WITH INTERMITTENT CLAUDICATION

Breno Q. Farah, MS[a,b], **Raphael M. Ritti-Dias, PhD**[a,c], **Gabriel G. Cucato, PhD**[c], **Polly S. Montgomery, MS**[d], and **Andrew W. Gardner, PhD**[d]

[a]Graduate Program in Physical Education. University of Pernambuco/Federal University of Paraiba, Recife, PE, Brazil

[b]Group Research in Health and Sport – ASCES College, Caruaru, PE, Brazil

[c]Albert Einstein Hospital, Sao Paulo, SP, Brazil

[d]Reynolds Oklahoma Center on Aging, Donald W. Reynolds Department of Geriatric Medicine, University of Oklahoma Health Sciences Center (OUHSC), Oklahoma City, OK

Abstract

Objectives—Time spent in sedentary behavior has been associated with cardiometabolic risk factor in the general population and in patients with symptomatic peripheral artery disease (PAD). Given the association of sedentary behavior and poor health outcomes, it is important to identify factors associated of sedentary behavior in these patients. The aim of this study was to identify factors associated with the sedentary time in patients with symptomatic PAD.

Methods—The sample included 297 patients with symptomatic PAD. Sedentary behavior was assessed using a step activity monitor and the patients were divided into tertiles. Demographic data, body mass index, comorbid conditions, and measures of severity of PAD (ankle-brachial index, ischemic window, claudication measurements, peak oxygen uptake and walking economy) were obtained.

Results—Patients in the highest tertile (i.e., more sedentary) have a higher body mass index and a higher prevalence of diabetes mellitus, metabolic syndrome and obesity than patients in the lowest tertile, whereas their peak walking time, peak oxygen uptake and walking economy were lower (P<.05 for all). Using multiple regression procedures, the factors associated of the sedentary time were male sex (b=0.217, R^2=0.180, p=0.001), body mass index (b=0.154, R^2=0.059, p=0.013), peak walking time (b=−0.360, R^2=0.066, p=<0.001) and walking economy (b=−0.187, R^2=0.142, p=0.004).

Address correspondence to: Andrew W. Gardner, Ph.D., Professor and Donald W. Reynolds Chair in Aging Research, OUHSC, Donald W. Reynolds Department of Geriatric Medicine, 1122 N.E. 13th Street, O'Donoghue Research Building, Suite 1200, Oklahoma City, OK 73117. Telephone (405) 271-8558 ext. 42743, FAX: 405-271-2882, andrew-gardner@ouhsc.edu.

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Conclusion—In patients with symptomatic PAD, greater time spent in sedentary behavior was found in men, and in patients with higher body mass index, lower peak walking time, and lower walking economy.

Keywords

peripheral artery disease; intermittent claudication; sedentary lifestyle

INTRODUCTION

Intermittent claudication is the most prevalent symptom of peripheral arterial disease (PAD)[1], with rates between 12 to 20% of the United States population aged ≥60 years[2]. Patients with intermittent claudication have impaired walking capacity[3], low physical fitness[4, 5], and many comorbid conditions[6], all of which reduce quality of life[7]. In addition, these patients have elevated time spent in sedentary behavior[8].

Sedentary behavior includes activities that are completed in a sitting or reclining posture, and activities consisting of low intensity characterized by energy expenditures ≤ 1.5 METs, such as watching TV, deskwork, riding in a car, and computer activities[9, 10]. Previous studies in non-PAD subjects showed that sedentary behavior is associated with fatal and nonfatal cardiovascular disease, and all-cause mortality independent of physical activity level[11, 12]. In patients with symptomatic PAD, sedentary behavior was associated with worse inflammation, coagulation, glucose, and lipid profiles[13] and greater functional decline[8].

Given the association of sedentary behavior and poor health outcomes in PAD patients, it is important to identify factors associated of sedentary behavior in these patients. Thus, the aim of this study was to identify factors associated with the sedentary behavior in patients with symptomatic PAD.

METHODS

Recruitment and Patients

PAD patients with Rutherford Grade I and Category 1 to 3[1] were evaluated at the Clinical Research Center at the University of Oklahoma Health Sciences Center. Patients arrived fasted, but were permitted to take their usual medications. Patients were recruited by referrals from the Health Sciences Center vascular clinics, as well as by newspaper advertisements for possible enrollment into an exercise study[14, 15].

Patients performed an initial progressive, graded treadmill exercise test to determine study eligibility. Patients were included in the study if they met the following criteria: (a) graded treadmill test limited by intermittent claudication symptoms, (b) an ankle brachial index (ABI) ≤ 0.90 at rest[16], or an ABI ≤ 0.73 after exercise[17]. Patients were excluded if they met any of the following criteria: (a) inability to obtain an ABI measure due to non-compressible vessels (ABI ≥ 1.40), (b) asymptomatic PAD determined from the medical history and verified during the graded treadmill test, (c) exercise tolerance limited by factors other than claudication symptoms (e.g. clinically significant electrocardiographic changes during exercise indicative of myocardial ischemia, dyspnea, poorly controlled blood pressure), and failure to complete the testing within three weeks.

The procedures of this study were approved by the Institutional Review Board at the University of Oklahoma HSC. Written informed consent was obtained from each patient prior to participation.

Primary Outcome Assessment

Sedentary behavior—Sedentary behavior was assessed using a step activity monitor (StepWatch3™, Orthoinnovations, Inc., Oklahoma City, OK) as previously described[18]. Step activity monitor data were analyzed by a single researcher in a blinded fashion. It was programmed by placing the unit on a USB docking station connected to a computer with StepWatch3™ Analysis Software. Physical activity was measured during seven consecutive days in which patients were instructed to wear the monitor during waking hours and to remove it before retiring to bed. The step activity monitor was attached to the right ankle above the lateral malleolus using an elastic Velcro strap, and continuously recorded the number of steps taken on a minute-to-minute basis. The step activity monitor quantifies ambulatory stride rate and time of ambulatory activity and inactivity, and characterizes short-duration bursts of activity as well as sustained endurance. Sedentary behavior was considered the total time of inactivity per day (min/d), defined as the number of minutes in which zero strides were taken, including sleeping time.

Secondary Outcome Assessment

Medical history and anthropometry—Demographic information, height, weight, body mass index, waist circumference, claudication history, physical examination and comorbid conditions (osteoarthritis, obesity, hypertension, diabetes, dyslipidemia, metabolic syndrome and heart disease) were assessed at the beginning of the study by a physician. Obesity was defined as body mass index > 30 $kg^{-1}.m^2$. Hypertension was defined as systolic blood pressure ≥ 140 mmHg or diastolic ≥ 90 mmHg, or use of anti-hypertensive medication. Diabetes was defined as fasting blood glucose ≥126 mg^{-1}.dl, or use of hypoglycemic medication. Dyslipidemia was defined as triglycerides ≥ 150 mg^{-1}.dL, LDL-C ≥ 160 mg^{-1}.dL, total cholesterol ≥ 200 mg^{-1}.dL or HDL-C ≤ 40 mg^{-1}.dL (men) and ≤ 50 mg^{-1}.dL (women), or use of lipid lowering medication. Metabolic syndrome was defined as three or more of the following components: (1) abdominal obesity (waist circumference > 102 cm in men and > 88 cm in women), (2) elevated triglycerides (> 150 mg/dl), (3) reduced HDL cholesterol (< 40 mg/dl in men and < 50 mg/dl in women), (4) elevated blood pressure (> 130/85 mmHg), and (5) elevated fasting glucose (> 110 mg/dl) as well as those with diabetes[19].

ABI and ischemic window—ABI was obtained after 10 minutes of supine rest by measuring the ankle and brachial systolic blood pressure using Doppler technique in the brachial artery and both posterior tibial and dorsalis pedis arteries. The higher of the two arterial pressures from each leg was recorded, and the leg yielding the lower ABI was used for the analyses, as previously described[20]. After completion of a graded treadmill test, ankle and brachial systolic blood pressures were measured at 1, 3, 5, and 7 minutes during supine rest after exercise. The time course of the reduction in ankle systolic blood pressure after treadmill exercise from the resting baseline value was quantified by calculating the area under the curve. Because the ischemic window is a function of both PAD severity and the amount of exercise performed, the ischemic window was normalized per meter walked[21].

Claudication measurements and peak oxygen uptake—Graded treadmill test was used to assess claudication measurements. Patients performed a progressive graded cardiopulmonary treadmill test until maximal claudication pain, as previously described for symptomatic PAD patients[22]. The test started at 2 mph with 0% grade and the workload was increased 2% every 2 minutes until maximal claudication pain was attained. All patients were familiarized with this test protocol by performing the initial screening treadmill test to determine study eligibility. The claudication onset time was defined as the walking time in which the patient first experienced pain in the legs, and the peak walking time was defined as the walking time in which the patients could not continue walking due the pain in the legs. Oxygen uptake (VO_2) was continuously measured by a metabolic cart (Medical Graphics Corp., St Paul, MN), and averages of 30 s were applied for analysis. VO_2 peak was defined as the 30 s window with the highest VO_2 achieved during the test. Using these procedures, the test-retest intra-class reliability coefficients are r=0.89 for claudication onset time, r=0.93 for peak walking time and r=0.88 for peak oxygen uptake[23].

Submaximal Walking Economy Test—Oxygen uptake was measured during a constant, submaximal work rate at a treadmill speed of 2 mph and a grade of 0% until maximal claudication pain, or for a maximum of 20 minutes at baseline[24]. Walking economy was measured as oxygen uptake during the final minute of exercise. Walking economy is clinically important because it indicates the efficiency in which walking occurs during a given work load.

Statistical analysis

All statistical analyses were performed using Statistical Package for the Social Sciences software – SPSS/PASW version 20 (IBM Corp, New York, USA). Continuous variables were summarized as mean and standard deviation, whereas categorical variables were summarized as relative frequency. Patients were grouped into tertiles according to total sedentary time (low 840 to 1127 min/d; moderate 1128 to 1224 min/d, and; high=1225 to 1425 min/d) and the clinical characteristics between the three groups were compared using a one-way analysis of variance followed by *post-hoc* Tukey test for continuous variables and chi-square test for categorical variables.

Multiple linear regression analysis was conducted to identify whether demographic data, cardiovascular risk factors, comorbid conditions, peak oxygen uptake and severity of PAD (ABI, ischemic window, claudication onset time and peak walking time) are factors associated with sedentary time. Stepwise backward techniques were used to enter all covariates into the linear models, with the criteria for remaining in the final model being $p<.05$. A residual analysis was performed, homoscedasticity was analyzed by graphical analysis (scatterplot), and adherence to the normal distribution was tested using the Kolmogorov–Smirnov test. Multicollinearity analysis was performed assuming tolerance below 0.20

RESULTS

The total of 440 patients were evaluated for the study, and a total of 143 patients were excluded (110 screen failures and 33 who were non-compliant with testing). Average age was 65 years. Although we did not record information about employment status, very few were working as most were either retired. Thus, the final analysis consists of data from 297 patients. Table 1 shows the clinical characteristics of patients.

Table 2 shows comparison of the clinical characteristics of patients by tertiles of sedentary time. Patients with high sedentary time presented higher prevalence of obesity and lower peak walking time, peak oxygen uptake, and walking economy compared to patients with low and moderate sedentary time ($P<0.05$). Patients with high sedentary time have higher body mass index, and higher prevalence of diabetes mellitus and metabolic syndrome compared to patients with low sedentary time ($P<0.05$). Using multiple regression procedures (Table 3), the predictors of sedentary time were male sex, body mass index, peak walking time and walking economy ($p<0.05$ for all).

DISCUSSION

The main findings of the present study were that low peak walking time, low walking economy, high body mass index and male sex were associated with high sedentary behavior in symptomatic PAD patients. In this study, the mean duration of time spent in sedentary behavior was 1165 min/day (included non-wearing periods) which was higher in comparison with type 2 diabetes patients (600 min/day)[25] and older adults (788 min/day)[26]. Although the methods were different from our study, these results suggest that leg pain during walking may be one reason for greater time spent in sedentary behavior by PAD patients than by other populations without PAD. In fact, a previous study showed that the most prevalent personal barriers to physical activity were those related to claudication symptoms, such as pain induced by walking and needing to rest because of pain during walking[27].

In the present study we found a negative association between time spent in sedentary behavior and peak walking time. These results are not surprising since previous studies showed that patients with low functional capacity present reduction in muscle strength[5], impairments in vascular reactivity,[28] lowest amount of calf area of muscle fiber[29], which could contribute to lower walking capacity and more sedentary behavior. Moreover, McDermott et al[8] observed that self-reported sitting hours were positively associated with faster decline in 6-min walk. On the other hand, there was no significant association with the claudication onset time with sedentary time. We speculate that as most of patients are accustomed to feel pain during walking, the quick onset of symptoms is not enough to encourage sedentary time, as patients are still able to walk and perform their daily activities.

Furthermore, sedentary time was negatively associated with walking economy, defined as the oxygen uptake during ambulation. Walking economy is a key aspect in sustaining ambulatory activities since it represents the metabolic cost of exercise. Less economical walking, measured by higher oxygen uptake at a constant work rate, indicates that exercise is performed at a higher percentage of exercise capacity, thereby reducing the walking tolerance[24]. The negative association between sedentary time and walking economy indicates that patients with greater sedentary time consume less oxygen to perform a given, standardized walking task than patients with lower sedentary time. Instead of interpreting that sedentary time is related to better cardiorespiratory fitness, a more reasonable explanation may be that the lower walking economy in patients with greater sedentary time reflects a greater reliance on anaerobic metabolism and less reliance on aerobic metabolism. Similar results were found in PAD patients with diabetes, in which it was observed that they had lower walking economy than non-diabetics[30]. Thus, greater sedentary time may lead to greater recruitment of fast-twitch motor units, thereby slowing the increase in oxygen uptake during exercise[31, 32].

Based on studies conducted in different population without PAD[10, 33] the bulk of the literature supports an association between higher body mass index and time spent in sedentary behavior. Association between obesity measures and sedentary time may relate to reduced energy expenditure due to increased activities with energy expenditures ≤ 1.5 METs. Moreover, long period of sedentary time is associated with decreased lipoprotein lipase activity[34] (associated with increases in plasma triglycerides and decreases in HDL-cholesterol), which are associated among other diseases with obesity[35].

Sedentary behavior was also associated with sex, wherein PAD men had more time in sedentary behavior in comparison with PAD women. Previous studies in subjects without PAD have demonstrated similar results although it is not a universal finding[10, 33]. Garcia el al.[36] found that an association between sex and sedentary behaviors depends on the specific behavior, as men spend more time watching TV and using cars, while women spend more time at work and doing housework.

This study has potential practical applications. The identification of those men with symptomatic PAD, who are obese and with low cardiovascular fitness are particularly prone to lead a long period in sedentary behaviors. This information is clinically relevant to exercise professionals or surgeons who rehabilitate patients with intermittent claudication because it identifies patients who need more attention with interventions designed to reduce time spent in sedentary activities. Thus, in addition to stimulate increases in physical activity levels, it is also important to recommend breaks in the sedentary behavior, as it have been associated with lower functional impairment[37].

The large patient number is an aspect that strengthens the study. In addition, this was the first study to analyze the relationship between objective measures of sedentary behavior and clinical predictors in patients with symptomatic PAD. On the other hand, this study has limitations that should be considered. The cross-sectional design of this study is a limitation, as no causality can be inferred. Patients with severe cardiac disease and patients with asymptomatic PAD (Rutherford Grade 1, Category 0) or more severe PAD than claudication (Rutherford Grade II, III, and IV) were excluded in the screening; therefore, the results of this study can only be generalized to our current sample of patients. The use of the step activity monitor to assess sedentary behavior does not quantify activity spent in aquatic physical activities or those made with arms, and the step activity monitor cannot distinguish between body positions of the patients spent during non-ambulatory time, such as standing, sitting, or laying supine. Furthermore, and no activity log book was used, and we did not measure social and psychological factors that might be associated with sedentary behavior. Finally, cut-off points for sedentary time using the StepWatch have not been established; therefore, we chose to perform analyses using the tertiles arbitrarily.

In conclusion, the predictors of sedentary time were low peak walking time and impaired walking economy, higher body mass index and male sex. However, in general the relationships found were weak, suggesting that these variables do not fully explain the sedentary behavior in these patients. Longitudinal studies are warranted to understand the underlying mechanisms responsible for the associations observed in the current study. In addition, clinical trials studies are needed to test interventions that can reduce sedentary behavior in PAD patients.

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WHAT THIS PAPER ADDS

Time spent in sedentary behavior has been associated with cardio-metabolic risk factors in patients with symptomatic peripheral artery disease. However, until now remains unknown the factors associated with sedentary behavior in these patients. We used objective measures of time spent in sedentary behavior and we found that men, and patients with higher body mass index, lower peak walking time, and lower walking economy had greater time spent in sedentary behavior.

Table 1

Characteristics of the patients with intermittent claudication (n=297).

Variables	Values
Mean ± Standard deviation	
Age, years old	65 ± 10
Body mass index, $kg^{-1}.m^{2}$	29.4 ± 6.1
Ankle brachial index	0.71 ± 0.23
Claudication onset time, seconds	215 ± 182
Peak walking time, seconds	421 ± 280
Ischemic window, $mmHg^{-1}min{\cdot}m^{-1}$	−0.58 ± 1.04
Walking economy, $ml.kg^{-1}.min^{-1}$	10.3 ± 2.3
Peak oxygen uptake, $ml.kg^{-1}.min^{-1}$	12.4 ± 3.5
Frequency	
Revascularization, % yes	42
Sex, % male	50
Obesity, % yes	44
Abdominal obesity, % yes	54
Diabetes mellitus, % yes	43
Hypertension, % yes	87
Dyslipidemia, % yes	89
Metabolic syndrome, % yes	80
Coronary artery disease, % yes	35
Osteoarthritis, % yes	59
Cerebrovascular diseases, %yes	15

Table 2

Characteristics of the patients with intermittent claudication separated into tertiles of sedentary time.

	Low (840 to 1127 $min^{-1}day$)	Moderate (1128 to 1224 $min^{-1}day$)	High (1225 to 1425 $min^{-1}day$)	p
Age, years old	65 ± 10	65 ± 11	66 ± 9	0.666
Body mass index, $kg^{-1}.m^2$	29.5 ± 5.3 *	29.2 ± 5.9	30.9 ± 6.9	0.025
Ankle brachial index	0.73 ± 0.21	0.73 ± 0.22	0.69 ± 0.26	0.390
Claudication onset time, seconds	218 ± 149	237 ± 210	186 ± 164	0.144
Peak walking time, seconds	464 ± 276 *	457 ± 289 *	337 ± 228	0.002
Ischemic window, $mmHg^{-1}min{\cdot}m^{-1}$	−0.49 ± .82	−0.56 ± 1.40	−0.67 ± .88	0.506
Peak oxygen uptake, $ml.kg^{-1}.min^{-1}$	13.0 ± 3.2 *	13.2 ± 4.0 *	11.1 ± 2.9	<0.001
Walking economy, $ml.kg^{-1}.min^{-1}$	10.6 ± 2.3 *	10.7 ± 2.3 *	9.6 ± 2.3	0.007
Revascularization, % yes	46	42	37	0.444
Sex, % male	52	55	46	0.509
Obesity, % yes	39 *	39 *	60	0.004
Diabetes mellitus, % yes	34 *	41	52	0.015
Hypertension, % yes	83	91	89	0.188
Dyslipidemia, % yes	86	90	91	0.247
Metabolic syndrome, % yes	73 *	82	86	0.030
Coronary artery disease, % yes	27	39	36	0.196
Osteoarthritis, % yes	63	57	57	0.339
Cerebrovascular diseases, %yes	15	11	18	0.515

* Significant difference from high sedentary time group (P<0.05).

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Table 3

Multiple regression models predicting sedentary time in patients with intermittent claudication.

Dependent variable	Independent variables	β (95%CI)	b	R^2	p
Sedentary time, $min^{-1}day$[a]	Sex, women=0; men=1	42.2 (15.6 to 68.9)	0.217	0.180	<0.001
	Body mass index, $kg^{-1}.m^2$	2.5 (0.46 to 4.51)	0.154	0.059	0.013
	Peak walking time, seconds	−0.90 (−0.14 to −0.04)	−0.360	0.066	<0.001
	Walking economy, $ml.kg^{-1}.min^{-1}$	−8.8 (−14.4 to 3.1)	−0.187	0.142	0.004

β (95%CI) – Regression coefficient (95% confidence interval); b – standardized coefficients.

[a] $F=8.38$; $p=<0.001$; $r=.35$; $r^2=0.12$; SEE=96.9 $min^{-1}day$.