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Clinical Research

Cardiovascular Responses during and after Maximal Walking in Men and Women with Symptomatic Peripheral Artery Disease

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Background: Walking is recommended for patients with peripheral arterial disease (PAD). It has been shown that patients with PAD present sharper increases in blood pressure (BP) and heart rate (HR) during maximal walking when compared with healthy subjects and women with PAD present a worse physiological profile, and is possible that women with PAD present higher cardiovascular load during and after a bout of maximal walking than men. The objective of this study was to compare cardiovascular and autonomic responses during and after maximal walking between men and women with PAD and intermittent claudication (IC).

Methods: Forty patients with PAD and IC (20 men and 20 women) underwent, in random order, 2 sessions: control (standing on treadmill) and exercise (maximal treadmill walking test with Gardner's protocol). During the exercise, HR and BP were measured. Before and after the sessions, cardiovascular variables (BP, HR, cardiac output, peripheral vascular resistance, and stroke volume) and autonomic modulation (HR and BP variabilities and baroreflex sensitivity) were assessed. In addition, an ambulatory BP monitoring was recorded after each session.

Results: Men and women presented similar maximal walking capacity. During the walking test, HR and systolic BP increased similarly in men and women. After the maximal walking, cardiovascular and autonomic responses did not differ between the genders. In addition, postintervention ambulatory BP parameters were also similar in men and women. Therefore, in men and women, maximal walking similarly reduced clinic systolic BP and stroke volume, and increased HR and total power of HR variability during the recovery period.

Conclusions: Men and women with PAD and IC present similar cardiovascular and autonomic responses during and after maximal walking.

INTRODUCTION

Peripheral arterial disease (PAD) affects more than 230 million people worldwide.¹ Its prevalence increases with age,^{2,3} being similar or greater in women than men at the advanced ages.⁴ This disease is mainly characterized by an atherosclerotic obstruction of the lower limb arteries, decreasing blood flow, and producing ischemia during walking.⁵ The main symptom of PAD is intermittent claudication (IC) defined as pain, cramps, or tingling that occurs in the legs during walking and relieves with a short period of rest.^{2,5}

Patients with PAD and IC present low walking capacity and poor quality of life.⁶ In addition, they

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Ann Vasc Surg 2020; ■: 1–9

<https://doi.org/10.1016/j.avsg.2020.07.051>

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Manuscript received: January 6, 2020; manuscript accepted: July 25, 2020; published online: ■ ■ ■

have impairments on cardiovascular function and autonomic modulation^{7,8}; which explain in part their high cardiovascular risk. Actually, coronary and cerebrovascular diseases are common in these patients, and their risk for cardiovascular death is even greater than in patients with other cardiovascular diseases.⁹ Therefore, the management of patients with PAD aims to increase functional capacity and decrease cardiovascular risk.²

Walking is recommended as the initial and preferential treatment for patients with PAD and IC because it increases walking capacity,¹⁰ improves cardiovascular function,¹¹ and reduces cardiovascular mortality.¹² Walking until maximal claudication pain is used in this population,^{13,14} but during the execution of each maximal walking, cardiovascular load increases. It has been shown that patients with PAD present sharper increases in blood pressure (BP) and heart rate (HR) during maximal walking when compared with healthy subjects.⁸ In addition, different from other populations, in these patients, BP remains elevated¹⁵ for more than 30 min after a maximal walking bout. These responses may increase the risk for acute cardiovascular events during and after exercise in this population.

It is important to highlight, however, that these acute responses to a bout of maximal walking have mainly been investigated in men. Few studies have evaluated the effects of PAD in women, and the current knowledge suggests they present more severe microvascular deficit and lower hemoglobin concentration and oxygen saturation than men,^{16,17} leading to a worse walking capacity.^{17,18} Thus, because of this worse physiological profile, it is possible to hypothesize that women with PAD and IC present higher cardiovascular load during and after a bout of maximal walking than men, which should be checked because this response may reflect a possible higher acute cardiovascular risk during and after exercise.

Therefore, the objective of this study was to compare cardiovascular responses during and after a maximal treadmill test in men and women with PAD and IC.

MATERIALS AND METHODS

The study was approved by the ethics committee of the School of Physical Education and Sport of the University of São Paulo, Brazil (CEP/5216/EEFE/30082016). A written informed consent was obtained from all patients before the study enrollment.

Men and women with PAD and IC were recruited from the Intermittent Claudication Clinic of the

Hospital das Clínicas of the University of São Paulo. Patients were included if they met the following criteria: (i) age ≥ 50 years; (ii) ankle-brachial index (ABI) ≤ 0.9 in at least in one of the lower limbs; (iii) presence of IC; and (iv) being at the stage II of the Fontaine classification. Exclusion criteria included: (i) having systolic (SBP) or diastolic (DBP) BPs greater than 160 and 105 mm Hg, respectively; (ii) incapacity to walk on a treadmill for at least 2 min at 3.2 km/h; (iii) presence of ischemia or complex arrhythmias during a maximal walking test; (iv) interruption of a maximal walking test for reasons other than pain in the affected limb; (v) reduction in ABI after a maximal walking test $<10\%$; (vi) having a musculoskeletal disorder that prevents exercise; (vii) current participation in any regular exercise program; (viii) taking beta-blockers, nondihydropyridine calcium channel inhibitors, insulin, or hormone therapy; and (ix) being a diabetic with uncontrolled blood glucose, diabetic complications, or clinical autonomic dysfunction. Compliance with study criteria was checked by preliminary evaluations.

Preliminary Evaluations

All patients were evaluated by a physician, who surveyed personal characteristics, health history, physical activity behavior and medication, and also performed clinical and orthopedic evaluations. Presence of IC was assessed using the San Diego Claudication Questionnaire,¹⁹ and the disease stage was determined based on Fontaine's classification.²⁰ Body mass and height (Welmy, 110, São Paulo, Brazil) were assessed, and body mass index was calculated. BP was measured in triplicate in 2 visits to the laboratory after 5 min of seated rest, using the auscultatory method and a mercury column sphygmomanometer (Unitec, São Paulo, Brazil).²¹ For ABI assessment, SBP was simultaneously measured at the arms and ankles with the patient at the supine position. Arm SBP was measured with a mercury sphygmomanometer (Unitec, São Paulo, Brazil) and ankle SBP with a Doppler (DV 6000; Martec, Ribeirão Preto, Brazil). ABI of each side of the body was calculated dividing each ankle SBP by the highest arm SBP.²

In addition, all patients underwent a maximal walking test preceded by a resting electrocardiogram (ECG—CardioPerfect, Ultima; Welch Allyn, Inc., Skaneateles Falls, NY). The test was performed on a treadmill (Imbrasport ATL, Porto Alegre, Brazil) with a specific protocol for PAD characterized by a fixed speed of 3.2 km/h and a 2% increment in grade every 2 min.²² During the test, HR was

Fig. 1. Experimental session. AU, autonomic evaluation; CV, cardiovascular evaluation.

continuously monitored by ECG and auscultatory BP was measured every 2 min. ABI was assessed before and immediately after the test.

Experimental Protocol

After the preliminary evaluation, all patients who met the study criteria participated in 2 experimental sessions: exercise and control. These sessions were conducted in random order (<https://www.randomizer.org/>), and with an interval of at least 2 days between them. They were held between 7 and 12 AM in a temperature-controlled laboratory (20–23°C). Patients were instructed to have a light meal at least 2 hr before the sessions, and to take their medications as prescribed. In addition, they were instructed not to drink caffeine-containing beverages on the day of the sessions, and not to exercise vigorously or drink alcoholic beverages in the previous 24 hr. Finally, smokers were asked not to smoke in the morning before the sessions.

In each session, measurements were taken before, during, and after the intervention as shown in Figure 1. In the exercise session, the intervention was a maximal walking test using the same protocol as in the preliminary evaluation. In the control session, the patients rested standing on the treadmill for the duration of the maximal test performed in the preliminary evaluation.

Measurements

During the intervention period of the exercise session, claudication onset distance (COD) was assessed as the distance walked until the patients first reported pain in the leg, and total walking distance (TWD) was assessed as the total distance walked during the test. In addition, auscultatory BP was measured (Unitec, São Paulo, Brazil) every 2 min, and HR was continuously assessed by ECG

and registered every minute (Welch Allyn, Cardio-Perfect PC-based ECG, NY). For analyses, maximal HR and SBP increases were calculated by the difference between peak and preexercise values.

In the preintervention and postintervention periods, cardiovascular function was evaluated. For that, HR was measured by 15s-pulse palpation, auscultatory BP was assessed with a mercury column sphygmomanometer (Unitec, São Paulo, Brazil), and CO was measured by the dioxide carbon (CO₂) rebreathing technique using a gas analyzer (Medical Graphics Corporation, Ultima, MN) as previously reported.²³ These variables were measured in triplicate in the preintervention and postintervention periods, and the mean value was calculated for each period. Peripheral vascular resistance (PVR) was calculated by the quotient between mean arterial pressure [$MAP = (SBP - DBP)/3 + DBP$] and CO, and stroke volume (SV) was calculated by the quotient between CO and HR.

For cardiac autonomic modulation assessment in the preintervention and postintervention periods, HR was continuously monitored by ECG (EMG SYSTEM, 030110/00B, São Paulo, Brazil), beat-to-beat BP by finger photoplethysmography (FINAPRESS MEDICAL SYSTEM, Finometer Pro, Amsterdam, the Netherlands) and respiratory movements by a piezoelectric chest belt (UFI, Pneumotrace, CA). These signals were amplified, digitized, and recorded by a biological converting system (AKRON, Windaq DI-720, OH) with a sampling frequency of 500 Hz/channel. Afterward, spectral analyses of HR and BP variabilities were performed at stationary periods of 300 beats using the autoregressive model and following the Task Force recommendations.²⁴ For analyses, total variance (TV) was calculated for the whole chosen period, and low (LF—0.04 to 0.15 Hz) and high (HF—0.15 to 0.4 Hz) frequency components of the spectrum

were calculated in absolute and normalized units. For data interpretation, normalized HF_{R-R} was considered as representative of cardiac parasympathetic modulation, normalized LF_{R-R} as mainly due to cardiac sympathetic modulation, the ratio between these components (LF/HF) as the cardiac sympathovagal balance. The absolute value of LF_{SBP} was considered as the sympathetic vasomotor modulation. Finally, spontaneously baroreflex sensitivity was evaluated by the maximum value of the transfer function between R-R interval and SBP variabilities at LF.

Finally, after the postintervention period of the experimental sessions, an ambulatory blood pressure monitoring (ABPM) was performed using an oscillometric device (SPACELABS 90207, Inc. Redmond, WA, USA) programmed to take measurements every 15 min for 24 hr. Subjects were instructed to record their activities' time (lunch, dinner, medication, and sleep) and were asked to maintain similar activities and times after the 2 experimental sessions (control and exercise).

Statistical Analysis

Based on published data regarding the agreements indices of SBP responses after exercise and control session (i.e., typical error = 4.6) and considering a smallest worthwhile effect of 4 mm Hg, the minimal sample size in each group was calculated to be 11 subjects.²⁵ A greater number of subjects were studied considering the secondary outcomes.

Normality and homogeneity of data were, respectively, verified by Shapiro-Wilk and Levene tests. Comparisons regarding sample characteristics were performed using chi-square test for the categorical variables and *t*-tests for continuous variables.

Responses during maximal walking considered only the exercise session. Cardiovascular responses were calculated by the difference between maximal workload and pre-exercise values (Δ peak). Comparisons between genders were performed by *t*-tests.

Responses after maximal walking were analyzed by mixed 2- (ABPM) or 3- (other variables) factors ANOVAs, establishing gender (women and men) as the between main factor, and session (control and exercise) and period (before and after intervention) as the within main factors. Newman-Keuls post-hoc test was used when necessary. In addition, the net effects of exercise [net effect for MAPA = postexercise – postcontrol values; and the net effect for the other variables = (postexercise – pre-exercise) – (postcontrol – precontrol)] were calculated for each gender and compared by *t*-tests.

Analyses were performed using Statistica for Windows, version 10.0 (Statsoft, Palo Alto, CA). $P < 0.05$ was considered as significant, and data are presented as mean $\pm$ standard error (SE).

RESULTS

Forty-eight patients accepted to participate in the study, but 8 were excluded during the preliminary examinations for not fulfilling the study criteria (4 due to personal reasons, 3 due to not presenting pain during walking, and 1 due to the use of a pacemaker). Thus, 40 patients (20 men and 20 women) completed the experimental protocol. The groups presented similar physical and clinical characteristics (all $P > 0.05$ in the chi-square and *t*-tests, Table I).

Responses during Exercise

No significant difference was observed between the genders for responses during the exercise (all $P > 0.05$ in *t*-tests). Thus, walking capacity was similar in men and women (COD = 306 ± 47 vs. 276 ± 52 m, $P = 0.669$, and TWD = 650 ± 65 vs. 597 ± 75 m, $P = 0.596$, respectively). In accordance, peak HR and SBP increases during the maximal walking also did not differ between the genders ($+46 \pm 4$ vs. $+49 \pm 5$ bpm, $P = 0.577$, and $+56 \pm 4$ vs. $+49 \pm 5$ mm Hg, $P = 0.329$ in men and women, respectively) (Fig. 2).

Responses after Exercise

For postexercise analyses, one woman refused to participate of the control session, decreasing the sample to 19 women. In addition, some data of specific variables were not possible to analyze. Thus, the actual number of subjects in each analysis is presented in Table II.

Cardiovascular and autonomic responses after the maximal walking did not differ between the genders for neither of the variables (no significant group interaction for all variables in the 3-way ANOVAs, all $P > 0.05$). Thus, regardless of the group (men or women), comparisons between preintervention and postintervention values showed that (1) SBP decreased significantly in the exercise and increased in the control session (combined gender's values—exercise: 130 ± 2 vs. 128 ± 3 mm Hg and control: 132 ± 3 vs. 134 ± 3 mm Hg, $P_{\text{session} \times \text{period}} = 0.002$); (2) DBP increased slightly but significantly and similarly in both sessions (combined gender's values: 77 ± 1 vs. 78 ± 1 mm Hg, $P_{\text{period}} = 0.008$); (3) PVR increased while CO

Table I. Characteristics of the men and women with peripheral artery disease and intermittent claudication

	Men (<i>n</i> = 20)	Women (<i>n</i> = 20)	<i>P</i>
Age (years)	67.3 ± 1.7	65.4 ± 1.8	0.45
Body mass index (kg/m ²)	25.6 ± 0.7	28.2 ± 1.5	0.12
ABI (most affected leg)	0.55 ± 0.03	0.56 ± 0.02	0.72
SBP (mm Hg)	128 ± 4	129 ± 3	0.83
DBP (mm Hg)	75 ± 2	76 ± 2	0.82
HR (bpm)	71 ± 3	70 ± 2	0.75
Prevalence of comorbidities			
Obesity (%)	10	25	0.21
Current or former smoking (%)	100	100	1.00
Hypertension (%)	80	80	1.00
Diabetes mellitus (%)	30.0	25	0.72
Dyslipidemia (%)	95	90	0.55
Coronary disease or stroke (%)	5	15	0.29
Frequency of medication			
Acetylsalicylic acid (%)	85	80	0.63
Statins (%)	95	90	0.55
Antihypertensive (%)	80	80	1.00
Oral Hypoglycemic (%)	30	25	0.72

Data = mean ± SE or %. Comparisons were performed by chi-square test for categorical variables and by *t*-tests for continuous variables.

BMI, body mass index.

Fig. 2. Claudication onset distance (COD), total walking distance (TWD), peak increase in heart rate (Δ peak HR) and in systolic blood pressure (Δ peak SBP) measured in the men and women with peripheral artery disease and

intermittent claudication. Data = mean ± SE. Comparisons were performed by *t*-tests. *P* > 0.05 for all comparisons.

Table II. Values of cardiovascular and autonomic variables assessed before and after intervention in the exercise and control sessions in the men, women, and combined group (men + women) with peripheral artery disease and intermittent claudication

	Men				Women				Combined groups (men + women)			
	Exercise		Control		Exercise		Control		Exercise		Control	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
SBP (mm Hg) ^a	129 ± 4	125 ± 4	132 ± 4	133 ± 4	131 ± 3	131 ± 4	132 ± 4	135 ± 4	130 ± 2	128 ± 3 ^{c,f}	132 ± 3	134 ± 3 ^c
DBP (mm Hg) ^a	76 ± 2	76 ± 2	77 ± 2	77 ± 1	76 ± 2	78 ± 2	77 ± 2	79 ± 2	76 ± 1	77 ± 1 ^c	77 ± 1	78 ± 1 ^c
CO (L/min) ^b	3.8 ± 0.2	3.4 ± 0.2	3.8 ± 0.1	3.5 ± 0.1	3.5 ± 0.2	3.2 ± 0.2	3.5 ± 0.2	3.3 ± 0.2	3.6 ± 0.1	3.3 ± 0.1 ^c	3.7 ± 0.1	3.4 ± 0.1 ^c
PVR (U) ^b	25.9 ± 1.3	28.4 ± 1.3	25.8 ± 1.1	27.8 ± 1.2	29.8 ± 2.5	32.7 ± 2.4	29.0 ± 2.1	32.4 ± 2.7	27.8 ± 1.4	30.4 ± 1.3 ^c	27.4 ± 1.2	30.0 ± 1.5 ^c
SV (mL) ^b	55.3 ± 2.4	48.3 ± 2.0	56.2 ± 1.9	54.3 ± 2.3	50.0 ± 4.0	43.7 ± 3.1	52.4 ± 4.0	48.9 ± 3.7	52.8 ± 2.2	46.1 ± 1.8 ^{c,f}	54.4 ± 2.0	51.8 ± 2.0
HR (bpm) ^a	70 ± 3	70 ± 3	68 ± 3	66 ± 3	68 ± 2	73 ± 3	67 ± 2	67 ± 2	69 ± 2	71 ± 2 ^{c,f}	68 ± 2	66 ± 2 ^c
TV _{R-R} (ms ²) ^c	908 ± 320	1,202 ± 326	1,275 ± 338	3,183 ± 784	1,647 ± 336	1,916 ± 318	2,484 ± 484	3,274 ± 659	1,277 ± 237	1,559 ± 233 ^f	1,879 ± 310	3,228 ± 504 ^c
LF _{R-R} (un) ^c	52 ± 4	50 ± 4	43 ± 5	41 ± 4	43 ± 5	49 ± 4	40 ± 4	43 ± 6	47 ± 3	50 ± 2	42 ± 3	42 ± 3
HF _{R-R} (un) ^c	41 ± 4	41 ± 3	45 ± 4	46 ± 3	48 ± 4	45 ± 5	45 ± 5	47 ± 5	44 ± 2	42 ± 2	45 ± 3	47 ± 3
LF/HF _{R-R} ^c	1.6 ± 0.3	1.4 ± 0.2	1.3 ± 0.3	1.0 ± 0.2	1.1 ± 0.2	1.4 ± 0.3	1.3 ± 0.3	1.4 ± 0.3	1.3 ± 0.2	1.4 ± 0.2	1.3 ± 0.2	1.2 ± 0.2
LF _{SBP} (mm Hg ²) ^d	44 ± 8	36 ± 7	29 ± 7	37 ± 6	37 ± 6	46 ± 6	39 ± 6	43 ± 6	40 ± 5	41 ± 4	34 ± 5	40 ± 4
BRS (ms/mm Hg) ^d	3.7 ± 0.4	6.1 ± 1.1	6.9 ± 1.0	8.4 ± 1.3	6.0 ± 1.0	6.0 ± 0.9	7.1 ± 1.3	6.7 ± 1.1	4.8 ± 0.6	6.1 ± 0.7	7.0 ± 0.8	7.5 ± 0.8

Data = mean ± SE. Analyses were performed by 3-way ANOVAs (group × session × period). In accordance with the absence of interaction with group for all variables, significances are only shown for the combined group.

CO, cardiac output; LF/HF, sympathovagal balance; BRS, baroreflex sensibility; SBP, systolic blood pressure.

^a20 men and 19 women.

^b20 men and 18 women.

^c16 men and 16 women.

^d15 men and 16 women.

^eSignificantly different from pre-intervention in the same session ($P < 0.05$).

^fSignificantly different from the control session in the same period ($P < 0.05$).

Table III. Ambulatory blood pressure measured after the exercise and control sessions in men and women with peripheral artery disease

	Men (<i>n</i> = 17)		Women (<i>n</i> = 16)		Combined (Men + Women)	
	Exercise	Control	Exercise	Control	Exercise	Control
24 hr						
SBP (mm Hg)	125 ± 4	128 ± 3	120 ± 3	119 ± 3	122 ± 2	123 ± 2
DBP (mm Hg)	71 ± 2 ^a	72 ± 2 ^a	65 ± 2	66 ± 2	68 ± 1	69 ± 1
HR (bpm)	73 ± 3	72 ± 3	71 ± 3	72 ± 3	72 ± 2	72 ± 2
Awake						
SBP (mm Hg)	128 ± 4	130 ± 3	122 ± 3	121 ± 3	125 ± 2	126 ± 2
DBP (mm Hg)	74 ± 2 ^a	75 ± 2 ^a	68 ± 2	68 ± 2	71 ± 1	72 ± 1
HR (bpm)	76 ± 3	74 ± 3	74 ± 3	74 ± 3	75 ± 2	74 ± 2
Asleep						
SBP (mm Hg)	121 ± 4	122 ± 4	116 ± 4	115 ± 4	118 ± 3	118 ± 3
DBP (mm Hg)	68 ± 2 ^a	67 ± 2 ^a	60 ± 2	60 ± 2	64 ± 2	64 ± 2
HR (bpm)	68 ± 3	68 ± 3	67 ± 3	67 ± 3	67 ± 2	67 ± 2

Data = mean ± SE. Analyses were performed by 2-way ANOVAs (group × session).

^aSignificantly different from women (*P* < 0.05).

decreased significantly and similarly in both sessions (combined gender and session's values: PVR = 27.5 ± 1.3 vs. 30.2 ± 1.3 U, *P*_{period} = 0.000 and CO = 3.6 ± 140 vs. 3.4 ± 1.3 L/min, *P*_{period} = 0.000); (4) HR did not change, while SV decreased significantly in the exercise session, while HR decreased and SV did not change in the control session (combined gender's values—exercise: 52.8 ± 2.2 vs. 46.1 ± 1.8 mL and control: 54.4 ± 2.1 vs. 51.7 ± 2.1 mL, *P*_{session × period} = 0.043; and exercise: 69 ± 6 vs. 71 ± 6 bpm and control: 68 ± 5 vs. 67 ± 4 bpm, *P*_{session × period} = 0.005); (5) TV_{R-R} increased significantly in the control session and did not change in the exercise session (combined genders values: exercise: 1,277 ± 238 vs. 1,559 ± 233 ms² and control: 1,879 ± 310 vs. 3,228 ± 503 ms², *P*_{session × period} = 0.000); and (6) all the other autonomic variables did not change in neither session.

ABPM could not be analyzed because of technical problems in some subjects. Thus, ABPM data were available for 17 men and 16 women DBP (Table III). There was no significant interaction of group and session for any variable of the ABPM in the 2-way ANOVAs (group versus session). However, a significant group effect was detected for 24-h, awake and asleep DBP, showing that these BPs were significantly higher in men than women regardless of the session.

Postexercise Net Effects

For all variables, the net effect of exercise in each gender was calculated. Statistical analysis showed

no significant difference between men and women (Fig. 3).

DISCUSSION

The main finding of the present study was that, differently from the hypothesis, men and women with PAD and IC presented similar HR and BP increases during the maximal walking test, and also showed similar BP and TV_{R-R} decrease as well as similar HR increase after the maximal walking.

In the present study, there was no difference in walking capacity (assessed either by COD or TWD) between the genders. This result differs from some previous studies^{16,18,26} that reported lower walking capacity in women than men with PAD and IC using the same exercise protocol (Gardner's test). The rigorous participation criteria of the present study assured a good matching process and guaranteed similarity between the genders in the baseline physical and clinical characteristics (Table I). Indeed, this similarity was essential to assure that any difference observed during or after exercise could effectively be attributed to the participants' gender and not to the baseline differences. However, the previous studies have mainly matched the groups based on age and ABI, although it is known that differences in obesity levels, physical activity level, comorbidities presence, and others may affect walking capacity in PAD.²⁷

Concerning analyses during exercise, men and women also presented similar cardiovascular responses. HR and SBP increased progressively as

Fig. 3. Comparison of the net effect of exercise (Δ net) calculated for each variable in the men and women with peripheral artery disease and intermittent

claudication. Data = mean $\pm$ SE. Comparisons were performed by *t*-tests. $P > 0.05$ for all comparisons. CO, cardiac output; BRS, baroreflex sensitivity.

expected, achieving adequate values for this population.²² Previous studies with healthy subjects have already shown no difference in cardiovascular responses to maximal exercise in elderly men and women who have similar peak capacities.²⁸ Thus, although different from hypothesis, the similarity in cardiovascular responses during maximal walking between men and women is coherent with the absence of differences in walking capacity.

Also in accordance with the absence of differences in walking capacity and responses during exercise, postexercise cardiovascular and autonomic responses also did not differ between the men and women. Regardless the gender, SBP decreased after the exercise and increased after the control session, whereas DBP increased similarly after both sessions. Thus, previous exercise promoted a net SBP reduction of -3.7 ± 1.1 mm Hg and did not change DBP. This magnitude of postexercise BP reduction is smaller than reported in a previous meta-analysis (about $-15/-4$ mm Hg for SBP/DBP).²⁹ Moreover, this response differs from that obtained

in men with PAD and IC, who showed an increase of $+4 \pm 17$ and $+5 \pm 9$ mm Hg for SBP and DBP, respectively, after a maximal test conducted with the same protocol.¹⁵ A possible explanation for this difference is the recovery body position that was lying in Lima et al.'s study¹⁵ and seated in the present study. The seated position may mitigate venous return, facilitating the reduction of SV and BP.³⁰ Another possible explanation is the fact that the study conducted by Lima et al.¹⁵ included muscle biopsy, and this procedure may generate anxiety, pain, and sympathetic activation, preventing the acute hypotensive effect of previous exercise.

In the whole sample, the significant decrease in SBP after the maximal walking cannot be explained by a decrease in CO or in PVR because these variables changed similarly after both experimental sessions (control and exercise), suggesting a change with time and not a response to previous exercise. Thus, BP decrease may have had a different systemic determinant (CO or PVR) in each patient, as previously reported.³¹ SBP decrease after the maximal

walking was accompanied by a reduction in SV, which may have facilitated the BP reduction. In addition, maximal walking promoted an increase in HR accompanied by a decrease in TV_{R-R} , which is consistent with a decrease in parasympathetic modulation to the heart.³¹ All these hemodynamic and autonomic responses are in accordance with previous findings regarding the systemic and autonomic mechanisms of postexercise hypotension in different populations.³²

Considering the duration of the postexercise BP reduction, in both genders, postintervention 24-hr, awake and asleep BPs did not show any difference between the sessions, showing that postexercise SBP reduction was not sustained under ambulatory conditions. These results are different from those reported in hypertensives,³² but agree with previous studies with patients with PAD and IC.³³ The lack of maintenance of the postexercise hypotensive effect during daily living activities in this population is mainly explained by the fact that when these patients walk during the day, they feel pain in the leg, which increases sympathetic activity⁸ and prevents the reduction of BP.

The results of this study may have important clinical implications. Based on previous background, it has been hypothesized that women with PAD and IC would have lower walking capacity and worse cardiovascular responses during and after a maximal walking; which might imply in higher acute risk and the need to adapt walking prescription for this gender. Differently, the current findings clearly showed no difference in these acute responses to maximal walking between the genders, suggesting no greater risk in women, and thus, no need for special care.

Limitations

This study has some limitations that should be considered. All patients were in the stage II of the disease and presented capacity to walk at 3.2 km/hr. Thus, the findings cannot be extrapolated to patients at other stages or with lower walking capacity. In addition, patients who were taking beta-blockers or nondihydropyridine calcium channel inhibitors were not studied. These medications can decrease HR and BP increases during exercise, but probably their effects were not different between the genders. The study used a maximal walking; however, as walking capacity and increase in cardiovascular responses during exercise did not differ between the genders, it is improbable that results regarding comparison between genders would be different with submaximal walking. Finally, some data were lost

in the analysis of ABPM and cardiovascular autonomic modulation which may have diminished the statistical power of the analyses of these secondary outcomes.

CONCLUSION

Men and women with PAD and IC have similar cardiovascular and autonomic responses during and after walking to maximal claudication pain.

Fundação de Amparo à Pesquisa do Estado de São Paulo (2017/12973-4) and CAPES.

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