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Effectiveness of Leisure Physical Activities in Vasodilatory Response and Blood Pressure in Middle-Aged and Elderly Women

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ABSTRACT

Dantas FFOD, Cabral TGC, Silvestre ACOM, Batista RMF, Santos MSB, Santos, AC. Effectiveness of Leisure Physical Activities in Vasodilatory Response and Blood Pressure in Middle-Aged and Elderly Women. **JEPonline** 2015;18(2):66-77. The purpose of this study was to investigate the effectiveness of leisure physical activities on blood pressure and vasodilatory response in middle-aged women and elderly women. Ten middle-aged women (mean age ± SD, 54.20 ± 3.19) and 8 elderly women (mean age ± SD, 69.25 ± 5.31) were included in this study. Interventions consisted of a 4-month supervised leisure physical activities program. The program consisted of 60-min exercise sessions 3 times·wk^{-1}. Blood pressure and blood flow were evaluated before and after the intervention period via the oscillometric method and plethysmography with venous occlusion, respectively. The elderly group had a significant increase in vascular conductance while at rest (Pre Md = 4.1 Q_{25} – Q_{75} = 3.9 – 4.4 vs. Post Md = 4.8 Q_{25} – Q_{75} = 4.3 – 5.2; $P<0.05$). The findings indicate that leisure physical activities are an effective alternative to commonly recommended programs of promoting cardiovascular benefits, especially for healthy elderly women. In this group, the clinical condition of the vasodilatory response was restored to levels obtained in middle-aged women.

Key Words: Aging, Cardiovascular System, Plethysmography, Vasodilatation

INTRODUCTION

Current literature has shown more detailed information about aging implications on the cardiovascular system and its regulatory mechanisms. It is known that the elderly have an increased vascular resistance and elevated oxidative stress (11) in addition to a higher cardiac sympathetic activity (7). These changes can lead to elevated blood pressure levels and decreased muscle blood flow at rest. Such changes are closely linked to endothelial dysfunction observed in the elderly (18).

The endothelium plays an important role in controlling the vasodilatory response, thus contributing to an adequate peripheral circulation. On the other hand, endothelial dysfunction is characterized as one of the first events in the pathogenesis of cardiovascular diseases (20). Among the nonpharmacologic therapeutic options, numerous studies have confirmed that regular physical exercise improves endothelial function in the elderly (10,31,33,34,37).

Although different types of physical exercise enhance endothelium-dependent vasodilatory function, such as endurance training (31), Tai Chi Chuan (38), and tennis (17), studies investigating the specific effect of leisure physical activities on vasodilatory response in the elderly are scarce. Leisure physical activities are understood as those that stimulate functional ability by freely and pleasurably participating in sport and physical activities (24).

In contrast to leisure physical activities, it is recommended that adults should engage in moderate-intensity exercise for least 30 min on most days of the week to maintain health and prevent chronic illnesses (29). Despite such recommendations, many middle-aged and elderly adults remain inactive and sedentary (14). While there are many reasons for a sedentary lifestyle, according to Justine and colleagues (21), the most common barriers to participation in physical activity and exercise among the middle-aged and elderly adults are: (a) not enough time; (b) no one to exercise with; and (c) lack of facilities.

Lack of exercise is a very serious problem, especially in the elderly population. When compared to middle-aged adults, there are significant impairments in vasodilatory response that indicate a decline in vascular function in older subjects (32). Because leisure physical activities are common place in the elderly population (1,23), it was decided to test the hypothesis that leisure physical activities may in fact improve the vasodilatory response and blood pressure in older adults in a similar way that more aggressive exercise programs do for middle-aged individuals.

Moreover, according to Floras (12), women are clearly underrepresented in the literature for this area. Thus, the purpose of this study was to investigate the effectiveness of a supervised program of leisure physical activities on blood pressure and vasodilatory response in middle-aged and elderly women.

METHODS

Subjects

This study consisted of 10 middle-aged (54.20 ± 3.19) and 8 elderly (69.25 ± 5.31) women. They were enrolled in the leisure and social inclusion program for the elderly (LISTI) at the Federal University of Paraiba (UFPB) – João Pessoa/PB, Brazil. The presence of clinical history of cardiovascular, metabolic, pulmonary diseases, and diabetes was used as exclusion criteria as well as any other factors that might limit the subjects' participation in physical activity. Further, only the subjects with an attendance of at least 85% of the training protocol were analyzed. All subjects in this study were asked to give their informed consent according to the 196/96 resolution of National Health

Council. This study was approved by the Health Sciences Center Ethics Research Committee from UFPB- Campus I, according to the Ethics guidelines for human being research (protocol number 226/11 CEP/CCS/UFPB).

Procedures

This study was characterized as an intervention study (35), in which the subjects in the supervised program were evaluated pre- and post-leisure physical activities.

Prior to proceeding with the evaluations, the subjects were asked not to engage in physical activity the day before taking measurements. They were also asked to maintain their usual dietary habits, with the exception of avoiding beverages such as coffee, chocolate, soda, and alcohol. Moreover, they were asked to go to the bathroom if they felt the urge. Measurements were always conducted in the morning, starting at 8:00 a.m.

On the experimental protocol days, all subjects arrived at the data collection site, remained at rest, and were instructed about the procedures that would be performed. In sequence, each subject was placed in a supine position on a stretcher for acquisition of blood pressure and blood flow data.

Baseline Measurements

Preparations began with the placement of surface electrodes on the subject's chest to capture electrocardiographic signals. Then, the occluder cuff was placed on the subject's left ankle to measure blood pressure. Plethysmography with venous occlusion was carried out on the subject's non-dominant arm, according to the technique described below (i.e., Outcome Measures). Following these measurements, each subject remained at rest for ~15 min before heart rate, blood pressure, and forearm blood flow baseline signals were recorded for 3 min (Figure 1).

Measurements during Moderate Isometric Exercise

After the analysis of the variables at baseline, moderate isometric exercise was conducted to evaluate the magnitude of changes in blood pressure and forearm blood flow during central command activation via mechanoreceptors and peripheral chemoreceptors (30). The subjects performed the maximal voluntary muscle contraction (MVMC) test with a Jamar Hydraulic Hand Dynamometer (Jamar® 5030J1 model), according to the protocol adopted by Coldham et al. (9). Women performed the exercise with their dominant arm at an intensity of 30% of the maximum voluntary contraction test for 3 min during which heart rate, blood pressure, and forearm blood flow were recorded. The subjects were instructed to breath normally to avoid the Valsava maneuver.

Measurements after Occlusion Maneuver

Ten seconds before the end of isometric exercise, blood flow in the dominant arm was occluded with sphygmomanometer that was inflated to a pressure of 200 mmHg for 3 min. At the end of the 3-min period, the subject's measurements were recorded. The purpose was to determine the changes in endothelium-dependent vasodilation in the subject's forearm (reactive hyperemia) during an isolated maneuver of muscle metaboreflex (which is known for increasing the shear stress on the endothelium of the blood vessel) (16).

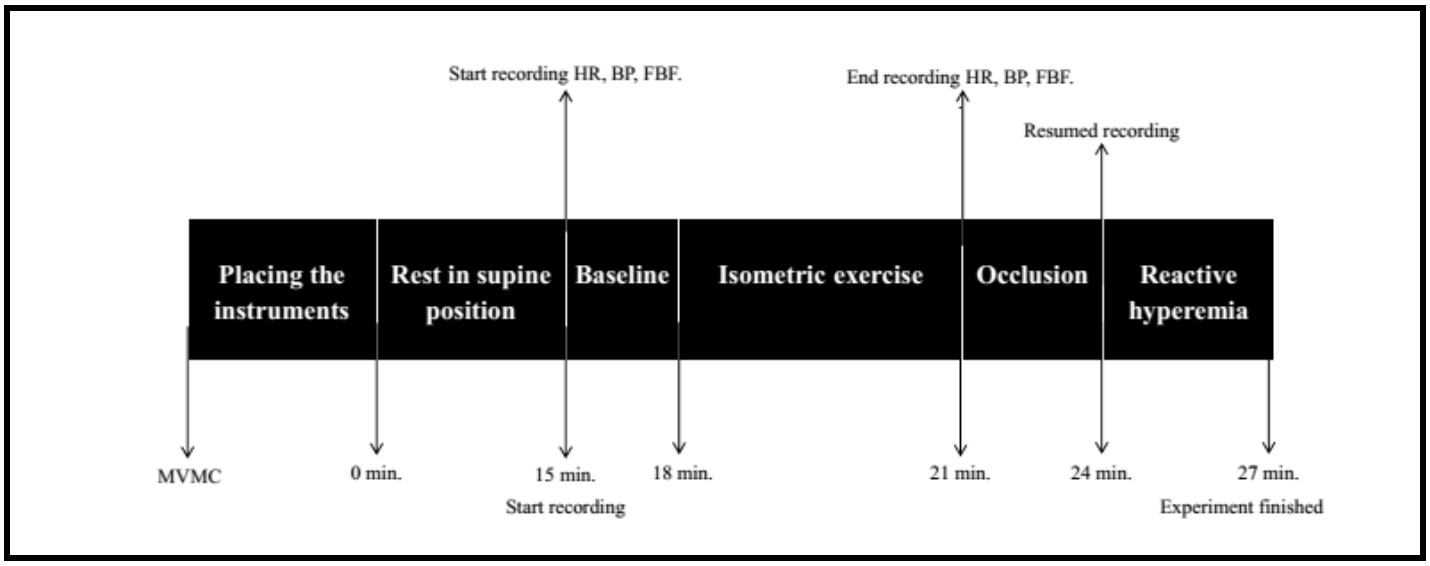


Figure 1. Timeline of the Experimental Protocol. MVMC – Maximal Voluntary Muscle Contraction, HR – Heart Rate, BP – Blood pressure, FBF – Forearm Blood Flow.

Outcome Measures

The main variables investigated were blood pressure and the brachial artery vasodilatory response by the evaluation of blood flow. Blood pressure was measured indirectly by oscillometric method (Dixtal DX2020) with subjects in the supine position. A cuff inflator was placed around the left ankle and was automatically inflated every 60 sec throughout the protocol.

Blood flow was measured on the forearm by plethysmography with venous occlusion. A silastic tube filled with mercury, connected to a low pressure transducer, was placed around the forearm, 5 cm away from the humeral radial joint and connected to a plethysmograph (Hokanson/EC6, Plethysmograph). One cuff was placed around the wrist and another on the proximal segment of the arm. One minute before measurements were taken, the wrist cuff was inflated to a suprasystolic level. Every 10 sec, the arm cuff was inflated above venous pressure for 10 sec. The increase of tension on the silastic tube was reflected in an increase in arm volume and, as a result, vasodilation. The wave signal of blood flow was obtained online by means of the WINDAQ DI200 computer program at a frequency of 500Hz.

After collecting blood pressure and blood flow data, the calculation of vascular resistance and conductance were performed. Vascular resistance (VR) was regarded as the ratio of the mean blood pressure (MBP) and forearm blood flow (FBF): (VR = MBP ÷ FBF). Vascular conductance (VC) was the ratio of FBF and MBP multiplied by 100: (VC = [FBF ÷ MBP] x 100) (6).

Heart rate was also measured. The assessment procedure included placing three electrodes on the chest, in bipolar positions, to capture electrocardiographic signals of DII derivation. After pre-amplifying the signal, it was converted from analog to digital and, then, recorded on a computer via WINDAQ DI 200 program at a frequency of 500 Hz.

Leisure Physical Activities Supervised Program

All activities performed were proposed by the leisure and social inclusion of the elderly project, which was consisted of 60-min exercise sessions 3 times·wk^{-1} on nonconsecutive days for 4 months (5).

The first session was comprised of sports practices, games, and group dynamics designed to stimulate the cardiorespiratory system. The second session consisted of stretching exercises and dance to improve flexibility and rhythm. The third session was characterized by water aerobics and other aquatic activities with the intention to increase muscle strength and endurance.

All activities were performed in the morning, where different aspects were given priority: the recreational, corporal awareness, and socio-emotional relationships. Classes were divided into four moments: (a) the first, called “waking up the body”, involved stretching and warm-up activities that lasted for 10 min; (b) the second, entitled “living the body”, was the main part of the class that lasted for 40 min; (c) the third, “feeling the body”, consisted of recovery activities that was 5 min in duration; and (d) the fourth moment, “reflecting on life”, contained reflective messages made by the women themselves, which lasted 5 min.

Statistical Analyses

Data were originally entered into the database of the software SPSS® (*Statistical Package for Social Sciences*), version 20, for Windows. After the final structuring of the database, a descriptive analysis of all data was performed on the dependent and independent variables. In comparing groups for dependent variables, we proceeded with the U Mann-Whitney statistical test, before and after the intervention period. Additionally, the Friedman test was used to analyze the variables within each group, doing so once every minute over a period of 3 min. When significant differences were found between the values analyzed, comparisons were made of the paired data between each two measurements (Wilcoxon test), penalizing the P values found by the Bonferroni procedure. A level of $P<0.05$ was considered statistically significant.

RESULTS

All women completed more than 85% of the scheduled exercise sessions. The initial characteristics of the women investigated in this study are presented in Table 1.

Table 1. Characteristics of Pre-Intervention Anthropometric and Hemodynamic Variables at Rest in Healthy Middle-Aged and Elderly Women.

	Pre-Intervention				
	Middle-Aged Women		Elderly Women		
	Median	$Q_{25} – Q_{75}$	Median	$Q_{25} – Q_{75}$	P
Age (yrs)	55	52 – 56	68	65 – 75	<0.001*
Body Mass Index ($kg \cdot m^{-2}$)	25	24 – 26	25	23 – 25	0.762
Heart Rate ($beats \cdot min^{-1}$)	62	57 – 69	66	59 – 77	0.315
Systolic Blood Pressure (mmHg)	124	113 – 125	118	115 – 129	0.829
Diastolic Blood Pressure (mmHg)	66	63 – 71	67	63 – 73	0.696
Mean Blood Pressure (mmHg)	83	73 – 84	84	77 – 86	0.315
Vascular Resistance (units)	20	20 – 23	24	23 – 26	0.027*
Vascular Conductance ($mL \cdot min^{-1} \cdot 100\ mL^{-1} \cdot mmHg\%$)	5.0	4.3 – 5.2	4.1	3.9 – 4.4	0.027*

*Indicate statistical significance

As presented in Table 1, the groups were statistically different in age as well as forearm vascular resistance and conductance. The resting values of forearm vascular resistance and vascular conductance in the elderly group showed higher resistance and decreased vasodilation when

compared to the middle-aged women. The resting blood pressure was not different between the two groups.

In Table 2 the behavior of the mean blood pressure is shown. It is observed that only the middle-aged women showed a significant progressive increase during the isometric exercise during both pre- and post-intervention. In addition, when comparing the mean blood pressure before and after the intervention period, it may be seen that there were no significant changes between the two groups.

Table 2: Changes in Mean Blood Pressure, Vascular Resistance, and Vascular Conductance during the Performance of Moderate Isometric Exercise in Healthy Middle-Aged and Elderly Women.

			Baseline Md (Q_{25} – Q_{75})	Minute 1 Md (Q_{25} – Q_{75})	Minute 2 Md (Q_{25} – Q_{75})	Minute 3 Md (Q_{25} – Q_{75})
MBP	**Elderly Women**	Pre	84 (77 – 86)	88 (81 – 92)	92 (81 – 96)	97 (87 – 104)
		Pos	83 (73 – 84)	84 (77 – 87)	89 (82 – 92)	93 (86 – 98)
	Middle-Aged Women	Pre	83 (73 – 84)	82 (79 – 87)	90 (82 – 93)*****	93 (88 – 96)*****
		Pos	81 (74 – 87)	85 (79 – 92)	92 (88 – 96)*****	98 (89 – 105)*****
VR	**Elderly Women**	Pre	24 (23 – 26)†	24 (23 – 26)†	23 (23 – 31)†	24 (23 – 29)†
		Pos	21 (19 – 24)**	18 (16 – 22)**	18 (17 – 23)**	18 (17 – 22)**
	Middle-Aged Women	Pre	20 (20 – 23)	20 (18 – 22)	20 (16 – 24)	20 (16 – 22)
		Pos	20 (16 – 23)	19 (14 – 24)	18 (14 – 22)	19 (15 – 23)
VC	**Elderly Women**	Pre	4.1 (3.9 – 4.4)†	4.2 (3.9 – 4.4)†	4.2 (3.2 – 4.3)†	4.1 (3.4 – 4.2)†
		Pos	4.8 (4.3 – 5.2)**	5.5 (4.5 – 6.4)**	5.5 (4.4 – 5.9)**	5.7 (4.6 – 5.9)**
	Middle-Aged Women	Pre	5.0 (4.3 – 5.1)	5.0 (4.5 – 5.7)	5.1 (4.2 – 6.1)	5.1 (4.6 – 6.1)
		Pos	5.1 (4.7 – 6.3)	5.2 (4.1– 7.1)	5.5 (4.5 – 7.0)	5.3 (4.3 – 6.7)

Md – Median; **MBP** – Mean Blood Pressure (mmHg); **VR** – Vascular Resistance (units); **VC** – Vascular Conductance ($mL \cdot min^{-1} \cdot 100\ ml^{-1} \cdot mmHg\%$); *P<0.05 intragroup from baseline; **P<0.05 intragroup pre- vs. post-intervention; †P<0.05 between groups in the pre-intervention period.

Table 2 also presents the values of forearm vascular resistance and vascular conductance. During the isometric exercise in the elderly women, a reduction in vascular resistance and a progressive increase in forearm vascular conductance occurred. However, when an intragroup comparison was made before and after intervention, it was observed that forearm vascular resistance decreased significantly in the elderly group while vascular conductance had increased significantly. Moreover, when comparing the two groups during isometric exercise in the pre-intervention period, there was a significant difference. Interestingly, in the post-intervention period, these differences ceased to exist, since the vascular resistance and the forearm vascular conductance between the groups were statistically similar.

The reactive hyperemia results are presented in Figure 2. In figure 2A, when comparing the intragroup before and after intervention, the forearm vascular resistance of elderly women decreased significantly (P=0.012). Furthermore, in Figure 2B, when comparing the forearm vascular conductance of the intragroup, there was a significant increase (P=0.012). In middle-aged women, no significant changes were observed (vascular resistance: P=0.203, Figure 2A, and vascular conductance: P=0.285, Figure 2B).

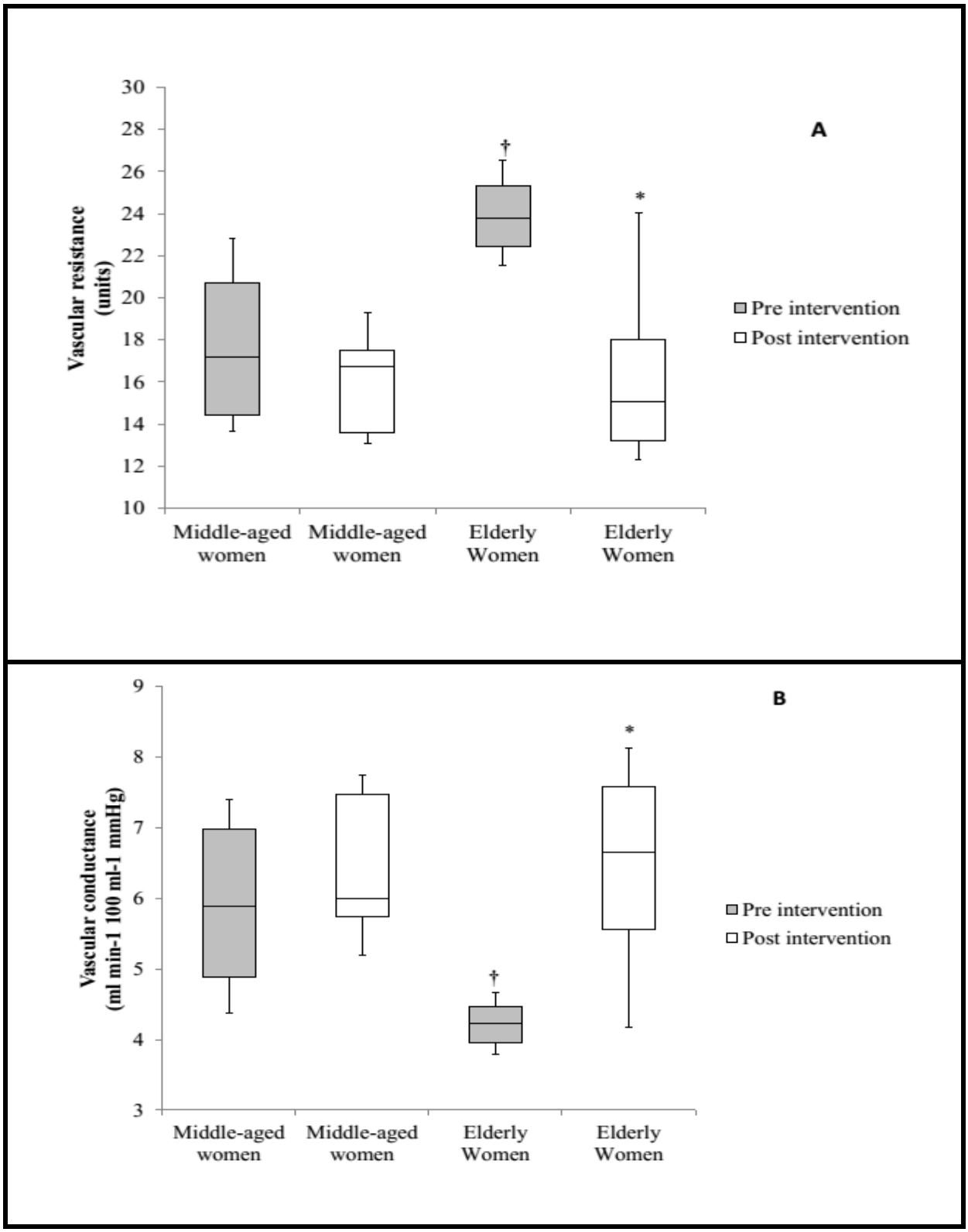


Figure 2A and 2B. Changes in Vasodilatory Response after Vascular Occlusion Maneuver (Reactive Hyperemia) in Health Middle-Aged and Elderly Women. *P<0.05 intragroup between pre- vs. post-intervention; †P<0.05 between groups in the pre-intervention period.

When comparing the two groups before intervention, a statistical difference was observed (vascular resistance: P<0.0001, Figure 2A, and vascular conductance: P<0.0001, Figure 2B). Finally, it can be

seen that the decrease in vascular resistance and the increase in vascular conductance in the elderly women, after the intervention period, that were statistically different from the middle-aged women in the pre-intervention period, ceased to exist in the post-intervention period (vascular resistance: P=0.829, vascular conductance: P=0.897).

DISCUSSION

In this study, no significant mean blood pressure reduction in the investigated groups was observed, while at rest. The main findings were that: (a) at rest the vasodilation of elderly women increased significantly; (b) during the isometric exercise and reactive hyperemia, after the intervention period, there was a significant increase in forearm vasodilation in the elderly women; and (c) differences regarding the vasodilator response between groups before intervention disappeared after 4 months of leisure physical activities supervised program.

Currently, there are reports in the literature indicating that physical exercise can promote autonomic and hemodynamic adaptations influencing the cardiovascular system (26). Results of several studies have shown that regular exercise practiced can decrease blood pressure in elderly (3,25). Similarly, Tsai, Wang (36) showed that senior citizens who practiced Tai Chi Chuan 5 times·wk^{-1} for over 10 yrs had lower blood pressure values than their sedentary counterparts, and their values were similar to young sedentary subjects.

In this sense, one of the reasons for not observing a reduction in the resting mean blood pressure, after the research intervention was probably due to the fact that the subjects in the present study were in good health. The literature indicates that post-exercise blood reduction is higher in subjects with higher baseline blood pressure (13).

When analyzing forearm vascular resistance and vascular conductance in the elderly group before intervention, it could be observed that vascular function was worse in this group when compared to the middle-aged group. This difference was expected, that is, according to what has been reported in the literature. A recent epidemiological study of middle-aged and elderly subjects on Ikaria Island (Greece) showed that middle-aged individuals had higher flow-mediated vasodilation compared to the elderly (32).

The present study found that the elderly women obtained a greater improvement in vasodilatory response compared to middle-aged women. This finding may be explained by the improvement in endothelial function or the reduction in sympathetic activity in the elderly group, which was likely due to a decrease in oxidative stress (19), an increase in the bioavailability of nitric oxide (4,27), or an increase in heart rate variability and baroreflex sensitivity (28). However, to confirm the role of either or all of them, it is necessary to conduct studies to determine whether the improvement in these mechanisms is influenced by performing leisure physical activities program.

Additionally, data from the present study support the hypothesis that the improvement of vasodilatory response during isometric exercise in the elderly women occurred through optimizing mechanisms mediated by two types of receptors. Thus, after 4 months of a leisure physical activities, there was a better activation of the sympathetic excitatory loop through central command by mechanoreceptors and metaboreceptors that promotes greater vasodilation (30).

Further, when the vascular occlusion maneuver was made, it was observed that during reactive hyperemia the vasodilator response was also significantly increased in the elderly women. These

results suggest an improvement in endothelial function, as previous studies have reported that the vasodilation observed in reactive hyperemia is at least 75% mediated by nitric oxide (16). This finding is very important since endothelial dysfunction is an early event for atherogenesis and markers of arterial injury, which precedes platelet formation (18).

The results of the present study are noteworthy, especially since there are only a few intervention studies with leisure physical activity assessing vascular function among elderly. The findings are in agreement with and, therefore, corroborate previous investigations, which found improvement in vasodilatory response (10,31,33,34,37). In particular, the exercise program used in this study was sufficient to increase vascular conductance by 16.7% and decrease vascular resistance by 14% in elderly women while at rest.

Several investigations have demonstrated that greater vasodilation at rest and improvements in exercise vasodilatory response are associated with increased bioavailability and vascular nitric oxide release (15,22,27). It is known that the shear stress and the increase of the flow velocity promoted by exercise are effective stimuli to increase the biodisponibility of nitric oxide (17). These results can be used to explain the improvements found in the elderly, at least in part, given that Taddei et al. (33) demonstrated the blocking of L-NMMA from nitric oxide decreased forearm blood flow after physical exercise program.

A study by Casey and colleagues (8) demonstrated that aging reduces the vasodilatory response in the face of the hypoxia stimulus in elderly. These authors evaluated 11 healthy elderly subjects during rhythmic exercise at 20% maximal voluntary contraction under conditions of normoxia and hypoxia with and without nitric oxide synthesis block with L-NMMA. In our investigation, it was found that the response of reactive hyperemia to the vascular occlusion maneuver (i.e., hypoxic condition) generated a vasodilatory response that was higher in the period after intervention, especially in the elderly group. Black et al. (2) observed that the endothelial-dependent vasodilatory response is increased with increasing shear stress and the blood flow velocity, thus explaining the increased vasodilation after the occlusion maneuver.

It should not go unstated that the present research study has certain limitations. The fact that this study is an intervention study that did not have a control group (without exercise) makes it difficult to relate the training program with the observed effects. Furthermore, the non-realization of sample size calculation may have led to a smaller number of subjects than necessary, especially in middle-aged group, which showed changes in the threshold of significance for the variable resistance and vascular conductance. Probably, with an increase in the sample size in this group, there could have been significant improvements in vasodilatory response after the intervention period, similar to that found in the elderly group.

CONCLUSIONS

The findings indicate that, although 4 months of leisure physical activities are an effective alternative to commonly recommended exercise programs to promote cardiovascular benefits (specifically, the vasodilatory response that was restored to levels obtained in middle-aged women), it is important to carry out more controlled and randomized studies to confirm the findings.

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