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Influence of Aerobic Training on Cardiovascular and Metabolic Parameters in Elderly Hypertensive Women

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Original Article

ABSTRACT

Background: Treatment of hypertension includes pharmacological and nonpharmacological interventions. Among the nonpharmacological interventions emphasizes the practice of regular physical exercise. However, the effects of aerobic exercise training on cardiovascular and metabolic parameters in elderly hypertensive women are still controversial.

Objectives: The purpose of this study was to assess the effects of a walking program on metabolic and cardiovascular parameters at rest and during the recovery period following maximal exercise by hypertensive elderly women.

Methods: Twelve elderly women with hypertension started a 2-week walking program. Rest blood cholesterol and anthropometric data, as well as blood pressure and heart rate at rest and after progressive maximal exercise were measured before and after training.

Results: There were significant differences between the pre- and posttraining periods in VO_2max, systolic blood pressure, diastolic blood pressure, and mean blood pressure. There were no changes in serum cholesterol levels after the training. During the recovery period following the progressive test, the fall in heart rate and mean blood pressure after 10 minutes of recovery was significantly higher after training.

Conclusion: The proposed walking program did not alter serum cholesterol, but it did reduce resting blood pressure, improve aerobic performance and accelerate the fall in heart rate and mean blood pressure during the postprogressive maximal aerobic exercise recovery period in elderly hypertensive women.

Key words: Aging, blood pressure, heart rate, walking

INTRODUCTION

Increased longevity has contributed to the demographic transition of the population and the world. Currently, the elderly represent a large and growing portion of the population.[1] According to the Brazilian Institute of Geography and Statistics

(BIGS), in 2020, the elderly population in Brazil will be 25 million, mostly composed of women.[2] In this population, there is a higher observed prevalence of chronic diseases such as hypertension,[3] especially in women. Currently, it is estimated that among women over 65 years, the prevalence of hypertension may reach 80%.[4]

The treatment of hypertension includes pharmacological and nonpharmacological interventions.[5,6] Among the nonpharmacological interventions, regular exercise has been recommended in the prevention.[7] Among the principal physiological benefits of physical training in hypertensive patients are reductions in heart rate (HR) and peripheral vascular resistance.[8] These factors are related to the fall of systolic and diastolic blood pressure (BP).[9] In addition to improvements in BP, aerobic training is associated with a reduction of serum cholesterol, which often is above the reference values in hypertensive subjects.[10]

The effects of aerobic exercise training on cardiovascular and metabolic parameters in hypertensive elderly women remain unclear and controversial. Some studies indicate beneficial effects[9,11] and others report no significant changes.[12,13] These effects seem to depend on AH stage[11,14] and the duration, intensity, and frequency[14] of the exercise. In addition, there is no information in the literature comparing the behavior of HR and BP during the recovery period to acute exercise before and after training in older hypertensive women. A substantial decrease of these parameters in the postaerobic exercise recovery period is a strong indication of reduced cardiovascular morbidity and mortality.[9]

This study aimed to evaluate the effects of an aerobic training program on the metabolic parameters and cardiovascular parameters at rest and during recovery following maximal aerobic exercise in hypertensive elderly women.

METHODS

Subjects

The sample size estimation to repeated measures comparison was performed, for the variables blood pressure (systolic and diastolic) and oxygen consumption, and the highest sample size obtained was considered. To obtain the needed values to conduct the sample size calculation – the standard deviation of the dependent variable – results from the study of Lima *et al*. (2011) were considered. The highest sample size was obtained for the variable oxygen consumption. Considering a significance level of 95%, the standard deviation of 6.38, and establishing a difference of 4.0 points in the oxygen consumption to be detected before and after the training, the sample size obtained was 10 participants. To cover eventual nonresponse, the sample was increased by 20%, resulting in a total of 12 participants in the study.

The study population sample was composed of 12 elderly women with hypertension (mean age 67 ± 5 years), with stage I hypertension, i.e., they had systolic blood pressure between 140 and 159 mmHg and diastolic blood pressure between 90 and 99 mmHg. The study participants were women over 60 years in age who did not use beta-blocker drugs. The volunteers were selected after evaluation of readiness for physical activity, PAR-Q questionnaire cardiovascular risk stratification and coronary risk evaluation.[15,16] After receiving information about the objectives and procedures of the study, all participants signed an informed consent form. The study was approved by the Ethics Committee of the UFVJM (protocol # 057/08).

Procedures

Clinical and demographic data were collected from the study volunteers using an evaluation questionnaire and initial physical assessments (preprandial cholesterol and HR and BP at rest). Subsequently, the volunteers underwent a maximum oxygen consumption assessment followed by the recording of HR and BP values during the 20-minute postexercise recovery period. After performing this procedure, the volunteers began the 12-week aerobic training program. At the end of this training program, all parameters evaluated in the pretraining period were reassessed [Figure 1].

The training program

The aerobic training was composed of three weekly sessions of walking and progressively monitored for a period of 12 uninterrupted weeks. The sessions were performed with a progressive duration of 30-55 minutes and 55-65% intensity of HR reserve. The HR reserve was obtained by the formula HR = maximum heart rate reserve - resting HR[17] and the maximum HR achieved in this test effort. The resting HR was considered the average of the values obtained in the last 5 minutes of measurement after 15 minutes of rest lying on a stretcher. During the walking sessions, the HR target was monitored by a Polar heart rate monitor (Finland) every 3 minutes and 10 minutes. In addition, a subjective perception of effort was recorded using a Borg scale.[18]

During the training period, the volunteers were instructed not to change, when possible, their normal food intake and the type and dosage of medication as to allow for a better assessment of the effects of the physical training. This was monitored via a weekly food questionnaire prepared by the research team.

Assessment during the periods of rest and recuperation

Assessment of body mass index (BMI), total cholesterol, and BP and HR during rest pre- and posttraining

Anthropometric measures were assessed using the body weight and height to calculate BMI using the formula: weight (kg)/height ^{2} (m).[19] In this study, a BMI less than 22 was classified as lean, 22-27 as higher than normal weight and 27 as overweight.[19] The BP measurement was obtained by auscultation using a sphygmomanometer and stethoscope (BD) and following the guidelines established by the V Brazilian Guidelines on Hypertension.[20] The values were presented in relation to systolic BP (SBP), diastolic (DBP), and mean (MBP) blood pressure.

Total cholesterol was measured using the Accutrend Roche system. The blood was collected with the subjects in the sitting position and after 12 hours of fasting. The procedure was performed by a single trained researcher by puncturing the digital pulp of the individual and discarding the first sample.

All samples were collected before and after the 12 weeks of physical training.

Assessment of maximal aerobic capacity, BP, and HR during recovery pre- and posttraining

All volunteers were submitted to a maximal exercise test to the point of fatigue following an adapted protocol composed of stages of 3 minutes, with variations of speed (1.6-6 km/h) and grade (0-22.5%) on a treadmill (Inbrasport, Brazil) [Table 1]. For the test, the protocol followed the pretest instructions and criteria for discontinuation as developed by the American College of Sports Medicine.[21] VO_2max values were used to assess maximum aerobic capacity and estimated using the formula described by the ACSM, where VO_2 (mlO_2) = 0.1 × (speed) + (speed × 1.8 × % grade) + 3.5,[21] taking into consideration the last stage completed by the volunteer. The assessment protocol was performed at the Emergency Service Department of the Holy House of Charity of Diamantina - MG under medical supervision.

For evaluation of HR and BP during the recovery period, all measurements were recorded immediately after the test with the individual on the treadmill and at 5, 10, 15, and 20 minutes during the recovery period with the patient in a sitting position.

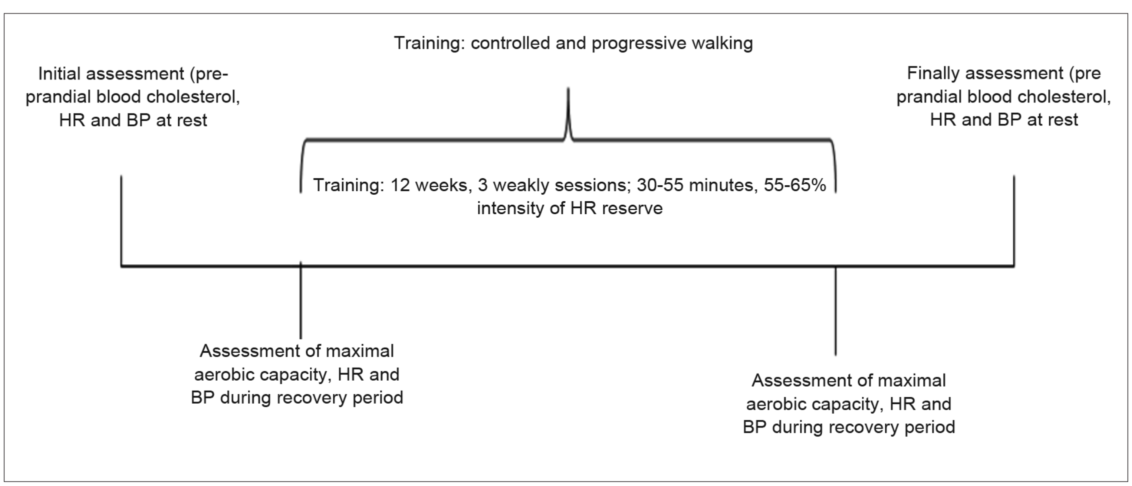

Figure 1: Study flow chart

Statistical analysis

Parametric tests were used, as the data fit the criteria of normality according to the skewness and kurtosis estimates. A comparison of pre- and postintervention resting values was performed using a paired *t*-test. To analyze the recovery, we used the delta (difference) measures of BP and HR after 5, 10, 15, and 20 minutes, compared to measurements obtained at time 0 (peak effort).

To verify that there were significant differences in BP and HR variables during the recovery period, we did an ANOVA test with repeated measures. To check the size of the differences between the pre- and posttraining periods, we analyzed the effect size. The effect size is an additional measure to the traditional statistical test of the null hypothesis, which aims to verify the clinical significance of the effect found and is not limited to dichotomous (significant or not significant) results. Thus, with effect size analysis, it is possible to identify whether observed differences are small, moderate or large. The SPSS software for Windows (SPSS Inc., Chicago, IL, USA) version 18.0 was used for all statistical analyses. The level of significance for all tests was 5% ($P < 0.05$).

Table 1: Progressive loading protocol on a treadmill until fatigue

Stage	Time (minutes)	Speed (km/h)	Grade (%)	MET
1	0	1.6	0	1.7
2	3	3.2	0	2.5
3	6	3.2	3.5	3.4
4	9	3.2	7	4.4
5	12	3.2	10.5	5.3
6	15	3.2	14	6.2
7	18	3.2	17.5	7.3
8	21	4.8	25	9.3
9	24	4.8	15	9.4
10	27	4.8	17	10.2
11	30	4.8	20	11.5
12	33	4.8	22.5	12.5
13	36	4.8	22.5	13.5
14	39	4.8	22.5	14.4
15	42	4.8	22.5	15.4
Recovery	3	2.0	0	1.9

MET = Metabolic equivalent of task.

RESULTS

The aerobic training program compliance was satisfactory (92%). Table 2 presents the pre- and posttraining period rest variables. There was a significant difference between the pre- and posttraining periods in the variables, except for the BMI, total cholesterol, and HR.

Though there were not statistically significant differences between the two periods for BMI and total cholesterol, a small magnitude of effect was noted in HR. MBP and SBP demonstrated statistical differences and an average magnitude of effect. There were also significant differences and a high magnitude of effect for VO_2max and DBP. There was improvement in 17% VO_2 max compared to the pretraining period, a mark of improved cardiovascular fitness.

Figure 2 presents the results for the delta values of HR (A) and MBP (B) during the recovery period after a maximal exercise test at 5, 10, 15, and 20 minutes postexercise. Note that before training, a significant drop in HR and MBP took longer than 5 minutes during recovery; after training, we also observed a significant drop at 5 minutes and 10 minutes postexercise, but the fall was significantly

Table 2: Effects of aerobic training on anthropometrics, metabolic, and cardiovascular parameters in elderly hypertensive patients

Variables	Pretraining	Posttraining	*P* value	d
BMI (kg/m^2)	28.4 ± 4.2	28.1 ± 4.4	0.753	0
Blood cholesterol (mg/dL)	184.4 ± 36.3	182.6 ± 26.6	0.096	0.03
VO_2max (mL/kg/min)	28.9 ± 9.7	34.4 ± 5.1*	<0.01	0.82
SBP (mmHg)	146 ± 16.7	137 ± 11.7*	<0.01	0.61
DBP (mmHg)	89 ± 6.5	82 ± 7.8*	<0.01	0.85
MBP (mmHg)	107 ± 8.9	102 ± 10.7*	<0.01	0.50
HR (mmHg)	78 ± 8.4	77 ± 10.4	0.05	0.21

BMI = Body mass index, VO_2max = Oxygen consumption maximum, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, MBP = Mean blood pressure, HR = Heart rate, d = Effect size. Significance: *post versus pre; $P < 0.01$.

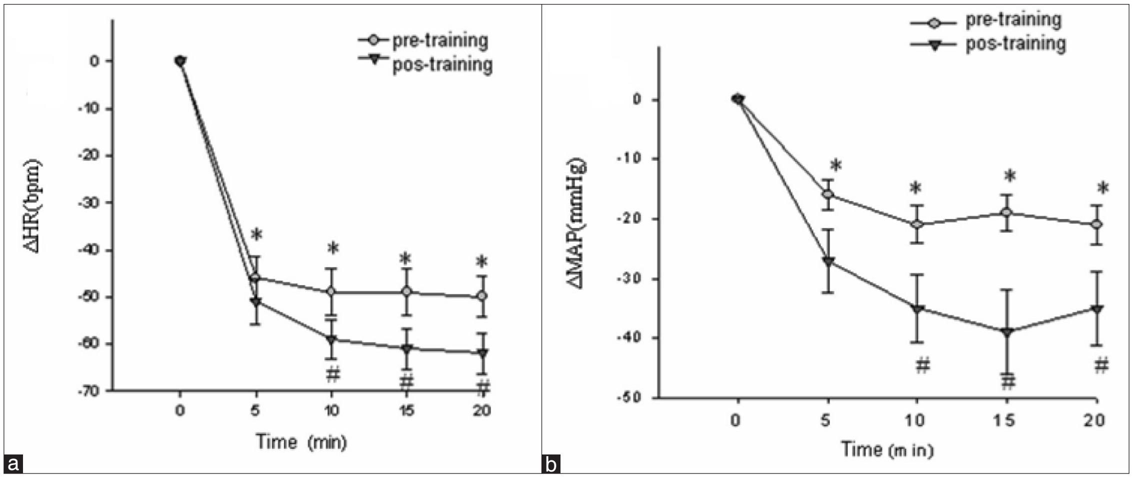

Figure 2: Behavior of (a) heart rate (HR) and (b) mean arterial pressure (MAP) during recovery from the progressive maximal aerobic test before and after aerobic walking in elderly hypertensive. Δ (delta). *$P < 0.05$ compared to the time immediately after exercise and #$P < 0.05$ compared to pretraining.

greater in the same period compared to the pretraining assessment ($P < 0.05$).

DISCUSSION

The principal findings of this study indicated that elderly hypertensive female patients subjected to an aerobic training program with a walking modality for 12 weeks (i) had an increase in maximal aerobic capacity, (ii) had a reduction of blood pressure values at rest, (iii) presented no significant changes in serum total cholesterol, and (iv) had an accentuated decrease in MBP and HR during a postprogressive maximal aerobic exercise recovery period. In addition, the study participants demonstrated a high level of compliance with the exercise program proposed, suggesting that a high level of adherence can be achieved in a chosen aerobic exercise activity. Walking is an easily accessible exercise method that is associated with the activities of daily living, low in cost and promotes an improvement in socialization.

Hypertension is commonly associated with metabolic abnormalities and about 36% of hypertensive patients present with dyslipidemia; however, the effects of exercise alone on blood cholesterol remain controversial.[22] In a study of elderly women who exercised for three moderate intensity aerobic sessions a week for 24 weeks, Cox *et al*.[22] observed a significant reduction in BMI (26.3 vs. 25.9 vs. pre- and posttraining, respectively) but also observed a significant reduction in total cholesterol. Miller *et al*.[23] demonstrated that after only 9 weeks of exercise, elderly women had significant reductions in total cholesterol (198 mg/dl vs. 181 mg/dl) and BMI (32.8 vs. 31.0). However, this author indicates that the positive effect observed in the short period of training was associated with a hypocaloric diet that accompanied the exercise program. In contrast to these cited studies, the present study did not demonstrate significant differences in BMI and serum total cholesterol pre- and posttraining. Taken together these results suggest that, at least in hypertensive elderly women, changes in cholesterol levels are achieved with an prolonged period of exercise training - (24 week) or with a shorter - ones (9 weeks) whereas it should be associated with a caloric restriction diet.

In regard to aerobic performance, the improved cardiorespiratory fitness (VO2max) of 17% found in this study represents an important clinical finding, considering that 10% increases in VO_2max can result in 15% reductions in mortality from cardiovascular disease.[24] Similar results were reported by Church *et al*.;[12] in the same period of aerobic training, older hypertensive patients demonstrated increased aerobic performance, although Church did not find observe changes in BP and HR as a result of training. Similar results were observed by Lima *et al.*[25] who had a similar study population and methodology. They observed a significant increase in VO2 max (24.9 ± 6.4 vs. 27.8 ± 6.1 mlO_2kg/min, $P = 0.028$). Sisson *et al*. reported that the improvement in aerobic performance depends on age, body weight and exercise intensity.[26] Despite similar age ranges in these cited studies, the other study characteristics differed including body mass index, duration, intensity, and type of aerobic training. Moreover, in elderly hypertensive patients an improved aerobic capacity resulting from physical training may be limited by the presence of musculoskeletal disorders commonly present in this population.[27] This aspect was not examined or reported in the studies cited. In addition, in the present study, the high rate of exercise session compliance (92%) likely contributed to the observed aerobic capacity improvement.

There is no consensus in the literature as to how aerobic training affects cardiovascular variables (BP and HR) in elderly hypertensive patients. Most studies indicate a reduction of BP values[11,23] and HR[28] during rest after aerobic training in this population. However, other authors conducting similar studies did not observe significant changes in these parameters.[12,13] Among the factors reported, the main contributors to this disagreement seem to be hypertension stage[26] in addition to the intensity, duration, and frequency of the aerobic exercise. The current recommendation is that exercise intensity should be confined to lower than 70% of maximum oxygen consumption[29,30] for 40 minute or longer durations.[15] However, Halbert *et al*.[31] reported that there is no additional benefit from more than three sessions per week. Our results indicated that elderly women had significant reductions in SBP and DBP without a significant change in resting HR after completion of an aerobic training program. A similar result for BP was shown by Lima *et al*.[25] with significant reductions in both systolic (142.7 ± 6.3 vs. 130.8 ± 5.8 mmHg, $P < 0.001$) and diastolic BP (87.0 ± 4.5 vs. 81.9 ± 4, 3 mmHg, $P = 0.002$) in just 30 days of aerobic training with three sessions per week of moderate intensity (50-70% HR reserve + HR rest) exercise. The reductions continued to decline at 60 and 90 days of training.

Hypertension is multifactorial, and several mechanisms may be involved in the decrease in BP and bradycardia caused by aerobic training. The related chronic adaptations include improvement of endothelial function,[31] reduction of sympathetic nerve activity, increased baroreflex sensitivity,[1] improvement in the hyperinsulinism state,[32] improvement in lipoprotein profile,[32] weight loss,[33] reduced cardiac output,[33] and reduced peripheral vascular resistance (PVR).[34] In the elderly, the main mechanism involved in the reduction of resting blood pressure in response to aerobic physical training seems to be a reduction in PVR.[35] As we observed a BP decrease without an accompanying significant change in HR, we speculate that the short training period may have been sufficient to promote vascular adaptations that favor the reduction of PVR but insufficient to promote long-term changes in the central autonomic nervous system, thus resulting in a bradycardia. Importantly and in line with this idea, a recent report found that a lower sympathetic baroreflex sensitivity in elderly women may predispose them to an increased prevalence of hypertension when compared with elderly men.[36] Thus, one could suggest that physical training is less effective in promote reduction in sympathetic nerve activity in hypertensive elderly women when compared with hypertensive elderly men.[36] However, explorations of such mechanisms were not an objective of this study.

In addition, the results of this study indicated a significant reduction in MBP and HR during recovery from maximum progressive exercise, and this fall was more pronounced after 10 minutes of recovery following completion of an aerobic training program. This behavior has been reported in studies with young adults and middle-aged individuals.[35] Moreover, we observed the same behavior in elderly hypertensive individuals. The time taken for BP and HR to return to resting levels after aerobic exercise is strongly dependent on autonomic function and fitness level.[35] During the period of initial activity, autonomic changes consist of inhibition of the modulation of parasympathetic and stimulation of sympathetic activity.[35] After the completion of activity, there is an inversion of control involving vagal reactivation followed by a gradual reduction in sympathetic activity.[33] A retardation of this mechanism, observed in the first minutes of the recovery period, provides strong evidence of an increased risk of cardiovascular mortality. The large decrease in HR during postexercise recovery following aerobic training in this study suggests a better parasympathetic reactivation after maximum aerobic effort with physical training. However, this hypothesis is only speculative, mainly because the most appropriate method for noninvasive assessment is indirect and occurs through the autonomic modulation of HR variability, which was not used in this study. However, these results suggest that even though the 12-week aerobic training period did not promote bradycardia at rest, there was still a favorable effect on the acute recovery period HR. As recovery period HR is an important marker of cardiovascular risk, physical training programs that favor a more pronounced decline in HR during recovery certainly favor the reduction of cardiovascular complications.

The large decrease in BP during posttraining recovery observed in this study may be associated with improvement in aerobic performance because VO_2max was the variable that showed the largest effect size (0.82), increasing about 17% after training. It has been widely reported that an increase in aerobic performance and consequent greater muscle vasodilation leads to significant reductions in BP after exercise, which may contribute to a more pronounced hypotensive effect after exercise.[27]

In general terms, our results reinforce the recommendations available in the literature about nonpharmacological treatment of hypertension with planned physical conditioning programs. Walking is a suitable exercise form for the elderly; it results in important beneficial health effects and weight effects and is low impact. Moreover, it can be done anywhere, is inexpensive, involves large muscle groups and helps to increase social contact.

More studies are needed to verify the effectiveness of different physical training programs on cardiovascular and metabolic parameters, specifically for the elderly hypertensive population. We also suggest that more studies should be conducted with this population to especially assess the behavior of BP and HR recovery and HR variability after exercise training.

In conclusion, the proposed walking program did not alter serum cholesterol; however, in a study population of elderly hypertensive women, the program reduced resting BP, improved aerobic performance, and accelerated the fall in HR and MBP during a postprogressive maximal aerobic test recovery period.

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