Original Article (short paper)

Influence of antihypertensive pharmacological treatment on the acute cardiovascular responses to the resistance exercise in hypertensive middle-aged women

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Abstract - Aim: To investigate the hypothesis that the resistance exercise (RE) may be safer if the blood pressure (BP) is properly controlled through antihypertensive pharmacological treatment in hypertensive middle-aged women. **Methods:** The final sample was comprised of 19 hypertensive women, with an average age of 58±5 years and a body mass index of 29±5 Kg/m^2. They were divided into three groups: controlled (n=6), uncompensated (n=8), and untreated (n=5). The subjects from all groups were submitted to a test of maximal strength on extensor chair and held a session of RE (knee extension, 3x12 to 60% 1RM) and the cardiovascular response (BP and heart rate) was monitored continuously by photoplethysmography during exercise and until five minutes after exercise (recovery). **Results:** Systolic BP (SBP) and diastolic BP (DBP) responses were lower in the controlled group compared to the other groups ($p<0.05$). The heart rate was not different between groups, while the double product was lower in the controlled group compared to the untreated group ($p<0.05$). The SBP and DBP peaks were lower in the controlled group compared to the other groups ($p<0.05$). **Conclusion:** The BP increases significantly during RE when the hypertension is not controlled. Pharmacological control was shown to be effective in preventing the increase of BP during the performance of the RE.

Keywords: Resistance training; Hypertension; Drug treatment.

Introduction

Cardiovascular diseases (CVD) have been the leading cause of death worldwide, accounting for 17.7 million deaths in 2017[1]. Arterial hypertension, with a worldwide prevalence of approximately 45%[2], is an independent risk factor for cardiovascular diseases and one of the leading causes of a modifiable risk factor for morbimortality. It may be prevented or controlled through changes in behavioral risk factors such as unhealthy eating, tobacco use, obesity, alcohol abuse, and physical inactivity.

Among these modifiable risk factors, we highlight physical exercise, which is indicated as an adjuvant in both prevention and treatment of arterial hypertension. Although aerobic training is well accepted in the treatment of hypertension, emerging evidence points towards the beneficial effects of resistance training. Meta-analyses studies have shown that resistance exercise (RE) alone may elicit BP reductions[3,4]. Thus, the Brazilian Society of Cardiology and Hypertension[5], the American Heart Association (AHA)/American College of Cardiology (ACC) and the task force workgroup[6], the most recent AHA/ACC Scientific Statement[7], the American College of Sports Medicine (ACSM)[8], and the European Society of Hypertension and European Society of Cardiology[9] recommend resistance exercise (RE) as a complement to aerobic exercise programs treating hypertension.

Despite the relevance that RE received in hypertension treatment, there are still concerns about its use in this population. These concerns are due to the compelling data published by MacDougall et al.[10], which had shown an exacerbated increase in BP during RE. This fact led to the hypothesis that this massive increase in BP could raise the risks associated with BP peaks in hypertensive people, such as the risk of rupture of pre-existing aneurysms[11,12]. Importantly, this risk is enhanced in middle-aged women since it is at this time that they begin to have an increased incidence of stroke[13]. Additionally, this risk might be even higher since most of the population worldwide that receives antihypertensive treatment does not have the BP controlled[14–18].

Thus, the present study aims to investigate the hypothesis that the RE may be safer if the BP is properly controlled through antihypertensive pharmacological treatment in hypertensive middle-aged women.

Methods

Ethical statement

The Ethics Committee of the Federal University of Sergipe approved this study (CAAE 37891914.9.0000.5546) under registration number 931.006. Informed consent was obtained from all participants of the study. All procedures of this study are in accordance with the regulation of the Health National Council (466/12) and with the 1975 Helsinki Declaration.

Participants

The sample was recruited through announcements and newsletters in the community respecting the inclusion criteria of being hypertensive with medical diagnostic, aged between 50 and 70 years who did not participate in resistance exercise programs in the three months before the study. As well as, it was respected the exclusion criteria of do not have ostheomyioarticular limitations, do not change medication or start pharmacological treatment during the protocol, and do not participate in all stages of data collection.

Thus, 30 subjects were eligible to participate in this investigation. From this total, 11 individuals were excluded due to did not attend in all stages of the protocol. The final sample consisted of 19 hypertensive women aged 58±5 years (Figure 1). The sample size was defined by convenience.

The controlled group consisted of six women who used antihypertensive medication (Table 1) and had normalized BP levels (≤140/90 mmHg). The decompensated group was composed of eight women who, even using antihypertensive medicine, had high BP levels (>140/90 mmHg). Moreover, the untreated group consisted of five women, who did not take medication and had high BP levels (>150/85 mmHg).

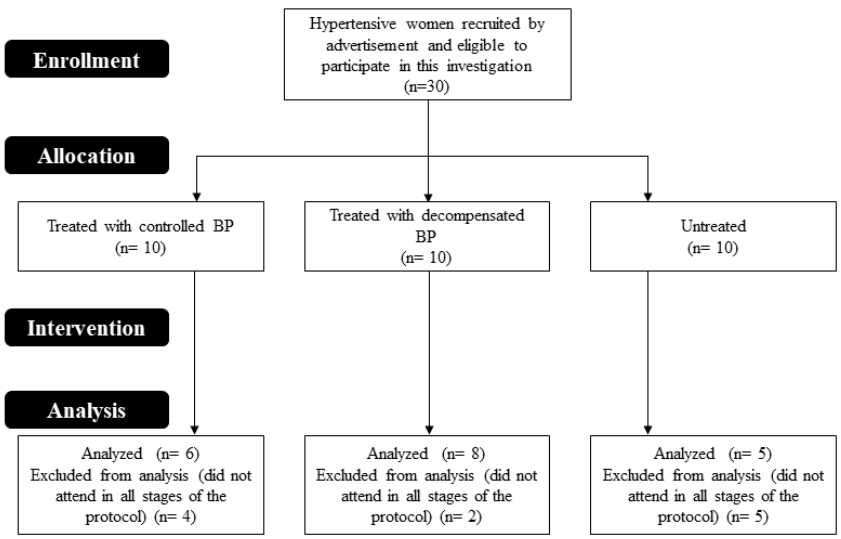

Figure 1 - Flowchart summarizing the enrollment and classification of subjects for this study. BP: blood pressure.

Table 1 - Antihypertensive therapy is currently used by the study participants.

	Controlled (n=6)	**Decompensated** (n=8)
Angiotensin-converting-enzyme inhibitor	33%	0%
Angiotensin-II receptor blockers	17%	12%
Calcium channel inhibitor	17%	12%
Diuretics	33%	37%
AT1 receptor blocker	50%	75%

Data collection procedures

After explaining all the steps of the research to the participants, they signed the informed consent. It was scheduled a visit for anthropometric measurements and familiarization with the exercise protocol, as well as a maximum repetition (1RM) test in an extensor chair. Subjects returned to the laboratory 24-hours after 1RM test to perform a RE session in the same machine, under the monitoring of cardiovascular responses. All procedures were performed in the clinical research laboratory at the Hospital of the University Hospital of Sergipe.

A maximum repetition test

It was shown previously to the individuals the correct execution of the exercise to avoid execution errors during the test and to maintain the pattern of the movement. Besides, the subjects were instructed to perform an expiration during the concentric phase and inspiration during the eccentric phase, at each repetition, to avoid respiratory interruption (Valsalva maneuver).

Individuals underwent specific warmup with 10 repetitions in the extension chair, without load. Then, the subjects performed the 1RM knee extension test following the ACSM guidelines[19]. The 1RM test was done with four attempts and 3-minute intervals between them. The weight was progressively increased until the individual could not do more than one repetition, perfectly and without performing Valsalva Maneuver19. The same evaluator, who was blinded, applied the tests to maintain the methodological standard.

Exercise protocol

The session consisted of warmup (one set of 10 repetitions, no addition of weights), two minutes of rest, followed by three sets of 12 repetitions at 60% of 1RM, with an inter-set interval of 60 seconds and five minutes of recovery, after exercise. The indicated intensity is based on the ACSM guidelines[19], which suggests intensities between 60% and 70% of 1RM for beginners.

All groups were submitted to the same experimental exercise protocol. The velocity of movement was maintained by voice commands, approximately two seconds per repetition (1s in the concentric phase and 1s in the eccentric phase)[5]. The laboratory was kept at the same temperature (25°C) for both 1RM and exercise testing.

Cardiovascular responses

Blood pressure (BP) and heart rate (HR) were measured continuously from rest to recovery period, allowing us to monitor the cardiovascular response during the exercise. Measurements were performed non-invasively using photoplethysmography (Finapress 2300, Ohmeda, Englewood, CO). This technique enables beat-to-beat BP and HR measurements by placing a cuff around the middle phalanx of the left-hand middle finger and electrodes at the heart level. The double product (DP) was obtained by the product of HR and systolic BP (SBP).

For resting HR and BP measurements, the subjects remained seated for 10 minutes in the equipment that was performed in the exercise. As aforementioned, HR and BP were measured continuously, being calculated the average of the last five minutes for resting parameters. It was also registered the highest values reached during the exercise and the values obtained in the last repetition of each set, besides measuring two and five minutes after exercise.

Statistical analysis

The data are presented as the mean and standard deviation. The Shapiro Wilk test was used to verify the normality of the sample. For the statistical analysis of the results, the two-way ANOVA was performed for repeated measurements, followed by the Tukey test. The analyses were done using the software GraphPad Prism 8. Values of $p<0.05$ were considered significant.

Results

The characteristics of the participants are presented in Table 1. The mean age, height, HR, and mean blood pressure (MBP) were similar between the groups. While the mean of body mass and BMI were lower in the untreated group compared to the controlled group. SBP and diastolic BP (DBP), as expected, were higher in the decompensated and untreated groups when compared to the controlled group.

Cardiovascular responses to RE are presented in figure 2. The SBP and DBP were lower at all times in the controlled group when compared to the other groups (Figure 2A and 2B, respectively; $p<0.05$), while the DP was lower in the controlled group at the end of each set, just when compared to the decompensated group (Figure 2D; $p<0.05$). HR was not different between the groups at any time (Figure 2C). An expected increase in the hemodynamic parameters was also seen during the execution of the sets compared with at rest moment of each group (Figure 2A-D; $p<0.05$). More interestingly, any remarkable change was seen in the controlled group, keeping the hemodynamic parameters under control.

Since the hemodynamic recovery immediately after exercise is also an important sign of health, we had measured these parameters two and five minutes following the last set. The untreated group reached a significant reduction of SBP and DBP after two minutes of recovery, while for DP the reduction was seen only compared to the last exercise set. The decompensated group had a reduction of SBP after two minutes compared to the second set and reduction of DP compared to the last set (Figure 2A and 2D, respectively; $p<0.05$). Nonetheless, a marked reduction was also seen after five minutes (Figure 2A-D; $p<0.05$), when all parameters were lower compared to every sets, with exception to HR in the decompensated group (Figure 2C; $p>0.05$).

The peak BP reached during exercise is shown in figure 3. The peak SBP values were lower in all sets in the controlled group

when compared to the other groups (Figure 3A; Decompensated – set 1: p=0.002, set 2: p=0.0007, set 3: p=0.006; Untreated – set 1: p=0.006, set 2: p=0.005, set 3: p=0.004), and there were no significant differences between sets in either group. Whereas the peak DBP values were lower in the controlled group in all sets when compared to the untreated group (Figure 3B; set 1: p=0.02, set 2: p=0.02, set 3: p=0.02) and just lower in the third set compared to the decompensated group (Figure 3B; p=0.03).

Table 2 - Sample characteristics.

	Controlled (n=6)	**Decompensated** (n=8)	**Untreated** (n=5)
Age (years)	59±4	60±5	55±5
Height (cm)	156±5	152±9	154±9
Body mass (kg)	82±15	67±6	60±11*
BMI (kg/m^2)	33±5	29±2	25±5*
SBP (mmHg)	124±14	171±23*	163±11*
DBP (mmHg)	69±6	92±9*	87±18*
MBP (mmHg)	91±15	110±27	102±22
HR (BPM)	78±12	80±15	72±8

*p<0.05 vs controlled. ANOVA one-way followed by Bonferroni posthoc. BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; MBP: mean blood pressure; HR: heart rate.

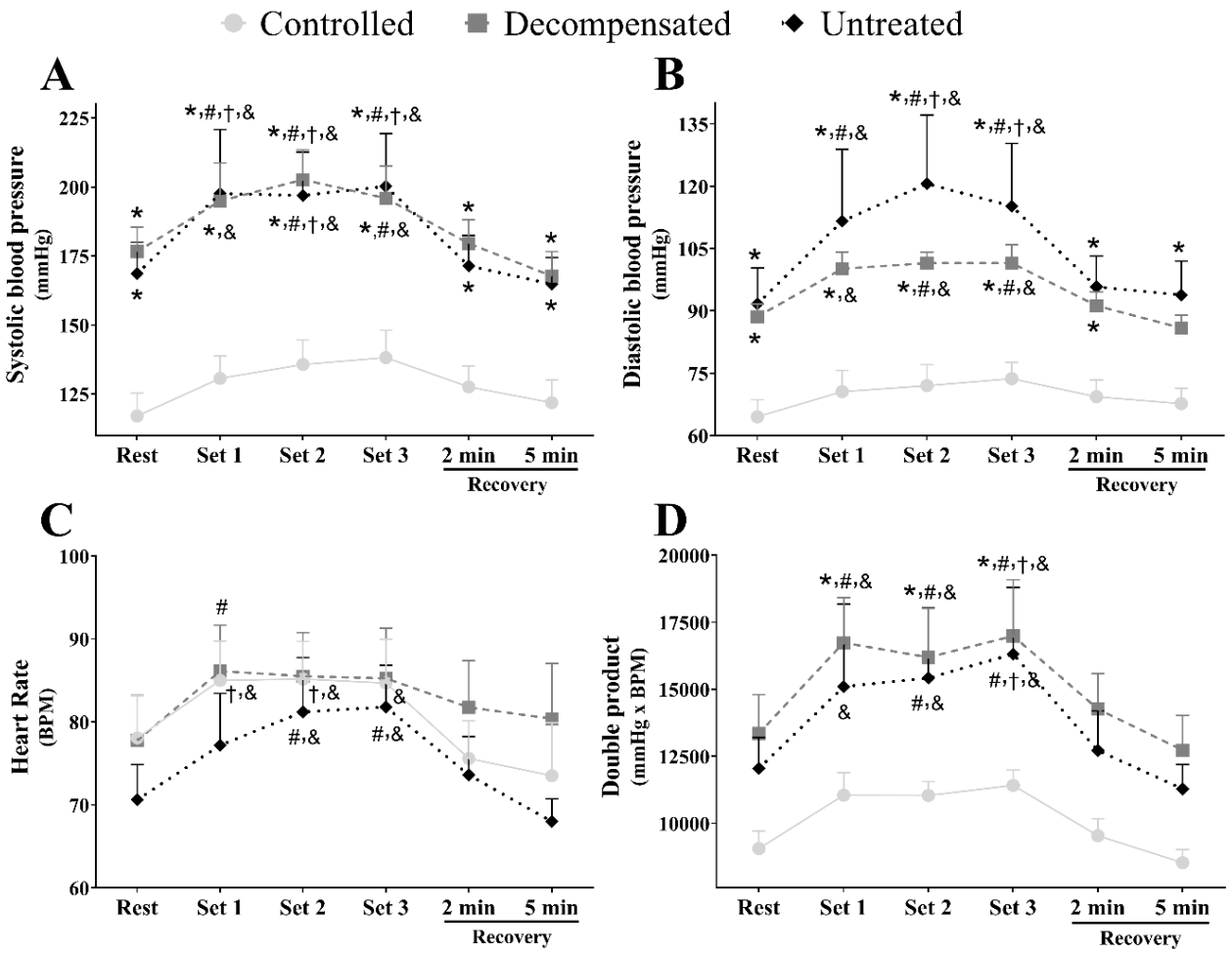

Figure 2 - Acute cardiovascular responses to a session of resistance exercise. *p<0.05 vs controlled; #p<0.05 vs rest, †p<0.05 vs 2 minutes, &p<0.05 vs 5 minutes in the same group. ANOVA two-way followed by Tukey posthoc.

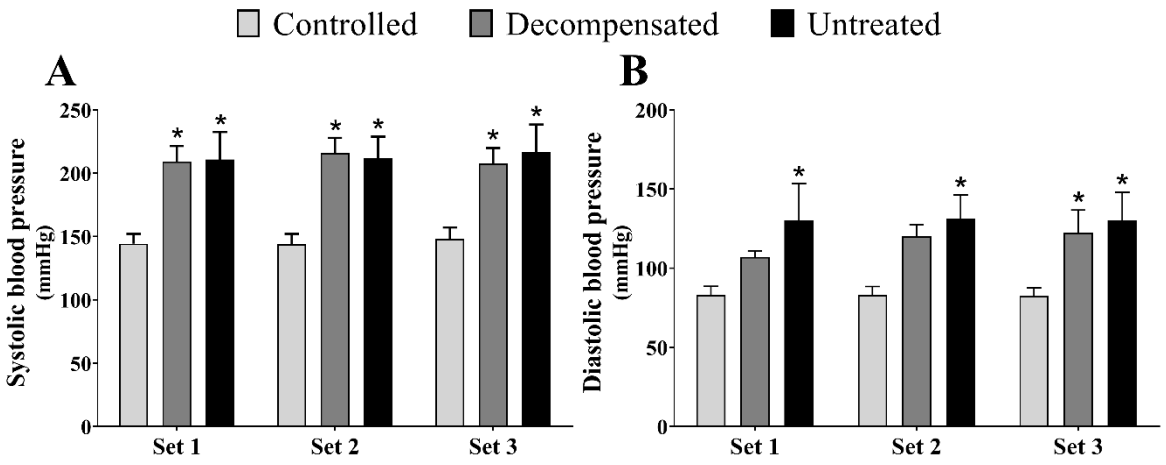

Figure 3 - Peak blood pressure responses during a session of resistance exercise. *p<0.05 vs controlled. ANOVA two-way followed by Tukey posthoc.

Discussion

The main findings of this study showed that RE did not promote a significant BP elevation in hypertensive individuals under effective BP control through antihypertensive medication. Furthermore, pharmacological treatment attenuated pressure peaks during RE in these individuals. Our findings are extremely important as they demonstrate the possibility of prescribing this training modality for hypertensive patients following the ACSM recommendations[19] for prescribing RE for healthy beginners. Thus, making it possible for this type of training to be increasingly used safely as a palliative non-pharmacological intervention for people with hypertension.

Souza et al.[20] found similar results when they had applied a single session of knee extension protocol until fatigue in individuals of both genders (47±2 years). They compared two groups of hypertensive patients. One of them was under pharmacological control (Amlodipine), and the other one was receiving a placebo treatment, after a washout period without taking their medicine for two weeks to eliminate the pharmacological treatment effect. Amlodipine treated patients yielded lower SBP and DBP responses (measured by intra-arterial catheter) during the exercise sets compared to the placebo group. This difference occurred regardless of the exercise intensity (three sets at 40%, three sets at 80%, and one set at 100% of 1RM, with a recovery interval of the 90s).

Using the auscultatory method to measure cardiovascular responses to RE, Miguel et al.[21] compared normotensive and hypertensive women under the use of β-blocker performing a protocol with three sets of 10 repetitions at 80% of 10RM in the 45° leg press, with 30 s rest interval between sets. They showed no significant difference between groups for DBP, but SBP, HR, and DP were lower during RE in hypertensive patients, likely due to β-blocker medication. Battagin et al.[22] also applied RE protocols with three sets of 10 repetitions at 50%, 60%, and 70% of 1RM and 60s recovery interval in hypertensive individuals with controlled BP of both sexes (64±10 years). They verified that, regardless of intensity, RE promoted similar increases and safe levels of SBP. Importantly, the DP seen after exercise is a remarkable effect since RE reduced the myocardial workload. This reduction is likely mediated by the decrease in SBP, as a compensatory response, in which RE induced a reduction in peripheral vascular resistance[23].

We have also analyzed the peak BP and observed that the maximum values of SBP were lower in all sets in the controlled group when compared to the other groups, and there were no significant differences between series in none of the groups. On the other hand, the maximum values of DBP were lower in the controlled group in all sets, when compared to the untreated group ($p<0.05$) and lower in the third series when compared to the decompensated group ($p=0.0346$). Taking into account the current ACSM[19] peak BP recommendation for aerobic exercise cessation, our data clearly show the safety of RE in hypertensive women with controlled BP. While the untreated and decompensated groups exceeded the ACSM recommended values, reaching DBP values above 115 mmHg. Nevertheless, the Brazilian Society of Cardiology Guidelines for Exercise Testing[24] provide a higher threshold for SBP (260 mmHg) and DBP (140 mmHg), in which our data are below.

Nery et al.[25] tested a protocol with three sets of knee extension at 40% and 80% of 1RM, performed to exhaustion. They analyzed cardiovascular parameters by intra-arterial catheter, in hypertensive individuals deprived of medication. They found that RE increased SBP considerably more in hypertensives than in normotensives, and this increase was greater when lower-intensity exercise was performed to the point of exhaustion. Those data corroborate the importance of pharmacological BP control for hypertensive people, such as is demonstrated by our results. In another study, done with hypertensive nonmedicated males (45 ± 8 years), Wiles et al.[26] investigated the isometric wall squat effects on the cardiovascular response, being also found DBP values above ACSMs' threshold.

RE generates a high cardiovascular demand with a consequent increase in BP, and this increase may cause risks for hypertensive patients. The findings of the present study have important clinical implications given the possibility of using this exercise modality without presenting a cardiovascular risk for hypertensive patients with controlled BP. Patients with controlled BP had pronounced protection against high BP peaks during the dynamic RE session. Therefore, allowing the use of RE as an aid in the treatment of hypertension. Furthermore, considering the discrepancies between the ACSM[19] and the Brazilian Society of Cardiology[24] guidelines for exercise testing aerobic capacity, further studies to establish the levels of cardiovascular response that may offer risks associated with RE are needed. Also, more considerable attention from societies that regulate professional practices related to training prescription should be given to this issue. Mainly due to the growing evidence demonstrating the potential of this type of exercise in the control of BP and the consequent growth in the number of hypertensive people doing this exercise modality. Moreover, despite the importance of the finding presented in our study, it was not possible to investigate the effects of different interval times. Thus, further research is warranted to elucidate whether a short recovery time would induce any risk.

Conclusion

Based on the obtained results, it is possible to affirm that if the blood pressure is not controlled previously, the blood pressure increases significantly during the resistance exercise. Pharmacological control was shown to be effective in preventing a massive increase in the cardiovascular parameters during the performance of a resistance exercise session. Thus, we can suggest that effective blood pressure control through pharmacological treatment can reduce the risk of peak pressure during the practice of resistance exercise and be essential in cardiovascular protection during physical exertion.

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