Reduction of Arterial Pressure and Double Product at Rest after Resistance Exercise Training in Elderly Hypertensive Women

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Summary

Background: Due to the existing controversies in literature about the potential benefits of resistance exercise training (RT) on arterial blood pressure (BP) at rest, and the lack of studies conducted with elderly hypertensive individuals, RT is seldom recommended as a non-pharmacological treatment for arterial hypertension.

Objective: To verify the effect of progressive RT on BP, HR, and RPP in elderly women with controlled hypertension.

Methods: 20 elderly women (66.8 ± 5.6 years of age), with a sedentary lifestyle, monitored with anti-hypertensive medication, participated in a 12-week RT program (resistance training group - RTG). Twenty-six elderly women (65.3 ± 3.4 years of age) with controlled hypertension did not engage in physical exercise during the study period, and composed the control group.

Results: After RT, there was a significant reduction in SBP, MBP, and DP values at rest. No significant drops in DBP and HR values at rest were observed after RT in both groups. The reduction in the RTG was 10.5 mmHg, 6.2 mmHg, and 2218.6 mmHg x bpm for SBP, MBP, and RPP, respectively.

Conclusion: Progressive RT reduced SBP, MBP, and RPP values at rest of hypertensive elderly women who were on anti-hypertensive treatment. (Arq Bras Cardiol 2008; 91(5) : 274-279)

Key words: Hypertension; exercise; physical fitness; aging.

Introduction

Over the past years, resistance training (RT) has been recommended as an important component of physical exercise programs for elderly people[1]. Among the benefits of RT, increases in muscle strength and mass are very well documented in literature[2-5]. Additionally, there is evidence that individuals who engage in 30 minutes or more of RT per session may have a 23% reduction in the risk of acute myocardial infarction (AMI) and fatal cardiovascular diseases, when compared to those who do not exercise[6].

On the other hand, there is no consensus in literature as to the potential chronic benefits of RT on arterial blood pressure (BP) at rest. There are studies showing reductions in systolic arterial pressure (SBP) and diastolic arterial pressure (DBP)[7-10], reductions in only SBP values[11], reduction in only DBP values[12], or yet, studies that have not identified changes in SBP after RT[13,14]. Moreover, two meta-analyses determined that there are no significant increases in BP after RT[15,16].

The small number of studies conducted with elderly and hypertensive individuals adds to the problem. According to the literature reviewed, there are only three studies conducted with elderly people[7,10,14] and two studies with hypertensive individuals[12,13] who were engaged in RT. Knowledge of these changes is important, since it has been shown that a reduction of merely 5 mmHg in arterial pressure is sufficient for a 40% reduction in the risk of cerebrovascular accidents, and a 15% reduction in the risk of AMI[16].

Consequently, it is critical to conduct research analyzing the effects of RT in elderly and hypertensive individuals. Thus, the aim of this study was to determine the effects of a 12-week RT program on BP, HR, and rate-pressure product (RPP) at rest in elderly women with controlled hypertension.

Methods

Sample

The study population consisted of elderly female volunteers over 60 years of age who lived in satellite cities of the Federal District, such as Águas Claras, Ceilândia, Gama, Samabaia, Santa Maria, and Taguatinga. The women were recruited at sites and centers of social interaction of this population, such as churches, handcraft groups, dance/*forró* (a type of popular Northeastern Brazilian dance) places, etc. All the elderly

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women were invited to enroll in our research, either as part of the control group or the experimental group. However, only those willing to participate in the research project and who met the inclusion criteria were selected.

The sample consisted of 52 hypertensive women (65.9 ± 4.5 years of age) who had their hypertension controlled with medication; 23 of them were enrolled in the RT program forming the resistance-training group (RTG). The control group (CG), consisting of 29 voluntary women with similar characteristics, but independent from the study population, was instructed to not change their regular activities. The participants were instructed to not change their medication throughout the study.

Before starting the training program, all participants signed the Informed Consent Form, which explained all the procedures to be carried out. This study was approved by UCB's Research Ethics Committee (Process No. 05/2007).

Inclusion criteria were: 60 years of age or older; history of a sedentary lifestyle for at least 6 months before the study (IPAQ long version); previously diagnosed blood hypertension (BP<140/90 mmHg) controlled with anti-hypertensive agents. Before starting the training program, all participants presented a release document signed by their physicians allowing them to engage in the resistance exercise training. Additionally, as an extra safety measure, all of them performed a maximal treadmill stress test to check for cardiac problems.

Exclusion criteria were medical contraindications to resistance training exercises, such as: non-controlled arterial hypertension, congestive heart failure, recent myocardial infarction, major joint impairments, among other diseases that could compromise cardiovascular responses, besides severe exertion electrocardiographic abnormalities.

Hemodynamic measurements

SBP, DBP, MBP, (calculated as per the DBP – 0.33 x SBP-DBP formula), HR, and RPP (SBP X HR) measurements were taken at rest before and after the 12 weeks of RT. The variables were measured after 5, 15, and 20 minutes of rest. The mean value of the three measurements was considered to establish values at rest. In order to minimize any potential acute effect on the variables, measurements were taken 48 hours after the last session of resistance training.

BP and HR measurements were taken with the automatic digital *Microlife*® device, BP 3AC1-1 model, validated according to the British Association of Cardiology specifications for measurements taken at rest[17], always by the same researcher and at the same time of the day.

The procedures to measuring BP were based on the VII Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (2003)[18], which recommends that the individual be seated, with feet on the floor and with the arm supported at heart level.

Exercise training program

Before RT, volunteers underwent a three-week-long period of adaptation to the exercises in order to learn the correct technique of the movements.

After the process of adaptation, one-repetition-maximum tests were performed (1-RM). No tests were performed for shoulder weight abduction, abdominal crunch, trunk extension, and standing calf exercises. Each individual had a maximum of five attempts to perform each exercise with an interval of 3 to 5 minutes between each attempt. The maximum weight lifted in one single repetition was defined as their maximum load.

The RT program performed during 12 weeks, three times per week on alternate days, consisted of three series of 12, 10, and 8 repetitions. Intensity training varied at different stages of the program. In the first four weeks, the intensity was 60% of 1-RM; in the following four weeks, 70% of 1-RM, and in the last four weeks, 80% of 1-RM. The training method chosen was alternate segments with exercises performed at random, provided the leg press was the last one to be performed.

The training program consisted of the following exercises: lateral pull down, knee extension, chest press, leg abductor chair, knee flexion, shoulder abduction (w/dumbbell), standing calf raise, abdominal exercises, trunk extension, and 45-degree leg press. The strength training equipment used for muscular development was *Righetto*®, HighOn line. The speed execution of the exercises was 2:2 with a 60-second rest interval during the first eight weeks, and 90 seconds during the last four weeks. Before and right after each session, stretching exercises targeting all the major muscle groups involved in the training program were performed.

Statistical analysis

Tabulation of results was carried out by the author of the study using the 2003 version of Excel software. Before beginning data analysis, a descriptive detailed examination was carried out aimed at finding potential errors in recording of the results. Two statistical software packages were used for the statistical analysis: Statistica 5.0 and SPSS 13.

The normality and homogeneity of data variance were analyzed using Shapiro-Wilks[19] and Levene[20] tests, respectively. The Chi-square test was used to compare the prevalence of cardiovascular risk factors and of the medication used between RTG and CG. Student's t test was used to assess the differences in clinical characteristics between RTG and CG.

For data analysis purpose, the following were considered dependent variables: SBP (continuous quantitative variable), DBP (continuous quantitative variable), MBP (continuous quantitative variable), HR (continuous quantitative variable) and RPP (continuous quantitative variable); and as independent variables: group (nominal qualitative variable) and time (ordinal qualitative variable)[21]. The effect of training on all variables except the double product was analyzed using the Two-way ANOVA test[20] (group x training). As to the DP variable, a difference was observed between the groups before the training, and the Two-way ANCOVA test was chosen for the analysis[22] (group x training). For both analyses, when the F value was significant, the *post hoc* Newman-keuls test[23] was used to identify differences.

The significance level adopted for all analyses was $p<0.05$. All values are expressed as mean ± standard deviation.

Results

Table 1 shows the clinical characteristics of RTG and CG. No differences between the groups were observed in the variables evaluated.

Of the 23 elderly women in RTG, 20 completed the training program with no problems resulting from the intervention. Reasons for abandoning the program included family problems and gallbladder surgery to be performed within a short time. Three CG participants left the study due to family problems. Therefore, the final sample consisted of 20 elderly women in RTG and 26 in CG.

Compliance with RT was 96% in RTG. As to CG, compliance during the study was 98%. Table 2 displays the results.

According to the results in Table 2, RT significantly reduced the SBP values at rest (time x group interaction: $F=11.5$; $P<0.01$), MBP (time x group interaction: $F=6.7$; $P<0.01$), and RPP (time x group interaction: $F=18.4$; $P<0.01$). No significant reductions were found in DBP and HR values at rest of RTG and CG.

Table 1 – Clinical, anthropometric, hemodynamic, pathological, and drug therapy characteristics of the resistance training group (RTG) and control group (CG) before the start of the intervention

Variables	RTG (n=20)	CG (n=26)	p
Age (years)	66.8 ± 5.6	65.3 ± 3.4	ns
Weight (Kg)	65.0 ± 14.5	66.9 ± 11.1	ns
Height (cm)	151.8 ± 7.9	153.7 ± 4.8	ns
BMI (Kg/m2)	28.3 ± 5.8	28.3 ± 4.2	ns
SBP (mmHg)	125.2 ± 9.3	124.6 ± 10.1	ns
DBP (mmHg)	72.0 ± 6.8	74.2 ± 7.3	ns
MBP (mmHg)	89.7 ± 6.9	90.8 ± 7.5	ns
Comorbidities			
Diabetes mellitus (%)	85.0	73.1	ns
Obesity (BMI>30kg/sqm) (%)	35.0	30.4	ns
Osteoporosis (%)	65.0	73.1	ns
Cholesterolemia (%)	70.0	50.0	ns
Anti-hypertensive drugs			
β-blockers (%)	5.0	11.5	ns
Associations with β-blockers (%)	30.0	23.1	ns
Calcium channel blockers (%)	15.0	11.5	ns
Angiotensin conversion enzyme inhibitors (%)	10.0	11.5	ns
Diuretics (%)	10.0	11.5	ns
Other associations (%)	30.0	30.8	ns

BMI - body mass index; SBP - systolic blood pressure; DBP - diastolic blood pressure; MBP - mean blood pressure

In the RTG, the drop with training was of 10.5 mmHg in SBP, 6.2 mmHg in MBP, and 2218.6 mmHg x bpm in RPP, representing reductions of 9.2%, 7.4%, and 33.0% in SBP values (Chart 1), MBP (Chart 2), and RPP (Chart 3), respectively.

Although the pre-training values in the variables of both groups had shown no differences except for RPP ($P<0.01$), post-training values were significantly lower in RTG as compared to CG for SBP (114.7 ± 9.2 *vs* 123.3 ± 13.5 mmHg; $P<0.01$), MBP (83.5 ± 8.1 *vs.* 89.8 ± 8.8 mmHg; $P<0.01$), and RPP (6816.2 ± 1392.0 *vs.* 9140.7 ± 1446.6; $P<0.01$).

Discussion

The results of this study have shown that 12 weeks of RT promoted significant reductions in SB, MBP, and RPP values at rest in elderly people with controlled hypertension. Moreover, it is important to stress that no adverse effects occurred during the resistance training sessions, which shows that this type of training is safe for the hypertensive elderly population.

Our results are relevant considering that the reduction in BP after RT may reduce the risks for cardiovascular events[18]. It has been suggested that the reduction of merely 5 mmHg in arterial blood pressure leads to a 40% reduction in the risk of cerebrovascular accidents, and a 15% reduction the risk of acute myocardial infarctions[16]. In this study, benefits could have been even greater since reductions observed at rest were greater than 5 mmHg for SAP and MAP.

The reduction of SBP after RT observed in our study is greater than the values found in literature (-3.2 mmHg)[10,15,24,25], and similar to some of the results achieved with aerobic training[25]. SBP and DBP values with aerobic training ranged from -20.0 to + 9.0 mmHg for SBP[25]. No mean values were found for MBP and RPP.

Our results of reduced SBP at rest are consistent with the results of several studies[7-10], thus indicating that RT may actually have a hypotensive effect on SBP and MBP values at rest. However, it is noteworthy that some authors did not observe a reduction in SBP values after RT[13,14,26,27]. As to DBP, the results found in this and other studies[11,14,26] have not indicated reductions in DBP values after a RT program. Nevertheless, a drop in DBP values after RT has been reported in other few studies[10,12]. These controversies can be attributed at least partially to two factors: the characteristics of the sample and the training program used.

This is the only study that has analyzed the effects of RT in elderly women with controlled hypertension. Moreover, the intensity of the training program used in this study varied throughout the program. Perhaps this type of training leads to adaptations different from those observed after a non-varied training program. However, further studies are needed to corroborate this hypothesis.

The mechanisms involved in the reduction of BP levels after RT have not been investigated. Although no one study in literature has investigated these mechanisms, it has been suggested that the control of BP after a RT program can be the result of a sum of acute effects from several strength exercise sessions[28,29]. In this sense, there is a study that has

Table 2 – Effect of twelve-week intervention on systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MBP), heart rate (HR), and rate-pressure product (RPP) in the resistance training group (RTG) and control group (CG)

	RTG	CG	ANOVA	F	p
SBP (mmHg)					
Pre-training	125.2 ± 9.3	124.6 ± 10.1	Group	1.9	0.2
Post-training	114.7 ± 9.2 * †	123.3 ± 13.5	Time	18.8	0.01
Δ%	-9.2% *	-1.1%	Interaction	11.5	0.01
DBP (mmHg)					
Pre-training	72.0 ± 6.8	74.2 ± 7.3	Group	1.1	0.3
Post-training	71.04 ± 7.9	73.3 ± 7.5	Time	1.2	0.3
Δ%	-1.4%	-1.2%	Interaction	0.0	1.0
MBP (mmHg)					
Pre-training	89.7 ± 6.9	90.8 ± 7.5	Group	2.9	0.1
Post-training	83.5 ± 8.1* * †	89.8 ± 8.8	Time	13.0	0.01
Δ%	-7.4% *	-1.1%	Interaction	6.7	0.01
HR (bpm)					
Pre-training	72.2 ± 12.0	74.1 ± 10.1	Group	0.3	0.6
Post-training	72.7 ± 10.1	74.0 ± 9.4	Time	0.0	0.9
Δ%	0.7%	-0.1%	Interaction	0.0	0.9
RPP (mmHg x bpm)					
Pre-training	9034.8 ± 1512.9 * †	9219.8 ± 1357.7	Group	12.0	0.01
Post-training	6816.2 ± 1392.0 * †	9140.7 ± 1446.6	Time	21.2	0.01
Δ%	-33.0% *	-0.9%	Interaction	18.4	0.01

**: significant difference as to pre-training, P<0.01; †: significant difference as to CG post-training, P<0.01; ‡: significant difference as to CG pre-training, P<0.01.*

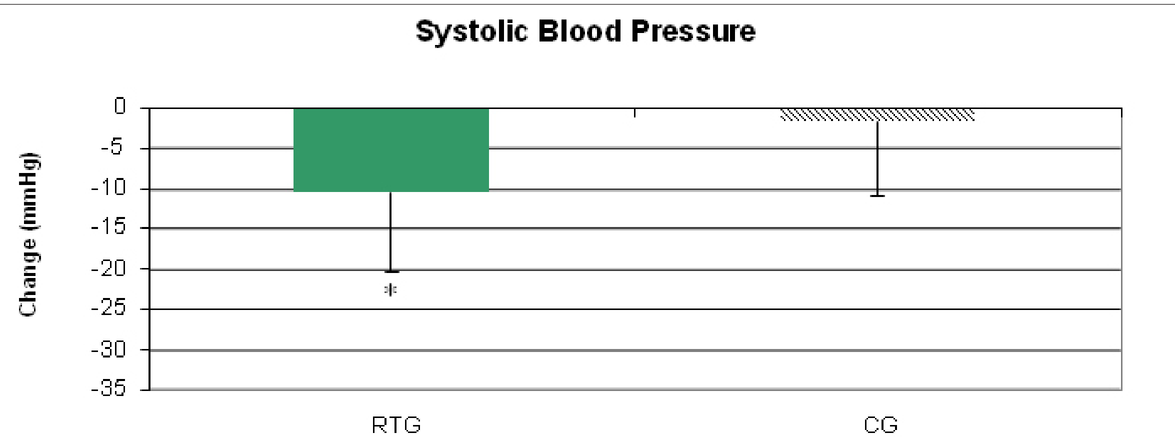

*Chart 1 – Effect of twelve-week intervention on systolic blood pressure (SBP) in the resistance-training group (RTG) and control group (CG); ** ***Significantly different from pre-training (P<0.01)***

investigated the mechanisms involved in the drop of BP values after strength training performed at 40% and 80% 1-RM[30]. Results found have shown that the reduction in BP values after an exercise training session results mainly from the drop in cardiac output. The reduced cardiac output, on the other hand, is mediated by a reduced ejection fraction (probably due to a drop in venous return), and increased HR (caused by increased sympathetic nervous activity). In this study, however, no reduction was observed in HR, suggesting that the drop in BP induced by RT can be the result of other mechanisms not yet fully understood. Additionally, it is important to stress that the only study[30] performed was undertaken with young

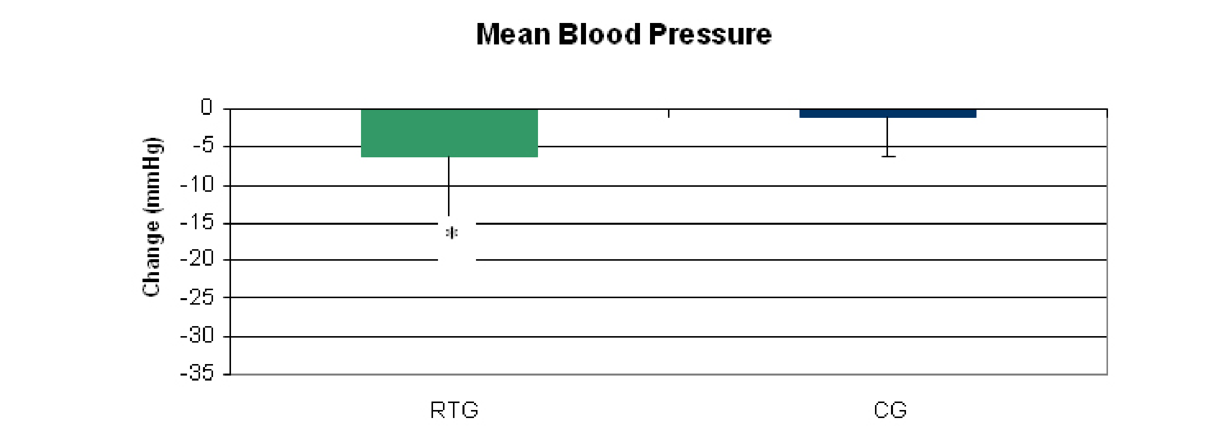

*Chart 2 – **Effect of twelve-week intervention on mean blood pressure (MBP) in the resistance-training group (RTG) and control group (CG); Significantly different from pre-training (P<0.01)***

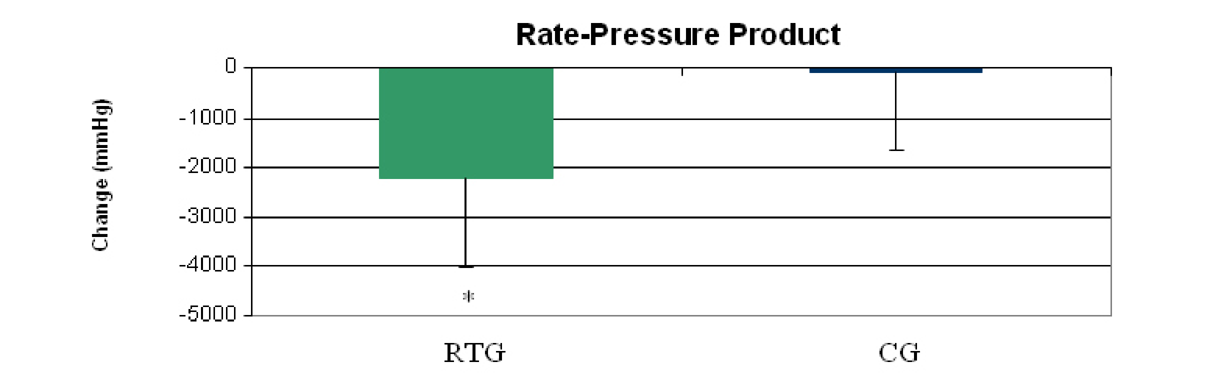

*Chart 3 – **Effect of twelve-week intervention on rate-pressure product (RPP) in the resistance-training group (RTG) and control group (CG); * Significantly different from pre-training (P<0.01)***

normotensive individuals, and it is likely that the mechanisms involved in controlling BP in elderly people are different due to age and the presence of health conditions such as systemic arterial hypertension[31]. Therefore, we suggest that further studies be conducted to analyze the mechanisms involved in reducing BP after RT in elderly people.

An important finding in this study was the reduction of RPP after RT, since no studies were found in literature that verified the response of RPP after RT. The reduction of RPP at rest plays a significant role in reducing risks of cardiovascular problems[31]. Thus, it seems that RT can lead to a reduction in cardiovascular work. This reduction, on the other hand, seems to be mediated by the reduction in SBP, since no significant changes were observed in HR.

A potential limitation of this study was the utilization of anti-hypertensive agents, such as beta-blockers. The use of medication does not allow the determination of the isolated effects of physical exercise on BP, HR, and RPP, but rather the effect of the association of exercise training and medication. On the other hand, the inclusion of elderly women who are on anti-hypertensive medication allows greater practical applicability of the results found, since it is known that most hypertensive individuals use drug therapy to control the condition. Additionally, no differences were observed between RTG and CG in the ratio of individuals medicated, which reduces the chances of any changes in BP having occurred due to drug effect alone. Another limitation in this study was that training was conducted at different intensities. For this reason, the reduction in BP values at rest cannot be attributed to any of the training intensities used. For this, besides the CG, a separate group would be needed for each exercise intensity.

Conclusion

RT reduced SBP, MBP, and RPP values at rest of elderly women with hypertension controlled with anti-hypertensive medication. This reduction in values can help reduce the risk of acute myocardial infarction and coronary diseases. Thus, RT can be used as a non-drug therapy, not only to prevent but also to treat and control systemic arterial hypertension. Despite the resistance to prescribe RT for elderly individuals, this type of training seems to be safe and effective for elderly hypertensive citizens.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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