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ORIGINAL RESEARCH

Sustained effect of resistance training on blood pressure and hand grip strength following a detraining period in elderly hypertensive women: a pilot study

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Introduction: Hypertension is the most prevalent modifiable risk factor with a high prevalence among older adults. Exercise is a nonpharmacological treatment shown to benefit all patients with hypertension.
Objective: This study examined the effects of a 14-week moderate intensity resistance training program (RT) on the maintenance of blood pressure and hand grip strength during an extended detraining period in elderly hypertensive women.
Methods: Twelve hypertensive sedentary elderly women completed 14 weeks of whole body RT at a moderate perceived exertion following a detraining period of 14 weeks.
Results: Following the training period, participants demonstrated an increase in absolute hand grip strength (P=0.001), relative hand grip strength (P=0.032) and a decrease of systolic (P=0.001), diastolic (P=0.008), and mean blood pressure (P=0.002) when compared to pre-exercise values. In addition, these effects were sustained after 14 weeks of detraining.
Conclusion: Resistance training may be a valuable method to improve muscular strength and blood pressure in elderly people with benefits being maintained up to 14 weeks following training cessation.
Keywords: aging, resistance training, hypertension, detraining, elderly

Introduction

Hypertension is the most prevalent modifiable risk factor for cardiovascular morbidity and mortality worldwide, with a high prevalence among older adults (≥65 years).[1] Some factors like endothelial dysfunction and increased arterial stiffness contribute to the increased prevalence of hypertension among the elderly, particularly systolic hypertension, while alarming data revealed a 68% prevalence of hypertension in elderly persons from Brazil.[2]

Nonpharmacological treatment, including exercise, has been shown to benefit all patients with hypertension, including elderly women. It has been suggested that resistance training (RT) can be a nonpharmacological intervention to prevent and treat high blood pressure.[3] This method of training has positive effects on functional capabilities and limitations of the elderly by increasing muscular strength, cardiovascular function, decreasing coronary artery disease (CAD), and preventing hypertension.[4–7] Moreover, studies have shown that there is a correlation between low muscular strength and degenerative conditions, such as sarcopenia, cognitive decline, cancer, CAD, disability, and eventually mortality.[8–13]

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For individuals who exercise, regardless of age, it is reasonable to assume that at some point, periods of training cessation or inactivity will occur. Among all age groups, older individuals have a higher propensity for training disruptions due to planned or unplanned factors, ranging from illness to vacations.[14]

It has been shown that muscular strength in older subjects can be maintained above baseline levels for 12–48 weeks of detraining following an RT program, while systolic (SBP) and diastolic blood pressure (DBP) can be maintained below baseline levels following four weeks of detraining in hypertensive middle-aged men.[15,16] Although there is evidence that the sustained effect of exercise on strength can be maintained for an extended period after training cessation, to the best of our knowledge, only one preview study verified the effect of training cessation on blood pressure. Additionally, no studies to date have examined the chronic effects of RT on blood pressure (BP) and muscular strength following a detraining period in elderly sedentary hypertensive women.[14–17]

Therefore, the aim of the present study was to investigate what effect a 14-week moderate intensity RT program would have on BP and muscular strength during an extended detraining period in elderly hypertensive sedentary women. The initial hypothesis was that BP and muscular strength would improve in response to RT and these beneficial effects would be sustained during the detraining period.

Materials and methods

Subjects

The sample of this study consisted of 12 elderly women (67.6±6.4 years; height, 1.51±0.05 m; weight, 62.75±11.78 kg; and body mass index, 27.49±5.81 kg/m²) from the local community. As stated by the Brazilian Ministry of Health under ordinance 1395/GM 1999, an older person is considered to be anyone aged 60 years or older. Additionally, all participants had to be sedentary, ie, someone who had not been engaged in regular exercise programs for at least six months prior to the study (<2 hours/week) and hypertensive stage 1.[18] All subjects were recruited through advertisements placed in the local community. According to the criteria set by the American College of Sports Medicine, the participants were considered "untrained."[19]

The exclusion criteria were: women younger than 60 years, undiagnosed hypertension, SBP greater than or equal to 160 or DBP greater than or equal to 100 mmHg, smoking history, cardiac arrhythmia, arterial coronary disease, history of acute myocardial infarction, stroke, congestive heart disease, and physical disabilities. The selection of the participants is presented in Figure 1.

The study was conducted at the strength training laboratory of the Euro American University Center (UNIEURO), from June 2011 to February 2012. According to the research involving humans of Resolution 196/96 on the National Health Council and Declaration of Helsinki,[20,21] all subjects were informed of the procedures and provided with a written informed consent to participate in the study. All methods and procedures were approved by the Research Ethics Committee of the UNIEURO (Protocol number 154/2011).

BP measurement

The procedures for BP measurement both before and after training, as well as during detraining were based on the guidelines set forth by the VII Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, which recommends a seated position with uncrossed legs, feet flat on the floor, and left arm supported at heart level.[18] Additionally, BP was measured with a calibrated automated oscillometric noninvasive validated BP device (model Microlife BP 3BTO-A, Onbo Electronic, Shenzhen, Co., Ltd).[22] The values of SBP and DBP were used to calculate the mean blood pressure (MBP) utilizing the formula:

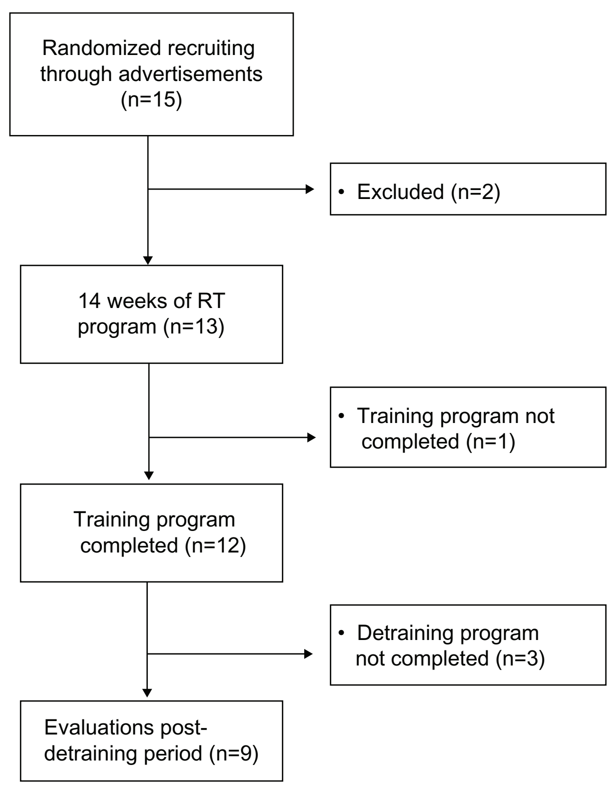

Figure 1 Scheme of the selection of the volunteers.
Abbreviation: RT, resistance training.

MBP = DBP + (SBP – DBP)/3. All BP (SBP and DBP) measures were assessed in triplicate (measurements separated by 1 minute) with the mean value used for analysis.

The elderly women were instructed beforehand not to carry out any kind of vigorous physical activity or ingest alcoholic and caffeinated beverages for 24 hours prior to the measurement days. All measurements of BP and grip strength were performed by the same researcher at the same time of day (between 2 pm and 4.30 pm) under controlled room temperature.

Hand grip strength (HGS) measurement

Isometric HGS was determined by the use of a hand grip dynamometer (TKK, GRIP D; Takei Scientific Instruments Co, Niijata, Japan) used in previous studies.[8,23] The three measures on the right and left hand were averaged to get the absolute HGS. The hand position and nail length were adjusted individually and a 1 minute rest period between measurements was adopted.[24] To calculate the relative HGS (HGS/kg), the HGS was divided by the individual's body weight in kilograms.[25]

Resistance training program

Subjects completed 2 weeks of familiarization prior to the RT program and were advised regarding the execution of proper technique and use of rating of perceived exertion (RPE). Sessions were completed twice each week with each exercise consisting of a single set of 15 repetitions.

The RT program was conducted two times per week over 14 weeks, consisting of three sets with a training zone of eight to twelve repetitions, at a moderate intensity, using a modified version of perceived exertion (1–10 point scale).[26–28] Although tolerance to the higher loads was observed, the same intensity (according to RPE) was used during the 14 weeks of resistance training. The training sessions were conducted during the same time of day (between 2 pm and 4.30 pm). Each training session began with 15 minutes of stretching with an emphasis on the ankle, hip, and lumbar joints followed by a warm up of 5 minutes on a treadmill walking with a standard speed of 4.0 to 5.0 km/h.[29] The exercises were performed on fitness machines (Johnson Health Technologies Inc, Taiwan) in the following order: seated bench press, rotary cuff, leg extension, leg curl, leg press, and front lat-pull down. The rest interval between sets and exercises was 2 minutes. The participants were instructed to avoid the Valsalva maneuver during exercises. The ratio of supervision was one instructor to every five participants (1:5).

Diet and physical activity control

No dietary advice was provided, and during the training and detraining period, participants were allowed to maintain any recreational activities they were currently involved in, but were discouraged from participating in any new activities or regular exercise training. Following 14 weeks of detraining, the subjects were reassessed with identical procedures at similar times of the day as the training phase.

Statistical analysis

The statistical analysis was initially done by the Shapiro–Wilk normality test and by the homoscedasticity test (Mauchly test). All variables presented normal distribution and homocedasticity. A repeated measures analysis of variance was used, and when the differences presented significance, the Bonferroni post hoc test was applied.[30] The intention to treat analysis was completed to account for missing data due to participant withdrawal.[31] The differences in the percent changes from pre-training to post-training and from pre-training to detraining were analyzed by the formula: (initial score – final score)/initial score ×100. To calculate the effect size, the eta (n^2) demonstrated by Statistical Package for Social Sciences (SPSS, Inc., v. 18.0; IBM Corporation, Armonk, NY, USA) was utilized. For determination of the magnitude of effect sizes the following values were used. Small (0.20–0.49), moderate (0.5–0.79), and large (0.8).[32] Considering a power of 80%, an alpha error of 0.05, number of groups (n=1), measurements, and a direct partial n^2 of 0.65 demonstrated in this study, the sample size necessary to detect differences of 5 mmHg within moments during the entire study period for the main variable SBP was calculated to be seven individuals.

An alpha level of $P \leq 0.05$ was considered statistically significant for all comparisons. The software SPSS (Inc., v. 18.0, IBM Corporation) and G*Power 3.1.6[33] was used for all statistical analysis and power calculations.

Results

A total of 15 participants agreed to participate, with twelve completing the 14-week RT program. Three participants were excluded and only one unspecified absence (personal reasons) occurred among the remaining twelve participants during the 14-week RT program. During the detraining period, nine participants completed the evaluations and three participants could not due to eye surgery (n=2) or vacation (n=1). All subjects who participated in the RT sessions did not exhibit any problems or adverse events associated with the intervention. The listing of the participants' medications is shown in Table 1. In addition, no medications changed during the study.

Table 1 Frequency and percentage of the medications consumed by the participants

List of antihypertensive drugs	Frequency	Percent (%)
Treatment of cholesterolemia (statins)	7	54
Angiotensin converting enzyme inhibitors	6	46
Treatment for osteoporosis (bisphosphonates)	4	31
Anti-inflammatory	4	31
Antihypertensive adrenergic β-blockers	3	23
Diuretics	3	23
Antidepressive drugs	3	23
Treatment of diabetes mellitus	2	15
Antivertigo	2	15
Antihypertensive associations	2	15
Antiarrhythmic drug	1	8
Anxiolytic	1	8
Treatment of glaucoma	1	8
Treatment of ulcers	1	8
Antipsychotic	1	8
Calcium channel blockers	1	8
Hormonal replacement	1	8

After 14 weeks of RT and 14 weeks of detraining, SBP (P=0.001, P=0.008, F[2.16] =15; P=0.001, effect size [ES] =0.65) and MBP (P=0.002, P=0.012, F[2.16] =11; P=0.001, ES =0.46) decreased significantly when compared with pre-training (Table 2 and Figure 2). DBP decreased after the training period when compared with pre-training (P=0.008, F[2.16] =7; P=0.007), although there was no significant difference in DBP during the detraining period (P=0.058, ES =0.46); it remained 13% lower when compared to pre-training values (Table 2 and Figure 2).

Following the 14 weeks of RT, relative HGS increased when compared with pre-training measures (P=0.032, F[2.16] =5; P=0.016), although there was no difference in relative HGS after the detraining (P=0.34, ES =0.59). It remained 6% higher when compared with pre-training values (Table 2 and Figure 3). The absolute HGS was higher in the post-training and detraining periods when compared with pre-training values (P=0.005 and 0.017, F[2.16] =13; P=0.001, ES =0.75) (Table 2).

Table 2 Hemodynamic parameters at pre-training, post-training and detraining

	Pre-training	Post-training	Detraining	n^2
SBP (mmHg)	130.60±8.05	112.50±9.66*	115.90±9.78*	0.65
CI 95%	125.25–137.63	106.66–118.22	108.37–123.40	
DBP (mmHg)	80.60±7.55	70.50±9.51*	69.70±7.12	0.46
CI 95%	73.77–85.33	62.22–74.66	64.19–75.14	
MBP (mmHg)	97.30±6.62	84.50±9.11*	85.10±7.24*	0.58
CI 95%	91.72–101.98	77.14–89.08	79.51–90.63	
HGS (kg)	20.20±3.69	24.10±4.11*	22.60±3.58*	0.75
CI 95%	17.48–21.34	21.36–26.08	19.88–25.38	
HGS/kg	0.33±0.07	0.39±0.08*	0.36±0.09	0.59
CI 95%	0.27–0.37	0.32–0.44	0.29–0.43	

Notes: Data are reported with mean and standard deviation. *P<0.05 from pre-training.

Abbreviations: CI, confidence interval; DBP, diastolic blood pressure; SBP, systolic blood pressure; HGS, absolute hand grip strength; HGS/kg, relative hand grip strength during 14-week training followed by 14-week detraining; MBP, mean blood pressure; n^2, eta squared.

Discussion

The aim of the present study was to investigate the effect of a 14-week moderate intensity RT program on the maintenance of BP and HGS during an extended detraining period in older hypertensive sedentary women. Confirming the initial hypothesis, after 14 weeks of detraining, SBP and MBP remained statistically significant compared to pre-training values, while the absolute HGS remained statistically significant compared to the pre-training values. Besides, the clinical significance demonstrated by the effect size remained above 0.5 for the SBP, MBP, HGS, and HGS/kg. Only for DBP was the effect small.

Although the ES is a measure of importance, it may not be clinically relevant.[34] We previously commented that an ES above 0.5 was observed for SBP among other variables, while a small ES was found for DBP. Despite the low magnitude of DBP effect sizes during the detraining period when compared to post-training, a small reduction of 2 mmHg in the DBP and SBP could help prevent CAD and stroke events.[35,36]

To the best of our knowledge, no previous study has evaluated the effect of RT followed by a detraining period on BP and HGS in elderly hypertensive sedentary women. The results of the present study revealed that even after a 14-week detraining period following RT, hypertensive older women were able to maintain the benefits on BP and muscular strength. Recently, Moraes et al[15] found a decrease of 16 mmHg in SBP of hypertensive middle-aged men after 12 weeks of RT. Moreover, the benefits of BP reduction achieved with RT training were sustained for up to 4 weeks without exercise. However, in contrast to the present study, the population was middle-aged men (46±3 years), with a shorter detraining period of 4 weeks and participants had all antihypertensive medications gradually withdrawn. The study by Moraes et al[15] is the only one that evaluated the effects of detraining (4 weeks) on BP in hypertensive individuals. Despite the clinical effect found (decreased BP sustained), the effects of RT cessation on BP without a washout period (medication withdraw) in elderly hypertensive women were poorly understood.

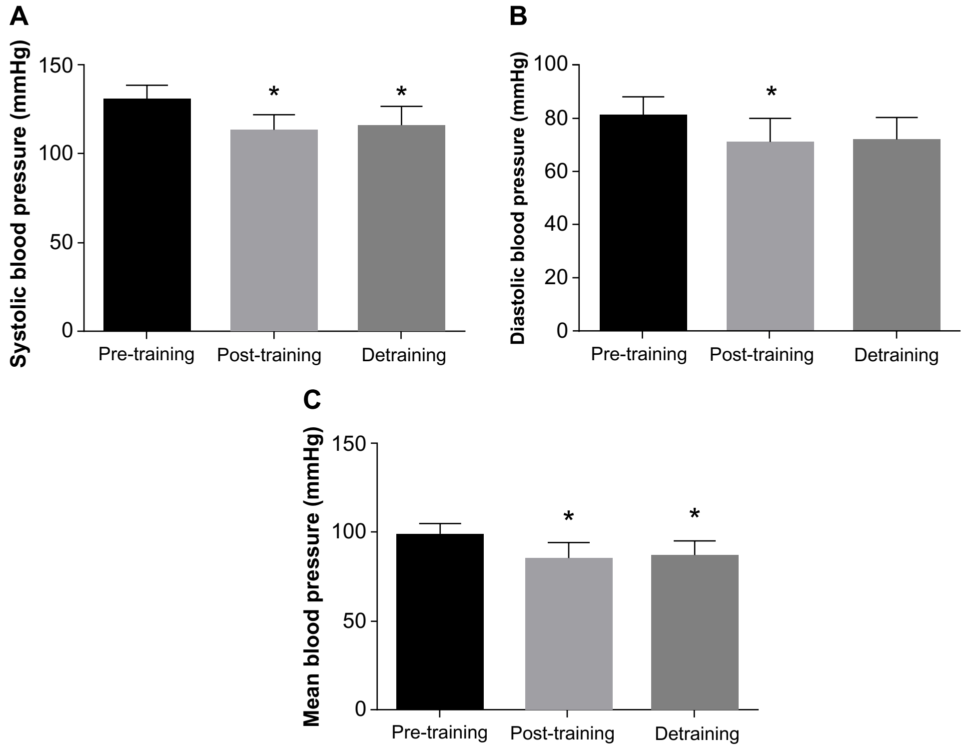

Figure 2 Blood pressure changes in elderly sedentary hypertensive women.
Notes: (**A**) Systolic blood pressure, (**B**) diastolic blood pressure, and (**C**) mean blood pressure during 14 weeks of resistance training followed by 14 weeks of detraining. Data are presented as mean ± standard deviation. *denotes $P<0.05$ versus pre-training.

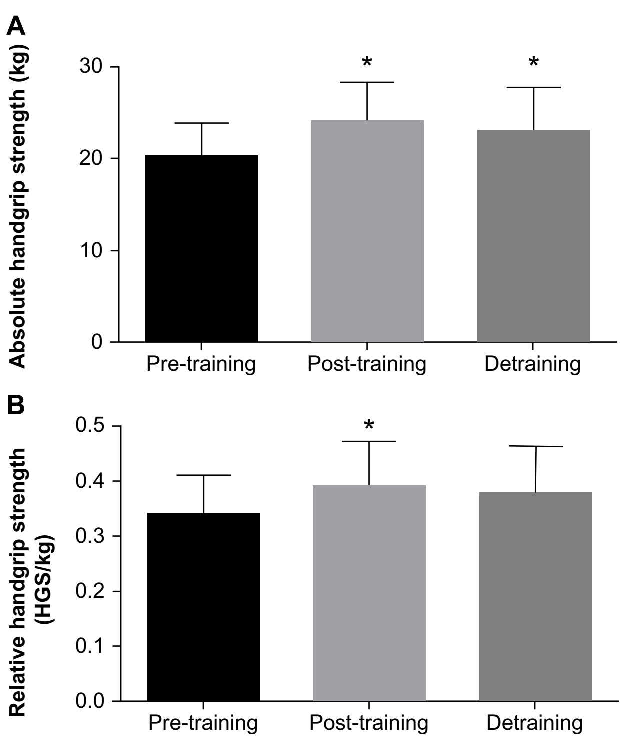

Figure 3 Hand grip strength changes in older sedentary hypertensive women.
Notes: (**A**) Absolute hand grip strength and (**B**) relative hand grip strength during 14 weeks of resistance training followed by 14 weeks of detraining. Data are presented as mean ± standard deviation. *denotes $P<0.05$ versus pre-training.

The potential mechanisms underlying the reduction and maintenance of BP following the detraining period have been previously studied. Some proposals indicate that reduction in peripheral vascular resistance by a decline in cardiac output, a release of vasoactive factors, an increase in baroreflex sensibility, and greater participation in physical activities unrelated to RT might be involved.[16]

For muscular strength, although measured by hand grip, our results are in accordance with previous results that show elderly individuals display decreased neuromuscular performance after a period of detraining, but retain higher values than pre-training levels. Correa et al[37] performed a similar longitudinal protocol using elderly women that consisted of twelve weeks of an RT program twice a week followed by twelve weeks of detraining. The results of this study found that strength gains were partially maintained following the detraining period. Lovell et al[38] found similar results in older men following four weeks of detraining. Furthermore, previous studies have shown that the muscular strength of elderly individuals, when subjected to RT of moderate to high intensity, can be maintained above baseline levels during 12 to 48 weeks of detraining.[16,17] Although, similar results were found for muscular strength, it is difficult to compare the data collected in this study with other studies because tests that involve one or more maximum repetitions were not utilized and the intensity control during the training period was made by participant self-report using an RPE scale, which results in higher intersubject variability.

The accurate measurement of muscle strength requires expensive equipment, and the results have low applicability when compared to simple measures of muscle strength utilizing HGS. HGS is strongly associated with muscle power and force of the lower limbs in older persons, and is relatively practical, reproducible, and inexpensive.[13] In addition, HGS is considered an important predictor of functional capacity, cardiovascular disease, cancer, mortality, dementia, and nutritional state in elderly people.[8,11,39]

The present study has some limitations. According to Lauretani et al,[13] HGS is appropriate to monitor the effectiveness of systemic treatments, both pharmacological and nonpharmacological, aimed to improve muscular strength. However, exercise interventions may have a more variable impact on different muscle groups and should be monitored with appropriate regional measures. Additionally, our analysis was made in the absence of a control group, so flaws in the causal relationships should be considered. Moreover, salt intake and hydration status were not controlled, although participants were advised to maintain their normal dietary habits during the study. During the training period, the intensity of RT was individually controlled by the participants utilizing an RPE scale. This strategy may not have normalized the relative effort in the group, because each participant has a different interpretation of their exertion level. Furthermore, the presence of heterogeneity in medications used by our subjects might have introduced bias in our hemodynamic results.

Despite the limitations, our findings raise interesting ideas for future research trials, such as the investigation of periodization, volume, intensity, and training frequency which may contribute to the maintenance and control of muscular strength and BP during short and long-term detraining periods.

Conclusion

This study highlighted that RT of moderate intensity controlled by RPE improved BP and HGS, and was sufficient to maintain these benefits for 14 weeks of detraining in older hypertensive women. These results present important clinical application, considering that this sustained decrease in BP and increased strength can protect older individuals from several degenerative processes associated with aging.

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Disclosure

The authors declare no conflict of interest. The authors alone are responsible for the content and writing of the manuscript.

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