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Exercise Physiology

Hemodynamics and functional outcomes after resistance training in hypertensive and normotensive elderly: An experimental study

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Abstract - Aim: To evaluate the chronic effects of resistance training on resting blood pressure, handgrip strength, gait speed, and Timed Up and Go test (TUG) in normotensive and hypertensive elderly individuals. **Methods:** Experimental study based on TREND. Hypertensive patients were diagnosed by an independent doctor. Before and after 12 weeks of progressive resistance training, we evaluated blood pressure, heart rate, body composition, Timed Up and Go test, gait speed, and handgrip strength. **Results:** Sample consisted of 41 participants divided into two groups (normotensive n = 28; hypertensive n = 13). We observed significant values in the reduction of blood pressure levels only in the group of hypertensive participants. In functionality outcomes, we observed significant values in all tests and both groups. Outcomes contemplate effect sizes ranging from small to moderate. **Conclusion:** Progressive resistance training lowers resting blood pressure levels, increases handgrip strength, and improves physical functional performance. Although the normotensive group did not show a reduction in blood pressure levels, an improvement was observed in the functional physical tests.

Keywords: hypertension, resistance training, physical functional performance, hand strength, health services for the aged.

Introduction

Prevalence of hypertension in the elderly is greater than 60%, the risk of developing it (after 50 years of age) is 90%[1], and it is associated with several pathological conditions (e.g., stroke, cerebrovascular diseases, chronic kidney disease, and retinal changes)[2]; besides, sedentary lifestyle and increased body mass contribute to the prevalence of hypertension[3] - exercise is one of the most important interventions, as it has low cost, easy access, and thus prevents and/or treats hypertension[4].

Regular exercise promotes health for blood pressure and regression of cardiovascular disease[5]. Reduction of 5 mmHg in Systolic Blood Pressure (SBP), decreases mortality from coronary heart disease by 9%; 14% for stroke, and 7% for all causes[6-8]. Meta-analysis with 464.000 patients showed that a 10 mmHg reduction in SBP or a 5 mmHg reduction in Diastolic Blood Pressure (DBP) protects the patient from ischemic heart disease and cerebrovascular events[9].

About mechanisms involved in blood pressure reduction after resistance training (chronic adaptation), the effect on arterial compliance is still questioned in the literature: a study observes a reduction in arterial stiffness[10]; another observes the absence of change[11]; another demonstrates that resistance training can reduce arteriolar myogenic tone and peripheral vascular resistance[12]. Other mechanisms have been reported, such as attenuation of renal and muscular sympathetic nerve activity, the lesser appearance of norepinephrine increased sensitivity of renal and cardiac baroreflexes, and decreased variability of the heart rate[13,14].

Resistance training is an effective exercise to decrease blood pressure in the elderly, in values that can vary from 3.2 to 13.5 in SBP, and 1.5 to 6.1 in DBP[6,7]. Two meta-analyses suggest that resistance training is as effective an alternative as aerobic exercise in maintaining optimal blood pressure levels[14,15], however, Jansen et al.[16] describe that clinical guidelines used in the studies are vague when analyzing elderly people, and studies do not show effect size, and adherence to exercise tested.

Also, as far as we know, has a paucity of studies to show a decrease in resting blood pressure, after a dynamic resistance training protocol, in hypertensive and normotensive elderly individuals; also, has a paucity of studies to show a reduction in SBP greater than 10.5 after 12 weeks of resistance training[17-20] - considered clinically relevant for the elderly[9]. Thus, it is important to observe hemodynamically, and functional variables that change with aging and assess them before and after a resistance training program.

Functionality and handgrip strength are considered biomarkers of aging; the amount of force the muscle can produce is associated with functionality variables in the elderly [21,22], including gait speed, balance, risk of falls, and the ability to sit and stand[23]. Resistance training is effective to prevent and treat the reduction of muscle strength and functional incapacity in the elderly[24]. However, the effect of resistance training on handgrip strength and functionality in hypertensive and normotensive older adults is still a field to be explored[25].

Thus, the present study aimed to evaluate the chronic effects of resistance training on resting blood pressure, Handgrip Strength (HS), Gait Speed (GS), and Timed Up and Go test (TUG) in normotensive and hypertensive elderly individuals.

Methods

Design

The present research is quasi-experimental and quantitative, with a controlled and non-randomized intervention. We used the Transparent Reporting of Evaluations with Nonrandomized Design (TREND) Statement as a guide[26].

Participants

Sample size of 41 individuals provided, a posteriori, a statistical power of 75% (1-β = 0.75), considering a 5% alpha with a large effect size (d = 0.8). This study was carried out at the Laboratório de Exercício Físico e Envelhecimento, of the Universidade da Maturidade, at Universidade Federal do Tocantins (LABEFE-UMA/UFT).

Inclusion criteria: Be regularly enrolled at the Universidade da Maturidade-UMA/UFT; not having serious insufficiencies (cardiac, coronary, respiratory, renal, hepatic, intense osteoporosis, symptomatic arthropathy, unstable diabetes, and uncontrolled hypertension); having performed the pre-participation examinations for the assessment of health status; not having a metallic prosthesis; be able to answer the requested questionnaires; do not participate in other exercise programs.

Recruitment

After signing the Informed Consent Form, the participants underwent a medical examination that consisted of investigating comorbidities, use of previous medications, and electrocardiogram examination at rest.

Volunteers were divided into two groups (normotensive and hypertensive) according to the clinic prior to the diagnosis of hypertension (diagnosis for hypertension was issued by an independent doctor). All the elderly received assessment (in fasting) of blood glucose and plasma insulin, complete blood count, electrocardiogram, and bioimpedance.

We classified participants as hypertensive (SBP ≥ 140 and/or DBP ≥ 90) and normotensive (SBP < 140 and DBP < 90)[27]. All procedures were previously approved by the human research ethics committee (CAEE: 15849519.2.0000.5516).

Body composition

We measured body mass with a digital scale with a precision of 0.1 kg and height using a stadiometer with a precision of 0.1 cm (Cardiomed, Brazil) mounted on the wall. We evaluated skeletal muscle mass, fat-free mass, and fat mass through bioimpedance (InBody 370®) with the protocol by Moon et al.[28] - absolute values were normalized for the individual's stature.

We guide participants to avoid consuming alcohol, diuretics, or energy drinks, exercise up to 48 h before the evaluation; also, not eat for 4 h, and to empty the bladder 30 min before the procedure.

Hemodynamic variables

SBP, DBP, and resting heart rate were measured by a single experienced examiner, before and after the 12-week intervention - all procedures followed the recommendations of Pickering et al.[29]. We evaluated SBP and DBP using the automatic device (Microlife BP 3AC1-1)[30];

mean arterial pressure as follows: DBP + (SBP - DBP)/3; Pulse Pressure (PP) by the difference between SBP and DBP[27].

Functionality and handgrip strength

We use TUG, which consists of getting up from a chair, walking for three meters, and returning to the beginning. Participants underwent an assessment after becoming familiar with the route, which should not be carried out with help or support. The test result was evaluated by the time (measured by a Casio® HS-3V-1) digital chronometer spent performing the test[31].

We evaluated the gait speed, for which the elderly should travel a distance of 4 meters at their usual speed (also with controlled time). The speed value was measured by the relationship between the distance covered and the time in seconds[32]. handgrip strength was measured using the Saehan dynamometer and its protocol[33].

Resistance training

The proposed training protocol is an adaptation by Lima et al.[34]. Initially, a two-week adaptation period was carried out to familiarize and learn the correct technique for performing the exercises, with an exercise program for large muscle groups and two sets of 8-12 repetitions with the load ranging from a little easy to a little difficult, according to the OMNI-RES; afterward, this same scale was used to better adjust the training loads[35].

Subjects performed two resistance training sessions per week[36] for 12 weeks (supervised by professionals with resistance training experience). Program followed a linear progressive periodization model, with training loads of 6 difficulty points during the first 4 weeks, 7 points (from a little difficult to difficult) during the next 4 weeks, and between 8 (difficult) and 9 points (from difficult to extremely difficult) in the remaining 4 weeks, with repetitions, respectively, decreasing from 12, 10, and 8[37] - elderly people were instructed to perform passive breathing to avoid the Valsalva maneuver.

Exercises performed in each of the exercise sessions were as follows: Vertical bench press, leg extension, pull down, one leg flexion, dumbbell shoulder abduction, hip abduction, plantar flexion, and horizontal leg press. Also, exercises to strengthen the abdominal and erector muscles of the spine were prescribed and performed, as well as plantar flexion in the orthostatic and sitting position. The Rest interval between sets and between exercises was approximately two minutes. The average duration to complete a repetition was 3 to 4 s (1 to 2 s for the concentric phase and 2 s for the eccentric phase), and the average time of the exercises' session was between 50-60 min.

Exercises sessions were held in small groups with a maximum of 8 people. All adaptation, assessment, and exercises session were held at the LABEFE-UMA/UFT. The diet was not controlled, although they were advised to maintain their usual food intake. Based on the American College of Sports Medicine, the elderly were considered untrained because they had no previous experience with resistance training[38].

Older individuals' adherence to follow-up

Figure 1 shows the sample recruitment flowchart, as well as the inclusion/permanence of individuals until the end of the experiment, both in the hypertensive and normotensive groups (n = 41). The adherence of each group was assessed through frequency records. The groups maintained a twice-a-week exercise record for a total of 24 sessions during the 3-month intervention and two or fewer absences or a total of 22 presences were considered as 100% adherence. The total number of records that were returned for the final assessment was counted and divided by 22 for a measure of adherence.

Statistical analysis

We verified the distribution of data using the Shapiro-Wilk test - normal data were described as mean (standard deviation); not normal as the median (interquartile range 25-75%). Characteristics of hypertensive and normotensive individuals, as well as the deltas of variation between pre and post-treatment, were compared using the unpaired t-test or Mann-Whitney test; categorical variables were compared using the chi-square test. We built the database in Microsoft Excel software and performed the statistical analysis using SPSS software (version 22.0). We set the significance level at 0.05 for all tests.

Results

All participants completed the resistance training protocol without cardiovascular complications. We included 41 participants (28 normotensive and 13 hypertensives), most of them women. In the baseline, only pressure levels varied significantly between groups (Table 1).

Of the patients classified as hypertensive, 57.14% regularly used antihypertensives, of which 25% used combined treatment schemes. Regarding the pharmaceutical classes of drugs used by the hypertensive patients, 38.46% used angiotensin receptor antagonists, 30.77% used nonsteroidal anti-inflammatory drugs, and 15.38% took selective serotonin reuptake inhibitors antidepressants, and 15.38% used thyroid hormones. Only 7.7% of individuals used drugs from the classes of anticonvulsants, hydroxymethylglutaryl coenzyme A (HMG-CoA) reductase 2 inhibitors, beta-blockers, thiazide diuretics, dipeptidyl peptidase-4 inhibitors, Biguanides, hypolipemiants, and antivertiginous. The use of supplements such as vitamin D and magnesium chloride was reported by 7.7% of hypertensive patients.

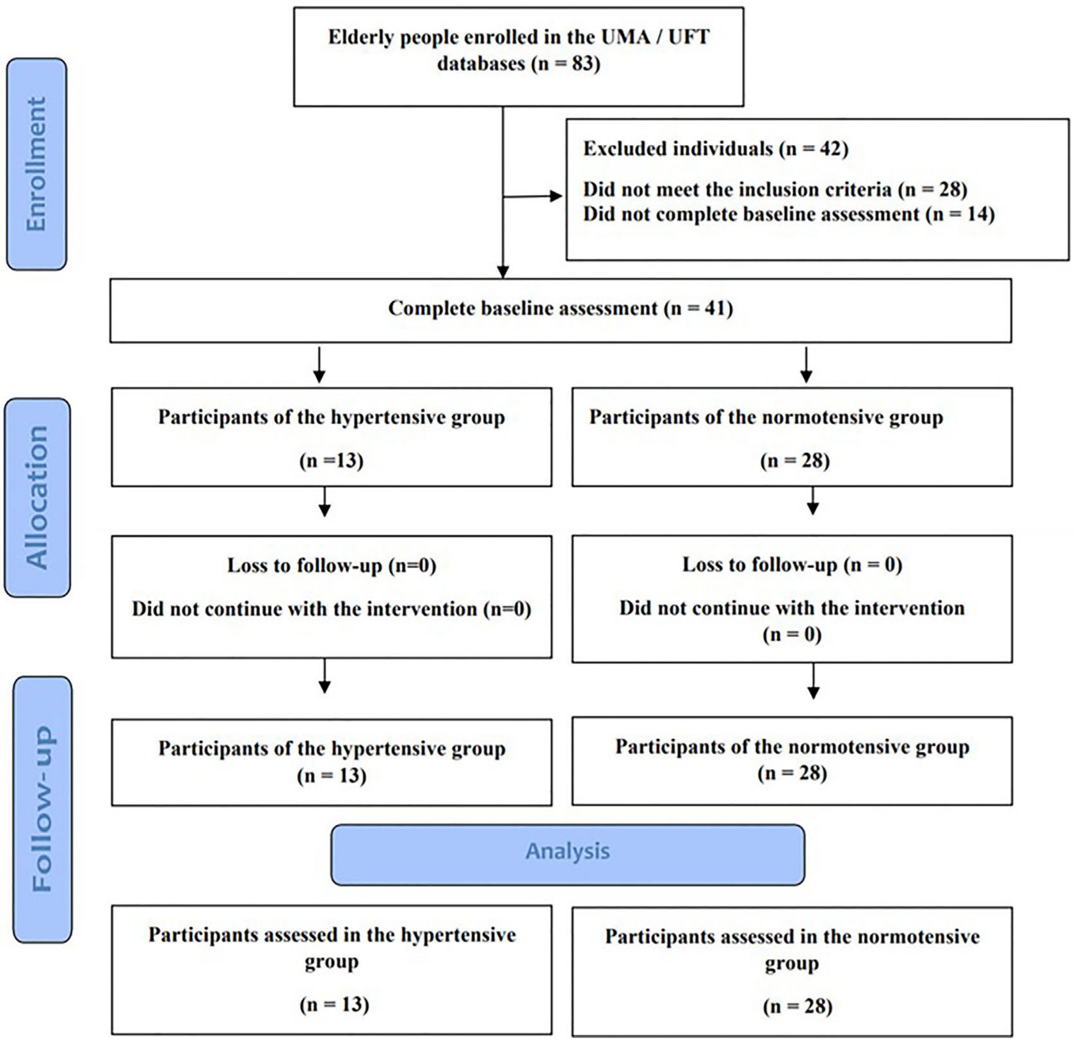

Figure 1 - Flowchart of the study.

Regarding the pre- and post-intervention moments, in hemodynamic outcomes, we observed significant values in the reduction of blood pressure levels in the group of hypertensive participants, with effect sizes ranging from small to moderate; normotensive participants did not show significant values (Tables 2 and 3).

In the outcomes of body composition, we observed significant values only in BMI, in hypertensive individuals, and appendicular fat mass, in normotensive individuals, however, with a small effect size. In functionality outcomes, we observed significant values in all tests and both groups, with effect sizes ranging from small to moderate (Tables 2 and 3)

Discussion

The present study shows that resistance training reduces resting blood pressure levels in hypertensive elderly individuals. We found a significant reduction in the values of SBP and DBP, in addition, our results describe significant improvements in participants' functionality; a clinically relevant outcome for the treatment and control of hypertension in the elderly.

According to Whelton et al.[39], small reductions in SBP (e.g., from 2 to 5) reduce the risk of infarction by 14%, coronary disease by 9%, and all-cause mortality by 7%. About mechanisms involved in blood pressure reduction after resistance training (chronic adaptation), the effect on arterial compliance is still questioned in the literature: a study observes a reduction in arterial stiffness[10]; another observes the absence of change[11]; another demonstrates that resistance training can reduce arteriolar myogenic tone and peripheral vascular resistance[12]. According to Collier et al.[11], this can occur regardless of changes in arterial stiffness.

Regarding hypertensive elderly people obtaining greater reductions in blood pressure levels, there is no consensus in the literature on the effects of resistance

Table 1 - Clinical characteristics of study participants at baseline (n = 41).

Variables	Normotensive (n = 28)	Hypertensive (n = 13)	p
Sex [a]			0.659
Male	4 (9.8%)	3 (7.3%)	
Female	24 (58.5%)	10 (24.4%)	
Age (years)[b]	63.17 (7.15)	66.53 (9.68)	0.782
Bloog glucose (mg/dL)	82 (3.17)	81.5 (3.11)	0.986
Hemodynamic			
SBP (mmHg)[c]	120 (110-125)	140 (132-168)	<0.001*
DBP (mmHg)[c]	75 (70-80)	90 (85-92)	<0.001*
MAP (mmHg)[b]	88.03 (8.32)	109.15 (10.58)	<0.001**
PP (mmHg)[b]	43.42 (10.47)	61.76 (21.74)	<0.001**
Body composition			
Body mass (kg)[b]	65.2 (12.4)	64.0 (13.9)	0.782
BMI (kg/m^2)[b]	26.1 (4.5)	26.2 (5.6)	0.933
AFFM (kg/m^2)[c]	6.7 (5.7-7.1)	5.91 (5.5-7.0)	0.413
FFMI (kg/m^2)[c]	16.3 (15-17.3)	18.8 (14.8-18.2)	0.901
SMI (kg/m^2)[c]	8.9 (7.8-9.5)	8.4 (7.7-9.8)	0.750
AFMI (kg/m^2)[c]	4.6 (2.9-5.6)	3.8 (2.61-5.2)	0.814
FMI (kg/m^2)[c]	10.6 (6.8-12.9)	8.9 (6.0-11.5)	0.814
Functionality			
TUG (s)[c]	9.3 (8.5-11.3)	10.1 (8.3-11.9)	0.989
GS (m/s)[b]	0.86 (0.12)	0.82 (0.24)	0.585
HS (kgf)[c]	28 (26-33)	27 (21-32.5)	0.226

SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; MAP: Mean Arterial Pressure; PP: Pulse Pressure; BMI: Body Mass Index; AFFM: Appendicular Fat-Free Mass Index; FFMI: Fat-Free Mass Index; SMI: Skeletal Mass Index; AFMI: Appendicular Fat Mass Index; FMI: Total Fat Mass Index; TUG: Timed Up and Go test; GS: Gait Speed; HS: handgrip strength.[a]absolute number (percentage); [b]mean (standard deviation); [c]median (interquartile range).*Mann-Whitney Test ($p < 0.05$); **Unpaired T-test ($p < 0.05$).

Table 2 - Effects of 12-week resistance training on study participants (n = 41).

Variables	Normotensive (n = 28)			Hypertensive (n = 41)		
	Pre	*Post*		*Pre*	*Post*	
Hemodynamic						
SBP (mmHg)[c]	120 (110-125)	118 (108-124)	−1.50 (−4.75-7.50)	140 (132-168)	128 (123-155)*	−12.0 (−30.0 - [−4.5])**
DBP (mmHg)[c]	75 (70-80)	74 (69-80)	0.0 (−3.0-4.75)	90 (85-92)	85 (74.5-90)	−6 (−12-4.0)**
MAP (mmHg)[b]	88.03 (8.32)	89.05 (7.54)	1.02 (6.64)	109.15 (10.58)	101.51 (11.81)	−7.64 (13.93)**
PP (mmHg)[b]	43.42 (10.47)	42.28 (8.47)	−1.14 (10.48)	61.76 (21.74)	51.38 (14.53)	−10.38 (15.88)**
Body composition						
Body mass (kg)[b]	65.2 (12.4)	64.8 (12.2)	−0.65 (4.44)	64.0 (13.9)	64.9 (13.7)	−0.84 (1.24)
BMI (kg/m^2)[b]	26.1 (4.5)	26.1 (4.5)	−0.1 (1.43)	26.2 (5.6)	26.6 (5.7)*	0.33 (0.60)
AFFM (kg/m^2)[c]	6.7 (5.7-7.1)	6.5 (5.8-7.2)	−0.05 (−0.17-0.30)	5.91 (5.5-7.0)	6.4 (5.5-6.9)	0.05 (−0.17-0.30)
FFMI (kg/m^2)[c]	16.3 (15-17.3)	16.5 (15.1-17.9)	0.10 (−0.30-0.67)	18.8 (14.8-18.2)	17.3 (14.4-18.4)	0.20 (−0.50-0.90)
SMI (kg/m^2)[c]	8.9 (7.8-9.5)	8.9 (8.0-9.8)	0.0 (−0.19-0.35)	8.4 (7.7-9.8)	9.2 (7.65-9.8)	0.07 (−0.27-0.40)
AFMI (kg/m^2)[c]	4.6 (2.9-5.6)	4.1 (2.8-5.1)*	−0.20 (−0.57-0.10)	3.8 (2.61-5.2)	3.4 (2.5-5.2)	−0.1 (−0.30-0.20)
FMI (kg/m^2)[c]	10.6 (6.8-12.9)	9.6 (6.7- 11.9)	−0.16 (−1.11 - 0.21)	8.9 (6.0-11.5)	8.2 (6.0-11.7)	0.0 (−0.46-0.44)
Functionality						
TUG (s)[c]	9.3 (8.5-11.3)	7.8 (7.4-8.9)*	−1.23 (−2.75-[−0.78])	10.1 (8.3-11.9)	8.0 (7.2-9.3)*	−1.58 (−2.50 - [−0.83])
GS (m/s)[b]	0.86 (0.12)	1.04 (0.19)*	0.19 (0.18)	0.82 (0.24)	0.99 (0.28)*	0.16 (0.27)
HS (kgf)[c]	28 (26-33)	32 (39-34)*	2 (1-4)	27 (21-32.5)	31 (26-35)*	4 (1-6)

Pre: baseline; Post: 12 weeks of progressive resistance training; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; MAP: Mean Arterial Pressure; PP: Pulse Pressure; BMI: Body Mass Index; AFFM: Appendicular Fat-Free Mass Index; FFMI: Fat-Free Mass Index; SMI: Skeletal Mass Index; AFMI: Appendicular Fat Mass Index; FMI: Total Fat Mass Index; TUG: Timed Up and Go test; GS: Gait Speed; HS: handgrip strength.[b]mean (standard deviation); [c]median (interquartile range).*paired T-test or Wilcoxon, $p < 0.05$ (within-group); **unpaired T-test or Mann-Whitney, $p < 0.05$ (between-groups).

Table 3 - Effect size (d value) of observed outcomes (within-group) after 12 weeks of progressive resistance training (n = 41).

Variables	Effect size	
	Normotensive (n = 28)	**Hypertensive (n = 13)**
Hemodynamic		
SBP (mmHg)	0.03	−0.68
DBP (mmHg)	0.18	−0.43
MAP (mmHg)	0.14	−0.66
PP (mmHg)	−0.13	−0.51
Body composition		
Body mass (kg)	−0.05	0.06
BMI (kg/m^2)	0.0	0.06
AFFM (kg/m^2)	−0.04	0.04
FFMI (kg/m^2)	−0.10	0.13
SMI (kg/m^2)	−0.02	0.12
AFMI (kg/m^2)	−0.12	−0.07
FMI (kg/m^2)	−0.08	−0.05
Functionality		
TUG (s)	−1.10	−0.43
GS (m/s)	1.08	0.62
HS (kgf)	0.52	0.39

SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; MAP: Mean Arterial Pressure; PP: Pulse Pressure; BMI: Body Mass Index; AFFM: Appendicular Fat-Free Mass Index; FFMI: Fat-Free Mass Index; SMI: Skeletal Mass Index; AFMI: Appendicular Fat Mass Index; FMI: Total Fat Mass Index; TUG: Timed Up and Go test; GS: Gait Speed; HS: handgrip strength.

training on the difference in blood pressure between these two groups. In fact, Diaz et al.[40] also found a greater hypotensive effect in hypertensive individuals when compared to normotensive individuals. Other researchers concluded that exercise reduces blood pressure regardless of the loss of mass in normotensive and hypertensive individuals, however, with a greater tendency to reduce Blood Pressure for the hypertensive group[41,42].

A meta-analysis, by Cornelissen et al.[43] shows no significant differences in the reduction of blood pressure between hypertensive and normotensive individuals, after a resistance training protocol. Due to the biological individuality of hypertensive individuals, some do not obtain benefits from resistance training[44], factors such as nutritional status, polymorphism in the angiotensin-converting enzyme gene, and sympathovagal balance may influence the dose-response of resistance training in hypertensive and normotensive individuals. Also, study designs, sample size, and exercise types (frequency, intensity, volume, adherence) contribute to the need for further analysis of the response of resistance training to blood pressure.

It is established that hypertension increases all-cause mortality, however, it is not yet known if the presence of functional limitations increases mortality, as little attention has been focused on the role of physical function in this population; besides, the functionality of patients is usually assessed through self-report, thus, the outcomes of epidemiological studies are subjective and widely criticized in the literature[45]. In this context, our results help to understand functional outcomes in this population, given that the findings of the present study come from objective assessments/tests.

Resistance training helped to reduce the time taken to perform the TUG test and increased gait speed and muscle strength in normotensive and hypertensive elderly people, and these outcomes, range of improvement in all functional tests, TUG[46], gait speed[47], handgrip strength[33] - are clinically important, as hypertensive elderly people have worse levels of functionality and muscle strength when compared to normotensive elderly people[48,49].

These tests (functional and muscle strength) are used in clinical practice to diagnose geriatric syndromes, risk of falls (conditions that predict hospitalization), institutionalization, and mortality in the elderly[50-52]. Low muscle strength is a negative predictor of functional capacity in the elderly, including those with arterial hypertension[53]. Low muscle strength is associated with high-pressure levels and higher levels of strength with less risk for the development of hypertension in the elderly[49,54].

A cross-sectional study with 795 elderly hypertensive individuals found that better levels of muscle strength prevented sarcopenia and improved the capacity for active endothelial repair[55]. Handgrip strength is negatively correlated with the arterial stiffness index in hypertensive individuals[56]. Thus, muscle strength impacts vascular health and cardiovascular risk in elderly hypertensive individuals; also, muscle strength is related to functionality[21,22] including, gait speed, balance, risk of falls, and the ability to sit and stand[23].

As in our study, Mangione et al.[57] verified that resistance training had a positive effect, both on TUG and gait speed. However, as far as we know, the effects of resistance training on the functional capacity of elderly hypertensive individuals are poorly investigated. Other analyzes considering age, sex, and body composition, among other risk factors for hypertension should be incorporated into further studies.

Resistance training protocols should benefit both the outcomes analyzed and the adherence of the elderly. Our resistance training protocol was periodically and progressively linearized, with training sessions held twice a week for 12 weeks. Previous studies have demonstrated the benefits of these strength training variables on the muscle functions of older individuals[58,59]. The progression from low to high intensities is used to vary the training, avoiding boredom and promoting training adaptations in periodized programs as the intensity advances to 90% of 1 repetition maximum[60], as is the case in our study.

Hu et al.[61], analyzed approximately 8,000 men and 9,000 women and reported that the rate of hypertension decreases as the exercise intensity increases from light, moderate to high, that is, progressively according to our exercise protocol. De-Freitas et al.[62], also found benefits in progressive resistance training on blood pressure in hypertensive elderly individuals, such as a significant improvement in post-exercise hypotension and increased vasodilation. Thus, this protocol may be useful for professionals who want to ensure cardiovascular safety and gains in functionality and muscle strength in a population of elderly hypertensive individuals.

The instrument used to define and monitor the load can influence the adherence of the elderly to resistance training programs; in our study, we used the OMNI-RES scale to define and monitor the training load. A study carried out by Buskard et al.[63] concluded that the OMNI-RES is the ideal scale for resistance training with the elderly, as it is more tolerable and pleasant, factors that determine adherence to exercise programs.

Our results may contribute to the prescription of resistance exercise for elderly people with hypertension. Because we present a resistance exercise protocol capable of promoting significant benefits in hemodynamic and physical functional performance outcomes. In addition, the progression of loads adopted in this study (OMNI-RES) ensures cardiovascular safety in hypertensive elderly people.

The present study has limitations that must be recognized, e.g., gender differences may reflect on Blood Pressure in response to resistance training, thus, due to our small sample size (and the small number of men), it generates little statistical power to carry out the subgroup analyzes and explore more appropriately. Also, the diet was not strictly controlled, even so, volunteers were given guidelines to maintain their eating habits during the training period; we suggest future studies to precisely address these issues.

Conclusion

Progressive resistance training reduces resting blood pressure levels, increases handgrip strength, and improves physical functional performance. Although the normotensive group did not show a reduction in blood pressure levels, an improvement was observed in the functional physical tests.

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