Effects of Concurrent Training with Elastic Tubes in Hypertensive Patients: A Blind Controlled Randomized Clinical Trial

Silas Nery de Oliveira, Antônio Renato Pereira Moro, Marcos Doederlein Polito, Jeniffer Helena de Jesus & Ewertton de Souza Bezerra

To cite this article: Silas Nery de Oliveira, Antônio Renato Pereira Moro, Marcos Doederlein Polito, Jeniffer Helena de Jesus & Ewertton de Souza Bezerra (2019): Effects of Concurrent Training with Elastic Tubes in Hypertensive Patients: A Blind Controlled Randomized Clinical Trial, Experimental Aging Research, DOI: 10.1080/0361073X.2019.1693030

To link to this article: https://doi.org/10.1080/0361073X.2019.1693030

Published online: 18 Nov 2019.

Submit your article to this journal

View related articles

View Crossmark data
Effects of Concurrent Training with Elastic Tubes in Hypertensive Patients: A Blind Controlled Randomized Clinical Trial

Silas Nery de Oliveira, Antônio Renato Pereira Moro, Marcos Doederlein Polito, Jeniffer Helena de Jesus, and Ewertton de Souza Bezerra

ABSTRACT
Background: Concurrent training (CT) has been recommended to minimize the deleterious effects of aging. However, few studies have investigated whether this type of training reduces blood pressure in the elderly. Therefore, our objective was to evaluate the effects of CT on the hemodynamic, cardiorespiratory, and muscle strength responses in medicated hypertensive patients. Methods: Twenty-three hypertensives (62.65 ± 6.4 years) of both sexes were allocated to the concurrent training group (CTG) or control group (CG). The CTG performed aerobic training (70–85% of reserve heart rate) combined with resistance training with elastic tubes (2sets × 15 repetitions) for 8 weeks. Resting blood pressure (BP), peak oxygen consumption (VO₂peak), and right knee and elbow flexion strength were evaluated. Results: A reduction of 6.37% was observed in BP and increases of 16.68% in VO₂peak and 16% in muscle strength for right elbow flexion in the CTG compared to CG (p < .05). Intragroup comparisons showed reduction of 5% for BP, and increases of 6.79% for VO₂peak, 24.79% for elbow flexion, and 16.47% for knee flexion in the CTG (p < .05), without significant improvement in the CG. Conclusion: CT promoted a reduction in BP, and increased cardiorespiratory fitness and muscular strength of the upper limbs in the hypertensive older adults.

ARTICLE HISTORY
Received 28 January 2019
Accepted 30 July 2019

Introduction
Hypertension is one of the most common medical disorders and is associated with an increased incidence of mortality from cardiovascular diseases, stroke, heart failure, peripheral arterial disease, and renal failure (Braith & Stewart, 2006; Pescatello, MacDonald, Lamberti, & Johnson, 2015). Between the years 2011 and 2014, the prevalence of hypertension (SBP ≥140 mmHg) among US adults was 45.6% (95% CI, 43.6% – 47.6%), moreover, the worldwide prevalence was estimated to be 20,526 per 100,000 (Benjamin et al., 2019). A change in lifestyle has been recommended as the
first line of non-pharmacological treatment in the prevention of hypertension, including increased physical activity (James et al., 2013).

Studies with meta-analyses (Carpio-Rivera, Moncada-Jiménez, Salazar-Rojas, & Solera-Herrera, 2016; Cornelissen & Smart, 2013) have demonstrated that aerobic (AT) and resistance training (RT) can reduce blood pressure (BP) both acutely and chronically when performed as isolated activities. The combination of these two training models (AT+RT) in the same session, denominated concurrent training (CT), also seems to be efficient in reducing BP in hypertensives during the aging process (Corso et al., 2016).

Although the meta-analysis conducted by Corso et al. (2016), which included 28 randomized clinical trials, showed promising results of CT on BP, there is little information on the different ways of performing RT within CT. To date, studies have shown that the practice of RT with elastic resistance is efficient in gaining muscle strength and functional capacity in older adults (Martins et al., 2013; Oliveira et al., 2017). In addition, elastic devices are inexpensive and easy to transport, allowing large-scale application and offering an opportunity for engagement and maintenance in long-term exercise programs for older adults (Motalebi, Amirzadeh Iranagh, Mohammadi, & Cheong, 2018; Motalebi & Loke, 2014).

The literature includes studies that evaluate the effects of RT with elastic devices on dynamic balance (Motalebi, Cheong, Iranagh, & Mohammadi, 2018), functional mobility (Motalebi & Loke, 2014), and the ability to perform mobility-related activities of daily living (Oesen et al., 2015) in institutionalized elderly. Other studies evaluate the clinical efficacy of RT with elastic devices in elderly people with sarcopenic obesity (Liao et al., 2017) and the effects on muscle strength in sedentary elderly subjects (Martins et al., 2015). However, these studies do not address the combination of RT with elastic and AT, and do not assess blood pressure as one of the main study variables in the elderly population with hypertension.

Thus, considering that the use of elastic devices in RT associated with AT in the elderly with hypertension is still scarce, the objective of this study was to evaluate the chronic effects of CT (aerobic + resistance with elastic tubes) on hemodynamic, cardiorespiratory, and muscle strength responses after an 8 week intervention, in medicated hypertensives. We hypothesized that CT using elastic resistance would reduce BP and increase cardiorespiratory variables and muscle strength in controlled hypertensives.

**Methods**

**Study Design**

The present study was a blind controlled randomized trial, and the study protocol was executed at the Sport Center of the Federal University of Santa Catarina, Brazil. All subjects were enrolled from March 2017 to June 2017. All outcome measure data were collected at baseline and after 8 weeks of intervention. The present study was approved by the ethics and research committee of the Federal University of Santa Catarina (nº. 1.694.065) and all procedures were conducted in accordance with the Declaration of Helsinki. The study is registered in the Brazilian Clinical Trial Registry under number RBR-5CGP6H.
Participants

Thirty subjects agreed to participate in the study, selected through advertisements on posters distributed throughout the community and in health centers. All volunteers used antihypertensive medication (except beta-blockers or non-dihydropyridine calcium channel blockers). Inclusion criteria were: aged 50 years or older, controlled hypertension (<130/80 mmHg), and medical release for physical exercise. Subjects were excluded if they had participated in a systematic training program in the previous 6 months, presented congestive heart failure, recent myocardial infarction, or joint or muscular limitations that compromised the movements in any of the exercises, or did not meet the minimum attendance in 85% of the total number of sessions planned. Subjects were instructed to maintain their regular medication, daily living activities, and eating habits.

All subjects were informed of the research procedures and subsequently signed an informed consent form. After signing, the participants were randomly allocated to the Control Group (CG) or Concurrent Training Group (CTG), through block allocation. A sequentially numbered, opaque, sealed assignment envelope was opened by a researcher in front of the participant; each envelope contained a concealed allocation number. The randomization of numbers was previously performed using a digital tool available at www.randomized.org. Two subjects from the CG did not complete the research for personal reasons, so the study finished with 10 people (6 men and 4 women) in the CG and 13 people (9 men and 4 women) in the CTG (Figure 1).

Figure 1. The CONSORT-Flow chart depicts the study-flow from screening until the analysis.
**Experimental Protocol**

The subjects were submitted to four days of pre and post training evaluations in the following sequence: anthropometric evaluation and body composition (DXA); cardiopulmonary test (VO\textsubscript{2}peak), maximal voluntary isometric contraction (knee and elbow), and BP at rest. All pre and post training assessments were performed at intervals of at least 48 hours by an assessor without knowledge of which group the subject belonged to.

After the pre-training evaluations, the participants of the CTG were submitted to six sessions of familiarization with the protocol exercises. Next, a period of 8 weeks of CT was performed with 3 sessions per week, each session took a maximum of 70 minutes that included a warm-up (10 minutes of light jogging and stretching), training program (TA: 25 minutes, RT: approximately 25 minutes), and cool down (10 minutes of stretching and joint mobility exercises). The aerobic exercise was always applied before the resistance exercise. The post-training evaluation started 48 hours after the final session.

**Familiarization Session**

During the familiarization sessions, the participants were adapted to the exercise movements and the use of the Omni scale. The familiarization sessions took a maximum of 70 minutes and the participants were instructed to use the correct exercise technique, movement amplitude, and maintain the correct position that would later be used during data collection. The participants performed two sets of each exercise, adjusting the grip width until they were able to perform 15 repetition maximum (RM), taking into account the suggestions of previous studies (Colado et al., 2012; Newsam, Leese, & Fernandez-Silva, 2005). In order to familiarize themselves with the scale, the participants performed the exercises using different colored elastic tubes and extensions. Three sessions with high and 3 sessions with low intensity were applied and, at the end of each session, the perceived effort of that session was explained, corresponding to the Omni scale (OMNI-RES).

**Training Program**

The AT was performed on a treadmill, for 25 minutes, with a progressive increase in intensity of 5% every two weeks. The AT prescription was performed through percentages of the Heart Rate reserve (HR\textsubscript{res}) (Pescatello et al., 2015), starting at 70% and ending at 85%. The intensity was controlled during the aerobic exercise using a heart rate monitor (Polar FS1 Dark Blue, Kempele, Finland). The intensity of AT was applied according to recommendations for the prescription of AT in cardiac rehabilitation (Mezzani et al., 2013), and the increase in load was gradual, avoiding large increases (Pescatello et al., 2015).

The RT consisted of 2 sets, with 15 repetitions and 30 second intervals between sets and exercises, in the following exercises for the upper limbs (rowing, standing bench press, arm curl), and lower limbs (extension of the knee, knee flexion, forward walking with a resistance elastic) (Figure 2). To control the intensity of the session and its progression over the RT program, the method described by Colado et al. (2012) was used, which consists of associating the number of repetitions with the rating of perceived exertion
(RPE) using the OMNI-RES. In the first four weeks the subjects trained with an RPE between 5 and 6; and in the final four weeks between 6 and 7. In addition, the color scale of elastic tubes was used, which consists of seven different intensities (in ascending order: Yellow, Red, Green, Blue, Black, Purple, and Gold) (Martins et al., 2014). In this way, the colors of the elastic tubes generate a certain tension according to their prior extension (50%, 100%, 150%, and 200% of their initial length when relaxed).

Thus, the subjects initially performed the resistance exercises with low colors and extensions (yellow at 50%, for example) and, according to the need to adjust the RPE, the elastic extension was progressively increased (yellow at 200%, for example) until it was necessary to change the color of the elastic tube. Physical Education professionals supervised all training sessions. The CG maintained their daily activities without specific training.

**Blood Pressure Assessment**

BP was evaluated using an automated device (Omron® M2- EM/7117/E) following the guidelines of the American Heart Association (Pickering et al., 2005). Resting BP was
measured in the left arm of the subjects, after resting in a seated position for a period of 10 minutes, at three moments separated by five minutes, the final value being determined by the average of the values obtained in the three measurements. The behavior of BP during the 8 weeks of training followed the same procedures adopted for resting BP.

To observe the chronic effect of training on hemodynamic variables, resting BP was assessed 72 h before and after the 8 week protocol for both groups. The variables obtained were systolic BP (SBP), diastolic BP (DBP), and mean BP (MBP) calculated using the equation: \( MBP = 0.33 \times (SBP-DBP) \). All measurements were performed by an independent evaluator both pre and post 8 weeks.

**Cardiorespiratory Test**

The cardiorespiratory analysis was conducted on a treadmill (Inbramed Millenium Super ATL10,200) and values of VO\(_2\)peak and maximal heart rate (HRmax) were obtained through the adapted Bruce test (Noonan & Dean, 2000). The VO\(_2\) was measured breath by breath throughout the test, from the exhaled gas (Quark PFTergo, CosmedSrl, Italy), and the data subsequently smoothed and calculated in 15 s averages. The VO\(_2\)peak was determined from the highest 15 second average obtained during the test, and the HRmax using an HR monitor (Garmin, CosmedSrl, Italy).

**Isometric Contraction**

The maximum voluntary isometric contraction was measured with a MicroFET 2 manual dynamometer (Hoggan Industries, Inc., West Jordan, USA) (Buckinx et al., 2017). Two consecutive measurements were performed with a one minute interval between contractions. The movements evaluated were right elbow flexion and right knee flexion. During the measurement the subjects were encouraged to increase the force gradually until reaching the maximum effort in an interval of 10 seconds. All measurements followed the body positioning pattern described by Kendall et al. (2005). The maximum voluntary isometric contraction was normalized by body mass (Nm. kg\(^{-1}\)).

**Body Composition**

For the measurements of total body mass and height, a digital scale (Filizola, Brazil) and stadiometer (Sanny, Brazil) were used, respectively. For the percentage of fat and fat-free mass, the dual-energy x-ray absorptiometry method – DXA was used (GE Electric Company, Lunar Prodigy). In addition, from the data provided by this method, the percentage of muscle mass was calculated using the mathematical model proposed by Kim, Wang, Heymsfield, Baumgartner, and Gallagher (2002) to estimate muscle mass in adult populations.

**Statistical Analysis**

The sample size was calculated considering: (1) the two-way analysis of variance (repeated measures, within-between interaction); (2) two groups; (3) type I error = 5%; (4) type II error = 20%; (5) the power of the statistical test = 80%; (6) effect size = 0.32. The
antihypertensive effect size of concurrent training was estimated at 0.32 for a reduction in systolic blood pressure (Corso et al., 2016). The sample size was estimated using G*Power software (version 3.1.9.2) and the total sample size calculated was 22 individuals (11 per group).

Results are presented as mean and standard deviation. The normality of the data was confirmed using the Shapiro-Wilk test and sphericity through the Mauchly test. The Student t test for independent samples was used to compare the mean age and height between the groups before the training period. The Fisher exact test was applied to compare antihypertensive medication between training groups. Two-way repeated-measures ANOVA was used to compare the pre and post-training differences between the groups. When significant F-ratios were observed, the Bonferroni post-hoc test was used. Statistical significance was defined as p ≤ 0.05 and all calculations were performed using SPSS 21 software for Windows (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). Additionally, to determine the magnitude of the findings, Cohen’s d effect sizes (ES) were calculated for the differences between the CG and CTG, according to the following classification: small (0.20 < ES < 0.30), medium (0.40 < ES < 0.70), or large (ES ≥ 0.80).

Results

The anthropometric and body composition results are presented in Table 1. No significant differences were observed between the groups before and after training for the anthropometric and body composition values (p > .05).

BMI, body mass index; FFM, fat free mass; ARA II, Angiotensin II Receptor Antagonist; ACEI, Angiotensin Converting Enzyme Inhibitor. Values are mean and standard deviation and frequency.

A significant group x time interaction was observed for SBP (F(1,21) = 7.423, p = .013, η² = 0.261), DBP (F(1,21) = 5.640, p = .027, η² = 0.212), and MAP (F(1,21) = 7.233, p = .014, η² = 0.256). After the training, a significant reduction of 6.73% was observed for the CTG in relation to the CG only for SBP (F(1,21) = 8.210, p = .009, η² = 0.281), with a large effect size.

Table 1. General characteristics of participants before and after 8 weeks.

<table>
<thead>
<tr>
<th></th>
<th>CTG (13)</th>
<th>CG (10)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>62.8 ± 6.07</td>
<td>62.7 ± 5.29</td>
<td>0.95</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.64 ± 0.09</td>
<td>1.65 ± 0.11</td>
<td>0.78</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>84.1 ± 18.22</td>
<td>71.4 ± 11.29</td>
<td>0.07</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>28.7 ± 2.45</td>
<td>26.8 ± 2.59</td>
<td>0.09</td>
</tr>
<tr>
<td>Fat mass (%)</td>
<td>36.9 ± 7.97</td>
<td>34.3 ± 8.39</td>
<td>0.47</td>
</tr>
<tr>
<td>FFM (g)</td>
<td>24.9 ± 6.89</td>
<td>23.7 ± 6.71</td>
<td>0.44</td>
</tr>
<tr>
<td>Medications (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diuretics</td>
<td>used</td>
<td>57.1</td>
<td>42.9</td>
</tr>
<tr>
<td></td>
<td>not used</td>
<td>38.5</td>
<td>40</td>
</tr>
<tr>
<td>ARA II</td>
<td>used</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>not used</td>
<td>66.7</td>
<td>33.3</td>
</tr>
<tr>
<td>ACEI</td>
<td>used</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>not used</td>
<td>63.2</td>
<td>36.8</td>
</tr>
</tbody>
</table>
(1.23) between the groups (Figure 3). Conversely, the ES calculated after the training between groups showed a large effect (0.81) for reduction in MAP and a medium effect (0.51) for DBP. For intra-group comparisons, the CTG presented significant reductions in SBP (p = .001; −5.12%), DBP (p = .001; −5.27%), and MAP (p = .001; −5.20%), whereas the CG did not present significant changes (SBP − p = .801, +0.38%; DBP − p = .800, −0.39%; MAP − p = .981, −0.03%), after the intervention period.

The VO₂peak presented a significant group x time interaction (F(1,21) = 12.757, p = .002, η² = 0.378) with a significant increase of 16.68% after the training for the

Figure 3. Resting values of systolic (SBP), diastolic (DBP), and mean (MBP) blood pressure, peak oxygen consumption (VO₂peak), and maximal isometric voluntary contraction of the elbow and right knee of the Concurrent Training Group (CTG) and Control Group (CG) before and after 8 weeks of intervention. * significant difference between groups; # significant difference intra-group.
CTG in relation to the CG (F(1,21) = 6.125, p = .022, $\eta^2 = 0.226$), with a large effect size (3.43) between the groups (Figure 3). Intra-group comparisons showed a significant increase in VO$_2$peak in the CTG ($p < .001$, +6.79%), whereas no significant changes were observed for the CG ($p = .514$, −1.19%).

A significant group x time interaction was observed for right elbow flexion (F(1,20) = 16.084, p = .001, $\eta^2 = 0.446$) and right knee flexion (F(1,20) = 7.430, p = .013, $\eta^2 = 0.271$). After the training, a significant increase of 16% for elbow flexion was observed in the CTG compared to the CG ($p = .008$, +16.47%), whereas there were no significant alterations for the CG ($p = .338$, −5.26%).

**Discussion**

The main objective of the study was to evaluate the chronic effects of CT on hemodynamic, cardiorespiratory, and muscle strength responses in hypertensive elderly patients controlled by medication after an 8 week intervention protocol. The main findings of this study were: CT promoted a reduction in SBP, and increased cardiorespiratory fitness and upper limb muscle strength after 8 weeks.

In the present study, a 6.7% reduction in SBP was observed in the participants who performed CT compared to those who did not perform any specific training, besides a reduction of 5.12% in SBP and 5.7% in DBP for the CTG when comparing the pre- and post-training periods. Similar results were found by Lima et al. (2017), and Ruangthai and Phoemsapthawee (2019), who submitted hypertensive older adults to CT and observed the BP behavior after the intervention, however, our results were different from those reported by Schroeder, Franke, Sharp, and Lee (2019) and Timmons et al. (2018).

In the study by Lima et al. (2017), 44 drug-controlled hypertensive elderly patients were submitted to 10 weeks of an intervention with 3 weekly sessions, in which the elderly were divided into CT (circuit, 2 turns, 15–20 repetitions, 50–60% of 1RM, 9 exercises + 20–30 minutes: treadmill, self-selected intensity), AT (20–30 minutes: exercise treadmill, self-selected intensity), and CG. The authors observed that, comparing the CG with the other experimental groups, there was a significant reduction in SBP only for participants who performed CT (9.2%), and no significant reduction for any of the groups in relation to DBP.

In the study by Ruangthai and Phoemsapthawee (2019), the effects of different types of training on BP and antioxidant capacity were evaluated in drug-controlled hypertensive elderly. Participants performed AT (60 minutes: walking, 50–70% of maximal HR), ST (60 minutes: 3 sets, 10–15 repetitions, 50–80% of 1 RM, 13 exercises), CT (20 minutes: walking, 50–70% of maximal HR + 30 minutes: 2 sets, 8–12 repetitions, 50–80% of 1 RM, 13 exercises), or CG (no physical activity), and
after 12 weeks of a supervised intervention with 3 weekly sessions, the authors observed a significant reduction in SBP after CT (8.4%) and AT (9.6%) when compared to CG, although a significant intragroup reduction was observed only for the CT (8.4%), and no significant change for any of the groups in relation to DBP.

Regarding the aforementioned studies, only Ruangthai and Phoemsapthawee (2019) present possible explanations for the results found. The authors explain that the reduction in SBP after CT may possibly be related to the improvement in endothelium-dependent vasodilatation, since, in the study developed by them, an increase in plasma nitric oxide concentration was observed in the subjects who underwent training; the bioavailability of nitric oxide being associated with vascular relaxation (Storch et al., 2017).

Different results from the present study were found by Schroeder et al. (2019), who compared the effects of AT (60 minutes: cycle ergometer, 40 – 70% HR reserve), ST (60 minutes: 2–3 sets 10–20 repetitions, 12 exercises), and CT (30 minutes, cycle ergometer 40 – 70% of the HR reserve + 30 minutes: 2 sets, 18–20 repetitions, 8 exercises) in sixty-nine women (58 ± 7 years) over an 8 week intervention, with 3 weekly training sessions. After the intervention, no significant reduction was observed in SBP for any of the groups and a significant reduction in DBP (5%) only in the CT group in relation to the CG and pre-training period. The authors explained that the absence of a reduction in SBP may have occurred due to the large number of participants with BP considered normal (120/80 mm Hg); however, they did not explain which factors influenced the reduction in DBP or why this reduction occurred only in the CT group.

The results of the present study were better than those presented by Timmons et al. (2018), who included older adults in a CT intervention for 12 weeks. The training was performed in a circuit format with 3 strength exercises (15 repetitions, 60% 1RM), followed by 4 minutes of aerobic activity on a cycle ergometer or cross trainer at 80% of HRmax, ending with 3 more strength exercises (15 repetitions, 60% 1RM). The authors did not observe any reductions in SBP or DBP when comparing the pre- and post-training periods, or any reduction when comparing the results with the CG. Timmons et al. (2018) did not discuss their findings regarding BP, but a possible explanation for the difference found in relation to the present study is the intensity of the training applied, which may not have been sufficient to generate a hypotensive effect.

It is important to emphasize that the mechanisms that explain a reduction in BP after the long-term practice of a training program have not yet been fully clarified (Halliwill, Buck, Lacewell, & Romero, 2013), however, some studies (Hecksteden, Grütters, & Meyer, 2013; Liu, Goodman, Nolan, Lacombe, & Thomas, 2012) report that the magnitude of post-exercise hypotension may predict the benefits attained in long-term training; so the mechanisms involved that explain the acute reduction in BP may also be related to its chronic reduction. According to Liu et al. (2012) the reduction in BP after training can be explained by both vascular (total peripheral resistance) and neural mechanisms (HR variability and baroreflex sensitivity), but the authors state that there is still a need for further studies to evaluate the mechanisms responsible for BP reduction after the different types of training.
In a clinical context, a reduction of 2 mm Hg in resting SBP reduces the chance of death from stroke by 10% and from ischemic heart disease by 7%, as well as which, a reduction of 5 mm Hg in DBP reduces deaths from stroke by 40% and the risk of death from ischemic heart disease or other types of coronary artery disease by 30% (Lewington, Clarke, Qizilbash, Peto, & Collins, 2002). In this way, the reductions in SBP and DBP in the present study have clinical relevance and demonstrate that the CT program used is able to reduce resting BP values in people with medication controlled hypertension.

In addition to the improvement in BP, the present study also demonstrated a 16.68% increase in VO\textsubscript{2}peak in the CTG compared to the CG, and a 6.79% increase in the CTG when comparing the pre- and post-training periods. Among the aforementioned studies, Ruangthai and Phoemsapthawee (2019) and Lima et al. (2017), also evaluated oxygen consumption and observed similar increases to that of the present study. In the study by Ruangthai and Phoemsapthawee (2019), an increase of 15.72% was observed in the maximum VO\textsubscript{2} after CT when compared to the CG and 15.36% when comparing the pre and post training periods. Lima et al. (2017) only reported comparisons between the pre- and post-training periods, observing a 19.2% increase in VO\textsubscript{2,max} for the elderly who performed CT.

The increase in VO\textsubscript{2} in our study was greater than those reported in the studies by Libardi et al. (2015) and Wilhelm et al. (2014). In the first study, 25 elderly subjects performed 12 weeks of CT where ST sessions (4 × 10 replicates, 70–80% of 1 RM in the Leg Press exercise) were performed on different days to the AT sessions (40–50 minutes: walking, 60–85% of VO\textsubscript{2}peak). Despite the higher volume of weekly training compared to the present study, the authors reported a significant increase of 9.5% in VO\textsubscript{2}peak. The study by Wilhelm et al. (2014) also submitted elderly patients to 12 weeks of CT, with two weekly sessions, in different orders of execution: ST + AT (2–3 series, 8–18 MRI, 7 strength exercises + 20–40 minutes, cycle ergometer, 85–95% of the second ventilatory threshold) or its inverse order. The authors observed increases of 8.8% and 6.8% in VO\textsubscript{2}peak after ST + AT and their inverse order, respectively, without differences between groups.

One of the main reasons for the different gains in VO\textsubscript{2} observed among the studies is the different training programs applied, however, regardless of the CT program, it is worth mentioning that the increase in VO\textsubscript{2} in the elderly is important to improve their cardiorespiratory condition, which is weakened by the advent of the aging process. In addition, the 10% increase in VO\textsubscript{2} results in a 15% reduction in the chance of death from cardiovascular problems (Dunn et al., 1999). Thus, the findings of the present study demonstrate the efficiency of the CT program used to improve the cardiorespiratory condition of hypertensive older adults.

Although the studies present positive results, none of them discuss which possible mechanisms could be related to the improvement in VO\textsubscript{2} after CT. Tamburús et al. (2014) explain that improvement in VO\textsubscript{2} may be related to peripheral adaptations, such as increased mitochondrial capacity and density and increased capillary density, as well as central adaptations, such as increased systolic volume, which may be possible explanatory factors for the improvement in VO\textsubscript{2} in both the present study and the others presented.

In the present study, a significant increase of 16% was observed in the muscle strength for elbow flexion in the CTG in relation to the CG, as well as an increase of 24.79% in the muscle strength for elbow flexion and 16.47% for knee flexion when comparing pre and post-training periods. Although the literature does not present a large number of studies
regarding the evaluation of muscle strength after ST with elastic tubes, especially after CT, we highlight two studies that are similar regarding the results (Ramos et al., 2014) and methodology (Martins et al., 2015) used in the present study.

In the study by Ramos et al. (2014) the effects of ST with elastic tubes and conventional ST for 8 weeks were investigated in older adults with chronic obstructive pulmonary disease. The study included 34 elderly people divided into two groups: ST with elastic tubes (60 minutes: 2–7 sets, repetitions until concentric failure, 5 exercises performed with elastic tubes) and conventional ST (60 minutes: 3 sets, 10 repetitions, 60–80% 1 RM, 5 exercises performed on machines), with a frequency of 3 weekly sessions. The authors observed significant increases of 20.6% and 18.4% in muscle strength for right elbow flexion after conventional ST and with elastic tubes respectively, as well as significant increases of 20.8% and 16.1% in muscle strength for right knee flexion after conventional ST and with elastic tubes, respectively, without significant differences between training methods.

For Ramos et al. (2014), ST performed with elastic tubes has an equivalent effect on muscular strength to ST when performed with machines in the elderly population, especially those with chronic obstructive pulmonary disease. In the study by Martins et al. (2015), twenty older adults, divided into CG and ST (2–3 sets, 15 RM, 7 exercises performed with elastic tubes, 5–10 on the OMNI-RES scale), performed an 8-week intervention with two weekly training sessions. The results of the study showed that there was no significant increase in muscle strength and that these findings are possibly related to the short intervention period and the low intensity of training applied.

Our study partially corroborates the findings of Ramos et al. (2014), as we also observed improvement in muscle strength in the upper limbs, however, the increase in muscle strength for knee flexion was not significantly different from the CG. Thus, for knee flexion, our result resembles that found by Martins et al. (2015) who also did not observe significant differences after an 8 week intervention. It is worth mentioning that in the study by Martins et al. (2015), the same type of elastic was used, the same number of repetitions per set, and the same instrument for measuring RPE.

A possible explanation for the absence of significant improvement is presented in an electromyographic activation study performed by Vinstrup et al. (2016). The authors observed that ST with elastic is more difficult to perform, especially in the knee flexion exercise, as there is an increase in activation of the antagonist muscles, which hinders the work of the agonist muscles and, consequently, strength improvement. Thus, further studies are needed to better understand the use of elastic tubes to improve lower limb muscle strength in older adults.

Although our study presents relevant information about the type of training and the effect on hemodynamic, cardiorespiratory, and muscle strength responses in controlled hypertensives, there are some limitations that need to be reported. Hypertensive patients may present relative variability in BP, whether caused by the use of medication with different dosages and active principles, or the possibility of endothelial dysfunction. In this context, we cannot homogenize the sample as a function of these variables. On the other hand, we understand that this sample profile increases the external validity of the study. In addition, the inclusion of men and women in the same groups may have influenced the physical conditioning, especially muscle strength. For this reason, we suggest that future studies should be carried out with larger groups that allow division by sex and, thus, allow more specific observation of the analyzed variables.
In conclusion, performing the CT program in the present study over eight weeks may facilitate clinically important reductions in BP values, as well as increases in upper limb strength and VO$_2$peak of drug-controlled hypertensives, and can be considered a non-pharmacological tool to aid in the control of arterial hypertension, besides improving physical fitness.

**Practical Applications**

Our study presents a practical and alternative protocol for the rehabilitation of older adults with drug-controlled hypertension. The training can be performed in different spaces, not limiting prescription of the activity, besides facilitating monitoring and load increases by health professionals. In addition, the materials used are easily accessible, where the AT can be performed outdoors and the ST with the aid of elastic tubes, which are low cost and easily applied materials.

**Acknowledgments**

The authors to thank specially to Ph.D. Daniel Umpierre de Moraes, and we also gratefully acknowledge all the participants who participated in this research. This work was supported by the CAPES master fellowship for SNO and FAPEAM for a PhD fellowship to ESB.

**References**


sion and sustained postexercise vasodilatation: What happens after we exercise? 
Experimental Physiology, 98(1), 7–18. doi:10.1113/expphysiol.2011.058065

Hecksteden, A., Grütters, T., & Meyer, T. (2013). Association between postexercise hypoten-
sion and long-term training-induced blood pressure reduction: A pilot study. Clinical Journal of 
Sport Medicine: Official Journal of the Canadian Academy of Sport Medicine, 23(1), 58–63. doi:10.1097/ 
JSM.0b013e31825b6974

James, P. A., Oparil, S., Carter, B. L., Cushman, W. C., Dennison-Himmelfarb, C., Handler, J., … 
Ortiz, E. (2013). Evidence-based guideline for the management of high blood pressure in 

Testing and function with posture and pain. Baltimore, MD: Lippincott Williams & Wilkins.

muscle mass: Estimation by a new dual-energy X-ray absorptiometry method. The American 

Lewington, S., Clarke, R., Qizilbash, N., Peto, R., & Collins, R. (2002). Age-specific relevance of 
usual blood pressure to vascular mortality: A meta-analysis of individual data for one million 
adults in 61 prospective studies. The Lancet, 360(9349), 1903–1913. doi:10.1016/S0140-6736(02) 
11911-8

of elastic resistance exercise on body composition and physical capacity in older women with 
sarcopenic obesity. Medicine, 96(23), e7115. doi:10.1097/MD.0000000000007115

Libardi, C., Chacon-Mikahil, M., Cavaglieri, C., Tricoli, V., Roschel, H., Vechin, F., … 

older hypertensive adults? Clinics (Sao Paulo, Brazil), 72(6), 363–369. doi:10.6061/clinics/2017(06)06

acute and chronic exercise are related in prehypertension. Medicine and Science in Sports and 
Exercise, 44(9), 1644–1652. doi:10.1249/MSS.0b013e31825408fb

Martins, W. R., Carvalho, R. S., Silva, M. S., Blasczyk, J. C., Araújo, J. A., Do, C. J., & 
Oliveira, R. J. D. (2014). Mechanical evaluation of elastic tubes used in physical therapy. 

Martins, W. R., de Oliveira, R. J., Carvalho, R. S., de Oliveira Damasceno, V., da Silva, V. Z. M., & 
Silva, M. S. (2013). Elastic resistance training to increase muscle strength in elderly: A systematic 
archger.2013.03.002

Martins, W. R., Safons, M. P., Bottaro, M., Blasczyk, J. C., Diniz, L. R., Fonseca, R. M. C., … de 
Oliveira, R. J. (2015). Effects of short term elastic resistance training on muscle mass and strength 
s12877-015-0101-5

Williams, M. A. (2013). Aerobic exercise intensity assessment and prescription in cardiac 
rehabilitation: A joint position statement of the European Association for Cardiovascular 
Prevention and Rehabilitation, the American Association of Cardiovascular and Pulmonary 
Rehabilitation and the Canadian Association of Cardiac Rehabilitation. European Journal of 

resistance training program for the institutionalized elderly. Topics in Geriatric Rehabilitation, 34 
(2), 105–111. doi:10.1077/TGR.0000000000000179

training on lower-limb strength and balance in institutionalized seniors. Experimental Aging Research, 


