

CHRONIC CONVENTIONAL RESISTANCE EXERCISE REDUCES BLOOD PRESSURE IN STAGE 1 HYPERTENSIVE MEN

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ABSTRACT

Moraes, MR, Bacurau, RFP, Casarini, DE, Jara, ZP, Ronchi, FA, Almeida, SS, Higa, EMS, Pudo, MA, Rosa, TS, Haro, AS, Barros, CC, Pesquero, JB, Würtele, M, and Araujo, RC. Chronic conventional resistance exercise reduces blood pressure in stage 1 hypertensive men. *J Strength Cond Res* 25(X): 000–000, 2011—To investigate the antihypertensive effects of conventional resistance exercise (RE) on the blood pressure (BP) of hypertensive subjects, 15 middle-aged (46 ± 3 years) hypertensive volunteers, deprived of antihypertensive medication (reaching $153 \pm 6/93 \pm 2$ mm Hg systolic/diastolic BP after a 6-week medication washout period) were submitted to a 12-week conventional RE training program (3 sets of 12 repetitions at 60% 1 repetition maximum, 3 times a week on nonconsecutive days). Blood pressure was measured in all phases of the study (washout, training, detraining). Additionally, the plasma levels of several vasodilators or vasoconstrictors that potentially could be involved with the effects of RE on BP were evaluated pre- and posttraining. Conventional RE significantly reduced systolic, diastolic, and mean BP, respectively, by an average of 16 ($p < 0.001$), 12 ($p < 0.01$), and 13 mm Hg ($p < 0.01$) to prehypertensive values. There were no significant changes of vasoactive factors from the kallikrein-kinin or renin-angiotensin systems. After the RE training program, the BP values remained stable during a 4-week detraining period. Taken together, this study shows for the first time that conventional moderate-intensity RE alone is able to reduce the BP of stage 1 hypertensive subjects free of antihypertensive medication. Moreover,

the benefits of BP reduction achieved with RE training remained unchanged for up to 4 weeks without exercise.

KEY WORDS strength training, hypertension, vasoactive factors, detraining

INTRODUCTION

It can be anticipated that hypertension will afflict up to a third of the world's population by the year 2025 (13). Among the nonpharmacological approaches to treat this condition, physical exercise is possibly one of the most promising (22). Although aerobic exercise (AE) has been extensively studied concerning its hypotensive effect (23), the same is not true in relation to resistance exercise (RE) (10). Despite its “adjuvant status,” RE is well suited for the prevention and treatment of numerous diseases like osteoporosis and sarcopenia (8,10), also contributing important benefits to aging hypertensive individuals that are not obtainable through AE (23,30).

Two meta-analyses on RE reported only 3 studies with hypertensive individuals out of a total of 12 studies (10,17). Two of these studies investigated the effect of circuit weight training (CWT) on the blood pressure (BP) of hypertensive adults (5,15). The third study investigated the effect of conventional RE on the BP of elderly hypertensive subjects (9).

In addition, some parameters like the use of antihypertensive medication, the gender, time course of BP decreases during the study, age, degrees of hypertension of the subjects under study, and the specific characteristics of the training programs (e.g., aerobic component) were not well documented in these studies (10,23). Furthermore, no information on the sustainability of BP decreases after ending the training program has been reported for adult hypertensive individuals (23).

Thus, considering that few studies evaluated the hypotensive effect of chronic RE on the BP of hypertensive subjects, the purpose of this pilot study was to investigate the effect of

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conventional moderate-intensity RE on the BP reduction, the duration of the effect after ending the training (detraining), and the possible contribution of vasoactive substances involved in BP reduction in nonmedicated hypertension stage 1 subjects.

METHODS

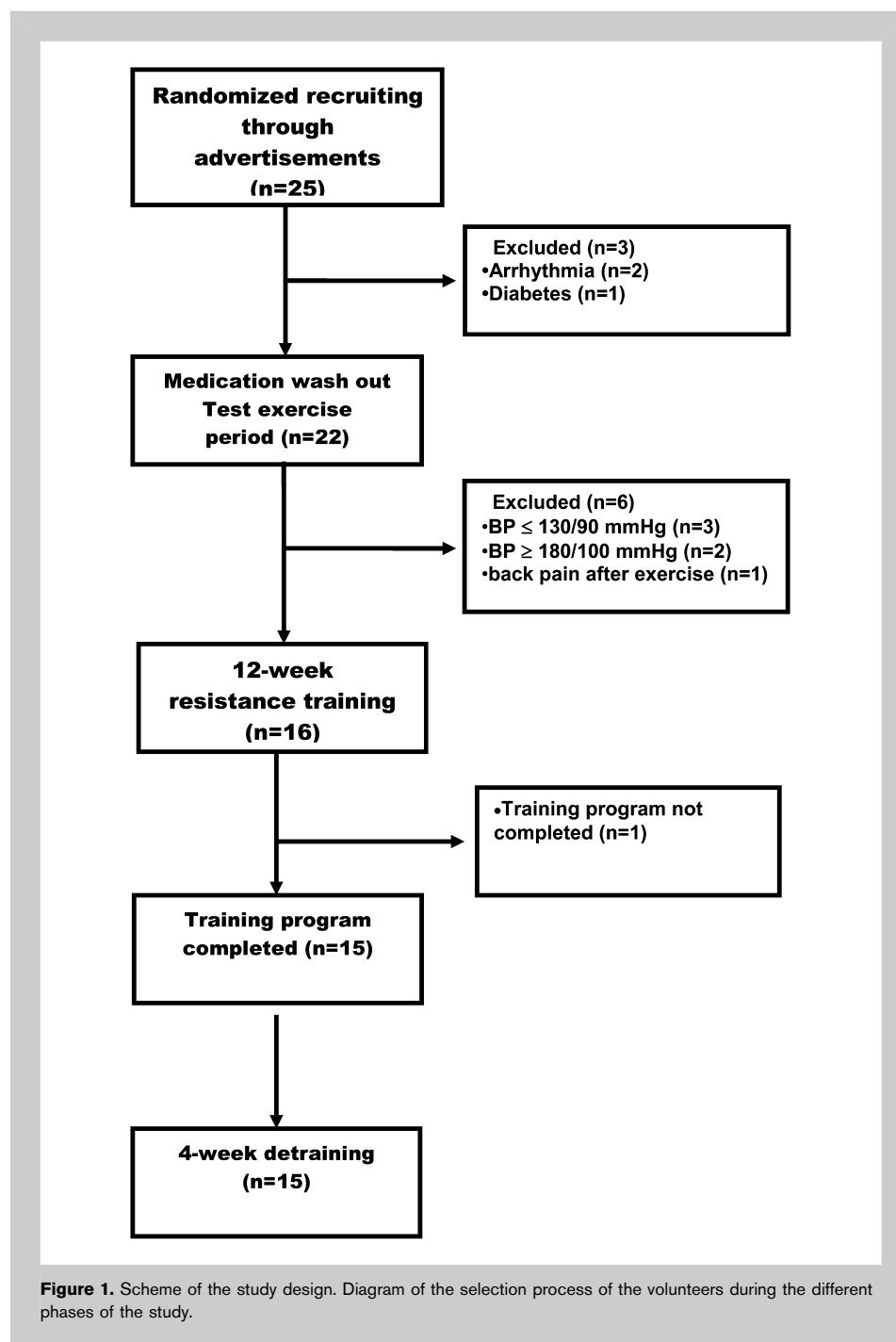
Experimental Approach to the Problem

This study evaluated the BP of 15 hypertensive adults without previous experience in weight training during 3 experimental stages: (a) withdrawal of antihypertensive medication; (b) 12 weeks of strength training after a conventional (noncircuited) model; and (c) a 4-week detraining period. The changes in BP were monitored weekly in all phases of the study. We found that after 12 weeks of training, the reduced BP values became similar to those using antihypertensive medication or those resulting from AE programs. Furthermore, 3 months of resistance training resulted in sustained lowered BP for up to 4 weeks after the RE sessions were ended.

Subjects

Fifteen sedentary (less than $2 \text{ h} \cdot \text{wk}^{-1}$ of physical activity) hypertensive male subjects (46 ± 3 years) were recruited for the study. Subjects were classified as hypertensive if they were on treatment for hypertension or had a systolic blood pressure (SBP) ≥ 140 mm Hg or a diastolic blood pressure (DBP) ≥ 90 mm Hg according to the American Heart Association (AHA) (7). They were recruited via advertisements from a local cardiology clinic (Mogi das Cruzes, São Paulo, Brazil). Eleven of these volunteers were under antihypertensive medication for an average of 6 ± 1 years before the beginning of the study. Individuals with an SBP ≥ 160 mm Hg or a DBP ≥ 100 mm Hg, diabetes, obesity, cardiac arrhythmias, end-organ injury, peripheral

arterial disease, myocardial infarction, stroke, coronary heart disease, heart failure, or a recent history of smoking or drug or alcohol abuse were excluded. The complete volunteer selection process is presented in Figure 1. Before participation in the research project, each subject completed a medical history questionnaire and signed a written informed consent. All methods and procedures were approved by the Institutional Review Boards of the Federal University of Sao Paulo.



Procedures

All data were collected at the Exercise Physiology Laboratory of the University of Mogi das Cruzes. The study consisted of 3 experimental phases: The first phase consisted in a medication washout period of 4 weeks. After a period of 48 hours of completion of first phase, the patients underwent with no less than 48 hours between each test at approximately the same time of the day (between 8:00 and 12:00 PM) (a) a blood sample collection; (b) an ergometric test; (c) an anthropometric, strength and flexibility test; (d) an aerobic capacity test. The second phase of study consisted in a 12-week conventional resistance training. Finally, during the third and final phase of the study, participants abstained from training for 4 weeks (detraining period).

Medication Washout Period

During the 6 weeks that preceded the study, under cardiological supervision, all antihypertensive medications were gradually withdrawn to avoid abrupt changes in BP. Thus, on the fourth week before beginning the experimental procedures, calcium channel blockers, angiotensin-converting enzyme inhibitors, and beta or AT1 receptor blockers were completely removed (4-week medication washout period). All subjects presented BP values corresponding to stage 1 hypertension after this medication washout period (7).

Effort Electrocardiogram

On the final 2 days of the medication washout period, maximal exercise testing was performed on all participants who had eligible BP. Each subject was allowed to become familiar with the treadmill and walk at a comfortable pace. A 12-lead electrocardiograph (model SM 400; TEB, New York, NY, USA) was used to record the maximal heart rate (HR) during the test performed using the modified Balke protocol, which was employed to rule out cardiovascular diseases (16). Arterial BP was measured during the test by auscultation (mercury sphygmomanometer and stethoscope; Becton Dickinson, Franklin Lakes, NJ, USA). Sessions were interrupted in the cases specified by norms from the AHA (11).

Peak Oxygen Consumption

Peak oxygen consumption ($\dot{V}O_{2peak}$) was measured as previously reported (26). Initially, the subjects performed an incremental exhaustion test on a treadmill (Quinton Medtrack ST 65; Quinton, Bothell, WA, USA) in accordance with the Balke protocol. Every 30 seconds, the $\dot{V}O_2$ values were recorded by a gas analyzer (Quinton QMC 000350) and the HR monitored using a 12-channel electrocardiograph (Quinton Q710). $\dot{V}O_{2peak}$ was calculated based on plateau oxygen consumption with increasing work rate and a respiratory exchange ratio greater than 1.1.

Measurement of Blood Pressure and Heart Rate

Resting BP and HR were measured blindly via auscultation by nurses during all the phases of the study after the participants had rested for 20 minutes in the sitting position (24). To exclude experimental bias, we additionally monitored BP

with a calibrated automated oscillometric noninvasive BP device (model Microlife 3AC1-1; Microlife AG, Widnau, Switzerland) (28). Pulse pressure (PP) was calculated as SBP – DBP and mean arterial pressure (MAP) was calculated as DBP + 1/3 PP. Blood pressure and HR were measured 4 times in 2-minute intervals using both techniques; however, no difference greater than 5 mm Hg between the conventional and automatic measurements were registered. Blood pressure was measured 3 times during the training sessions (each time 3 exercises were completed) and immediately after each session to ensure that it remained within safe limits (<220/110 mm Hg) (11). During the experimental protocols, preexercise BP did not exceed 160 mm Hg and 100 mm Hg, respectively, for SBP and DBP (11,23). During exercise, the HR was continuously measured and recorded on a beat-by-beat basis using a Polar Vantage NV (Polar Electro Oy, Oulu, Finland) HR recorder.

Anthropometry

Body mass, height, and body circumferences were measured according to the World Health Organization (31). Body composition was determined using the Jackson and Pollock 7-sites skinfold protocol (25) by Lange skinfold calipers (Santa Cruz, Santa Cruz, CA, USA). Total body water was estimated using a Biodynamic 310 Bioelectrical Impedance Analyzer (Biodynamic, San Diego, CA, USA) (29).

Physical Strength and Flexibility Tests

All volunteers were familiarized to the different exercises 1 week before the beginning of the training. Maximal contractile strength was assessed for 7 distinct muscle groups using the 1 repetition maximum (1RM) technique and custom-designed, pin-loaded weight-stack resistance equipment (Biotech, São Paulo, Brazil). During the program, volunteers were evaluated in relation to their strength in maintaining a load at 60% of their 1RM. Isometric handgrip strength was determined in the dominant hand with the use of a hydraulic hand dynamometer (Jamar Hydraulic Hand Dynamometer, 0-200 lb, Sammons Preston Inc., Bolingbrook, IL, USA) (21). Body flexibility was evaluated through the sit-and-reach test (2). To guarantee objectivity, all the tests (anthropometry, body composition, physical strength, and flexibility tests) were performed before and after training sessions by the same researcher (M.R. Moraes).

Phase 2: Resistance Exercise

The RE sessions were performed during a 3-month period 3 times a week on nonconsecutive days in a fitness center (Trainer Gym, Mogi das Cruzes, Brazil). The sessions were held in the afternoon between 01:00 and 04:00 PM during the spring. All the sessions were supervised by trained exercise physiologists who directed each stage of the session, instructing the subjects about what should be performed. The first 2 weeks were used to familiarize the subjects with the training program. Eight exercises were carried out with usually available fitness equipment (Biotech) conducted in the following order: (a)

abdominal crunch, (b) leg press, (c) leg curl, (d) chest press, (e) lat pull-down, (f) shoulder press, (g) biceps curl, and (h) triceps extension. Conventional RE was performed according to the American College of Sports Medicine (ACSM) (1,23) guidelines at a moderate intensity of 60% of 1RM in 3 consecutive sets of 12 repetitions (abdominal crunch: 20 repetitions per set), with 2-minute pauses between the sets and 1.5-second concentric (lifting phase) and 1.5-second eccentric (lowering phase) muscle contraction intervals (average time of each set: 36 seconds) and 1-minute pauses between the exercises (total exercise approximately 45 minutes). In addition, subjects were requested to exhale during the most strenuous phase (concentric) of the repetition and to inhale during the less strenuous phase (eccentric) of the repetition. Volunteers were also instructed to avoid the Valsalva maneuver during the entire movement, following ACSM guidelines (23). Subjects did not perform any physical activity for at least 24 hours before the evaluations and avoided caffeine or alcohol. During exercise, subjects received 15 ml of water per kilogram of body weight to replace water loss because of sweating.

Phase 3: Detraining Period

After the 12-week training program, volunteers were requested to avoid any regular physical training for 4 weeks. Blood pressure and HR continued to be measured 3 times a week on nonconsecutive days on Exercise Physiology Laboratory during this period, in the same manner and sequence as that in phases 1 and 2.

Biochemical Analyses

Venous blood samples were obtained from the forearm before and 48 hours after the last day of the 12-week RE program at 07:00 AM, after fasting for 12 hours. After collection, blood samples were immediately processed in a refrigerated centrifuge to obtain plasma (4°C for 15 minutes at 2,000g). Plasma samples were stored in multiple aliquots at -80°C. All assays were performed within 2 months of sample collection, in duplicate, and on first thaw. Samples for kinins and angiotensins' analyses were treated with proteinase inhibitors (Roche, Basel, Switzerland) to prevent degradation.

Kinins and Angiotensins

Plasma concentrations of kinins (bradykinin [BK] and DesArg9) and angiotensins (Ang I-II and 1-7) in plasma were determined

as described by Casarini et al. (6) and Ronchi et al. (27), respectively. For BK and angiotensins extraction, 1 ml of human plasma was loaded onto a Sep-Pak C18 cartridge (Waters, Milford, MA, USA) equilibrated in 5% acetonitrile containing 0.1% H₃PO₄. The cartridges were eluted with 3 ml of 35% acetonitrile containing 0.1% H₃PO₄. The prepurified extracts were dried in a Speedvac concentrator, resuspended in 500 ml of 0.1% H₃PO₄ containing 5% acetonitrile and then used for high-performance liquid chromatography (HPLC). For chromatographic identification and quantification, 100 ml of sample extract was injected into an HPLC system and separated on a reverse-phase RP18 Brownlee column (4.6 × 250 mm; Millipore, Billerica, MA, USA) equilibrated with 5% acetonitrile containing 0.1% H₃PO₄ (phase A). After 5 minutes of isocratic elution, peptides were eluted with a 0–35% linear gradient of 90% acetonitrile containing 0.1% H₃PO₄ (phase B) developed for 20 minutes at a flow rate of 1.5 ml·min⁻¹. The UV absorbance of the effluent was monitored at 214 nm. Bradykinins and angiotensins were identified by their elution position and quantified by peak area integration using synthetic BK and angiotensin as a standard. Intra- and interassay coefficients of variation were <10%.

Nitric Oxide

Plasma nitrate concentrations were measured on a nitric oxide (NO) analyzer (NOA TM280; Sievers Inc., Boulder, CO, USA) (14). Plasma was previously deproteinized in cold ethanol (1:2, vol/vol) for 30 minutes at 0°C, then centrifuged at 10,000g for 10 minutes. A 10-ml aliquot of the supernatant was injected

TABLE 1. Anthropometric parameters and blood pressure of the hypertensive volunteers pre- and posttraining.*

Variable anthropometric	Resistance exercise		<i>p</i>
	Pretraining	Posttraining	
Age, years	46 ± 3		
Body mass, kg	88 ± 6	87 ± 5	NS
BMI, kg·m ⁻²	29 ± 2	28 ± 1	NS
Fat-free mass, kg	61 ± 2	64 ± 3	0.005
Fat mass, kg	27 ± 2	23 ± 2	0.001
Body fat, %	30 ± 2	26 ± 2	0.001
Total body water, L	47 ± 2	48 ± 2	0.01
Σ Skinfold, mm	191 ± 14	153 ± 12	0.001
Total weightlifting, kg	140 ± 5	185 ± 11	0.001
Strength handgrip, kg·f ⁻¹	43 ± 2	48 ± 2	0.041
Sit-and-reach, cm	16 ± 2	22 ± 2	0.001
VO ₂ peak (ml·kg ⁻¹ ·min ⁻¹)	41 ± 3	44 ± 3	NS
Blood pressure, mm Hg			
Systolic	150 ± 3	134 ± 3	0.001
Diastolic	93 ± 2	81 ± 1	0.01
Mean	112 ± 2	99 ± 3	0.01

*BMI = body mass index; Σ = sum of 7 skinfold; NS = not significant.

into the analyzer. A calibration curve was plotted for standards of sodium nitrate. In the NOA TM280 analyzer, plasma nitrate is reduced to NO with vanadium(III) at 90°C, and the NO formed is detected by gaseous-phase chemiluminescence after reaction with ozone. The analyzer remained stable, so that linearity was maintained over the test period to $\leq 1\%$ with a coefficient of variation $\leq 10\%$. The results are expressed as millimolar units. All participants were instructed to maintain a nitrite- or nitrate-restricted diet over the 24 hours before testing, because NO can be affected by diet.

Arginine Vasopressin

Arginine vasopressin (AVP) was measured by double-antibody RIA (Alpco Diagnostics, Salem, NH, USA) (4). The assay range is between 1.25 and 80 $\text{pg}\cdot\text{ml}^{-1}$ with sensitivity of 0.35 $\text{pg}\cdot\text{ml}^{-1}$. The intraassay coefficient of variation was 4%.

Angiotensin-converting Enzyme

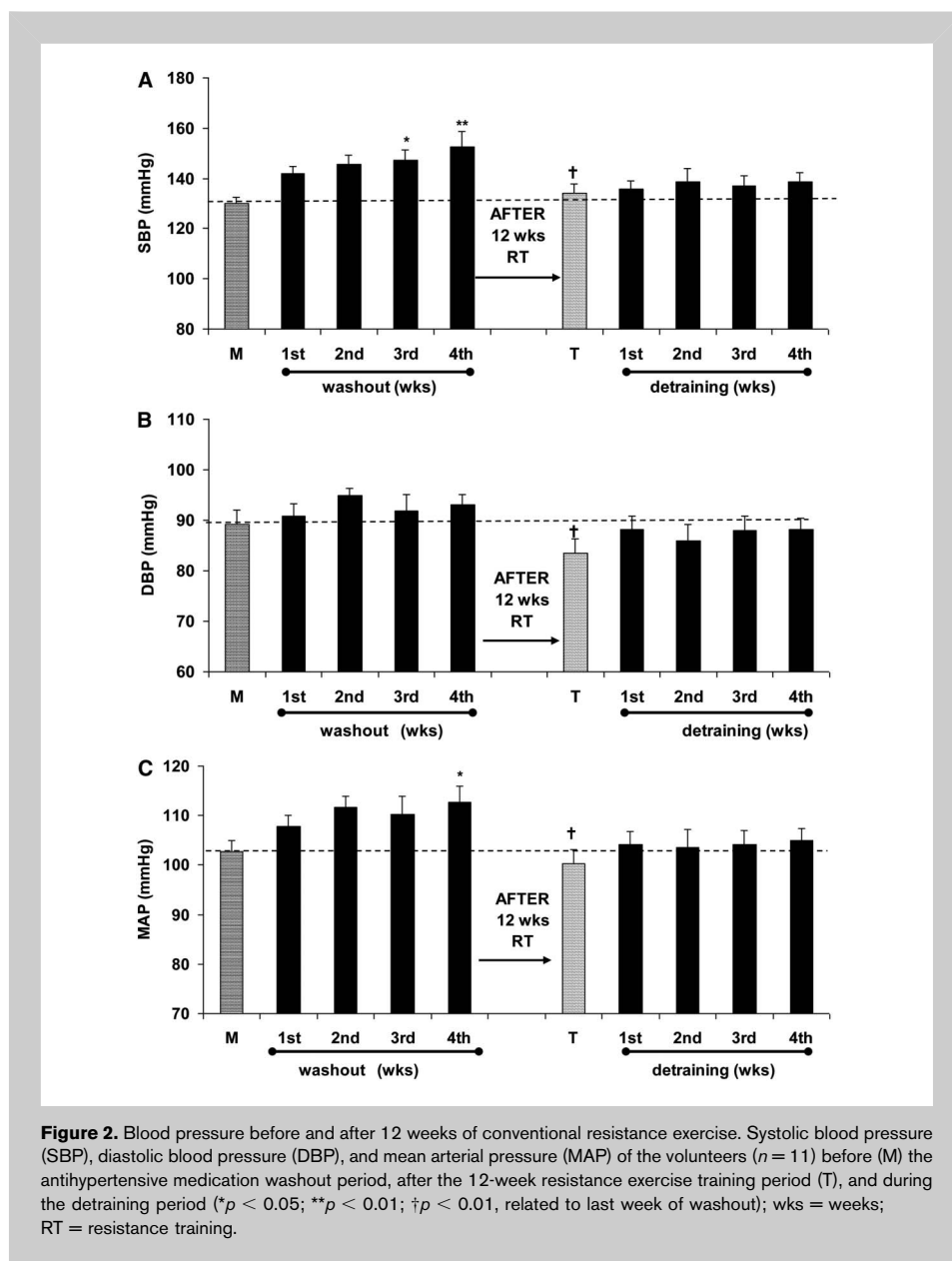
Angiotensin-converting enzyme catalytic activity was determined fluorimetrically as described by Friedland and Silverstein (12). An aliquot of serum (20 μl) and urine (50 μl) was incubated with a 200- μl assay solution containing 1 $\text{mmol}\cdot\text{L}^{-1}$ Z-Phe-His-Leu or 5 $\text{mmol}\cdot\text{L}^{-1}$ Hippuryl-His-Leu in 100 $\text{mmol}\cdot\text{L}^{-1}$ potassium phosphate buffer, pH 8.3, with 300 $\text{mmol}\cdot\text{L}^{-1}$ NaCl and 0.1 $\text{mmol}\cdot\text{L}^{-1}$ ZnSO_4 , for 10 minutes at 37°C. The enzymatic reaction was stopped by the addition of 1.5 ml of 280 $\text{mmol}\cdot\text{L}^{-1}$ of NaOH and incubated with 100 μl of o-phthalaldehyde (20 $\text{mg}\cdot\text{ml}^{-1}$ methanol) for 10 minutes. The fluorescent reaction was stopped by the addition of 200 μl of 3N HCl. The liberated dipeptide HL (L-HIS-LEU) was measured fluorimetrically (360 nm excitation and 500 nm emission) using a Hitachi fluorimeter (Hitachi, Tokyo, Japan). The standard curve was obtained using varying concentrations of L-HL (L-HIS-LEU) in the blank reaction mixture, and it showed a linear relation between relative fluorescence and HL (L-HIS-LEU) concentration.

Diet and Physical Activity Control

No dietary advice was provided, and participants were asked to maintain their normal caloric intake during the study. Participants were instructed to refrain from any other regular exercise during all phases of the entire study period.

Statistical Analyses

Three-way analysis of variance with repeated measures was used to test BP differences between the washout, training, and detraining period. The Tukey's post hoc test was used to identify significant data points. Student's *t*-test based on the difference or percent difference between the pre- and posttreatment measurements was applied to test the effect of training on physical and biochemical parameters. Pearson's correlation coefficient was used to examine



associations between changes in variables. Statistical analysis was performed using the Prism 5 software package. Differences were considered significant for p values ≤ 0.05 . All data are expressed as mean \pm SEM.

RESULTS

Subject Characteristics

To examine the effects of RE on stage 1 hypertensive patients, the subjects were withdrawn from antihypertensive medication and submitted to 12 weeks of a carefully designed and medically monitored RE program. The mean compliance of the 15 volunteers, calculated from the number of attended sessions, was $91 \pm 2\%$. The subject characteristics are shown in Table 1.

Anthropometrics, Strength, and Flexibility

From the several anthropometrical parameters measured (Table 1), total weightlifting capacity at 60% of 1RM, total body fat-free mass (+5%), total body fat mass (-15%), and sum of skinfold (-20%) changed significantly with the training program, as expected. At the end of program, the dynamic strength of the volunteers increased 32% ($p < 0.001$) in comparison to the untrained condition as demonstrated by the greater total weight lifted. The isometric force, evaluated by the handgrip test also increased (+12%, $p < 0.05$) in comparison to the untrained condition (Table 1). Body flexibility as evaluated by the sit-and-reach test improved significantly (+37%, $p < 0.001$) as demonstrated in Table 1.

Hemodynamics

Eleven of the 15 volunteers in this study were under antihypertensive medication before beginning the training protocol. To be able to compare the effects of RE on BP, the individual's medication was withdrawn during a 6-week antihypertensive medication washout interval. As shown in Figure 2, during this period, the SBP, DBP, and MAP increased. Although we observed only a slight increase in DBP, increases in SBP and MAP were significant, leading to $153 \pm 6/93 \pm 2$ mm Hg SBP/DBP

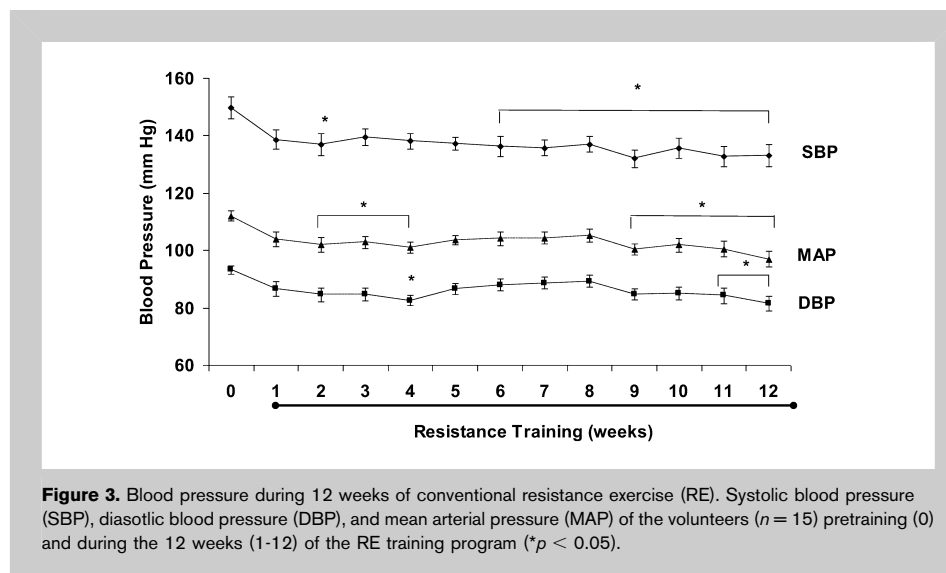


Figure 3. Blood pressure during 12 weeks of conventional resistance exercise (RE). Systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) of the volunteers ($n = 15$) pretraining (0) and during the 12 weeks (1-12) of the RE training program ($*p < 0.05$).

after washout. These values are similar to the values of the other 4 non-BP-controlled volunteers ($145 \pm 4/91 \pm 0$ mm Hg) and are indicative of stage 1 hypertensive patients (7).

Twelve weeks of RE promoted a significant reduction of SBP, DBP, and MAP in the 15 hypertensive volunteers (SBP 150 ± 3 to 134 ± 4 mm Hg, $p < 0.001$; DBP 93 ± 2 mm Hg to 81 ± 1 mm Hg, $p < 0.01$; MAP 112 ± 2 to 99 ± 3 mm Hg, $p < 0.01$) (Table 1). All these BP end values are in fact very similar to the values of the volunteers under antihypertensive medication (Figure 2).

Previous studies evaluated the effect of RE on BP only after the conclusion of an exercise program (15,23). Instead, we decided to investigate how much time was necessary for the effects of exercise on BP to appear. Our results demonstrated that the responsiveness of SBP, DBP, and

TABLE 2. Vasoactive blood factors of the hypertensive volunteers pre and posttraining.*

Variable, humoral factors	Resistance exercise		p
	Pretraining	Posttraining	
Bradykinin, pmol·ml ⁻¹	27 \pm 7	32 \pm 9	NS
DesArg9 BK, pmol·ml ⁻¹	17 \pm 3	18 \pm 8	NS
Nitric oxide, mM	26 \pm 2	27 \pm 2	NS
Angiotensin I, pmol·ml ⁻¹	57 \pm 8	56 \pm 10	NS
Angiotensin II, pmol·ml ⁻¹	52 \pm 10	56 \pm 7	NS
Angiotensin 1-7, pmol·ml ⁻¹	66 \pm 14	96 \pm 38	NS
ACE activity HHL, mU·ml ⁻¹	19 \pm 2	22 \pm 1	NS
ACE activity ZPhe-HL, mU·ml ⁻¹	28 \pm 3	33 \pm 2	NS
Arginine vasopressin, pg·ml ⁻¹	20 \pm 7	11 \pm 3	NS

*ACE = angiotensin-converting enzyme; DesArg9 BK = DesArg9 bradykinin; NS = not significant; HHL = Hippuryl-His-Leu; ZPhe-HL = Z-Phe-His-Leu.

MAP were different in our RE program when compared with conventional RE. Systolic blood pressure was lowered in the second week of the RE program, whereas DBP and MAP were affected by exercise only in the 2 last weeks of the program. The weekly pattern of these hemodynamic variables is presented in Figure 3.

Detraining

To address the question of how long the RE program normalizes BP, all volunteers were requested to avoid any exercise for 4 weeks after ending the training program. The BP values during these 4 detraining weeks are shown in Figure 2. All values remained similar to the values measured immediately after the ending of the training program. Although we measured a slight nonsignificant increase in SBP and MAP during detraining, these values remained significantly lower than the BP values before the training.

Peak Oxygen Consumption

There were no significant differences before and after RE in $\dot{V}O_2$ peak (Table 1), indicating that changes in BP were not related to improvements in endurance capacity.

Vasoactive Factors

The components of the renin-angiotensin system (RAS) and kallikrein-kinin system (KKS) were evaluated and AVP and NO before and after the RE program. Results are shown in Table 2. No significant changes were detected after 12 weeks of training.

DISCUSSION

The present study shows that chronic conventional RE is able to reduce BP in hypertensive individuals not under antihypertensive medication. This is an important finding because despite a report indicating that RE is able to reduce SBP and DBP by 4.6 and 3.8 mm Hg and 6.0 and 4.7 mm Hg in normotensive and prehypertensive individuals, respectively (10,23), no previous studies have reported the effect of chronic noncircuited RE on hypertensive adults (10,17).

We observed a BP reduction of SBP and DBP by 16 and 12 mm Hg after 12 weeks of conventional moderate-intensity RE in individuals with a pretraining average BP of 150/93 mm Hg. These results are similar to those obtained with hypertension patients after aerobic training (18).

Concerning CWT, only 2 studies investigated the chronic effect of this type of training on adult hypertensive patients and neither demonstrated BP reduction (5,15). Although CWT has been recommended to hypertensive individuals, it is interesting to note that (23) in comparison to conventional RE, this mode of training has more repetitions (15,20) and less rest pauses (≤ 30 seconds) and this can increase HR and SBP during the practice (19).

As far as we know, no previous studies evaluated the effect of a detraining period on the BP reduction induced by RE in hypertensive individuals. Our data demonstrated that the BP-lowering effect our training protocol had remained

sustained for at least 4 weeks. During this period, the BP of the subjects remained lower than the BP levels observed before the RE training. This information could be very relevant for the design of RE programs.

Additional to effects on BP, efficient RE programs should improve physical parameters such as body composition, muscle strength (dynamic and isometric), and even flexibility, changes that are associated with an improved quality of life (8). Furthermore, increased muscle strength is very important for hypertensive individuals because it may lead to less cardiovascular efforts when there is need to mobilize a certain weight (30). Of note, a recent study was conducted on 1,506 hypertensive men for 2 decades suggested that high levels of muscular strength seem to protect these individuals against all-cause mortality (3).

Because the potential mechanisms underlying BP reduction induced by RE have been poorly investigated and because there is evidence that components of the KKS or RAS could be involved in the acute hypotensive response to exercise (20,26), we evaluated the plasma levels of several vasoactive factors. Our data demonstrated that none of the vasoactive factors investigated was changed by 12 weeks of conventional RE. To our knowledge, only one study investigated the possible mechanistic effects of RE in elder medicated hypertensive subjects (9) and similarly to us, those authors did not observe changes in plasma levels of the RAS components angiotensin I and II.

In conclusion, this study documents the potential usefulness of conventional moderate-intensity RE in the treatment of middle-aged male hypertensive individuals. Furthermore, we showed that the reduction in BP values may last for at least 4 weeks after interruption of the training.

PRACTICAL APPLICATIONS

Controversy exists on the specific form of resistance training (circuited or conventional) and the type, intensity, duration, and training intervals of the specific form of RE in the control and prevention of hypertension (24). The present study documents for the first time the potential usefulness of conventional moderate-intensity (60% 1RM, no aerobic component) RE in the treatment of middle-aged, stage 1 hypertensive male patients without antihypertensive medication. After 12 weeks of training, BP values dropped to values similar to those obtained with 6 years of treatment using antihypertensive medication. Furthermore, BP remained lowered for at least 4 weeks after the training was ended. These findings are relevant for the better understanding and development of therapies that allow the prescription of RE to hypertensive individuals by health professionals.

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