Postexercise hypotension induced by low-intensity resistance exercise in hypertensive women receiving captopril

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Objective **The present study investigated the effect of a single bout of low-intensity resistance exercise on recovery blood pressure in hypertensive women receiving captopril.**

Methods **Twelve essential hypertensive women, who were receiving captopril, underwent two experimental sessions: control (C – 40 min of seated rest) and low-intensity resistance exercise (E – six resistance exercises, three sets, 20 repetitions, 40% of one repetition maximum). Clinic blood pressure was measured in the laboratory, before and for 120 min after exercise or rest. Moreover, ambulatory blood pressure was also measured for 21 h after exercise or rest.**

Results **Clinic blood pressures decreased significantly after exercise (systolic blood pressure = –12 ± 3 mmHg and diastolic blood pressure = –6 ± 2 mmHg, *P* < 0.05), but not after rest. Mean awake blood pressures (systolic: C = 132 ± 5 mmHg vs. E = 125 ± 4 mmHg and diastolic: C = 83 ± 3 mmHg vs. E = 78 ± 2 mmHg, *P* < 0.05) were significantly lower in the E than in the C session, while 21-h (systolic blood pressures: C = 128 ± 5 mmHg vs. E = 123 ± 4 mmHg; and diastolic blood pressures: C = 80 ± 3 mmHg vs. E = 76 ± 2 mmHg) and asleep (systolic blood pressures: C = 120 ± 7 mmHg vs. E = 118 ± 5 mmHg; and diastolic blood pressures: C = 73 ± 4 mmHg vs. E = 71 ± 3 mmHg) blood pressures did not differ between the experimental sessions. Moreover, there was a positive correlation between blood pressure measured in the C session and blood pressure reduction observed in the E session, showing that blood pressure decrease was greater when blood pressure level was higher.**

Conclusion **In hypertensive women receiving captopril, a single bout of low-intensity resistance exercise reduces blood pressure. This reduction persists for 10 h, during the awake period, while patients were engaged in their daily living activities. It was greater in patients with higher ambulatory blood pressure. *Blood Press Monit* 11:183–189 © 2006 Lippincott Williams & Wilkins.**

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Keywords: ambulatory blood pressure, angiotensin-converting enzyme inhibitors, clinic blood pressure, hypertension, resistance exercise

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Introduction

Hypertension is a cardiovascular disorder that affects approximately 1 billion individuals worldwide, and represents an important risk factor for cardiovascular disease [1,2]. Aerobic exercise is recommended as a nonpharmacological treatment for hypertension because of its well-demonstrated hypotensive effect [3,4]. In fact, even a single bout of aerobic exercise provokes a significant fall in blood pressure (BP) during the recovery period, which has been called postexercise hypotension. This phenomenon has been accepted to have clinical relevance, as it occurs in hypertensive patients, has significant magnitude, and lasts for many hours after the finishing of the exercise bout [3].

Nowadays, in addition to aerobic exercise, resistance exercise has been recommended as a supplementary component of the training program for hypertensive patients [3,5]. The main and classic health benefit of this kind of exercise is the improvement of the muscle–skeletal function [6,7]. Some other health improvements, however, have also been reported, such as the reduction on cardiovascular risk profile [6,8]. Nevertheless, to assure the efficacy of this kind of exercise in hypertensive patients, it is important to know its effects on BP.

A recent meta-analysis [5] showed that, chronically, resistance training might reduce BP; however, as pointed out by the authors, the decrease is smaller in hypertensive patients, and more studies are needed in this population.

In regard to the acute effects of resistance exercise on postexercise BP, the results are controversial. Some studies observed an increase [9–12], others a decrease [9,10,13–19], and others a maintenance [12,20,21].

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Exercise intensity might be one of the factors responsible for the controversy, because most of the studies [9,10,13–15,17–19] that observed a fall in BP after resistance exercise employed low-intensity exercises [40–65% of 1 repetition maximum (RM)]. Moreover, Focht and Koltyn [10], comparing exercise of different intensities, observed BP decrease only after the low-intensity exercise. Similarly, we observed in normotensive patients [19] that exercise at 40% of 1 RM provoked a greater diastolic BP fall than exercise at 80% of 1 RM.

It is also important to report, however, that only two of the previous studies [15,16] involved hypertensive patients, and they observed a slight fall in BP. Moreover, in these studies, patients were not receiving any antihypertensive drugs, which usually occurs in clinical practise, and makes it important to investigate whether the hypotensive effect of resistance exercise is maintained when patients were medicated.

The maintenance of BP fall for many hours after resistance exercise is another important point that was investigated by three studies [13,16,21], which that reported conflicting results. Only one of them [16] involved hypertensive patients, and BP fall lasted for only 1 h. This study, however, employed a high-intensity exercise, which might have influenced the results.

Thus, the acute effect of resistance exercise on recovery BP, and the maintenance of this effect for many hours after exercise in hypertensive patients receiving antihypertensive drugs need further investigation. In Brazil, most of the patients treated by public health services are women [22]. Moreover, many of them are receiving captopril as treatment, as this is one of the drugs recommended by the Hypertension and Diabetes Program of the Brazilian Federal Health Department (http://hiperdia.datasus.gov.br/medicamentos.asp).

Therefore, the present study was designed to investigate the effects of low-intensity resistance exercise on postexercise BP levels measured in the laboratory, and during activities of daily living in hypertensive women receiving captopril. We hypothesize that low-intensity resistance exercise would promote a significant postexercise hypotension that would persist for many hours after exercise.

Methods

Subjects

Eleven essential hypertensive women aged 41–50 years gave written consent to participate in this study, which was approved by the Ethical Committee of the General Hospital, Faculty of Medicine, and of the School of Physical Education and Sport, both from the University of São Paulo.

Table 1 Physical and functional characteristics of the patients

Age (years)	46 ± 1
Weight (kg)	62.7 ± 2.3
Height (cm)	152 ± 2
Body mass index (kg/m^2)	26.9 ± 0.5
Resting systolic blood pressure (mmHg)	134 ± 6
Resting mean blood pressure (mmHg)	104 ± 4
Resting diastolic blood pressure (mmHg)	89 ± 3
Resting heart rate (bpm)	80 ± 2
Maximal heart rate (bpm)	151 ± 3
Maximal systolic blood pressure (mmHg)	204 ± 3

All patients were taking captopril, an angiotensin-converting enzyme (ACE) inhibitor (25 or 50 mg/day), as antihypertensive therapy. Moreover, five of them were also taking other medications – two diuretic (hydroclorotizide, 25 mg), one acetylsalicylic acid (100 mg), and two diuretic plus acetylsalicylic acid.

None of the patients was engaged in any regular physical activity program, and patients who had any cardiovascular disease, high cholesterol levels (serum cholesterol $\geq$ 240 mg/dl), diabetes (fasting glucose $\geq$ 126 mg/dl), obesity (body mass index $\geq$ 30 kg/m^2), and/or any target organ damage were excluded. Physical and cardiovascular characteristics of the patients are shown in Table 1.

Preliminary evaluation

Before the study inclusion, auscultatory BP was measured on two occasions, three times after 5 min of seated rest, and a mean value was calculated [1,2]. Electrocardiogram performed before and during a maximal exercise test performed on a treadmill using the modified Balke protocol was employed to exclude cardiovascular diseases.

Procedures

During the study, patients were instructed to take their antihypertensive drugs regularly, and not to change either the drug, the dose, or the hour of medication. Moreover, they were asked to avoid any physical exercise for at least 48 h before the experiments.

Before the experimental sessions, 1 RM test was performed for the bench press, leg-press, lat pull down, leg curl, biceps curl, and squat, using Kraemer and Fry's protocol [23]. In order to get accustomed to the machines, and to guarantee the correct execution of the exercises, patients underwent four familiarization sessions before the 1 RM test. In these sessions, they performed three sets of 20 repetitions of each exercise with the minimum weight allowed by the equipment. An interval of at least 3 days was allowed between the sessions.

Patients underwent two experimental sessions, control (C) and low-intensity resistance exercise (E) performed in a random order with an interval of at least 7 days. All

experiments were performed in the morning, and patients were instructed to take a light meal 1 h before and to avoid caffeine. As experiments involved exercise, the recommendations from the American College Sports Medicine's guidelines [6] were followed; in other words, experiments were initiated only if the patient's systolic/diastolic BPs were below 160/105 mmHg. Moreover, to assure that the initial conditions were similar in both experimental sessions, experiments were initiated only if BP values were similar to the average values measured in the preliminary evaluation.

In each session, patients rested in the laboratory in the seated position for 20 min. During this period, auscultatory BP was measured every 5 min, and a mean value (excluding the first and last measurements) was calculated. Then, patients went to the exercise room, where they performed the low-intensity resistance exercise protocol in the E session or stayed resting in the machines in the C session. Afterwards, they returned to the laboratory, and rested in the seated position for 90 min. During this period, auscultatory BP was measured every 5 min, and averaged every 15 min. Moreover, an ambulatory BP monitor was placed in the nondominant arm of the patients, and measurements were taken every 10 min. After 90 min of recovery, all the equipment was disconnected; patients took a bath, and returned to the laboratory within 30 min. Thus, 120 min after the end of the exercise or rest, the ambulatory BP monitor was reinstalled, and auscultatory BP was measured again before the patients left the laboratory. In the laboratory, air temperature was kept constant between 21 and 23°C. Patients were instructed to maintain their usual activities, to avoid physical exercise, and to record the time of meals and sleep while using the monitor. They were also asked to keep similar activities and times in both experimental days.

The resistance exercise protocol was preceded by 5 min of cycling warm-up and static stretching. Patients performed three sets of 20 repetitions in each one of the six resistance exercises described above with an intensity of 40% of 1 RM. An interval of 45 s was applied between the sets and 90 s between the exercises.

Blood pressure measurements

Auscultatory BP was measured on the dominant arm by a trained observer. Phases I and V of the Korotkoff sounds were employed to determine systolic and diastolic BPs, respectively.

Ambulatory BP was measured by an oscillometric device (SpaceLabs 90207; SpaceLabs Medical, Inc., Redmond, Washington, USA) programmed to take measurements every 10 min for 21 h. The device's calibration was regularly checked by comparison with a mercury column. Recordings were accepted only if at least 75% of the readings were successfully performed. Twenty-one hour, awake and asleep BPs were expressed by the average of all measurements taken during the 21-h, awake and asleep periods reported by each patient. BP loads were calculated as the percentage of measurements $\geq$ 140/90 and $\geq$ 120/80 mmHg during awake and asleep periods, respectively. Nocturnal BP fall was calculated in absolute values by the difference between mean awake and asleep BPs, and in relative values by the quotient between this difference and the awake BP.

Statistical analysis

Auscultatory BP responses to exercise or rest were calculated by the difference between values measured after and before exercise or rest in the E and C sessions, respectively. These responses were compared by a two-way analysis of variance for repeated measures (Statistica for Windows 4.3, Statisoft Inc., 1993; Statisoft Inc., Tulsa, Oklahoma, USA), establishing sessions (C and E) and stages (pre, 15, 30, 45, 60, 75, 90 and 120 min) as the main factors. Post-hoc comparisons were made by Newman–Keuls test.

To verify the effect of exercise on ambulatory BP parameters, BPs measured in the C and E sessions were compared by paired Student's t-test. Correlations were established by Pearson's coefficient.

$P < 0.05$ was accepted as statistically significant. Data are presented as mean $\pm$ SE.

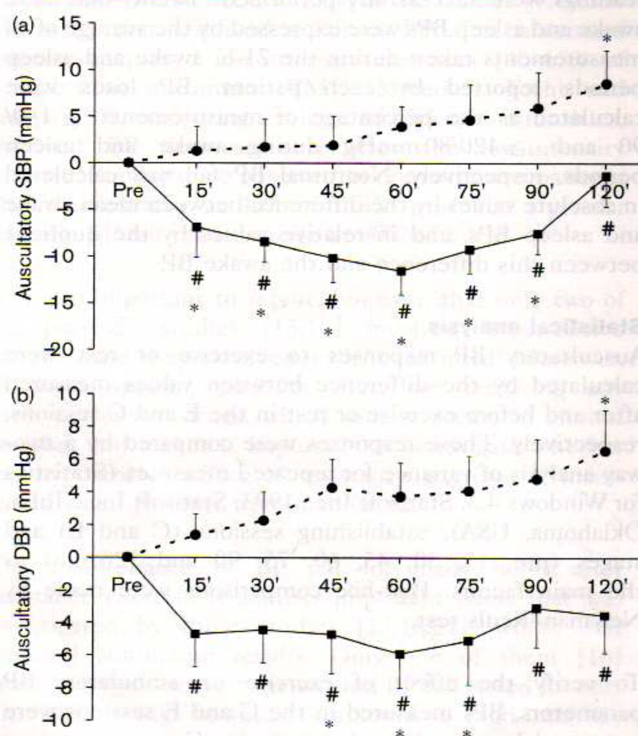
Results

The workloads corresponding to 40% of 1 RM were 6.5 $\pm$ 0.5 kg for bench press, 51.8 $\pm$ 4.6 kg for leg press, 17.8 $\pm$ 0.6 kg for lat pull down, 15.5 $\pm$ 1.1 kg for leg curl, 10.9 $\pm$ 0.6 kg for biceps curl, and 18.7 $\pm$ 1.6 kg for squat. All patients completed 20 repetitions in the first set of all exercises; however, in the second and third sets, some patients did not reach 20 repetitions because of fatigue, but all of them performed at least 15 repetitions.

Auscultatory systolic and diastolic BP responses observed in the C and E sessions are shown in Fig. 1. Systolic BP decreased significantly after exercise from 15 to 90 min of recovery, whereas in the C session, it increased significantly 120 min after the intervention. Diastolic BP also decreased significantly after exercise from 45 to 75 min of recovery, and it increased significantly in the C session at 120 min of the postintervention period.

Ambulatory BPs measured in the C and E sessions are shown in Table 2. Awake systolic, mean, and diastolic BPs, as well as awake systolic and diastolic BP loads, were significantly lower in the E than in the C session. All the other ambulatory BP parameters were similar in both

Fig. 1



Auscultatory systolic (SBP – panel a) and diastolic (DBP – panel b) blood pressure responses observed before (Pre) and after interventions in the control (dashed line with circles) and low-intensity resistance exercise (solid line with squares) sessions. *Significantly different from Pre ($P<0.05$). #Significantly different from the control session ($P<0.05$).

experimental sessions. As all the patients were awake for at least 10 h, an analysis of hourly BPs during this period is presented in Fig. 2, and showed that systolic and diastolic BPs were also lower in the E than in the C session.

A positive and significant correlation existed between some of the ambulatory BP parameters measured in the C session and their fall observed in the E session. These correlations were significant for 21-h and night-time systolic, mean, and diastolic BPs (21-h: $r=0.605$, 0.745 and 0.813 and night-time: $r=0.689$, 0.731, and 0.720, respectively, $P<0.05$), and for awake mean and diastolic BPs ($r=0.758$ and 0.699, respectively, $P<0.05$), showing that patients with higher BP levels in the C session presented higher BP fall after exercise (Fig. 3).

Discussion

The most important and new findings of the present study are that, in hypertensive women receiving ACE inhibitor therapy (with or without diuretics and/or acetylsalicylic acid), a single bout of low-intensity resistance exercise: (a) decreased BP during the recovery period; (b) this reduction persisted for 10 h, while patients were awake; and (c) this reduction was greater in patients with greater ambulatory BP levels.

Table 2 Ambulatory blood pressure measured after rest and low-intensity resistance exercise in the control and exercise sessions

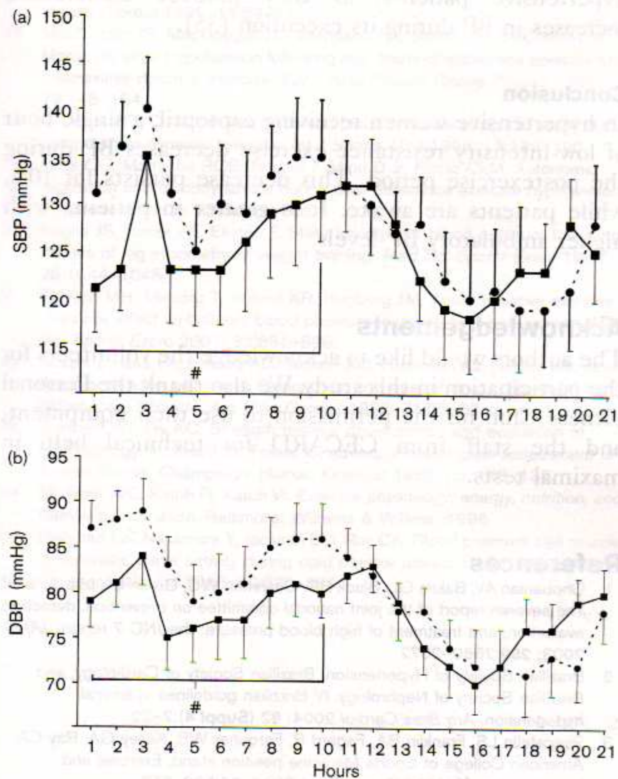
	Control	Exercise
21-Hour		
Systolic blood pressure (mmHg)	128 ± 5	123 ± 4
Diastolic blood pressure (mmHg)	80 ± 3	76 ± 2
Mean blood pressure (mmHg)	97 ± 4	92 ± 3
Heart rate (bpm)	74 ± 2	76 ± 2
Awake		
Systolic blood pressure (mmHg)	132 ± 5	125 ± 4[a]
Diastolic blood pressure (mmHg)	83 ± 3	78 ± 2[a]
Mean blood pressure (mmHg)	100 ± 4	94 ± 3[a]
Heart rate (bpm)	78 ± 2	80 ± 2
Asleep		
Systolic blood pressure (mmHg)	120 ± 7	118 ± 5
Diastolic blood pressure (mmHg)	73 ± 4	71 ± 3
Mean blood pressure (mmHg)	90 ± 5	88 ± 3
Heart rate (bpm)	66 ± 1	67 ± 2
Blood pressure load		
Awake systolic blood pressure (%)	33 ± 11	21 ± 9[a]
Awake diastolic blood pressure (%)	32 ± 9	13 ± 6[a]
Asleep systolic blood pressure (%)	50 ± 13	40 ± 12
Asleep diastolic blood pressure (%)	39 ± 11	25 ± 9
Nocturnal blood pressure fall		
Systolic blood pressure (mmHg)	11 ± 4	7 ± 3
Diastolic blood pressure (mmHg)	11 ± 3	7 ± 2
Systolic blood pressure (%)	9 ± 3	6 ± 2
Diastolic blood pressure (%)	13 ± 4	9 ± 3

[a]Significantly different from the control session ($P<0.05$).

Postexercise hypotension has already been reported after resistance exercise in normotensive [9,10,13–15,17–19] and also in hypertensive [15,16] patients. The magnitude of clinic systolic/diastolic BP decreases observed in this study were $-12\pm3/-6\pm2$ mmHg, and the greatest fall was observed 60 min after exercise. These BP reductions were similar to the ones usually reported after aerobic exercise [3], and they were greater than the ones previously reported after resistance exercise in non-treated hypertensive patients [15,16]. This is the first time that this hypotensive effect was observed in hypertensive patients receiving ACE inhibitor antihypertensive therapy. As some of the patients ($n=4$) were also receiving diuretics, the results might have been influenced by this medication; however, this does not seem to be the case, because when patients receiving diuretics were excluded, results remained similar.

We observed an increase in BP 120 min after the rest in the C session. As this measurement was recorded when patients returned to the laboratory after taking a bath, which is usually cold in the hot regions of Brazil, the increase in BP in this session might be related to the physical activity [24] and/or to the thermoregulatory mechanisms [25,26] associated with the cold bath.

Fig. 2

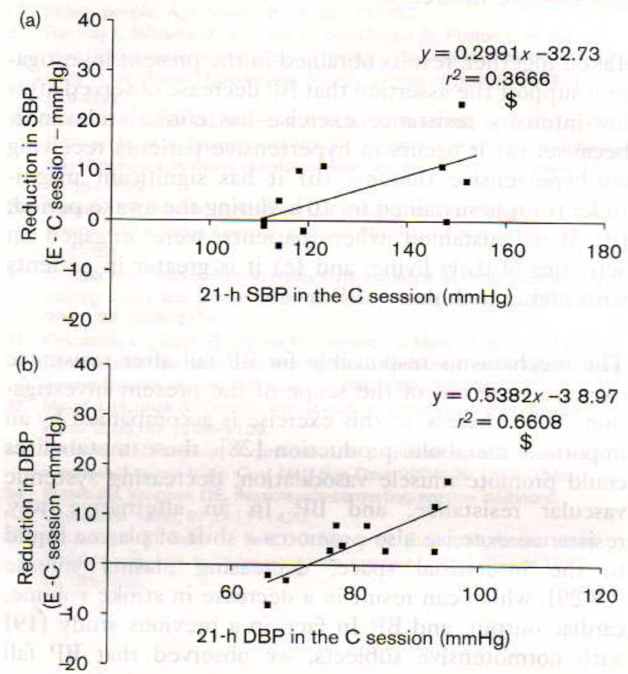


Mean systolic (SBP – panel a) and diastolic (DBP – panel b) blood pressures measured in each hour after rest or low-intensity resistance exercise in the control (dashed line with circles) and exercise (solid line with squares) sessions. #Significantly different from the control session ($P<0.05$).

Nevertheless, as the cold bath was also taken in the E session, this procedure should not have influenced the results.

With regard to the duration of BP decrease, it was maintained throughout the awake period, which lasted at least 10 h in all the patients. This result is especially relevant, because it shows that resistance exercise decreases BP during the period of the day when BP is usually higher. To our knowledge, only one previous study [16] investigated the duration of hypotension after resistance exercise in hypertensive patients, and reported a BP fall for only 1 h. In this study however, patients were not taking any antihypertensive drug, and the exercise intensity was higher. Both these factors might explain the different results. With regard to the exercise intensity, the comparison between the studies suggests that low-intensity resistance exercise might be better for promoting a long-lasting BP fall in hypertensive patients. In fact, previous studies in normotensive subjects [10,19] have already observed greater BP falls after resistance exercises

Fig. 3



Correlation between systolic (SBP – panel a) and diastolic (DBP – panel b) blood pressure (BP) measured in the control session (C), and their reduction promoted by the low-intensity resistance exercise (E), calculated by the difference between values observed in the C and the E sessions (positive values means decrease in BP). \$ $P<0.05$.

of lower intensities; however, this aspect was not investigated in hypertensive patients. Nevertheless, the present results demonstrate that low-intensity resistance exercise, which is usually recommended for hypertensive patients, has an important and long-lasting hypotensive effect.

It is important to note that the positive correlation between BP measured in the C session, and BP fall observed after exercise shows that patients who had greater ambulatory BP level, also presented greater BP fall after exercise. In fact, this relationship has already been reported for aerobic exercise, and has been called 'law of initial values' [3]. These results suggest that exercise is more effective in reducing postexercise ambulatory BP in patients who do not have a good BP control besides the drug therapy. In the present study, although all patients were receiving antihypertensive therapy, 37% of them presented abnormal ambulatory BP levels (awake BPs higher than 135/85 mmHg [27]) in the C session. Thus, the acute hypotensive effect of exercise might help to control ambulatory BP parameters. Nevertheless, the number of patients in the present study does not allow the division of the sample in order to get a

conclusion about this aspect, which should be investigated in the future.

Taken together, results obtained in the present investigation support the assertion that BP decrease observed after low-intensity resistance exercise has clinical relevance, because: (a) it occurs in hypertensive patients receiving antihypertensive therapy; (b) it has significant magnitude; (c) it is sustained for 10 h, during the awake period; (d) it is sustained when patients were engaged in activities of daily living; and (e) it is greater in patients with higher ambulatory BP levels.

The mechanisms responsible for BP fall after resistance exercise were out of the scope of the present investigation. Nevertheless, as this exercise is accompanied by an important metabolic production [28], these metabolites could promote muscle vasodilation, decreasing systemic vascular resistance, and BP. In an alternative way, resistance exercise also promotes a shift of plasma liquid to the interstitial space, decreasing plasma volume [28,29], which can result in a decrease in stroke volume, cardiac output, and BP. In fact, in a previous study [19] with normotensive subjects, we observed that BP fall after low-intensity resistance exercise was due to a decrease in cardiac output. We did not find any other study that investigated hemodynamic mechanisms after acute resistance exercise. After aerobic exercise however, hemodynamic mechanisms might be different in regard to the population studied [30], including normotensive and hypertensive patients [31]. Thus, in hypertensive patients, who usually present high systemic vascular resistance [32], the mechanism responsible for BP decrease after resistance exercise might be different, and should be investigated in the future. Moreover, as ACE inhibitors alter systemic vascular resistance [33,34], they may also affect the mechanism responsible for BP fall after exercise.

Study limitations

Data were collected in untrained hypertensive women receiving captopril with and without diuretic and/or acetylsalicylic acid. Results in men and trained patients might be evaluated by future researches. With regard to antihypertensive therapy, results might be similar in hypertensive patients taking other ACE inhibitors. Its reproducibility in patients receiving other classes of medication, however, should also be tested. The exercise protocol employed in the present study consisted of three sets of 20 repetitions of six exercises for major muscles at an intensity of 40% of 1 RM. This protocol was chosen because it is recommended for muscle resistance improvement, and it is used in clinical practise [23]. Results might be similar with other protocols involving exercise for main muscles, performed with low intensity and a high number of repetitions. High-intensity exercise, however, might bring different results, and is not recommended for hypertensive patients, as they produce exacerbated increases in BP during its execution [35].

Conclusion

In hypertensive women receiving captopril, a single bout of low-intensity resistance exercise decreases BP during the postexercise period. This decrease persists for 10 h, while patients are awake. It is greater in patients with higher ambulatory BP levels.

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References

1 Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, *et al.* The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. *JAMA* 2003; **289**:2560–2572.
2 Brazilian Society of Hypertension, Brazilian Society of Cardiology, and Brazilian Society of Nephrology. IV Brazilian guidelines in arterial hypertension. *Arq Bras Cardiol* 2004; **82** (**Suppl 4**):7–22.
3 Pescatello LS, Franklin BA, Fagard R, Farquhar WB, Kelley GA, Ray CA. American College of Sports Medicine position stand. Exercise and hypertension. *Med Sci Sports Exerc* 2004; **36**:533–553.
4 Whelton SP, Chin A, Xin X, He J. Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. *Ann Intern Med* 2002; **136**:493–503.
5 Cornelissen VA, Fagard RH. Effect of resistance training on resting blood pressure: a meta-analysis of randomized controlled trials. *J Hypertens* 2005; **23**:251–259.
6 American College Sports Medicine. *ACSM's guidelines for exercise testing and prescription.* Philadelphia: Lippincott Williams & Wilkins; 2000.
7 Fleck SJ, Kraemer WJ. *Designing resistance training programs.* Champaign: Human Kinetics; 1987.
8 Pollock ML, Franklin BA, Balady GJ, Chaitman BL, Fleg JL, Fletcher B, *et al.* AHA Science Advisory. Resistance exercise in individuals with and without cardiovascular disease: benefits, rationale, safety, and prescription: an advisory from the Committee on Exercise, Rehabilitation, and Prevention, Council on Clinical Cardiology, American Heart Association; Position paper endorsed by the American College of Sports Medicine. *Circulation* 2000; **101**:828–833.
9 Brown SP, Clemons JM, He Q, Liu S. Effects of resistance exercise and cycling on recovery blood pressure. *J Sports Sci* 1994; **12**:463–468.
10 Focht BC, Koltyn KF. Influence of resistance exercise of different intensities on state anxiety and blood pressure. *Med Sci Sports Exerc* 1999; **31**:456–463.
11 Koltyn KF, Raglin JS, O'Connor PJ, Morgan WP. Influence of weight training on state anxiety, body awareness and blood pressure. *Int J Sports Med* 1995; **16**:266–269.
12 O'Connor PJ, Bryant CX, Veltri JP, Gebhardt SM. State anxiety and ambulatory blood pressure following resistance exercise in females. *Med Sci Sports Exerc* 1993; **25**:516–521.
13 Bermudes AM, Vassallo DV, Vasquez EC, Lima EG. Ambulatory blood pressure monitoring in normotensive individuals undergoing two single exercise sessions: resistive exercise training and aerobic exercise training. *Arq Bras Cardiol* 2004; **82**:65–71.
14 DeVan AE, Anton MM, Cook JN, Neidre DB, Cortez-Cooper MY, Tanaka H. Acute effects of resistance exercise on arterial compliance. *J Appl Physiol* 2005; **98**:2287–2291.
15 Fisher MM. The effect of resistance exercise on recovery blood pressure in normotensive and borderline hypertensive women. *J Strength Cond Res* 2001; **15**:210–216.

16 Hardy DO, Tucker LA. The effects of a single bout of strength training on ambulatory blood pressure levels in 24 mildly hypertensive men. *Am J Health Promot* 1998; **13**:69–72.
17 MacDonald JR, MacDougall JD, Interisano SA, Smith KM, McCartney N, Moroz JS, *et al.* Hypotension following mild bouts of resistance exercise and submaximal dynamic exercise. *Eur J Appl Physiol Occup Physiol* 1999; **79**:148–154.
18 O'Connor PJ, Cook DB. Anxiolytic and blood pressure effects of acute static compared to dynamic exercise. *Int J Sports Med* 1998; **19**:188–192.
19 Rezk CC, Marrache RCB, Tinucci T, Mion D Jr, Forjaz CLM. Autonomic regulation and hemodynamics during post-resistance exercise hypotension. *J Hypertens* 2005; **23(Suppl)**:S37.
20 Raglin JS, Turner PE, Eksten F. State anxiety and blood pressure following 30 min of leg ergometry or weight training. *Med Sci Sports Exerc* 1993; **25**:1044–1048.
21 Roltsch MH, Mendez T, Wilund KR, Hagberg JM. Acute resistive exercise does not affect ambulatory blood pressure in young men and women. *Med Sci Sports Exerc* 2001; **33**:881–886.
22 Akashi D, Issa FK, Pereira AC, Tannuri AC, Fucciolo DQ, Lobato ML, *et al.* Antihypertensive treatment. Prescription and cost of drugs. Survey in a tertiary care hospital. *Arq Bras Cardiol* 1998; **71**:55–57.
23 Kraemer WJ, Fry AC. Strength testing: development and evaluation of methodology. In: Maud PJ, Foster C, editors. *Physiological assessment of human fitness.* Champaign: Human Kinetics; 1995. pp. 115–138.
24 McArdle WC, Katch FI, Katch VI. *Exercise physiology: energy, nutrition, and human performance.* Baltimore: Williams & Wilkins; 1996.
25 Dishman RK, Nakamura Y, Jackson EM, Ray CA. Blood pressure and muscle sympathetic nerve activity during cold pressor stress: fitness and gender. *Psychophysiology* 2003; **40**:370–380.
26 Goodwin J, Pearce VR, Taylor RS, Read KL, Powers SJ. Seasonal cold and circadian changes in blood pressure and physical activity in young and elderly people. *Age Ageing* 2001; **30**:311–317.
27 Ramsay L, Williams B, Johnston G, MacGregor G, Poston L, Potter J, *et al.* Guidelines for management of hypertension: report of the third working party of the British Hypertension Society. *J Hum Hypertens* 1999; **13**: 569–592.
28 Bush JA, Kraemer WJ, Mastro AM, Triplett-McBride NT, Volek JS, Putukian M, *et al.* Exercise and recovery responses of adrenal medullary neurohormones to heavy resistance exercise. *Med Sci Sports Exerc* 1999; **31**:554–559.
29 Kraemer RR, Kilgore JL, Kraemer GR. Plasma volume changes in response to resistive exercise. *J Sports Med Phys Fitness* 1993; **33**: 246–251.
30 Senitko AN, Charkoudian N, Halliwill JR. Influence of endurance exercise training status and gender on postexercise hypotension. *J Appl Physiol* 2002; **92**:2368–2374.
31 Pescatello LS, Miller B, Danias PG, Werner M, Hess M, Baker C, *et al.* Dynamic exercise normalizes resting blood pressure in mildly hypertensive premenopausal women. *Am Heart J* 1999; **138**:916–921.
32 Mayet J, Hughes A. Cardiac and vascular pathophysiology in hypertension. *Heart* 2003; **89**:1104–1109.
33 Bertrand ME. Provision of cardiovascular protection by ACE inhibitors: a review of recent trials. *Curr Med Res Opin* 2004; **20**:1559–1569.
34 Brown NJ, Vaughan DE. Angiotensin-converting enzyme inhibitors. *Circulation* 1998; **97**:1411–1420.
35 MacDougall JD, Tuxen D, Sale DG, Moroz JR, Sutton JR. Arterial blood pressure response to heavy resistance exercise. *J Appl Physiol* 1985; **58**:785–790.