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ORIGINAL RESEARCH

Isometric handgrip does not elicit cardiovascular overload or post-exercise hypotension in hypertensive older women

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Background: Arterial hypertension is a serious health problem affecting mainly the elderly population. Recent studies have considered both aerobic and resistance exercises as a non-pharmacological aid for arterial hypertension treatment. However, the cardiovascular responses of the elderly to isometric resistance exercise (eg, isometric handgrip [IHG]) have not yet been documented.

Objective: The purpose of this study was to investigate cardiovascular responses to different intensities of isometric exercise, as well as the occurrence of post-isometric exercise hypotension in hypertensive elderly people under antihypertensive medication treatment.

Patients and methods: Twelve women volunteered to participate in the study after a maximal voluntary contraction test (MVC) and standardization of the intervention workload consisting of two sessions of IHG exercise performed in four sets of five contractions of a 10-second duration. Sessions were performed both at 30% of the MVC and 50% of the MVC, using a unilateral IHG protocol. Both intensities were compared with a control session without exercise. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) at rest (R), during peak exercise (PE), and after 5, 10, 15, 30, 45, and 60 minutes of post-exercise recovery were evaluated.

Results: No significant changes were observed after isometric exercise corresponding to 30% MVC for either SBP (R: 121 ± 10; PE: 127 ± 14; 5 min: 125 ± 13; 10 min: 123 ± 12; 15 min: 122 ± 11; 30 min: 124 ± 11; 45 min: 124 ± 10; 60 min: 121 ± 10 mmHg) or DBP (R: 74 ± 9; PE: 76 ± 6; 5 min: 74 ± 5; 10 min: 72 ± 8; 15 min: 72 ± 5; 30 min: 72 ± 8; 45 min: 73 ± 6; 60 min: 75 ± 7 mmHg). Similarly, the 50% MVC did not promote post-isometric exercise hypotension for either SBP (R: 120 ± 7; PE: 125 ± 11; 5 min: 120 ± 9; 10 min: 122 ± 9; 15 min: 121 ± 11; 30 min: 121 ± 9; 45 min: 121 ± 9; 60 min: 120 ± 7 mmHg) or DBP (R: 72 ± 8; PE: 78 ± 7; 5 min: 72 ± 7; 10 min: 72 ± 8; 15 min: 71 ± 7; 30 min: 72 ± 8; 45 min: 75 ± 10; 60 min: 75 ± 7 mmHg).

Conclusion: Our data reveal that cardiovascular overload or post-exercise hypotension did not occur in elderly women with controlled hypertension when they undertook an IHG session. Thus this type of resistance exercise, with mild to moderate intensity, with short time of contraction appears to be safe for this population.

Keywords: hypertension, resistance exercise, elderly, cardiovascular response, antihypertensive medication, isometric exercise

Introduction

Hypertension is estimated to affect 1 billion people worldwide, and is associated with an increased risk of cardiovascular disease and all-cause mortality, especially in the elderly. The proportion of older adults in the American countries is steadily rising, such that the portion of the population aged 65 and older is expected to double in the next 30 years. In addition, more than half of 55-year-old people are expected to develop hypertension within 10 years.[1]

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It is well established that blood pressure (BP) increases with advancing age; however, it was only in the 1990s that several guidelines began to advise physical exercise and the adoption of a healthy lifestyle to prevent arterial systemic hypertension (ASH).[2–4] Nevertheless, there is little evidence regarding the effect of strength training on cardiovascular responses in this population, as well as insufficient information on the interaction between exercise and drugs used to treat ASH.[2,5,6]

Among the effects associated with the practice of exercise, post-exercise hypotension (PEH) has been studied mainly in aerobic exercises,[2] while strength exercises have been investigated less.[7–11] In a recent meta-analysis on the hypotensive effects of strength exercise, Cornelissen et al[12] reported favorable effects of isometric training for BP control. However, it is known that cardiovascular responses to isometric exercise (IE) depend on factors such as the volume of muscle mass involved, the duration and intensity of the IE, the number of contractions, and total workload.[2,13]

To the best of our knowledge, only one study has evaluated medicated hypertensive elderly people.[14] In that study, the authors found a significant reduction in systolic pressure (−19 mmHg), diastolic pressure (−7 mmHg), and mean arterial pressure (−11 mmHg) after 8 weeks of handgrip training. Studies have shown that moderate handgrip IE reduces BP in normortensive[15–22] and hypertensive[15–24] subjects. Moreover, the information available in the literature on the acute effects of an IE session on post-isometric exercise hypotension (PIEH) in hypertensive older people is unclear.[25–27] Additionally, IE may result in an increased BP correlating to duration of contraction.[25]

Thus, the practice of IE could be a recommendation for older people with weakness or motor limitation, given that this type of capability is usually required to perform the activities of daily living and especially in situations related to clinical practice.[12] Therefore, the purpose of this study was to investigate the cardiovascular responses to different intensities of IE, as well as the occurrence of PIEH in hypertensive elderly people being treated with antihypertensive medication.

Patients and methods

Sample

After approval by the Research Ethics Committee of Mogi das Cruzes University (33/2009), twelve older (64 ± 1 years) people who were physically inactive and had hypertension controlled by antihypertensive medication participated in this study. Exclusion criteria were: clinical diagnosis of diabetes mellitus, current smoker, organ damage, and musculoskeletal complications and/or cardiovascular alterations confirmed by physical test. All procedures were performed according to the Declaration of Helsinki.[28]

Measures

Anthropometric parameters

The anthropometric measures conformed to those previously reported by our group.[29–33] Height was measured to the nearest 0.1 cm using a Cardiomed® WCS stadiometer (Curitiba, Brazil). Body mass was measured to the nearest 0.1 kg using a Filizola Personal Line 150 scale (São Paulo, Brazil). Body mass index (BMI; kg/m^2) was calculated as follows: BMI = weight/height^2. Body composition was determined using anthropometric measures.

Exercise testing protocol

All volunteers were submitted to a maximal treadmill walking test, using the modified Balke protocol.[19] A twelve-lead SM 400 electrocardiograph (TEB, New York, NY, USA) was used to record the maximal heart rate (HR). Arterial BP was measured during the test using a sphygmomanometer (BP cuff) and stethoscope (both Becton Dickinson, New York, NY, USA). Participants were excluded in case of ST segment depression > 1 mm, complex arrhythmias, or when ischemic symptoms were observed during exercise testing.[34]

BP and heart rate

Systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial blood pressure (MAP) (MAP = DBP + [SBP – DBP]/3) and HR were measured before, during, and immediately after each IE training session using an automated noninvasive BP monitor (Microlife 3AC1-1PC, Microlife, Widnau, Switzerland).[35] Rate-pressure product (RPP) was evaluated according to the following equation: RPP = HR * SBP. The measurement was performed after the subjects completed each set (a total of four); the objective of this measurement was to guarantee that BP did not fall during the exercise session.[4] All BP measurements were taken on the left arm. Individual cuffs were labeled with the ranges of arm circumferences.[36] Pre-exercise BP did not exceed 160 and 100 mmHg for SBP and DBP, respectively. During exercise, HR was continuously measured and recorded on a beat-by-beat basis using a Polar Vantage NV (Polar Electro, Oulu, Finland) HR recorder. Volunteers were also instructed to avoid the Valsalva maneuver during the entire movement, following American College of Sports Medicine guidelines.[4]

To evaluate the occurrence of PEH, BP, and HR were also measured in the sitting position (resting) at 5, 10, 15, 30, 45, and 60 minutes of post-exercise recovery.

Maximal voluntary contraction

Subjects were asked to refrain from eating, smoking, and ingesting caffeine and alcohol for at least 4 hours before testing. All volunteers participated in a battery of tests to determine their maximal voluntary contraction (MVC) using a handgrip dynamometer (Jamar Hydraulic Hand Dynamometer 5030 J1, Patterson Medical, Bolingbrook, IL, USA). Before the test, subjects underwent three familiarization sessions (two sets of 10 seconds each using the minimum weight allowed by the equipment separated by a 2-minute rest, in conformation with Schlüssel et al[37]) on nonconsecutive days. Following a brief warm-up, each subject's MVC value was determined as the highest value obtained of the three attempts. To guarantee objectivity, all tests were performed by the same researcher with the Valsalva maneuver.

IE sessions

After the MVC testing and standardization of the intervention workload, volunteers underwent two sessions of IHG exercise consisting of four sets of five contractions of a 10-second duration each. Sessions were performed both at 30% of the MVC and 50% of the MVC, using a unilateral IHG protocol. Both interventions were compared with a control session without exercise. SBP and DBP were evaluated at rest (R), peak exercise (PE) and at 5, 10, 15, 30, 45, and 60 minutes post exercise.

The IE protocol was adapted from an earlier study that demonstrated significant reductions in arterial BP at rest after a chronic intervention.[15] Upon arrival in the laboratory (between 13:00 and 16:00) after a light standard meal, subjects remained resting in sitting position for 20 minutes before starting the exercise. 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 kg of body weight for water replacement. Exercise sessions were randomized and performed at least 72 hours apart. The laboratory temperature was maintained between 22.5°C and 25.8°C during all testing sessions.

Statistical analyses

All statistical analyses were performed using SPSS software (v 12.0; IBM, Armonk, NY, USA). Analysis of comparisons between groups over the periods was performed with two-way analysis of variance with repeated measures, followed by Kruskal–Wallis or Bonferroni's post-hoc test when appropriate. The D'Agostino–Pearson test was applied to Gaussian distribution analysis. Statistical significance was established at $P < 0.05$. Data are expressed as mean ± standard deviation.

Results

The anthropometric parameters, resting hemodynamics, and medications used are presented at Table 1. The maximal voluntary strength test did not differ between the right and left limbs. Additionally, there were no differences in hemodynamic parameters during the peak of contraction compared with the control situation, demonstrating that the test did not promote cardiovascular system overload, as shown in Table 2.

The changes in hemodynamic parameters before, during exercise peak, and isometric post-exercise are presented in Table 3. No changes were observed in hemodynamic parameters immediately after the end of the exercise protocol, despite exercise intensity. Similarly, no hemodynamic overload was identified during the exercise session intervals (Table 4).

Discussion

The main finding of this study was that no PEH was observed at any IHG exercise intensity. This is important because isometric sessions should not provoke acute cardiovascular responses. Li et al found no acute cardiovascular changes in coronary patients submitted to 3 minutes of

Table 1 Sample characteristics

Parameters	
Anthropometric parameters	
Weight (kg)	68 ± 3
Height (cm)	157 ± 2
BMI (kg/cm^2)	27 ± 1
Hemodynamic parameters	
HR (bpm)	72 ± 6
SBP (mmHg)	121 ± 7
DBP (mmHg)	72 ± 6
MAP (mmHg)	88 ± 5
RPP (bpm*mmHg)	8874 ± 888
Medicine	
β-blocker	75%
ACE inhibitor	83%
Angiotensin II antagonist receptor	50%
Diuretic	58%
Calcium channel blocker	50%

Note: Values expressed as the mean ± standard deviation unless otherwise specified.
Abbreviations: ACE, angiotensin-converting-enzyme; BMI, body mass index; DBP, diastolic blood pressure; HR, heart rate; MAP, mean arterial pressure; RPP, rate-pressure product; SBP, systolic blood pressure.

Table 2 Maximal voluntary contraction parameters

	Control	Right arm	Left arm
Maximal voluntary contraction (kg)	–	25 ± 3	24 ± 4
Hemodynamic parameters			
HR (bpm)	74 ± 5	72 ± 1	71 ± 1
SBP (mmHg)	122 ± 7	126 ± 1	126 ± 3
DBP (mmHg)	74 ± 3	78 ± 1	77 ± 2
MAP (mmHg)	90 ± 5	94 ± 1	93 ± 2
RPP (mmHg*bpm)	9028 ± 275	9063 ± 235	8945 ± 279

Note: Values expressed as the mean ± standard deviation.
Abbreviations: DBP, diastolic blood pressure; HR, heart rate; MAP, mean arterial pressure; RPP, rate-pressure product; SBP, systolic blood pressure.

isometric contraction.[38] This same response was found by Auerbach et al using the dead lift exercise at 50% MVC sustained for 3 minutes in 18 heart transplant recipients.[39]

We may infer that even for IE involving large muscle mass, no hemodynamic abnormalities or electrocardiographic or clinical abnormalities that contraindicate this type of strength exercise would be presented by this population.[27] Note that variables such as weather and load voltage are crucial points to be considered when IE is to be carried out.[40,41] Further, the intensity used in this study was different from that used in other clinical studies,[38] showing that the practice of IE under the conditions used in this study is safe and does not promote excessive elevation of BP in elderly women.

Significant changes in BP associated with IE were observed in the scientific literature,[14–16,18–21] mostly in chronic studies, which justifies the proposal of the present research in analyzing the behavior of acute post-exercise BP. Besides, in these previously mentioned studies the IHG exercise was performed only at 30% MVC and involved 4 × 2-minute bilateral[15,18] or unilateral contractions[26] with a rest period of 3 minutes or 1 minute, respectively, between contractions.

Recent studies have investigated the effects of acute IE in the elderly. Araújo et al, for example, examined the effects of IE on post-exercise BP in 41 elderly cardiac patients using 30% MVC with four sets of 2 minutes of contractions.[27] The authors concluded that after IHG exercise, BP and HR returned to baseline values after 1 minute of post-exercise recovery. These results are similar to our finding, in that, at 5 minutes of post-exercise recovery, no abnormality in cardiovascular parameters was observed in elderly women with controlled hypertension.

Millar et al investigated the acute effects of four IHG protocols on BP and neurocardiac reactivity.[26] In that study, twelve healthy older subjects completed four bilateral 12-minute protocols (control, IHG1, IHG2, IHG3) on separate visits. The IHG1, IHG2, and IHG3 exercises consisted of 4 × 2-minute,

Table 3 Hemodynamic parameters at control condition and 30% and 50% of maximal voluntary contraction

	SBP (mmHg)			DBP (mmHg)			MAP (mmHg)			HR (bpm)			RPP (bpm*mmHg)		
	Control	30%	50%	Control	30%	50%	Control	30%	50%	Control	30%	50%	Control	30%	50%
Rest	121 ± 13	121 ± 10	120 ± 7	76 ± 12	74 ± 9	72 ± 8	91 ± 11	90 ± 8	88 ± 7	72 ± 9	77 ± 11	74 ± 11	8681 ± 1486	9261 ± 1096	8874 ± 1256
Exercise peak	121 ± 12	127 ± 14	125 ± 11	76 ± 11	76 ± 6	78 ± 7	91 ± 11	93 ± 7	94 ± 7	72 ± 8	75 ± 10	72 ± 11	8749 ± 1374	9553 ± 1331	8973 ± 1481
5 min	120 ± 12	125 ± 13	120 ± 9	73 ± 8	74 ± 5	72 ± 7	89 ± 8	91 ± 6	88 ± 7	68 ± 8	71 ± 11	67 ± 8	8201 ± 1245	8867 ± 1331	8053 ± 1216
10 min	118 ± 5	123 ± 12	122 ± 9	72 ± 8	72 ± 8	72 ± 8	87 ± 7	89 ± 8	89 ± 7	68 ± 8	70 ± 10	67 ± 7	8034 ± 1166	8651 ± 1513	8151 ± 1108
15 min	117 ± 8	122 ± 11	121 ± 11	73 ± 7	72 ± 5	71 ±7	87 ± 7	88 ± 6	88 ± 8	67 ± 10	70 ± 11	65 ±7	7900 ± 1490	8530 ± 1538	7960 ± 1276
30 min	118 ± 7	124 ± 11	121 ± 9	72 ± 7	72 ± 8	72 ± 8	87 ± 7	89 ± 8	88 ± 7	66 ± 10	70 ± 12	66 ±7	7835 ± 1516	8661 ± 1609	8058 ± 1134
45 min	123 ± 8	124 ± 10	121 ± 9	75 ± 6	73 ± 6	75 ± 10	91 ± 7	90 ± 6	90 ± 8	65 ± 9	70 ± 11	69 ±7	7993 ± 1337	8595 ± 1377	8375 ± 995
60 min	122 ± 7	121 ± 10	120 ± 7	73 ± 6	75 ± 7	75 ± 7	89 ± 6	90 ± 7	90 ± 5	64 ± 7	68 ± 11	67 ± 6	7841 ± 1014	8186 ± 1435	8058 ± 885

Note: Values expressed in as the mean ± standard deviation.
Abbreviations: DBP, diastolic blood pressure; HR, heart rate; MAP, mean arterial pressure; RPP, rate-pressure product; SBP, systolic blood pressure.

Table 4 Hemodynamic parameters at interval session at control condition and 30% and 50% of maximal voluntary contraction

	1st interval			2nd interval			3rd interval		
	Control	30%	50%	Control	30%	50%	Control	30%	50%
SBP (mmHg)	120 ± 5	125 ± 6	122 ± 11	121 ± 4	127 ± 6	127 ± 10	122 ± 5	125 ± 6	125 ± 10
DBP (mmHg)	70 ± 6	76 ± 6	73 ± 4	71 ± 5	75 ± 6	73 ± 5	70 ± 4	75 ± 8	74 ± 6
MAP (mmHg)	88 ± 7	92 ± 5	89 ± 6	89 ± 7	93 ± 5	91 ± 5	91 ± 4	92 ± 7	91 ± 7
HR (bpm)	74 ± 4	73 ± 10	74 ± 10	73 ± 6	73 ± 10	74 ± 9	74 ± 5	73 ± 10	74 ± 9
RPP (bpm*mmHg)	9039 ± 202	9099 ± 1169	8948 ± 1269	9019 ± 262	9285 ± 1079	9321 ± 1248	9089 ± 322	9183 ± 1371	9305 ± 1407

Note: Values expressed in as the mean ± standard deviation.
Abbreviations: DBP, diastolic blood pressure; HR, heart rate; MAP, mean arterial pressure; RPP, rate-pressure product; SBP, systolic blood pressure.

8 × 1-minute, and 16 × 30-second isometric contractions, respectively, completed at 30% MVC, while the sham consisted of 4 × 2-minute contractions completed at 3% MVC. BP and neurocardiac modulation were assessed during each protocol and at 5, 10, 15, 20, 25, and 35 minutes post exercise. In conclusion, recovery responses from rhythmic IHG appear independent of contraction duration and/or rest period between sets, but rather are related to contraction frequency and total duration of exercise. In addition, similar to our results, no difference in the BP or HR response after a single IHG session was verified in healthy older people not on regular antihypertensive medication.

Although studies have shown that hypotension post-exercise may be of higher magnitude with mild to moderate physical activity than at high intensities,[42] it is not clear in the literature if the intensity of IE influences the magnitude or the rate of reduction of rest BP.[4] This is because the available studies have often used intensity corresponding to 30% MVC, considered a moderate level.[21] In our study, we found no reduction in BP after exercise, which can be explained by the low volume of protocols used; however, the workloads used were strongly associated with tasks of daily living. Our protocol involved four sets of five contractions of 10 seconds' duration each (total approximately 4 minutes) at 30% and 50% MVC, which differs from the protocols used in other studies,[16,18,26,43–45] in which four series of contractions for 2 minutes each, totaling approximately 8 minutes, were used.

In a similar study using a short-duration IE protocol, Kiveloff and Huber reported significant reductions ranging from 16 to 43 mmHg in resting SBP and from 2 to 24 mmHg in resting DBP as a result of 5–8 weeks of static exercise (6-second contractions for all large muscle groups, $3 \cdot d^{-1}$, $5\ d \cdot wk^{-1}$) in hypertensive adults.[46] However, unfortunately, the methodological differences – for example, the fact that adult hypertensive individuals were submitted to chronic IE – compromise any eventual comparison between their results and ours.

Another important feature is the volume of training. Our study used half the volume (~4 minutes) of IE than that used in other studies. Mediano et al concluded that a higher training volume resistance exercise session can promote reductions in SBP level in medicated hypertensive older individuals.[47] In our study, the absence of HPE in older women with IHG exercise may be related to increased vascular resistance and large-artery stiffness caused by aging.

Conclusion

Our data lead us to conclude that older women with controlled hypertension who undertake IE of short duration at intensities of 30% and 50% MVC do not present any exacerbated BP responses to exercise and do not show PEH. Thus, the exercise was safe for our patients. Similar studies should be conducted on patients with elevated BP. Further, as exercise physiologists are called upon to perform strengthening exercises for elderly people with cardiovascular disease, these findings may be useful for the monitoring of cardiovascular responses in such patients during the practice of IE.

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Disclosure

The authors declare no conflicts of interest in this work.

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