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Original Article

CARDIOVASCULAR RESPONSES AFTER ISOMETRIC HANDGRIP EXERCISE AT DIFFERENT INTENSITIES IN HEALTHY MEN

RESPOSTAS CARDIOVASCULARES APÓS EXERCÍCIO ISOMÉTRICO COM *HANDGRIP* EM DIFERENTES INTENSIDADES EM HOMENS SAUDÁVEIS

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RESUMO

O protocolo com 30% da contração voluntária máxima do exercício isométrico com handgrip é amplamente utilizada para melhoria do sistema cardiovascular. Todavia, é desconhecido se a modulação da intensidade afetam essas respostas. Objetivou analisar as respostas cardiovasculares agudas após exercício isométrico com *handgrip* realizado em diferentes intensidades. Fizeram parte deste estudo *cross-over* 23 homens saudáveis. Os voluntários realizaram três sessões experimentais: 4x2 minutos de contração a 30% (S30) e 4x2 minutos de contração a 50% (S50) da contração voluntária máxima e controle (SC). A pressão arterial (PA) e os parâmetros da variabilidade da frequência cardíaca do domínio do tempo (SDNN, RMSSD e PNN50) e da frequência (LF, HF e LF/HF) foram obtidos antes e após as sessões. Nenhuma das sessões experimentais promoveram alterações estatisticamente significantes na PA sistólica e diastólica (p>0,05 para todos). Após a S50, houve menor aumento do SDNN nos cinco minutos pós-exercício (S50:+5±6; S30:+20±5;SC:+10±2 ms, p<0,05) e maior aumento do LF/HF após 20 minutos (S50:+1,59±0,80;S30:-0,49±0,49;SC:+0,39±0,49, p<0,05) comparado as demais sessões. Conclui-se que as respostas da PA ao exercício isométrico de handgrip são similares entre as intensidade, no entanto, o exercício mais intenso promoveu maior aumento da modulação simpática e redução da modulação parassimpática após exercício.
Palavras-chave: Pressão arterial. Exercício. Treinamento de resistência. Frequência cardíaca.

ABSTRACT

The 30% maximal voluntary contraction protocol for isometric handgrip exercise is widely used to improve the cardiovascular system. However, it is unknown whether intensity modulation affects these responses. Objective: To analyze acute cardiovascular responses after isometric handgrip exercise performed at different intensities. Twenty-three healthy men participated in this cross-over study. The volunteers performed three experimental sessions: 4x2 minutes of contraction at 30% (S30) MVC and 4x2 minutes of contraction at 50% (S50) MVC, besides control (CS). Blood pressure (BP) as well as time (SDNN, RMSSD and PNN50) and frequency (LF, HF and LF/HF) domain heart rate variability parameters were obtained before and after sessions. None of the experimental sessions promoted statistically significant changes in systolic and diastolic BP (p> 0.05 for all). After S50, there was a smaller increase in SDNN five minutes after the exercise (S50: +5±6, S30: +20±5, SC: +10±2 ms, p <0.05) and higher LF/HF after 20 minutes (S50: +1.59±0.80, S30: -0.49±0.49, SC: +0.39±0.49, p <0.05) compared to the other sessions. In conclusion, BP responses to isometric handgrip exercise are similar between intensities; however, the most intense exercise promoted a greater increase in sympathetic modulation and decrease in parasympathetic modulation after exercise.
Keywords: Blood pressure. Exercise. Resistance exercise. Heart rate.

Introduction

Isometric handgrip training is being proposed as an alternative to treating and preventing systemic hypertension, as review studies and meta-analyses have been showing that this type of training reduces blood pressure (BP)[1-3]. The American Heart Association[4] is already indicating, though with caution, potential benefits of this type of training.

Although chronic effects of isometric handgrip exercise on BP have been consolidated, mechanisms are not yet clear. Some studies have suggested that this exercise acute responses are directly related to chronic effects on BP[5-7], which makes this an important mechanistic area. However, the literature addressing acute effects of isometric handgrip exercise on BP is incipient and controversial, since some studies have observed reductions in prehypertensive[8] and hypertensive[9] individuals, while others have found no changes in healthy seniors[10], people with coronary artery disease[11] and prehypertensive ones[12], which suggests a need for further researches.

Curiously, studies that have analyzed acute responses have used the 30% MVC protocol, with unknown cardiovascular effects at other intensities, although, chronically, the 50% MVC intensity has proved to be more effective in reducing BP[13]. In addition, also chronically, increasing parasympathetic modulation concomitantly with reducing sympathetic modulation for the heart is being suggested as a mechanism responsible for decreasing BP after handgrip training[3,14], which corroborates with acute responses found in seniors[15,16] and youths[17]. On the other hand, it is unknown whether different intensities would also modulate cardiac autonomic modulation responses..

Therefore, the objective of the present study was to analyze acute cardiovascular responses after isometric handgrip exercise at different intensities in healthy men.

Methods

Subjects and Ethical Considerations

This cross-over study sample was composed of 23 healthy men recruited by means of posters placed inside and outside of the Tabosa de Almeida University Center (ASCES-UNITA), as well as through announcements on social media. For participation, individuals should be aged between 18 and 30 years old, be normotensive and present low cardiovascular risk, in accordance with the American College of Sport Medicine recommendations[18]. The study excluded those who, during its conduction, used substances that could affect the cardiovascular system, such as anabolic steroids, energy drinks, hypercaloric supplements and others.

All study procedures were approved by the University of Pernambuco Ethics Research Committee (CAAE: 30806014.0.0000.5207), and those individuals who agreed to participate signed a Free and Informed Consent Form (FICF).

Screening and Norm tension Diagnosis

The individuals were subjected to a cardiovascular risk assessment, as well as to BP measurement, in order to have their inclusion in and eligibility for the study guaranteed. Other pieces of data included demographics, health history, use of medication and supplements, in addition to anthropometric measures (body mass and height).

BP was taken on two different days with a 48-hour interval in order to guarantee that pressure values were accurate[19,20]. The individuals received instructions that should be followed 24 hours before each assessment, such as not performing any type of physical exercise, maintaining their normal routine as to sleep and eating times, not ingesting tea, coffee or any other compound with caffeine, and not ingesting alcoholic beverages. On the days when BP was taken, the individuals were questioned about compliance with recommendations and then requested to empty their bladders for measurements.

BP was measured with the individuals seated in a quiet room at controlled temperature and by means of the automatic device Omron HEM 742. Measures were taken from the right arm with a cuff that fitted the arm circumference and until the difference between the two last measures were inferior to 4 mmHg, as recommended by the 7th Brazilian Hypertension Guidelines[21]. Individuals considered as normotensive were those with systolic BP lower than 140 mmHg and/or diastolic BP lower than 90 mmHg on two different days[21].

Maximum Voluntary Contraction Assessment

For maximum voluntary contraction (MVC) assessment, a handgrip device, CAMRY brand, was used; it was adjustable and calibrated with a scale from 0 to 100 kgf. The individuals were assessed while seated with their shoulders slightly forward, their elbows flexed at 90^{o}, their forearms and fists in neutral position, in accordance with the American Society of Hand Therapists[22]. Hand position was adjusted so that the proximal interphalangeal joint of the hands was adjusted under the bar for gripping to be performed between the fingers and the thenar eminence with maximum comfort.

During the test, the participants performed two 5-second maximum contractions for each arm with a 1-minute interval; at the end, the highest value found for each arm was considered. These procedures present good reproducibility indicators (intraclass correlation coefficient: 0.986 for the non-dominant arm, and 0.989 for the dominant one)[23].

Experimental Design

The individuals were subjected to three experimental protocols, whose order was randomized, with them being: two exercise sessions (S30 and S50) and one control session (CS). The study design is displayed in Figure 1.

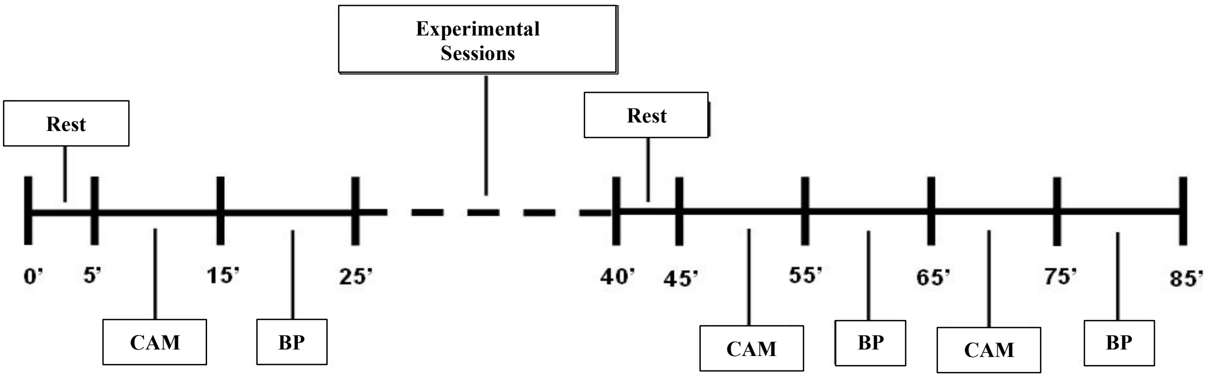

Figure 1. Study Experimental Design
Note: BP – Blood Pressure; CAM – Cardiac Autonomic Modulation
Source: The authors

In S30, the individuals executed four 2-minute isometric contraction series with a 1-minute interval in between and at a 30% CAM intensity; in S50, the individuals performed four 2-minute isometric contraction series with a 1-minute interval in between and at a 50% CAM intensity; in CS, the individuals did four 2-minute isometric contraction series with a 1-minute interval in between and at a 3% CAM intensity.

BP assessment and cardiac autonomic modulation occurred before and after the sessions were performed. BP was taken after 15 and 30 minutes, while cardiac autonomic modulation was checked five and 20 minutes after the session.

Blood Pressure and Cardiac Autonomic Modulation

Before collection, the individuals were instructed to maintain their sleeping pattern, not to perform physical exercises or ingest caffeinated and alcoholic beverages 24 hours before the sessions. BP measurement followed the same protocols adopted in the cardiovascular screening and complied with the 7th Brazilian Hypertension Guidelines[21].

Cardiac autonomic modulation was assessed by analyzing heart rate variability. To do so, the individuals were required to remain seated for more than 10 minutes, period during which RR intervals were recorded by means of a heart rate monitor valid for this function

(Polar RS800CX, Polar Electro, Finland), considering as valid those signals with at least five minutes of stationary signal, identified by visual inspection[24].

After collection, the RR intervals were exported to software Kubios HRV (Biosignal analysis and Medical Imaging Group, Finland) and analyzed for time and frequency domains. Time domain, standard deviation of all RR intervals (SDNN), root mean square of the successive differences (RMSSD) between adjacent RR intervals, and percentage of adjacent intervals with more than 50 ms (PNN50) were calculated. These parameters represent heart rate variability, with the highest values being indicative of good cardiovascular system functionality[24].

The frequency domain parameters were obtained by spectral analysis technique through autoregressive method, with the fixed-model order set at 12. Frequencies between 0.04 and 0.4 Hz were considered as physiologically significant, with the low frequency (LF) component represented by oscillations between 0.04 and 0.15 Hz, and the high frequency (HF) component, between 0.15 and 0.4 HZ. The power of each spectral component was calculated in normalized terms, which was done by dividing the power of each band by total power, from which the very low frequency band value (<0.04 Hz) was subtracted, with the result being multiplied by 100[24]. The LF/HF component was used as a sympathetic and vagal balance indicator.

All procedures were carried out by a single blind assessor for the sessions to which the individuals were subjected. This assessor's intraclass correlation coefficient for the heart rate variability parameters ranged from 0.980 to 0.995[25].

Statistical Analysis

All analyses were run using software Statistica 7.0. Normality and variance homogeneity were analyzed by means of the Shapiro-Wilk and Levene's tests, respectively.

One factor analysis of variance was used to compare pre-session values. Experimental session effects on BP were analyzed by two factor analysis of variance for repeated measures, with session (S30, S50 and CS) and time (pre-intervention, 15 and 30 minutes after intervention) as factors. To analyze experimental session effects on cardiac autonomic modulation, the absolute delta of each HRV parameter was calculated (post 5 minutes – pre and post 20 minutes – pre). Newman-Keuls *post hoc* was adopted to check for significant differences. For all analyses, the $P<0.05$ value was considered as significant, and data were presented as mean ± standard deviation.

Results

General characteristics of the individuals included in the present study are displayed in Table 1.

Table 1. General characteristics of the subjects included in the study (n=23)

Variables	Mean ± Standard Deviation
Age (years)	21.0 ± 0.4
Body Mass (kg)	71.0 ± 1.9
Height (m)	1.75 ± 0.02
Body Mass Index (kg/m²)	23.0 ± 0.7
Systolic Blood Pressure (mmHg)	117 ± 2
Diastolic Blood Pressure (mmHg)	63 ± 1

Source: The authors

No statistically significant difference was found between experimental sessions in the pre-session moment ($p>0.05$). There was no statistically significant differences in the experimental sessions for systolic BP (S50 - pre: 116±2 mmHg; 15’ post: 119±2 mmHg; 30’ post: 119±2 mmHg; S30 -pre: 117±3 mmHg; 15’ post: 118±2 mmHg; 30’ post: 119±3 mmHg; SC - pre: 117±2 mmHg; 15’ post: 118±2 mmHg; 30’ post: 120±3mmHg) and diastolic BP (S50 - pre: 62±1 mmHg; 15’ post: 65±1 mmHg; 30’ post: 65±1 mmHg; S30 -pre: 61±1 mmHg; 15’ post: 64±2 mmHg; 30’ post: 66±2 mmHg; CS - pre: 63±2 mmHg; 15’ post: 64±2 mmHg; 30’ post: 66±2 mmHg) (Figure 2).

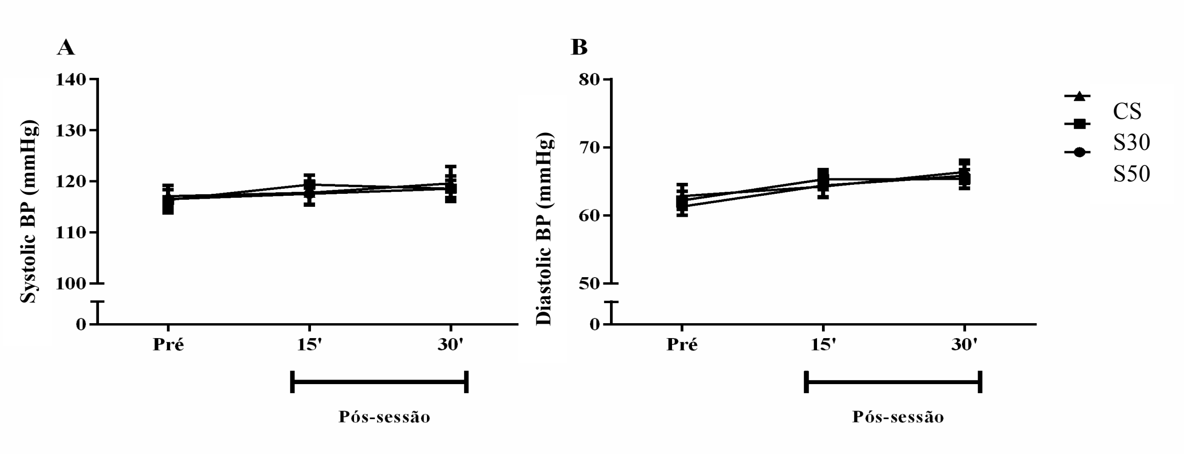

Figure 2. Systolic and c **Post-session** pressure acute responses a **Post-session** ıtal sessions
Note: S50: 2-minute session at 50%; S30: 2-minute session at 30%; CS: Control Session; BP – Blood Pressure. Panel A - Session: F=0.127, p=0.881; Time: F=2.462, p=0.097, Interaction: F=0.389, p=0.816. Panel B – Session: F=0.269, p=0.767; Time: F=26.181, p<0.001; Interaction: F=1.061, p=0.381
Source: The authors

After S50, the individuals showed lower PNN50 compared to the other sessions, and higher LF/HF compared to S30 (P<0.05) (Figure 3). For the other parameters, no statistically significant changes were observed.

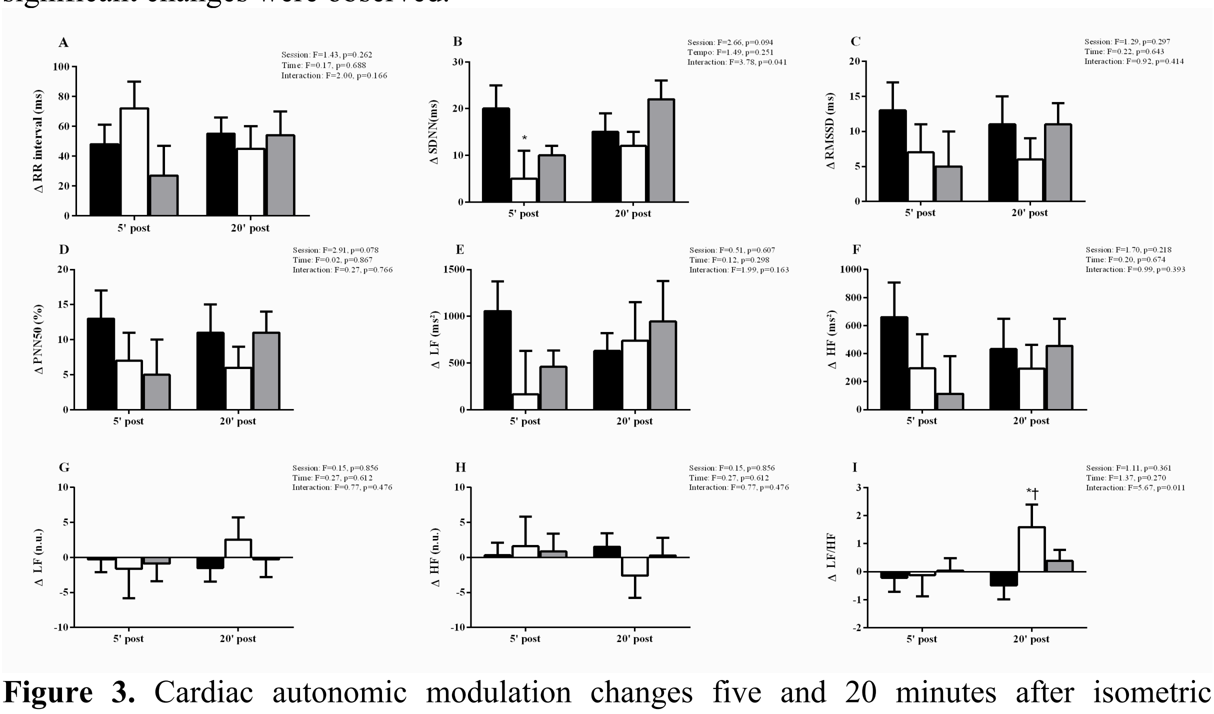

Figure 3. Cardiac autonomic modulation changes five and 20 minutes after isometric handgrip exercise in healthy young men
Note: Black bars S30; White bars S50; and grey bars control. SDNN – Standard Deviation of Normal-to-Normal intervals; RMSSD – Root Mean Square of the Successive Differences between adjacent NN intervals; PNN50 – percentage of adjacent NN intervals with more than 50ms; LF – low frequency band; HF – high frequency band; LF/HF – Sympathetic and vagal balance. *Statistically different from S30; † Statistically different from control (P<0.05)
Source: The authors

Discussion

This is the first study analyzing BP acute responses and cardiac autonomic modulation after isometric handgrip exercise performed at different intensities. The research main results showed that isometric handgrip exercise did not change pressure responses, regardless of the intensity applied. On the other hand, isometric handgrip exercise executed at 50% MVC increased sympathetic modulation and reduced parasympathetic modulation after 20 minutes of exercise.

Although chronically the effects of isometric handgrip exercise are well established in the literature, with meta-analysis studies showing reductions of approximately 6 mmHg for systolic BP and 4 mmHg for diastolic BP, in hypertensive or normotensive subjects, acute responses are still uncertain. The present study did not observe any statistically significant changes in BP after 15 and 30 minutes of exercise, and these results are independent on intensities employed. These findings are in line with some studies in the literature; Millar et al.[16] as well found no changes in BP after 30 minutes by subjecting 12 healthy elderly individuals to a protocol identical to S30. This is similar to the findings of Older et al.[10], who, by subjecting hypertensive elderly women to exercises with 30 and 50% MVC, though with shorter series (5 series of 10 seconds each), reported no changes in BP for a period of 60 minutes.

On the other hand, Millar et al.[9] observed reduced systolic BP in seniors five minutes after isometric handgrip exercise at 30% MVC. The differences found could be explained, at least in part, by the BP assessment protocol, suggesting that the hypotensive effect is fast, which is perhaps only temporary and could return after 15 minutes, as well as by the subjects' characteristics, since in the study by Millar et al.[9], initial BP values were higher than those of this study subjects, and it is known that people with higher BP levels are more responsive[26].

Although no statistically significant changes were found in BP, this study evidenced that S50 increased sympathetic modulation and reduced parasympathetic modulation for the heart after the exercise, which was indicated by higher LF/HF and lower SDNN, respectively. This was the first study to analyze these responses at an intensity of 50% MVC. Previously, Millar et al.[9] had already described that exercise at 30% MVC increased rest parasympathetic modulation after five minutes in 18 healthy seniors. Thus, these results suggest that performing isometric exercise at 50% MVC may not be the most effective way to improve BP. In fact, an increase in sympathetic modulation along with a decrease in parasympathetic modulation for the heart is associated with higher cardiac debt and, consequently, higher BP[27].

The present study did not intend to investigate the mechanisms through which S50 promoted a higher cardiovascular stress compared to S30. However, it is known that isometric exercise is performed with sustained muscle contraction, without any changes in the length of the muscle group involved. Nevertheless, an intensity increase during isometric action, for increasing the peripheral vascular resistance as a result of a mechanical obstruction of muscle blood flow, can activate pressure reflex, which would stimulate an increase in sympathetic nervous activity and a decrease in parasympathetic activity[28,29].

It is worth highlighting that there were some limitations that must be considered for interpretation of results. First, the sample was made up of healthy young men, which makes it difficult to extrapolate data to other population groups that would benefit more from isometric handgrip exercise, such as people with cardiovascular diseases. There was no control at the physical fitness level of the sample subjects, although none of them had experience in isometric handgrip training. Time for response analysis was set at 30 minutes after exercise, which requires future studies that conduct a longer assessment – for instance, 24 hours. Finally, although LF is widely used as sympathetic modulation indicator[24], it should be taken into account that there are divergences in the literature[30,31], and results should be analyzed with caution.

In conclusion, BP responses to isometric handgrip exercise are similar between intensities of 30% and 50% MVC; however, the most intense exercise promoted a higher increase in sympathetic modulation and decrease in parasympathetic modulation after exercise.

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