




## Acute hemodynamic modulation caused by handgrip exercise

### Modulação hemodinâmica aguda provocada pelo exercício de handgrip

Josias Melo Leite<sup>1</sup> , Alice Miranda de Oliveira<sup>2,3,4</sup> , Marvyn de Santana do Sacramento<sup>1,2,5</sup> , Pedro Elias Santos Souza<sup>2,3</sup> , Luan Araújo de Pinho<sup>6</sup> , Jefferson Petto<sup>1,2,4,6</sup> 

1. Escola Bahiana de Medicina e Saúde Pública (EBMSP), Salvador, BA, Brazil

2. Actus Cordios Serviço de Reabilitação Cardiovascular e Metabólica, Salvador, BA, Brazil

3. Universidade Católica do Salvador (UCSAL), Salvador, BA, Brazil

4. Faculdade Centro de Treinamento Acadêmico (CTA), São Paulo, SP, Brazil

5. Faculdade Adventista da Bahia, Capoeiruçu, BA, Brazil

6. Centro Universitário UniFTC, Salvador, BA, Brazil

#### ABSTRACT

**Introduction:** The chronic effects of Hand Grip (HG) are already consolidated in the literature, however, the studies that evaluated the acute effects of this intervention are heterogeneous in relation to intervention protocols and sample characteristics (gender and age). **Objective:** This study aimed to describe the acute responses of SBP, DBP, HR and Double Product (DP) through isometric exercises with GH. **Methods:** This is a systematic literature review based on the criteria of the Preferred Reporting Items guideline for Systematic Reviews and Meta-Analyses (PRISMA), registered in PROSPERO under id: CRD42021238275. **Results:** A total of 619 studies were found in the databases and 6 in the gray literature, totaling 625 studies. After using the eligibility criteria, 5 articles were included in this review. **Conclusion:** We verified that the GH promotes an increase in HR, SBP, DBP and DP, with this increase being more accentuated, the greater the duration and intensity of the protocol. However, HR has a smaller increase in elderly people when compared to young individuals.

**Keywords:** physical exercise; blood pressure; heart rate determination; hand strength.

#### RESUMO

**Introdução:** Os efeitos crônicos do Hand Grip (HG) já estão consolidados na literatura, entretanto, os estudos que avaliaram os efeitos agudos dessa intervenção são heterogêneos em relação aos protocolos de intervenção e as características amostrais (sexo e idade). **Objetivo:** O presente estudo teve como objetivo descrever o efeito agudo que o HG promove sobre a Pressão Arterial Sistólica (PAS), Pressão Arterial Diastólica (PAD), Frequência Cardíaca (FC) e Duplo Produto (DP) em indivíduos saudáveis. **Métodos:** Trata-se de uma revisão sistemática da literatura baseada nos critérios do *Preferred Reporting Items guideline for Systematic Reviews and Meta-Analyses* (PRISMA), com registro no PROSPERO sob id: CRD42021238275. **Resultados:** Foram encontrados um total de 619 estudos nas bases de dados e 6 na literatura cinzenta, totalizando 625 estudos. Após a utilização dos critérios de elegibilidade, 5 artigos foram incluídos nesta revisão. **Conclusão:** Verificou-se que o HG promove aumento da FC, PAS, PAD e DP, sendo essa elevação mais acentuada, quanto maior for a duração e a intensidade do protocolo. Entretanto, a FC apresenta menor acréscimo em idosos quando comparados a indivíduos jovens.

**Palavras-chave:** exercício físico; pressão arterial; frequência cardíaca; força da mão.

## Introduction

The Hand Grip (HG) is a training alternative that emerged around the 1970s as an intervention tool to assist in the diagnosis of cardiovascular changes [1,2]. Clinically, isometric training with HG has been used for the treatment of Systemic Arterial Hypertension, its effects in a chronic form are able to reduce the levels of Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) [3], since the hemodynamic effects of this training point to an increase in SBP, DBP and Heart Rate (HR).

Acute changes are regulated by a feedback system involving the central nervous system. The afferent pathways of the nervous system receive information from muscle mechanoreceptors and metaboreceptors (type III and IV nerve fibers) promoting the reflex of pressure elevation to exercise, through the modulation of sympathetic tone, a factor that adjusts blood pressure (BP), FC, DP [4-6]. However, these variables seem to depend directly on the volume and intensity variables used in the protocols and on the age of the individuals [7-9].

Studies that assess acute effects are scarce and heterogeneous in terms of intervention protocols and sample characteristics (gender and age). Therefore, the aim of the present study is to describe the acute effect that HG promotes on SBP, DBP, HR and PD in healthy individuals.

## Methods

The present study is a systematic literature review based on the criteria of the Preferred Reporting Items guideline for Systematic Reviews and Meta-Analyses (PRISMA) [10]. The searches took place between September and November 2021 in the following databases: Medline via Pubmed, Cochrane Library, Scientific Electronic Library Online (SciELO), Virtual Health Library (BVS) and Physiotherapy Evidence Database (PEDro). Google Scholar and the references of the selected works were also checked in order to find other studies related to the topic. This revision is registered in PROSPERO under id: CRD42021238275.

### *Eligibility criterion*

We considered eligible clinical trials with or without randomization and cross-sectional studies with intervention that evaluated adult and/or elderly individuals (18 to 80 years old) of both sexes, submitted to different intensities of isometric training with HG and/or submitted to dynamic physical exercise without the use of HG. The outcomes observed in the studies involved the acute effects of training with HG on the hemodynamic variables HR, SBP, DBP and PD. Studies composed of individuals with cardiovascular diseases, orthopedic and/or autoimmune pathologies were not considered eligible.

### *Study search and selection strategy*

For the search, the Medical Subject Headings (MeSH) terms were crossed: “Hand Strength” AND “Hemodynamic” with the respective synonyms. In the Portuguese language databases, the same searches were repeated using the Health Sciences Descriptors (DeCS). No restrictions on publication period or language.

The searches and sorting of articles were carried out by 2 reviewers independently, initially by titles and abstracts. Subsequently, all articles that met the selection criteria of at least one of the reviewers were taken for full text reading. Duplicates were identified and manually removed by the same reviewers.

### *Data synthesis*

After confirming the selected articles, the data were transferred to a spreadsheet previously prepared by the authors. Disagreements about the selection of studies and/or about the extracted data were discussed among the researchers. Data extraction sought information about the sample, HG intervention protocol, methods of measuring BP, HR, PD, and main outcomes in the participants' hemodynamics.

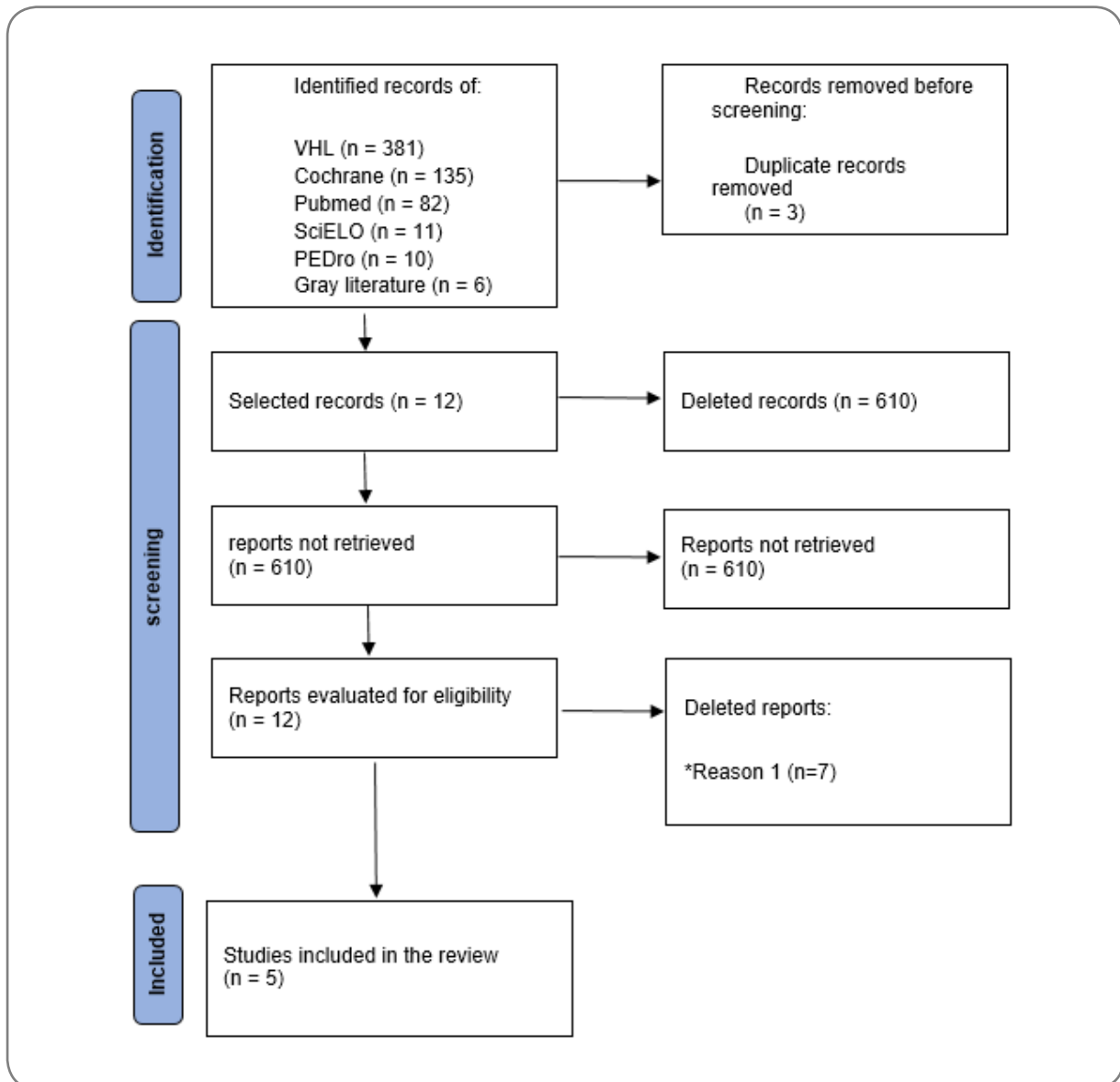
### *Quality of evidence and risk of bias*

The risk of bias in each study was achieved using the Downs and Black risk of bias tool [11]. It was evaluated by 2 independent authors and discrepancies were discussed and judged by a third author. This checklist is a valid checklist suitable for evaluating randomized and non-randomized studies as it provides an overall score for study quality and the profile of scores that go beyond report quality, external and internal validity and study power.

## **Results**

According to the proposed methodological strategy, a total of 619 studies were found in the databases and 6 in the gray literature, totaling 625 studies. After using the eligibility criteria, 5 articles were included in this review. Figure 1 presents a detail of the selection of articles.

The samples of the selected studies comprised 23 to 62 volunteers, totaling 198 individuals, of which 117 were male. The age of the sample ranged from  $18 \pm 0.66$  to  $71 \pm 5.6$  years, the time under voltage of the HG varied from 30sec to 8min, in addition to the different measurement intervals of hemodynamic parameters, which fluctuated during the protocol around 30sec. at 60sec, and immediately after intervention at 30min. Of the 5 studies included, only 1 was a randomized clinical trial, 3 were uncontrolled trials and 1 was a cross-sectional study. Table I presents the methodological aspects and the results of the 5 studies that make up the present review.



\*Reason 1: Not obtaining hemodynamic variables (BP, HR and/or PD) as the primary outcome, not using HG as an intervention, or not assessing the hemodynamic effects of HG acutely

**Figure 1** - Flowchart of article selection

The scale proposed by Downs and Black [11] was used to assess the quality of evidence and risk of bias in the studies included in the qualitative synthesis. The results of its different domains can be seen in Chart 1.

Table I - Qualitative synthesis of selected articles

Author, Year	Objective	Study design	Sample	Intervention protocol	Collection instrument	Results
Silva et al. [12], 2019	To analyze acute cardiovascular responses after isometric handgrip exercise at different intensities in healthy men	Crossover randomized clinical trial	Total: 23 men Age: 21 ± 0.4 years	Three experimental protocols were developed at 30%, 50% and 3% of MVC with an interval of 1 min between sets. Protocol 1: 4 sets of 2 minutes of contraction at 30% of MVC. Protocol 2: 4 sets of 2 minutes of contraction at 50% of MVC. Control protocol: 4 sets of 2 minutes of contraction at 3% of MVC. BP was measured between 15 and 30 min after application of the protocols	BP: measured using the Omron HEM 742 automatic device	There was no difference in SBP and DBP comparing the pre and post period (15min and 30min) of exercise with HG (p > 0.05).
Hartog et al. [13], 2018	To investigate changes in vascular hemodynamics in response to isometric handgrip exercise in people of different ages.	Uncontrolled trial	Total: 62 participants 33 male Age: 20 to 80 years	Three groups (n = 22: 28 ± 5.5 years; n = 20: 49.8 ± 5.9 years; n = 20: 71 ± 5.6 years) performed an experimental protocol lasting 30 seconds performing a MVC. BP was measured at rest and after the intervention.	BP: measured by the Mobil-o-Graph® device	There were changes in SBP among younger (1.9%), middle-aged (0.6%) and older (8.6%) participants. The values being more expressive in the older group. However, DBP only showed statistically significant differences (P < 0.02) between middle-aged (0.3%) and older (6.9%) participants.
Knobelsdorff-Brenke et al. [14], 2013	Establish a robust setup for isometric handgrip exercise during SRM imaging and to assess the cardiovascular effects that can be expected in this setting.	Uncontrolled test	Total: 53 volunteers 31 male. Age: 45 ± 17 years	An experimental protocol with HG at 30% of MVC for a period of at least 6min and, if tolerable, for 8min, in the SRM. HR, BP and DP were measured at rest, at peak stress and 2 min after termination.	BP: measure by a semi-automatic clamp sphygmomanometer; HR: calculated from the interval between beats obtained by the ECG. SD: calculated as an indicator of myocardial oxygen consumption and cardiac work	Hemodynamic parameters showed an increase of 19% for HR (p < 0.001), 14% for SBP (p < 0.001), 19% for DBP (p < 0.001) and 35% for PD (p < 0.001). Results referring to the comparison of the stress peak with the resting state.

Table I - Continuation

Author, Year	Objective	Study design	Sample	Intervention protocol	Collection instrument	Results
<b>Boutcher et al. [15], 1999.</b>	To compare the cardiovascular response of young and older subjects to light isometric and aerobic exercise using various measures of cardiovascular function.	Uncontrolled trial	Total: 30 men Age: 21 to 59 years old	An experimental protocol with HG at 30% of MVC for 2 min with a 4min interval being continued or preceded by the cycle ergometer at a rate of 60rpm with the load adjusted to keep HR within the desired range for 7min, with 8min recovery. applied in two groups: 15 young (Young, 21 ± 0.7 years) and 15 older (Old, 59 ± 0.8 years). BP, HR and DP were monitored every 30sec during the protocol and recovery up to 240sec.	BP: measured by the Ohmeda Finapres monitor (Model 2300); HR: calculated from the interval between beats obtained by the ECG. SD: by the formula (PAS*FC/100)	In the comparison between the volunteers (Young and Older) the older group presented higher percentage hemodynamic values in HR (10%), SBP (10%), DBP (5%) and DP (17%). Changes also occurred in the intra-group analysis with an increase in HR (Youth: 8%; Older: 7%), SBP (Youth: 23%; Older: 14%), DBP (Youth: 22%; Older: 15 %) and PD (Young: 32%; Older: 15%). Results referring to the comparison of the stress peak with the resting state.
<b>Anand et al. [16], 2018</b>	To evaluate the influence of the different phases of the menstrual cycle on cardiovascular responses, a product of blood pressure to the static isometric handgrip exercise.	Cross section	Total: 30 eumenorrheic women Age: 18 ± 0.66 years	An experimental protocol with HG at 30% of MVC and duration of up to 4min. BP was measured on the 1st, 2nd and 4th min of intervention, 2nd min. recovery and 4th min. recovery.	BP: measured by standard mercury sphygmomanometer and stethoscope. FC: Not mentioned	At the 1st minute of the protocol, HR and DBP were higher in the luteal phase (7% HR) (8% DBP) (p < 0.005), similar results are expressed at the 2nd min (8% HR) (4% DBP) (p < 0.005). However, at 4min and 2min of recovery, HR, SBP and DBP were also higher in the luteal phase. 4th min: PAS (9%), PAD (5%) and HR (5%). Recovery 2nd min: SBP (5%), DBP (6%) and HR (7%) (p < 0.005).

CVM = Maximum voluntary contraction; DP = Double product; ECG = Electrocardiogram; HR = Heart Rate; HG = Hand Grip; BP = Blood Pressure; DBP = Diastolic Blood Pressure; SBP = Systolic Blood Pressure; RPM = Rotation per minute; SRM = Magnetic Resonance Scanner

**Chart 1** - Quality of evidence using the Downs and Black scale [11]

Author, Year	Communication	External validity	Internal validity: Bias	Confounding variable	Power	Total
	(11 points)	(3 points)	(7 points)	(6 points)	(1 points)	(28 points)
Silva <i>et al.</i> [13], 2019	9	0	4	4	1	18
Hartog <i>et al.</i> [14], 2018	7	1	4	2	1	15
Knobelsdorff-Brenkenhoff <i>et al.</i> [15], 2013	8	1	5	1	1	16
Boutcher <i>et al.</i> [16], 1999	9	0	4	2	1	16
Anand <i>et al.</i> [17], 2018	9	2	4	2	1	18

## Discussion

The present review found that the acute hemodynamic responses (HR, SBP, DBP and PD) to HG vary according to the duration and intensity of the protocol, age of the sample and time of evaluation. In general, the studies pointed to an increase in SBP [13-15], DBP [13-16], HR [14-16] and DP [14,15] during the intervention protocol and soon after its end. A limitation to this analysis is presented by the heterogeneity of the studies (different intervention protocols and sample characteristics, such as gender and age), in addition to the small sample included in the present review.

In view of the above, it is interesting at this point to discuss individually the influence of each variable of the intervention protocol on the results obtained and later the influence of the sample characteristic on the results obtained.

The intensity expressed by the percentage of FPmax, time under tension and the interval between sets varied between 30% - 100%, 30 seconds to 8 minutes and from 0 to 1 minute, respectively [12-16], and the volume expressed by the number of series were from one CVM to four isometric contractions. In our findings, we identified an increase in HR, SBP, DBP, and DP during the intervention protocol [13-16] and no changes in BP after 15 and 30min of application of the protocols at different intensities (30%, 50% and 3% of the CVM).

Due to the influence of time under tension and the interval between sets, the hemodynamic effects are greater in the presence of a shorter interval and longer time under tension [7-9]. The mechanism that helps us to elucidate this response is the metaboreflex, which on the action of mechanoreceptors and muscle metaboreceptors (type III and IV nerve fibers) mediated through modulation of sympathetic tone, controls BP, HR, PD and peripheral vascular resistance [5,6]. These factors promote the hemodynamic changes found in the studies [13-16], not being observed post-intervention [12] due to a rapid modulation of the autonomic nervous system



(withdrawal of sympathetic tone and increase of parasympathetic tone) [17]. Although these results are present in healthy individuals, in patients with heart disease the response is possibly not the same, since in this population the sympathetic activity is increased, which would consequently lead to a longer recovery time of these post-exercise variables [6,8,18].

Despite the greater influence of the intervention protocol on the outcome, two points within the studies that we evaluated deserve to be highlighted (gender and age).

The influence of age on hemodynamic effects is shown in the findings of Hartog et al. [13] and Boutcher et al. [15]. Among our analyses, the older the age, the lower the HR elevation and the greater the BP and DP elevation. Corroborating these studies Goldstraw et al. [19] when evaluating young (30 years old) and elderly (73 years old) individuals in different occasions and tensions in the HG, found statistically significant differences in SBP ( $p < 0.001$ ) and DBP ( $p < 0.05$ ) during the protocol, with the highest values in the elderly group with the exception of HR. Such results reflect that the older the age, the more expressive are the effects on BP, with increased vasoconstrictor responsiveness due to sympathetic stimulation and endothelial dysfunction that affects endothelium-dependent vasodilation, the variables with the greatest influence on this outcome [20,21]. However, the decrease in HR over the years may occur due to a decrease in sensitivity to myocardial-related beta-adrenergic activity [15,22].

According to Bassareo and Crisafulli [23] and Maruf et al. [24]), the responses presented between men and women regarding hemodynamic parameters (HR and BP) do not differ between groups when equated with body composition and physical training status. However, the studies included in this review that evaluated both genders did not compare the hemodynamic differences between the sexes [13,14], however, when comparing women in different phases of the menstrual cycle (luteal phase and follicular phase), it was observed that in the lutea, BP and HR are higher than in the follicular phase, as demonstrated by Anand et al. [16] when finding higher hemodynamic parameters (HR, SBP and DBP) in women in the luteal phase compared to the follicular phase ( $p < 0.05$ ), with static isometric handgrip exercise at 30% of MVC for up to 4min. Pivarnik et al. [25] suggest that thermoregulation in the luteal phase is compromised, which may promote greater body heating, when compared to the follicular phase. Thus, we assume that the change in HR and BP starts through the mediation of thermoreceptors that transduce the stimulus to the CNS, which by efferent pathways stimulate the effector system (cardiovascular system and sweat glands) to balance the disorder, promoting vasodilation and an increase in HR with consequent increase in SBP and increase in sweating rate [26].

The hemodynamic responses addressed in the present review are seen in sedentary or irregularly active individuals. It is believed that active individuals present smaller responses than those found in the results. These findings help to elucidate the hemodynamic influence of HG in different protocols, ages and genders.



## Conclusion

Handgrip promotes an increase in HR, SBP, DBP and DP and this increase is directly related to the duration and intensity established in the protocol. Despite the elevation during the effort phase, no maintenance of hemodynamic changes was observed after 15 minutes.

### Potential conflict of interest

No potential conflicts of interest relevant to this article have been reported.

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### Authors' contribution

**Research conception and design:** Leite JM, Oliveira AM and Petto J. **Data collection:** Leite JM, Oliveira AM. **Data analysis and interpretation:** JM Leite, Sacramento MS, Souza PES and Pinho LA. **Manuscript writing:** Leite JM, Oliveira AM, Souza PES and Pinho LA. **Critical review of the manuscript for important intellectual content:** Sacramento MS and Petto J.

**Academic affiliation:** This article represents part of the Master's thesis by Josias Melo Leite, supervised by Professor Jefferson Petto in the Medicine and Human Health Program of the Bahia School of Medicine and Public Health, Salvador-BA.

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