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Original Article

Hemodynamic responses to isometric exercise and water immersion: a randomized controlled pilot study with older women

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Abstract:
Background: Isometric handgrip exercise is known to lower resting blood pressure and is simple to perform. Furthermore, water immersion could have a positive impact on hemodynamic response. This study sought to assess whether the association between isometric handgrip exercise and water immersion could enhance these hypotensive effects. **Material and Methods**: Nine physically active, medicated hypertensive older women underwent two isometric handgrip exercise in different environments: water exercise and land exercise, composed of four sets of two min at 40% of maximum handgrip contraction and two min of rest intervals. They also underwent two control conditions: water control and land control. During water conditions, volunteers were immersed at the xiphoid process depth and remained in a standing posture with their arms relaxed. In the land control, participants remained in a standing posture. Heart rate and blood pressure measurements were taken before, during (heart rate only), immediately after, 10, 20, and 30 minutes after each condition. For statistical analysis, a two-way ANOVA (time × condition) and Bonferroni's post-hoc test was used ($\alpha \leq 0.05$). **Results**: systolic blood pressure and diastolic blood pressure had no condition main effect or time-condition interaction, but there was a time main effect, without a hypotensive effect for any condition. Heart rate increased significantly during land exercise and decreased significantly during water control. Under water control and water exercise conditions heart rate decreased significantly compared to the pre-session moment. **Discussion** and **Conclusions**: A single session of isometric handgrip exercises neither on land nor in water resulted in a hypotensive response in medicated, physically active older women. Pharmacological treatment added to the fact that the sample participated in a water-based program, could result in lower resting BP levels, which may explain the absence of a hypotensive effect.
Key Words*:* **- hypertension, static exercise, aquatic environment, elderly, blood pressure.**

Introduction

Cardiovascular diseases can result in high healthcare costs as well as significant economic losses (Stevens et al., 2018). The graded associations between higher blood pressure (BP) levels and increased risk of cardiovascular diseases are evident, coronary heart disease, heart failure, stroke and even death are highly associated with hypertension (Carey; Wright; Taler; Whelton, 2021). In 2019, hypertension was the chronic non-communicable disease with higher prevalence in the Brazilian population (23.9%), furthermore, self-reported hypertension rises with aging, and individuals from 60 years old covers 46.9% of hypertensive population (IBGE, 2020). Non-drug treatment for hypertension, which includes the practice of physical exercises, is capable of reducing BP, in addition exercises can enhance the performance of hypertensive medication (Carey; Wright; Taler; Whelton, 2021; Pescatello; Buchner; Jakicic; Powell *et al.*, 2019). Evidence states that adults should practice physical exercise for at least 150 to 300 minutes of moderate and/or vigorous intensity per week and there is a proportionally inverse relationship between amount of exercise practiced and the risks of mortality from all causes (Bull; Al-ansari; Biddle; Borodulin *et al.*, 2020).

It is well know that both aerobic and resistance exercise modalities lead to hypotension (Ferret, Jhainieiry Cordeiro Famelli *et al.,* 2021; Goessler, Buys, VanderTrappen, Vanhumbeeck, & Cornelissen, 2018; Prokopets, T., Osipov, A., Lyakh, V., *et al*., 2021), but usually these modalities require adequate space and greater availability of time. Among resistance exercises, the isometric handgrip (IHG) exercise has the potential for greater cardiovascular adaptations, with some advantages, including low time demands, little space and inexpensive equipment. The IHG exercise three times a week, for eight minutes, may decrease systolic BP from 10 to 13 mmHg, and diastolic BP from 6 to 8 mmHg, which can be equivalent to a 13% reduction in myocardial infarction risk and 22% in vascular encephalic accidents (Smart, Gow, Bleile, Van der Touw, & Pearson, 2020). Significant clinical results in the reduction of BP after IHG exercise have been reported, however, the mechanisms that underlie these adaptations are not fully understood. A decrease in BP after IHG has been associated with cardiac adaptations, changes in autonomic nervous system modulation, improvements related to oxidative stress, and vascular adaptations (Ogbutor, Nwangwa, & Uyagu, 2019; Souza; Vicente; Melo; Moraes *et al.*, 2018).

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Due to its physical properties (pressure, density, and thermal conductivity), another exercise modality with important physiological repercussions is that performed in the aquatic environment . Specifically, regarding its effects on BP, a growing body of evidence has shown that water exercises are a good BP control method, water immersion results in significant changes in some parameters directly involved in cardiovascular control and it has been shown to be safe and a efficient way to control BP (Guimãraes; Fernandes-silva; Drager; De barros cruz *et al.*, 2018; Reichert; Costa; Barroso; Da rocha *et al.*, 2018; Ngomane, Fernandes, Guimarães, & Ciolac, 2019; Tkachova, Anna *et al.* 2020).

According to our searches, no study has evaluated the IHG exercise effect while the body is immersed in water. This method can be characterized as an important exercise prescription tool for the treatment and prevention of arterial hypertension and cardiac modulation improvement. Furthermore, the present investigation could allow new discoveries, since the execution of static exercises in the aquatic environment removes the effect of water resistance, a difficult variable to control in studies that compare dynamic exercises in land and water. Although guidelines for the use of resistance exercise recommend working all major muscle groups, it is essential to evaluate the effects of IHG exercise alone, to later incorporate and combine them with other exercises (e.g., dynamic and aerobic exercises) in a water-based exercise program.

The aim of the present study was to compare hemodynamic HR and BP responses after a single IHG exercise session in both land and water, and to verify whether the aquatic environment can enhance post-exercise hypotension compared to land. Our hypothesis is that IHG exercise in water will result in lower HR during its performance and greater reduction in BP after completion.

Material & methods

Experimental Approach to the Problem

Were two control and two IHG exercise conditions: land control (LC), water control (WC), land exercise (LE), and water exercise (WE). In all of them, BP was assessed before and after each condition. HR was assessed continuously: before, during, and after each condition (Figure 1).

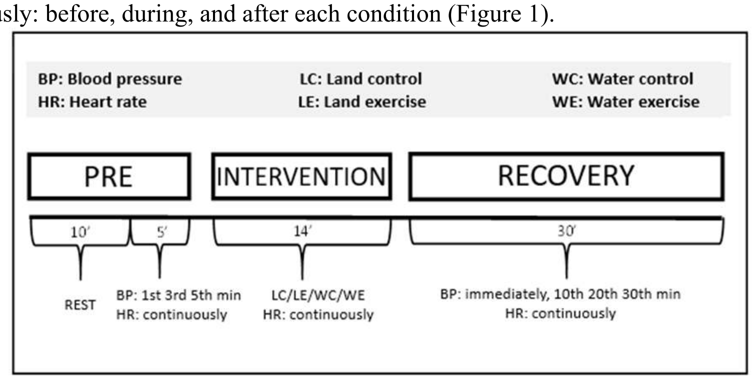

Figure 1: Experimental design of the study.

Participants

Twelve older women (≥60 years) were recruited (verbal invitation, on a convenience sampling basis). They were physically active and regularly exposed to water aerobic exercise, three times a week, one hour per session, but not to IHG exercise. Five participants used angiotensin receptor blockers, three angiotensin receptor blockers associated with a diuretic, and one participant ACE inhibitors. The medication remained the same throughout the study. Exclusion criteria were uncontrolled chronic illnesses, orthoses or prostheses that did not allow exercise practice, or not receiving treatment for one of these conditions. Twelve participants agreed to participate in the study, nine attended all conditions, and three were excluded because they missed one of the conditions. The Health Research Ethics Committee (protocol number 01247218.0.0000.8124) approved this study. One day before the first condition, participants sign the consent form, perform a complete anamnesis, a familiarization with equipment, and the handgrip maximal voluntary contraction (MVC) assessment.

Procedures

Maximal voluntary contraction assessment

MVC was assessed using a dynamometer (Crown® 100kgf, Filizola, São Paulo, Brazil), with a seated participant and elbow at 90º °on a table. Three attempts were made with a dominant hand, making a maximum contraction (about three seconds), and receiving verbal stimulation. The interval between measurements was one min, and the highest value among three attempts was considered the final measure.

Experimental conditions

Participants were submitted to four conditions in a randomized order (randomization.com), with a 24–48 hours rest between them. In the control conditions (LC and WC) participants remained static, standing in an upright posture, with their arms relaxed and hands positioned freely. Control conditions lasted 14 min, a period equal to the time spent to perform the condition with IHG exercise. For conditions performed in water, participants remained in the same position, however they were immersed up to the xiphoid process.

During exercise conditions (LE and WE) a handgrip equipment was used (Oxer-10–40 Kg adjustable handgrip spring). This equipment consisted of two rods, one fixed and one flexible, and a spring that acted as a load. Handgrip equipment had an indicator that allowed, through a screw, the adjustment of the load with a range of 10–40 kg. From the MVC (100%), 40% load was calculated as a measure of intensity during the execution of IHG exercise. Similar to other studies, the exercise protocol involved performing unilateral isometric contraction with dominant hand, for four sets of two min, with two min of rest between sets (14 min total) (Hess et al., 2016; McGowan et al., 2006; Ogbutor et al., 2019). Participants remained standing, with the device positioned in their dominant hand. Isometric contraction was performed bringing the rods together and keeping them as close as possible. The researcher positioned himself near the participants to ensure that they kept the equipment rods close to each other.

BP measurement and analysis

Before intervention, in a room near the pool, all participants rested in a sitting position for 10 minutes, and during the subsequent five minutes, BP was measured following the Seventh Brazilian Arterial Hypertension Guideline (Malachias, 2016). While remaining seated with the dominant arm supported at 90º on a table, three measures (Automatic Digital Blood Pressure Monitor Model 2005 Bioland) were taken from participants, with a one-minute interval between them to set the PRE moment measure. BP was not measured during IHG exercise in LE and WE conditions or during standing position maintenance in LC and WC conditions. At recovery after intervention, volunteers returned to the room and remained seated, where BP was measured immediately, 10, 20, and 30 min after each condition. For all conditions, the same experienced researcher took BP measurements.

The BP value at the PRE moment was determined from the average of the three measures before each condition. For BP measurements performed immediately after, 10, 20, and 30-min during recovery (Brito et al., 2019), a simple average of all participant results was calculated for each moment.

HR measurement and analysis

After 10 min of rest, HR was measured continuously (Polar RS800 CX, validated for this measurement) (Williams et al., 2017) for five min, during 14 minutes of intervention (regardless of condition) as well as in recovery after each condition. The Polar tape was placed on the chest (xiphoid process) of the participant.

Initially, data were transferred to the Polar ProTrainer 5 program, and subsequently tabulated on an electronic data sheet. The PRE value was determined from the average of the initial five minutes. To determine the exposure period (EXP), means of the 14 minutes of intervention were used, and an average of the final 30 minutes was used as a value representative of the POST moment. For HR graphic presentation, the same means protocols were used, except for 14 minutes of intervention where an average was made for each two min.

Statistical analysis

Normal distribution was verified using the Shapiro-Wilk test. Data were processed using descriptive procedures (mean and standard deviation). To compare BP and HR measurements at different times between different conditions, a two-way ANOVA (condition × time) was used. Sphericity was assessed with the Mauchly test: for data that violated this hypothesis, the degrees of freedom were corrected using Greenhouse and Geisser's estimates of sphericity. Bonferroni's post-hoc test was used to determine specific differences between conditions and time. The intraclass correlation coefficient (ICC) was calculated using three BP measurements and five HR measurements (mean of each min) from the PRE moment of each condition. For main effects and interactions, effect sizes are presented using partial squared eta ($\eta p2$), according to the following classification: <0.06, 0.06–0.14, and >0.14, indicating low, medium, and high effects, respectively. The significance level was set at $\alpha \leq 0.05$. Statistical procedures were performed using SPSS version 18.0.

Results

Sample and environment characteristics are shown in Table 1.

Table 1: Sample and environment characteristic (n = 9).

	MEAN ± SD
Age (years)	64.11 ± 5.16
Body mass (kg)	71.71 ± 11.33
Height (cm)	155.22 ± 3.42
BMC (kg/m^2)	28.64 ± 3.66
100% MVC (kgf)	25.50 ± 6.54
40% MVC (kgf)	10.18 ± 2.62
Room temperature* (°C)	36.00 ± 1.53
Water temperature* (°C)	30.78 ± 0.72

BMC: Body mass index. MVC: Maximal voluntary contraction. * Monitored not controlled.

SBP and DBP measures showed high ICC values (0.93 for both measures). There was no condition main effect for SBP ($p = 0.75$; $\eta p2 = 0.05$) and DBP ($p = 0.89$; $\eta p2 = 0.03$), and no interaction condition * time for SBP ($p = 0.80$; $\eta p2 = 0.07$) and DBP ($p = 0.98$; $\eta p2 = 0.04$). On the other hand, the time's main effect was observed for both SBP ($p < 0.01$; $\eta p2 = 0.62$) and DBP ($p < 0.01$; $\eta p2 = 0.37$). The SBP was significantly higher ($p \leq 0.05$) immediately after, with subsequent reduction, but with no difference between PRE to the moments POST10, POST20 and POST30 (Table 2). The post hoc analysis did not identify differences between the moments for the DBP (Table 2).

Table 2: Systolic blood pressure (SBP) and diastolic blood pressure (DBP) (mean ± standard deviation) before (PRE), immediately, 10 (POST10'), 20 (POST20') and 30 (POST30') minutes after handgrip isometric exercise and control conditions.

	PRE	IMMEDIATELY	POST10'	POST20'	POST30'
SBP (mmHg)					
LC	108.15±13.80	112.66 ± 16.58	102.00 ± 10.01	103.88 ± 10.97	104.33 ± 13.77
WC	108.11±13.53	116.11 ± 8.46	107.33 ± 13.00	107.55 ± 14.97	107.88 ± 12.37
LE	106.33±14.05	111.55 ± 13.61	104.55 ± 16.37	107.33 ± 10.96	106.44 ± 11.15
WE	106.85±9.33	116.55 ± 17.73	109.00 ± 13.50	107.44 ± 13.17	106.11 ± 11.14
DBP (mmHg)					
LC	63.44 ± 13.3	66.78 ± 16.18	61.77 ± 9.06	63.00 ± 10.55	62.55 ± 8.30
WC	63.96 ± 9.62	66.22 ± 9.38	59.11 ± 7.94	60.55 ± 8.56	61.11 ± 6.88
LE	63.22 ± 11.16	66.22 ± 12.67	62.55 ± 12.79	64.00 ± 10.27	63.44 ± 9.36
WE	63.30 ± 4.89	67.44 ± 12.54	62.66 ± 7.36	63.88 ± 8.93	64.11 ± 5.98

LC, land control. WC, water control. LE, land exercise. WE, water exercise.

In Figure 2, HR at different times of the four analyzed conditions can be observed.

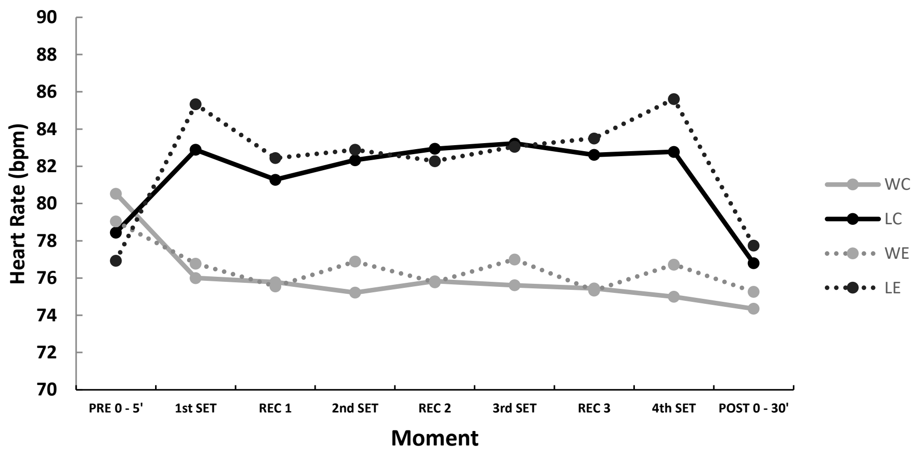

Figure 2. Heart rate before (PRE), during four exercise sets (1st, 2nd, 3rd, 4th SETS) and respective recovery intervals (REC 1, 2 and 3) and post recovery (POST) conditions Water Control (WC), Land Control (LC), Water Exercise (WE) and Land Exercise (LE).

The ICC for HR measurements was high (0.97). No condition main effect was found ($p= 0.74$; $\eta p2 = 0.05$), but time's main effect ($p < 0.01$; $\eta p2 = 0.65$) and interaction time*condition ($p < 0.01$; $\eta p2 = 0.52$) was observed. Compared to PRE, WC showed a significant reduction in HR during EXP ($p = 0,04$), while LE increased significantly ($p < 0.01$). For LC ($p = 0.01$) and LE ($p < 0.01$) the reduction in HR was significant in POST compared to EXP. Compared to PRE, WC ($p < 0.01$) and WE ($p < 0.01$) showed a significant reduction in HR in POST (Table 3).

Table 3: Heart rate (mean ± standard deviation), before (PRE), during exposition (EXP) and post recovery (POST) to land control (LC), water control (WC), land exercise (LE) and water exercise (WE) conditions.

Condition	PRE	EXP	POST
LC	78.48 ± 9.94	82.57 ± 12.02	76.80 ± 10.38#
WC	80.44 ± 7.95	75.33 ± 7.42$*	74.33 ± 7.57*
LE	76.88 ± 7.16	83.49 ± 7.70*	77.78 ± 8.42#
WE	79.00 ± 10.69	76.27 ± 10.90	75.26 ± 11.36*

Statistically significant difference in comparison to EXP moment; $ statistically significant difference in comparison to LE condition; * statistically significant difference in comparison to PRE moment.

Discussion

The main findings show that IHG exercise did not cause hypotension, regardless of the environment. A significant increase ($p <0.05$) in HR was observed during LE, but not in WE. The current investigation hypothesis was that IHG exercise performed in water would result in lower HR during performance and potentiate the acute hypotensive effect, however, our results partially refute this hypothesis.

The acute BP response after isometric exercise are corroborated by other researchers. Olher et al. (Olher; Bocalini; Bacurau; Rodriguez *et al.*, 2013) and Silva et al. (Silva; Leonardo sobrinho; Ritti-dias; Sobral *et al.*, 2019) assessed the acute effect of IHG exercise at two different intensities, 30% and 50% of MVC, and found no significant BP reductions in hypertensive people. In agreement a study with normotensive young men, did not observe significant BP reductions after four sets of two-minute isometric knee extension (Devereux; Wiles; Howden, 2015). On the other hand, a few studies have shown a significant reduction (-19 mmHg) after IHG exercise with hypertensive elderly (Souza; Vicente; Melo; Moraes *et al.*, 2018) also found a significant Systolic BP reduction in healthy older men and women after four sets of two minutes of IHG exercise at 30% of MVC (Millar; Macdonald; Bray; Mccartney, 2009).

Discrepancy between studies may be related to pre-exercise BP values. In the study by Souza et al. (Souza; Vicente; Melo; Moraes *et al.*, 2018), for example, pre-intervention BP was above 130mmHg (135/77 mmHg) such as by Millar et al. (Millar, Bray, McGowan, MacDonald, & McCartney, 2007) (139/80 mmHg), initial values higher than in the present study (107/63 mmHg). Studies that found a significant reduction in BP in the long term also presented high initial values, such as The hypothesis that BP reductions may be greater in those with higher pre-training BP is discussed (Millar, Bray, McGowan, MacDonald, & McCartney, 2007; Silva; Leonardo sobrinho; Ritti-dias; Sobral *et al.*, 2019), even when individuals are normotensive (Devereux; Wiles; Howden, 2015). This is relevant because low BP values prior to the intervention may be related to a minor or no hypotensive effect. The low BP values found here can be explained by the use of antihypertensive medications by our participants. Previous studies with medicated hypertensive patients reported lower success rates compared to studies with unmedicated individuals. Another important factor for low BP levels may be the fact that participants were physically active, as they participated in a water-based program (water aerobic exercise three times a week, one hour per session). Recent studies have shown that aquatic training results in a chronic reduction in resting BP (Reichert; Costa; Barroso; Da rocha *et al.*, 2018). Although the participants were not accustomed with the IHG exercise, we believe that the ease of handling the handgrip equipment and the low exercise load, as well as the familiarization procedures were sufficient to avoid any effect of the user's inexperience on the results.

Notwithstanding no significant difference was found, an interesting result was the reduction of approximately 6 mmHg in SBP after 10 min of recovery in the LC condition. After 30 min of recovery, the SBP was still on average 3.8 mmHg below to the PRE condition values. According to our searches, no study sought to evaluate BP response after maintaining a standing posture during a similar period (i.e., 14 min). Maintenance of the vertical orthostatic position results in an increase in blood flow to the lower limbs due to the force of gravity action and, consequently, a venous return and ejection volume reduction. In response, an increase in sympathetic activity is observed, which increases peripheral resistance and HR for maintaining BP at normal levels (Gois; Simões; Porta; Kunz *et al.*, 2019).

Although the autonomic control variables and peripheral resistance have not been evaluated, the results found here lead us to believe that the chain of events involved in maintaining a standing posture may have determined hypotensive stimulus for elderly women.

The LE condition did not show a significant decrease in BP. During IHG exercise, multiple factors were related to BP control. The main variances are the rise in sympathetic modulation and reduction in vagal modulation of the sinus node (António, Cardoso, Amaral, Abreu, & Valenti, 2015), which increase HR and peripheral vascular resistance with a consequent increment in mean BP (Bond; Curry; Adams; Obisesan *et al.*, 2016; Gois; Simões; Porta; Kunz *et al.*, 2019). Exacerbated BP increase and peripheral resistance were observed during IHG exercise in hypertensive patients. In older women studied here, summed effects of maintaining standing position and IHG exercise possibly exacerbated BP rise during IHG exercise, precluding the occurrence of a possible hypotensive effect in hypertensive participants in our study. These hypotheses can be corroborated by Bond et al. (2016), who found that pre-hypertensive women with exacerbated BP responses and peripheral resistance did not experience hypotension after three min of IHG exercise (Bond; Curry; Adams; Obisesan *et al.*, 2016). BP measures over a longer period during recovery could reveal greater reductions. However, these statements are merely speculations since measures related to the action of autonomous control and peripheral resistance have not been made here.

Since immersion is the focus of this study and it has important physiological repercussions, it is essential to discuss immersion impacts in the face of the demands employed here. During immersion, water exerts pressure on peripheral vessels in the lower limbs, enhancing venous return, increasing central volume, and decreasing HR (immersion bradycardia) in thermoneutral conditions (Guimãraes; Fernandes-silva; Drager; De barros cruz *et al.*, 2018; Reichert; Costa; Barroso; Da rocha *et al.*, 2018; Ngomane, Fernandes, Guimarães, & Ciolac, 2019). The results observed in conditions involving immersion (WC and WE) confirm such mechanisms related to HR reduction and corroborate other studies that also found bradycardia during immersion (Gabrielsen; Warberg; Christensen; bie *et al.*, 2000). In addition, in the WC condition, an average reduction of 4.85 mmHg (n.s) was observed for diastolic BP. After 30 minutes, the values were 2.85 mmHg (n.s) less than PRE. Effect size shows that there is a high effect ($\eta p2 > 0.14$) for the diastolic BP when the main time effect was evaluated. Concomitantly with an increase in central volume, there is a decrease in enzymatic proteins and hormone circulation, both related to vasoconstrictor mechanisms. Additionally, a decrease in efferent sympathetic activity results in a systemic vascular resistance reduction during immersion. Combined, these effects induce BP reductions during immersion (Gabrielsen; Warberg; Christensen; bie *et al.*, 2000).

However, few studies have evaluated BP responses after immersion, Luza et al. (2011) found a decrease of 11 (n.s.) and 2 mmHg (n.s.) 90 minutes after immersion in hypertensive and normotensive individuals, respectively (Luza; Siqueira; Paqualotti; Reolão *et al.*, 2011). Other authors found that during immersion, a reduction of 12 and 8 mmHg for Systolic BP and Diastolic BP, respectively, however this decrease was not sustained after participants left the aquatic environment (Sramek; Simeckova; Jansky; Savlikova *et al.*, 2000).

Our findings showed that immersion (WC) resulted in a significant decrease in DBP by approximately 5 mmHg, 10 minutes after participants got out of the water. This reduction may be directly related to the decrease in total peripheral resistance during immersion, caused by concomitant reduction in plasma renin activity and responses from aldosterone levels that can remain during recovery (Bond; Curry; Adams; Obisesan *et al.*, 2016; Elvan-Taspinar et al., 2006; Gabrielsen; Warberg; Christensen; bie *et al.*, 2000). However, care must be taken when comparing these studies. Differences related to age, sex, sample health status and differences in immersion time must be considered to avoid erroneous conclusions.

Finally, when immersion was combined with IHG exercise, no BP reduction was observed, indicating that association between IHG exercise and immersion did not optimize a possible hypotensive effect. According to our searches, this was the first study to analyze IHG exercise effects during and after immersion. Only one study that analyzed the effect of isometric exercise during immersion was found (Fujisawa; Kamimura; Ohtsuka; Nanbu *et al.*, 1996). HR and BP responses were analyzed during and after an isometric knee extension at 60% of maximum isometric strength until fatigue, both in water and on land. The average time that contractions lasted was 58 and 57 seconds for land and water conditions, respectively. Although mean values of SBP, DBP, and mean BP during contraction were lower in the water condition, there was no statistically significant difference in comparison to isometric exercise performed on land. However, during recovery, measurements were taken for only 30 seconds. BP remained significantly higher than baseline, with no difference between conditions. Recovery time taken to analyze BP behavior after intervention may have been too short to observe a hypotensive effect.

Regarding the absence of reduction in BP in the WE condition, antagonistic mechanisms related to cardiovascular responses during isometric and immersion exercises should be discussed. While isometric exercise result in increased sympathetic modulation and reduced vagal modulation, with increased peripheral vascular resistance and mean BP immersion, in contrast, induces vasodilation and systemic vascular resistance reduction, which occurs due to efferent sympathetic activity loss In this sense, IHG exercise and immersion association could result in concurrent mechanisms, which in turn, do not result in enough stress to cause a hypotensive effect after WE. However, only an analysis of autonomic and hormonal responses, beyond other factors involved with hypotension, could show how BP responds to IHG exercise during immersion. Age, health status, muscle size, initial (PRE) BP and HR levels, and training level can interfere with these responses. Additionally, since the greatest BP decrease have been observed after 30 min or more of recovery period Guimãraes; Fernandes-silva; Drager; De barros cruz *et al.*, 2018; Reichert; Costa; Barroso; Da rocha *et al.*, 2018; Ngomane, Fernandes, Guimarães, & Ciolac, 2019), the timing of measurements after conditions performed here may be insufficient to identify a possible reduction in BP after IHG exercise. New studies should evaluate IHG exercise effects during immersion in different samples, under different exercise conditions and by BP assessment for a longer period after exercise.

This study has important limitations to be considered, such as no control of sleep, diet, caffeine intake, alcohol use, and physical activity prior to blood pressure measurements. Another important factor is the sample size. On the other hand, this study brings relevant contributions to the scientific community, as it is the first study to examine immersion and IHG exercise combined effects. Additionally, we highlight: a) exercise that suffers no influence from water resistance, which is impossible to achieve in aerobic exercises or other dynamic exercises in aquatic environment; b) use of low-cost and accessible equipment for a large part of the population; c) detailed analysis of isolated effects of each independent variable. All these associated factors allow the results obtained here to reveal a unique and innovative perspective on immersion effects during isometric exercise, creating a new path for new research in this theme.

Conclusions

The BP responses of treated hypertensive older women, after a single IHG session with handgrip equipment, showed similar responses in land and water, evidencing that immersion does not positively interfere with BP modulation after IHG. Pharmacological treatment added to the fact that the sample participated in a water-based program, could result in lower resting BP levels, which may explain the absence of a hypotensive effect, perhaps a longer session can find significant results, as well as a longer evaluation time. Future studies should evaluate the effects of performing isometric exercise in populations with different characteristics and using different isometric exercise protocols. Due to the physical properties of water, when prescribing physical exercises, Physical Education professionals should consider the differences in heart rate responses during exercises in water and on land. The isometric aquatic handgrip exercise may be an alternative when lower heart rates under physical exertion are necessary.

Conflicts of interest - The authors report no conflict of interest.

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