



High-Intensity Interval Aquatic Exercise Session Promotes Post-Exercise Hypotension in Hypertensive Elderly: A Randomized Controlled Trial

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ABSTRACT

Santos Júnior EA, Suassuna JAS, Melo ABSR, Ferreira CHL, Souza AA, Marques ACO, Sarmento AO, Brasileiro-Santos MS, Barbosa BT. High-Intensity Interval Aquatic Exercise Session Promotes Post-Exercise Hypotension in Hypertensive Elderly: A Randomized Controlled Trial. **JEPonline** 2018;21(1):149-161. This study evaluated the effects of a high-intensity interval aquatic exercise (HIAE) session on post-exercise hypotension (PEH) in 12 hypertensive elderly female subjects (67.3 ± 4.7 yrs, BMI of 28.0 ± 1.8 kg·m⁻²). The subjects were submitted to both 45-min HIAE and control (no exercise) sessions. Systolic (SBP) and diastolic (DBP) blood pressure (BP) were obtained at rest and at 15, 30, 45, and 60 min post-sessions. SBP decreased significantly in all measurements post-HIAE session compared to rest (from rest: 130.1 ± 13.3 to 15: 115.1 ± 11.8 ; 30 min: 114.9 ± 11.8 ; 45 min: 112.0 ± 13.1 and 60 min: 115.7 ± 14.7 mmHg, $P < 0.05$) with no changes in DBP ($P > 0.05$). Systolic PEH magnitude post-HIAE session was greater compared to control (15 min: -14.2 ± 13.9 , 30 min: -14.8 ± 9.0 , 45 min: -17.8 ± 8.0 and 60 min: -13.8 ± 10.4 mmHg, $P < 0.05$). HIAE promotes systolic PEH in hypertensive elderly.

Key Words: Aged, Exercise, Hemodynamics

INTRODUCTION

Post-exercise hypotension (PEH) is characterized by reduced blood pressure (BP) after one exercise session to levels below those found at rest, and its effects can last for up to 24 hrs. Apart from the anti-hypertensive effects of aerobic training (35), the PEH contribution to exercise should be used as a first-line tool for the non-pharmacological treatment and control of arterial hypertension (HTN) (4,7,15,26).

The physiological mechanisms responsible for PEH are still unclear, thus studies have been devoted to understanding the causes of this hemodynamic response (19,29). It is believed that PEH is determined by neural, humoral, and hormonal factors (28). The literature suggests that the attenuation of sympathetic nervous system activity and the reduced cardiac output and peripheral vascular resistance may contribute to the reduced blood pressure response in normotensive and hypertensive individuals (20,29).

Among the different types of exercise, it is known that continuous aerobic training is widely recommended for its hypotensive effect that has been demonstrated at different intensities (9) on the cycle ergometer (16) and treadmill (37), and while free walking (41). In the aquatic environment, studies indicate hypotensive responses in normotensive individuals (12), in hypertensive individuals (36), and overweight individuals (10). Similarly, PEH has also been reported in subjects submitted to aquatic walking (40) and to a water aerobics session (11,42).

Besides the hypotensive effects of exercise in different populations and under distinct protocols, water-based exercise may contribute to better health for the elderly. It may also promote a reduced articular stress and an attenuated perceived exertion compared to exercises performed on land. These points should be considered in the development of an exercise prescription since the elderly population is usually affected by bone and muscle mass loss issues (8,45).

Although the literature suggest that a single exercise session can promote PEH, new approaches should be elaborated in order to offer to the elderly a safer prescription to improve and protect their cardiovascular system without physical damages. Thus, the purpose of the present study was to evaluate the effect of an acute high-intensity interval aquatic exercise (HIAE) session on PEH in hypertensive elderly.

METHODS

Subjects

The present study was designed as a randomized controlled crossover trial study (Register code: REBEC RBR-9h3c2b). Individuals aged 60 or older who were diagnosed with HTN (Systolic BP (SBP) ≥ 140 mmHg or BP diastolic (DBP) ≥ 90 mmHg) (30) were included in the study. Subjects with a body mass index (BMI) ≥ 30 kg·m⁻² and those affected by diabetes mellitus were excluded from the study in order to avoid potential effects from mechanisms that involve both pathologies.

This study is consistent with the ethical standards of research with human beings from resolution 466/12 of the National Health Council (CNS). It was submitted to the research

ethics committee of the Centro Universitário de João Pessoa (UNIPÊ), which approved and registered the study under CAAE number: 50775315.3.0000.5176. The volunteers signed the informed consent form, and were informed about the risks and benefits of participating in the study. The experimental procedures were carried out on the premises of UNIPÊ.

Procedures

In the first meeting between volunteer and researcher, the hypertensive elderly had their body mass and height measured in the Laboratory of Physical Evaluation (LAF) using a stadiometer (Standard Sanny, model ES2030) and a model PI 150 Filizola scale (São Paulo, São Paulo). All volunteers who participated in the study were submitted to two randomly (<https://www.randomizer.org/>) distributed activity sessions with a week difference between them: (a) experimental session (high-intensity interval aquatic exercise); and (b) control session (immersed without exercise). None of the volunteers were informed about which session would be performed.

Both experimental and control sessions were performed in a pool at room temperature (29°C) with the water level at the imaginary line of the volunteer's xiphoid process, and without the use of auxiliary aquatic material or musical stimulus. The sessions were held between 7:00 and 11:00 am and lasted 45 min each. The volunteers were instructed not to exercise in the 24 hrs preceding the sessions and to avoid the intake of caffeine-containing foods on each session's day. The volunteers were instructed to maintain usual food intake before both sessions.

A waterproof heart rate monitor (Polar®, model FT7, Kempele, Finland) was used to determine the threshold set for both sessions. Maximum heart rate (HR_{max}) was calculated using the formula proposed by Tanaka (43), where $HR_{max} = 208 - (0.7 * age)$. The formula proposed by Karvonen (25) [$HR_{at} = (HRR * \% intensity) + HR_{rest}$ – where HR_{at} , HR at work threshold; HRR, reserve HR; and HR_{rest} , HR at rest] (25) was used to calculate the target training zone in order to determine the intensity of both experimental and control sessions.

Physical exercise intensity was prescribed according to the guidelines of the American College of Sports Medicine (17,34). In the experimental session, the subjects were encouraged to maintain between 30 to 39% of the HRR during both the warm-up and the cool down periods (light intensity). During the main part the session, the subjects remained between 60 and 89% of the HRR (vigorous intensity). For the control session, the subjects were below 30% of their %HRR (very light intensity) throughout the session.

HIIAE Session

The subjects performed a HIIAE session that was divided into 3 phases: (a) warm-up (10 min); (b) main part (30 min); and (c) cool down (5 min). The warm-up took place in about 10 min. At this stage, a guided walk in the aquatic environment was carried out to ensure that the subjects were prepared for the next phase of the experimental session.

The subjects performed the main part of the HIIAE session for 30 min, in which the high-intensity protocol (60 to 89% of HRR) in the water was performed in 5 rounds of 4 exercises. Each exercise lasted 30 sec combined with an active recovery period of 1 min. The following exercises were carried out: (a) jumping jacks (shoulder abduction and adduction); (b) horizontal adduction and abduction of the shoulder; (c) stationary running with knee

elevation; and (d) stationary running with knee flexion (heel to gluteus maximus) + shoulder flexion/extension. For exercises 'a' and 'b', the legs alternated in movements in the sagittal plane to provide greater stability to the subjects' movement. The subjects' active recovery corresponded to a guided walk in the aquatic environment.

The cool down phase lasted 5 min to allow for a decrease in the subjects' heart rate. The subjects walked around the pool while moving their upper limbs that was consistent with horizontal adduction/abduction of the shoulders with elbow flexion (simulating a hug).

Control Session

The subjects were instructed to remain in an orthostatic position immersed in water up to the xiphoid process for 45 min without performing jerky body movements. They did not perform a warm-up or a cool down at this stage.

Heart Rate Monitoring

A waterproof heart rate monitor (Polar®, model FT7, Kempele, Finland) was used to ensure that the subjects remained on the threshold set during both the experimental and control sessions. To guarantee that the subjects achieved the threshold set in both sessions, the elderly performed HIIAE and control sessions individually and, then, went into the water accompanied by a researcher who verified the exercise intensity performed.

The subjects were instructed to perform the movements at their highest speed and with the greatest possible amplitude in order to achieve the desired intensity at this stage of the HIIAE session. From inside the pool, the instructor also verbally encouraged (e.g., "come on" and "faster, faster") the subjects to perform the exercises so that the expected intensity was reached. At the end of both HIIAE and control sessions, all subjects remained within appropriate target training zones for the objectives of the study. To define the mean %HRR during both HIIAE (1) and control (2) sessions, the researcher inside the pool was instructed to inform that one outside the pool (1) two HR measures at 15 and 30 sec for each exercise performed and (2) one measure every 1 min until the end of control session. In both the HIIAE and the control sessions, the subjects achieved 78.8 ± 10.3 and 24.4 ± 4.2 of %HRR during entire sessions, respectively ($P < 0.05$ between sessions).

Blood Pressure Measurement

The blood pressure measurements were obtained according to the Brazilian Guidelines for Hypertension (30). Subjects remained seated in a chair for 15 min in a calm environment prior to the start of each session to measure blood pressure at rest (BP_{rest}).

At the end of the HIIAE and the control sessions, the subjects were instructed to sit on a chair in a land environment with back support and their feet resting on the floor until blood pressure measurements were carried out in the moments immediately after and every 15 min for one-hr post-HIIAE and control sessions. The subjects were not allowed to be in contact with anybody but the researcher in blood pressure measurement moments (at rest and post-HIIAE and control sessions). Mean BP (MBP) was obtained according to the formula $MBP = [SBP + (DBP * 2)] / 3$. PEH magnitude was measured by the delta value, represented by $\Delta HPE = BP_{post} - BP_{rest}$. A previously validated automatic OMRON® HEM-7200 blood pressure monitor (Osaka, Japan) was used to measure blood pressure (44).

Statistical Analyses

Data were tabulated and analyzed using the statistical package for social sciences version 24.0 (SPSS, IBM, USA). The normality and the homogeneity of the data were confirmed by the Shapiro-Wilk and Levene tests, respectively. A two-way ANOVA for repeated measures (Condition [control session and experimental session] x time [rest and at 15, 30, 45, and 60 min post-session]) was used for the main effects for each variable. When a significant condition x moment interaction was verified, multiple comparisons with Bonferroni adjustment were used to examine simple effects. The level of significance was set at $P < 0.05$. Data are presented as mean \pm standard deviation. Using G*Power software (GPower 3.1) for a sample size of 12 people considering an alpha level error of 0.05, it was verified a power level of 0.99.

RESULTS

Twelve female hypertensive elderly subjects performed the HIAE session and the control session without statistically significant differences between SBP, DBP, MBP, and HR at rest (SBP_{rest} , DBP_{rest} , MBP_{rest} and HR_{rest} , respectively) ($P > 0.05$). The baseline characteristics of the subjects are presented in Table 1.

Table 1. Baseline Characteristics of Hypertensive Elderly Subjects.

Variables	Sample (N = 12)	
Demographics		
Age (yrs)	66.8 \pm 4.8	
BMI ($kg \cdot m^{-2}$)	28.0 \pm 1.7	
Medication (%)		
Diuretic	4 (30.8)	
Angiotensin Antagonist	6 (46.2)	
Calcium Channel Blocker	5 (38.5)	
Hemodynamic	Control session	Experimental session
SBP_{rest} (mmHg)	129.8 \pm 15.6	132.8 \pm 21.1
DBP_{rest} (mmHg)	71.8 \pm 10.9	75.5 \pm 10.9
MBP_{rest} (mmHg)	91.1 \pm 12.1	94.6 \pm 15.1
HR_{rest} ($beats \cdot min^{-1}$)	71.0 \pm 14.2	70.0 \pm 12.7

BMI = Body Mass Index; **SBP_{rest}** = Resting Systolic Blood Pressure; **DBP_{rest}** = Resting Diastolic Blood Pressure; **MBP_{rest}** = Mean Resting Blood Pressure; **HR_{rest}** = Resting Heart Rate. No significant statistical differences were found between hemodynamics variables compared to both sessions ($P > 0.05$). * $P > 0.05$; Chi-Squared test.

Figure 1 shows the systolic, diastolic and mean blood pressure during rest and recovery moments of both sessions. It was observed that SBP values (Figure 2A) were significantly lower for all moments of the post-HIAE session compared to the control (HIAE vs. Control, 15 min: 115.1 \pm 11.8 vs. 136.0 \pm 9.5; 30 min: 114.9 \pm 11.6 vs. 132.4 \pm 14.9; 45 min: 112.0 \pm

13.1 vs. 133.0 ± 15.3 ; 60 min: 115.7 ± 14.7 vs. 130.5 ± 15.1 mmHg; $P < 0.05$). With respect to the rest measurement, SBP was significantly attenuated in all evaluated post-HIAE measurements (at rest: 130.1 ± 15.1 ; 15 min: 115.1 ± 11.8 ; 30 min: 114.9 ± 11.6 ; 45 min: 112.0 ± 13.1 ; 60 min: 115.7 ± 14.7 mmHg; $P < 0.05$).

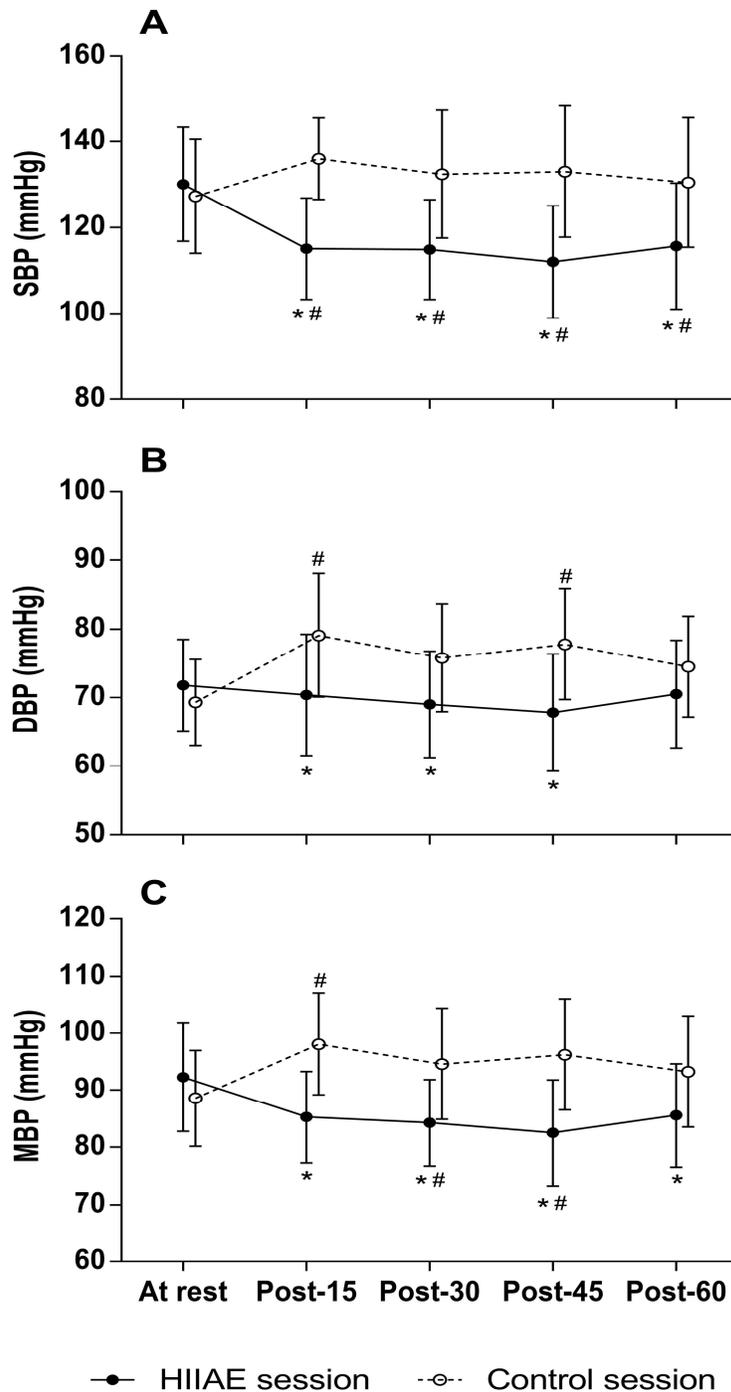


Figure 1. Behavior of Systolic (SBP, Panel A), Diastolic (DBP, Panel B) and Mean (MBP, Panel C) Blood Pressure at Rest, and at 15, 30, 45, and 60 min of Recovery after a High-Intensity Interval Aquatic Exercise (HIAE) and Control Session. *difference from the control session $P < 0.05$; #difference from at rest $P < 0.05$.

No significant differences were found in DBP (Figure 1B) between at rest and the post-HIIAE measurements (at rest: 71.8 ± 6.7 ; 15 min: 70.4 ± 8.9 ; 30 min: 69.0 ± 7.8 ; 45 min: 67.8 ± 8.6 ; 60 min: 70.5 ± 7.9 mmHg; $P > 0.05$). However, it was noticed an increase in the DBP at minutes 15 and 45 in the post-control session compared to at rest value (at rest: 69.3 ± 6.3 ; 15 min: 79.1 ± 9.0 ; 45 min: 77.8 ± 8.1 mmHg; $P < 0.01$). DBP was significantly decreased at minutes 15 to 45 post-HIIAE session compared to the same measurement moments post-control session (HIIAE vs. Control, 15 min: 79.1 ± 9.0 vs. 79.1 ± 9.0 ; 30 min: 69.0 ± 7.8 vs. 75.8 ± 7.9 ; 45 min: 67.8 ± 8.6 vs. 77.8 ± 8.1 mmHg; $P < 0.05$).

MBP (Figure 1C) was significantly reduced post-HIIAE session from 15 to 60 min compared to post-control session (HIIAE vs. Control, 15 min: 85.3 ± 8.0 vs. 98.1 ± 8.9 ; 30 min: 84.3 ± 7.6 vs. 94.6 ± 9.7 ; 45 min: 82.5 ± 9.3 vs. 96.2 ± 9.7 ; 60 min: 85.6 ± 9.1 vs. 93.2 ± 9.7 mmHg; $P < 0.05$). Compared to at rest, post-HIIAE session presented significantly lower MBP values at minutes 30 and 45 (at rest: 92.3 ± 94.5 ; 30 min: 84.3 ± 7.6 ; 45 min: 82.5 ± 9.3 mmHg; $P < 0.05$).

Figure 2 shows that the systolic post-exercise hypotension magnitude (Panel A) was significantly higher in all measurements post-HIIAE session compared to post-control session (HIIAE vs. Control, 15 min: -15.0 ± 14.2 vs. 8.8 ± 13.0 ; 30 min: -15.2 ± 9.3 vs. 5.2 ± 18.3 ; 45 min: -18.1 ± 8.3 vs. 5.8 ± 14.6 ; 60 min: -14.4 ± 10.7 vs. 3.3 ± 15.1 mmHg; $P < 0.05$).

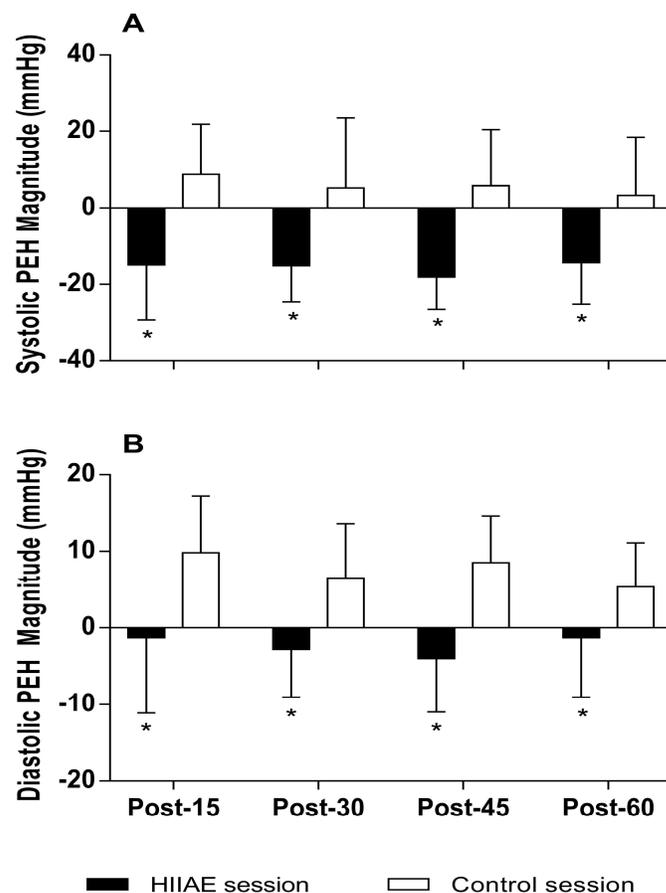


Figure 2. Magnitude of Systolic (Panel A) and Diastolic (Panel B) Post-Exercise Hypotension at 15, 30, 45, and 60 min of Recovery. *difference from the control session ($P < 0.05$).

Besides no statistically significant change in DBP response to HIIAE session, the DBP drop post-HIIAE was greater compared to control (Panel B) in all measurements (HIIAE vs. Control, 15 min: -1.3 ± 9.8 vs. 9.8 ± 7.4 ; 30 min: -2.8 ± 6.2 vs. 6.5 ± 7.1 ; 45 min: -4.0 ± 7.0 vs. 8.5 ± 6.1 ; 60 min: -1.3 ± 7.7 vs. 5.3 ± 5.8 mmHg; $P < 0.05$).

DISCUSSION

Aging, PEH, and Associated Factors

The results of the present study indicate that a high-intensity interval aquatic exercise session promotes post-exercise hypotension in hypertensive elderly individuals for up to 1-hr post-exercise. In turn, the magnitude of this hypotension reached reduction values of up to 18 mmHg for SBP and of 9 mmHg for MBP.

The aging process is associated with alterations in autonomic cardiovascular control, leading to reduced vagal tone, increased sympathetic tone, and attenuation of autonomic regulatory mechanisms such as baroreceptors (33) and endothelial dysfunction, which may lead to a decrease in vasomotor tone and blood flow due to the dysfunction responding positively to nitric oxide, in addition to its reduced synthesis (1,31). Such dysfunctions in the autonomic mechanisms of cardiovascular control contribute to the development of cardiovascular events throughout the aging process, which are one of the main causes of death in the elderly population. The changes observed with advancing age, especially sympathetic hyperactivity, are probably associated with increased blood pressure levels in hypertensive elderly (32), because of decreased vasomotor tone and regional blood flow, explained by the increase in peripheral vascular resistance (6,21).

Some studies have reported post-exercise hypotension after an aquatic exercise session in hypertensive patients, but not in elderly hypertensive patients. A study by Dutra et al. (12) found a reduction in SBP in adult women who had undergone an aqua-gymnastic session. Figueiredo et al. (13) observed a decrease in SBP of normotensive middle-aged women after a hydrogymnastic session of moderate intensity, suggesting that even at less vigorous intensities aquatic exercise also appears to be effective in reducing blood pressure levels. Amorim et al. (2) analyzed the duration of the hypotensive effect of a hydrogymnastic session in hypertensive middle-aged women and observed a reduction in SBP and DBP, suggesting daily aquatic exercise as a non-pharmacological therapy for blood pressure control.

In the study by Pontes Jr. et al. (38), the results showed systolic and diastolic PEH after exercise in sedentary hypertensive adults submitted to a 50-min running session in the water at a moderate intensity (50% HRR). Recently, in 2016, Cunha et al. (10) studied hypertensive adult women who were overweight and obese, and found a decrease in SBP after 10 and 20 min post-exercise in overweight women compared to the control session. In obese women, SBP only decreased at 10 min post-exercise. The experimental session consisted of a 45-min training period at 70 to 75% HRR intensity.

In a recent 2016 study, Gomes et al. (18) evaluated the effect of a physical exercise session performed in an aquatic environment in hypertensive elderly, the same sample of our study. They showed that SBP significantly decreased after a 50-min aquatic exercise session at 70% of the HRR as a consequence of an acute response to exercise. However, no studies

were found evaluating PEH for high-intensity interval aquatic exercise in hypertensive elderly subjects.

HPE and Associated Mechanisms

The physiological mechanisms of blood pressure control would act more strongly after intense interval exercise in order to minimize pressure stress generated during the session and to achieve homeostatic balance (5). The physiological mechanisms responsible for PEH were not analyzed in the present study; however, some studies (7,31) suggest that the hypotensive response is caused by baroreceptor action, reduced total peripheral vascular resistance, and decreased cardiac output.

Due to the increase in peripheral vascular resistance specifically in hypertensive elderly inherent to the aging process associated with arterial hypertension (24), it is believed that the reduced cardiac output in the elderly hypertensive population is the main mechanism responsible for PEH due to reduced systolic volume and cardiac output, both resulting from the reduced final diastolic volume (4). In addition, the main mechanism associated with PEH is the reduction of sympathetic activity (27) and reduction in renin-angiotensin-aldosterone system activity as a result of decreased catecholamine synthesis and releases (39).

It is well established that exercise improves baroreflex sensitivity, but is more related to chronic exercise. Baroreflex sensitivity reduction is probably the major determinant of blood pressure variability in systemic arterial hypertension (22), and indirectly associated with the consequent lesions of target organs (14), due to the reduction of tissue perfusion. In addition, impairment of baroreceptor function may act as a permissive element in the establishment of primary alterations in other mechanisms of cardiovascular function control, since it does not modulate sympathetic and parasympathetic activity adequately (23), which impairs the reestablishment of autonomic cardiovascular control during and after exercise since the sympathetic activity decreases and the parasympathetic activity increases during exercise recovery.

High blood pressure represents an independent risk factor for cardiovascular disease with possible complications such as cerebrovascular disease, coronary artery disease, heart failure, chronic renal failure, and vascular end-organ disease (33). In addition to arterial hypertension, the high prevalence of risk factors and comorbidities make this clinical condition along with aging responsible for the high incidence of cardiovascular events (3). As a result, high-intensity interval aquatic exercise sessions may potentially be recommended for blood pressure control as a potential non-pharmacological strategy, especially due to the PEH-related effects, in hypertensive elderly considering its high effectiveness and low injury and cardiovascular risk. Also, aerobic exercise in water is highly recommended specially for the elderly because of the low load and mechanical stress on weight-bearing joints and muscles.

Limitations in this Study

As study limitations, it was not possible to subject the hypertensive elderly to the same diet regime. Therefore, in order to minimize these biases and to preserve the clinical condition of the elderly, each subject from both groups was instructed to maintain the same food, especially salt consumption.

CONCLUSIONS

A high-intensity interval aquatic exercise session promotes post-exercise hypotension in hypertensive elderly individuals for up to 1-hr post-exercise.

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