# Post-exercise hypotension in hypertensive individuals submitted to aerobic exercises of alternated intensities and constant intensity-exercise

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## ABSTRACT

Acute exercise may result in post-exercise hypotension (PEH), which has been observed both for normotensive and hypertensive individuals, especially after continuous exercise (low to moderate intensity). The purposes were to compare the hypotensive effects of continuous exercise performed with alternated (AI) and constant intensities (CI) and verify if AI is more effective on inducing PEH. Eleven hypertensive subjects (56.8 ± 2.6 years; BMI of 26.5 ± 0.3 kg/m²) performed, on different days, an incremental test (IT) and two submaximal exercise sessions (45 min) on treadmill (AI and CI). The AI consisted of 2 min at 55.9 ± 2.6% and 1 min at 74.5 ± 4.0% of heart rate reserve (HRR) while the CI consisted of 45 min at 60 ± 2.5% of HRR. On both sessions participants rested for 10 min before exercise for blood pressure (BP) and heart rate (HR) measurements and then performed a 5 min warm-up followed by 45 min of either AI or CI. BP and HR were monitored at each 5 min of exercise and at the 5th, 10th, 15th, 30th, 60th, 90th and 120th min of post-exercise recovery (rec). ANOVA and Student t-test evidenced PEH of systolic blood pressure (SBP) after both sessions when compared to resting ($p < 0.001$) at all moments of rec with no differences between AI and CI. PEH of diastolic blood pressure (DBP) was observed at the 5th, 10th, 15th and 30th min of rec after CI ($p < 0.05$), but not after AI. PEH of mean blood pressure (MBP) was observed after CI and AI at all moments of rec. In spite of the similar PEH for SBP, the CI resulted in PEH of DBP, with longer reduction of MBP. No differences were observed between treatments for the absolute values of BP during the rec period. The authors conclude that the exercise intensities applied during AI did not induce additional hypotensive effects in relation to CI during the rec.

**Keywords:** Post-exercise hypotension. Hypertension. Treadmill. Intensity variation.

## INTRODUCTION

Arterial hypertension (AH) is considered one of the most important risks for the development of cardiovascular diseases[1], representing in Brazil one of the public health problems of most prevalence in the population. Moreover, it is able to lead to death approximately 40% of the compromised individuals[2]. The AH treatment is conducted through medication and should be associated with a change in life-style, such as alterations in eating patterns as well as regular physical exercises practice[3].

The product of the cardiac debt by the total peripheral resistance defines blood pressure (BP), once BP is influenced by the strength played by the blood against the arteries walls as well as by the resistance imposed by them to the blood flow[4]. The BP reference indices considered normal are ≤ 120 mmHg for systolic blood pressure (SBP) and ≤ 80 mmHg for diastolic blood pressure (DBP), being indices ≥ 140 mmHg (SBP) and/or ≥ 90 mmHg (DBP) considered AH[5].

It has been demonstrated that the performance of a single physical exercise session may promote pressor decrease below the indices observed in the pre-exercise period; such phenomenon is called post-exercise hypotension (PEH). PEH may be benefic for the BP control, especially in hypertensive individuals[6-9]. Moreover, its magnitude and duration seem to be related to factors such as the exercise type, duration and intensity[10].

Several studies have demonstrated that physical activities of aerobic characteristics present significant reduction of the post-exercise pressor indices[6,8-9], while after endurance exercises controversial results have been observed, such as increase[11], maintenance[12], or even decrease[13] of the post-endurance exercise blood pressure.

The effect of the duration of the exercise session over the PEH has been investigated in hypertensive and normotensive individuals. Moreover, there is evidence that the longer the exercise session duration (45 min vs 25 min), the more remarkable and longer the PEH is[7]. Such phenomenon has been observed both in normotensive and hypertensive individuals[14]. Yet, there is no consensus about which exercise intensity should be applied. There is evidence that exercise performed at 30%, 50% and 80% of the $\dot{V}O_2$peak results in similar reductions in the post-exercise blood pressure in normotensive subjects[15]. On the other hand, it has been suggested that the exercise performed in alternated intensities, alternating between 50% and 80% of the RHR, results in lower pressor indices during 24 h post-exercise in relation to the indices obtained in the constant intensity exercise performed at 60% of the RHR, in hypertensive subjects[16]. Only few studies evaluated the pressor response to the exercise with intervals or of alternated intensities, with a higher number of research contemplating the rectangular exercise, reflecting thus, the recommendations by the ACSM[3] of aerobic exercises at constant intensities for BP control or non-medicated treatment of the AH.

Further research about the effect of the exercise intensities variation over the PEH is still needed. Thus, this study had the aim to investigate and compare the hypotensive effects of two sessions of aerobic exercises performed on treadmill by hypertensive individuals, being one with constant intensity exercises (CIE) and another with alternated intensities (AIE), verifying whether there is PEH improvement after AIE.

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## METHODS

### Participants

The procedures used in the present study were previously approved by the Human Research Ethics Committee of the University of Mogi das Cruzes, SP, Brazil.

Eleven hypertensive individuals with BP controlled by medication were selected. The participants' characteristics and medication used by them are represented in tables 1 and 2 respectively. The participants were recruited after having signed an informed consent form about the procedures and benefits of the study. They also answered a questionnaire (anamnesis) about their health history. Sedentarism, smoking history, obesity and diabetes, as well as presenting orthopedic problems, having coronary arterial condition or using beta-blockers medication, were the exclusion criteria.

**TABLE 1**
**Biometrical characteristics of the participants of the study and mean standard error (MSE) for SBP, DBP and resting HR indices**

| (n = 11) | Age (years) | Weight (kg) | Height (m) | BMI (kg/m²) | SBP (mmHg) | DBP (mmHg) | HR (bpm) |
|---|---|---|---|---|---|---|---|
| Mean | 56,8 | 71,7 | 1,64 | 26,5 | 120 | 72 | 70 |
| MSE | ± 2,6 | ± 2,6 | ± 0,0 | ± 0,3 | ± 3,4 | 2,3 | ± 1,8 |

BMI = Body Mass Index; SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate Seven (n = 7) participants out of eleven performed both exercises sessions.

**TABLE 2**
**Medication types that were being used by the participants of the study**

| Medication | CIE | AIE |
|---|---|---|
| Diuretics | 5* | 3* |
| Calcium channel blockers (Dihydropiridines) | – | 1 |
| Antagonists of the angiotensine II receptor | 2 | 2 |
| Inhibitors of the conversor enzyme of angiotensine | 4* | 3* |

* Participant who makes use of two types of medication.

### Procedures

The participants were submitted, on distinct days, to three exercise sessions on treadmill (Moviment®). On the first session an ergometric test was conducted until exhaustion and on the two following sessions the volunteers were submitted to 45 min of continuous exercise of constant (CIE) and alternated intensity (AIE), which were randomly performed, with interval of at least 48 hours between the sessions.

### Ergometric test (ET)

It consisted of a test of growing loads according to protocol proposed by Ellestad[17], with initial velocity of 2,4 km/h, inclination of 10% and increases of 1,6 km/h and 2% of inclination at each stage of 3 min, without pause between stages, until voluntary exhaustion. The BP was monitored at each 3 min during the test through a sphygmomanometer of mercury column (Missouri®) and stethoscope (Premium®). All participants were monitored with electrocardiogram, supervised by a cardiologist. On the day before the ET, the participants were told not to perform physical exercise and not to stop the medication of blood pressure control on the ET day. Moreover, a light meal was served two hours prior to the ET and the intake of stimulating substances such as coffee, tea, and soda was not allowed. Before the ET beginning, the participants were instructed to interrupt the exertion when the voluntary exhaustion was reached, being used the maximal HR (MHR) obtained during the ET (exhaustion momentum) for later establishment of the intensities of the exercises sessions. The exercises intensities were established considering the HR reserve (HRR) as reference, according to description by Karvonen *et al.*[18]. The HRR was determined subtracting the resting HR from the maximal HR obtained in the ET, and the target intensities were calculated through the multiplication of the HRR by the % of the desired intensity, added to the resting HR index as following:

target HR = *[HRR] * target intensity (%) [+ resting HR]*.

The ET could also be interrupted in case the participant presented abnormalities in the electrocardiographic register and/or in the pressor response during the exercise, according to criterion of the cardiologist in charge.

### Exercises sessions (CIE and AIE)

After 10 min rest in a seating position, the participants began 5 min of warming-up on treadmill and the intensity was adjusted in order to reach the target HR (HRR percentage) previously determined for the exercise sessions of constant intensity (CIE) and alternated intensity exercise (AIE).

Both sessions consisted of 45 min of exercise on treadmill, being one exercise session with the aim to keep 60% of the HRR (CIE), and an exercise session with variation of intensities (AIE) with the aim to alternate intensities between 50% and 80% of the HRR, at each fraction of 2 and 1 minutes respectively, so that that exercise periods in higher intensities could be well tolerated by the participants, and with total work and mean intensity not different from the CIE session (table 3). After the ending of each exercise session the participants would stay in post-exercise recovery, in the seating position, during 120 min.

**TABLE 3**
**Mean volume (pondered average) and mean standard error (± MSE) of the exercise sessions**

| | CIE | AIE |
|---|---|---|
| Expected mean intensity (%HRR) | 60% | 60%* (50% and 80% – 2:1) |
| Real mean intensity (%HRR) | 60,0 ± 2,5% | 62,1 ± 3,1%** (55,9 ± 2,6% and 74,5 ± 4,0% – 2:1) |
| Exercise characteristics | Constant intensity per 45 min | Varied intensities (55,9 ± 2,6% and 74,5 ± 4,0% – 2:1) alternated at each 2 and 1 min (2:1) |

* Expected mean intensity for AIE: (2 * 50 + 80)/3 (50 and 80 are the relative intensities in the AIE).

** Real pondered mean for AIE: (2 * 55,9 + 74,5)/3 (55,9 and 74,5 are the real intensities obtained in the AIE).

### Measured variables

The SBP, DBP, MBP and the HR (Polar®, Finland) were checked at each 5 min during the 10 min rest prior to the exercise, at each 5 min during the exercise (CIE and AIE), as well as at the 5, 10, 15, 30, 60, 90 and 120 min of post-exercise recovery.

### Overload of the exercises sessions

The exercises sessions resulted in an equal total overload, once both had the same performance time (45 min), and mean intensity (pondered average) which was not different between AIE and CIE.

### Statistical treatment

The data obtained at the different moments of the same exercise session were presented in average and standard deviation (ASD). ANOVA *one-way* for repeated measures and Tukey test as post-hoc were applied in the comparison in the variables studied in the pre-exercise resting and post-exercise recovery periods. The paired Student T-test was applied in the comparison of corresponding points between the exercises sessions, being considered in this case, the variation delta indices (BP rec – BP res) in mmHg at each moment. The software used for the calculations was the *Prism 3.0*. The significance index adopted was $p < 0,05$.

## RESULTS

Tables 1 and 2 present the biomedical characteristics and the type of anti-hypertensive medication used by the participants. It is observed that the resting SBP and DBP indices of the participants are presented within the normality[1] (SBP of 120 ± 3,4 mmHg and DBP of 72 ± 2,3 mmHg) due to the participants' AH being controlled through the use of anti-hypertensive medication.

The mean intensities calculated through the pondered averages of the HR indices obtained during the exercise, in the minutes that should correspond to 50% and 80% of the HRR for AIE and 60% of the HRR for CIE, were 62,1 ± 3,1% of the HRR for AIE and 60 ± 2,5% of the HRR for CIE without statistical differences between sessions. Although the initial objective was to reach 50% and 80% of the HRR in the AIE session, the intensities varied between 55,9 ± 2,6% of the HRR during intervals of 2 min and 74,5 ± 4,0% of the HRR during intervals of 1 min, during the 45 min of exercise (table 3).

The SBP and DBP behaviors in the post-exercise resting and recovery conditions in the AIE and CIE sessions are presented in figure 1, while the SEA and the HR are presented in figure 2 and table 4 respectively.

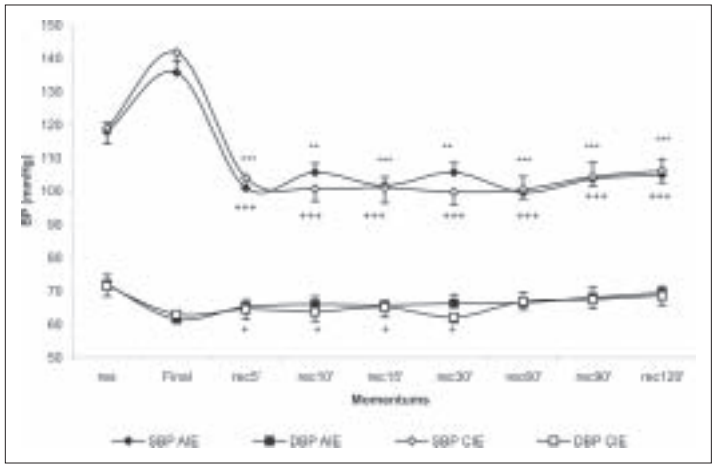


***Figure 1*** *– Systolic blood pressure (SBP) and diastolic blood pressure behavior (DBP), as well as MSE during the pre-exercise resting (res), at the end of the exercise (Final) and during the post-exercise recovery period after session of AIE and CIE.*

*** p < 0,001, ** p < 0,01 and * p < 0,05 in relation to the res of AIE and +++ p < 0,001, ++ p < 0,01 and + p < 0,05 in relation to the res of CIE

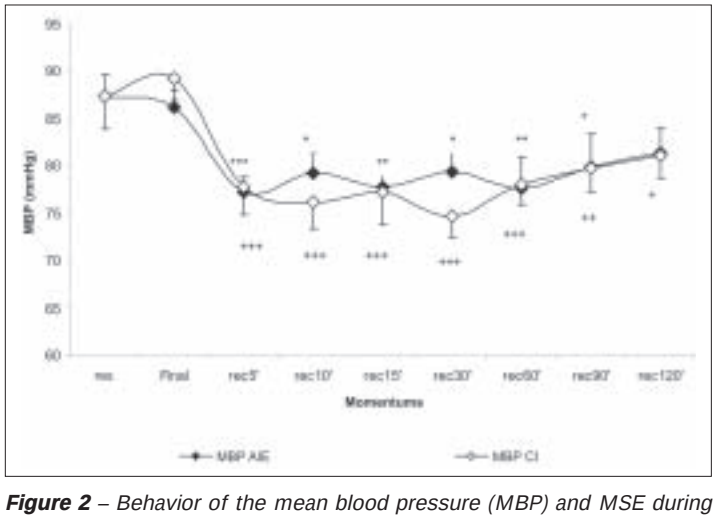


***Figure 2*** *– Behavior of the mean blood pressure (MBP) and MSE during pre-exercise resting (res) exercise ending (Final) and during the post-exercise recovery period after session of AIE and CIE*

*** p < 0,001, ** p < 0,01 and * p < 0,05 for AIE and +++ p < 0,001, ++ p < 0,01 and + p < 0,05 for CIE in relation to res

**TABLE 4**
**Mean results (± mean standard error) of the response of the Heart Rate (bpm) during the pre-exercise resting (res), end of the exercise (Final) and during post-exercise recovery period after session of AIE and CIE**

| | | Rep | Final | Rec5' | Rec10' | Rec15' | Rec30' | Rec60' | Rec90' | Rec120' |
|---|---|---|---|---|---|---|---|---|---|---|
| CIE | Mean | 70 | 126*** | 85*** | 80*** | 78* | 74 | 71 | 66 | 65 |
| | MSE | ± 3,36 | ± 5,73 | ± 3,65 | ± 4,71 | ± 4,92 | ± 4,64 | ± 3,22 | ± 2,62 | ± 1,95 |
| AIE | Mean | 70 | 142*** | 98***§§ | 91*§ | 88**§ | 86* | 77* | 75 | 71 |
| | MSE | ± 2,23 | ± 7,63 | ± 5,05 | ± 4,46 | ± 4,60 | ± 4,23 | ± 3,97 | ± 4,65 | ± 3,54 |

* p < 0,05; *** p < 0,001 in relation to res
§ p < 0,05; §§ p < 0,01 in relation to corresponding points of both sessions (CIE vs. AIE)

It was observed PEH of SBP in both exercises sessions (CIE and AIE p < 0,001) in all recovery moments when the pre-exercise resting indices were compared. The lowest indices of SBP were observed between the 5th min and the 60th min of post-exercise recovery. Concerning resting, theses indices represent decrease of up to 18 mmHg for VIE and 19 mmHg for CIE. The comparison between sessions showed SBP indices similar after CIE and AIE (figure 1). The DBP presented PEH after CIE at 5, 10, 15 and 30 min of recovery (p < 0,05), with decrease of up to 9 mmHg at 30 min of rec, not being observed PEH of DBP after AIE session (figure 1). It was observed PEH of CIE during the 120 min of recovery after CIE, and during 90 min of recovery (p < 0,05) after AIE. The highest decrease of CIE (13 mmHg) was observed at 30 min of rec after CIE, while the highest decreases after AIE (10 mmHg) were observed at 5, 15 and 60 min of rec (figure 2). The HR indices remained high during rec in relation to pre-exercise resting during the first 15 min of recovery (p < 0,05) after CIE and in the first 30 min of rec (p < 0,001) after AIE. The differences between the sessions were verified only at 5,10 and 30 min of rec (p < 0,05), with higher HR indices after AIE (table 4).

## DISCUSSION

The present study compared the hypertensive effects of CIE and AIE performed by hypertensive individuals under the use of anti-hypertensive medication. The main results showed that the AIE (2 min at 55,9 ± 2,6% of the HRR and 1 min at 74,5 ± 4,0% of the HRR alternated during 45 min) presented a hypotensive effect of SBP similar to the CIE performed at 60 ± 2,5% of the HRR. It was observed as well the hypotensive effect in the DBP only after CIE, besides of higher number of momentums (post-exercise recovery minutes) of PEH of CIE after CIE.

These results contribute for a better comprehension of the PEH phenomenon, once it was demonstrated that continuous exercises performed in steady intensities and varied intensities as well, result in PEH in hypertensive individuals under the use of anti-hypertensive medication. Within the used medication, the calcium channel blocker (dihydropiridine) may decrease, increase or not have effect over the HR in the rec and in exercise, decreasing the BP. The diuretics do not directly influence the HR, decreasing or not having effect over the BP (in exercise). The angiotensin conversion inhibitors do not directly influence the HR, being able to result in BP decrease[3]. Nonetheless, considering that the participants made use of the same medication in both sessions, any difference observed between sessions cannot be attributed to the medication, but as an additional effect derived from the exercise sessions performance (CIE and AIE).

The results observed in this study are according to research that verified the acute exercise benefit to the BP control, both in normotensive[6-8] and hypertensive individuals[9,14,16,19-20]. The hypotensive response and the SBP observed after CIE and AIE is according to other studies, which verified similar PEH both in normotensive[7] ans hypertensive individuals[14] and that aerobic exercises performed at different intensities (30%,50% and 80%)

result in PEH of same duration and magnitude[6,8]. Nevertheless, Ciolac *et al.*[16] observed higher hypotensive effect during 24 h after exercise with intervals when compared with continuous exercise, confronting our results, despite the present study having investigated the PEH only during 2 hours of post-exercise recovery.

The lack of PEH of DBP after AIE was contrary to the results obtained in the research protocols with exercise with intervals, as showed by Ciolac *et al.*[16]. However, they agree with the research results which did not show significant differences between exercise intensities and decrease in the DBP. Moreover, significant decrease was verified only at 30 min post-exercise of 45 min at 50% of the $\dot{V}O_2$peak in cycle ergometer, as shown respectively in the studies by MacDonald *et al.*[8] and Rondon[9].

As can be observed in figure 2, the CIE presented more significant decrease after CIE; however, no significant differences were observed between CIE and AIE, having similar results to the ones by Forjaz *et al.*[6] and MacDonald *et al.*[8] who did not observe effect of the exercise intensity in the PEH.

Despite of that, other studies have demonstrated that the PEH is dependent on the intensity in which the exercise is performed. Willianson *et al.*[21] showed the intensity effect comparing exercise intensities performed in cycle ergometer (session at 60-70% vs. session at 20% of the HRR) and observed PEH only after session performed at 60-70% of the HRR, suggesting that this PEH was associated with alterations of brain flow in insular cortex areas, which is related with the autonomic control of the cardiovascular function. These authors verified as well that the exercise performed at 20% of the HRR did not result in any significant alteration of the BP (without PEH) or flow alteration in brain areas related with the cardiovascular control. In the present study, although having resulted in similar PEH of SBP and DIE, the exercise of higher intensity (AIE) did not present PEH of DBP, confronting the results by Willianson *et al.*[21] concerning the effect of the intensity on the PEH. Nonetheless, the study by Willianson *et al.*[21] compared very different intensities, and since both exercise sessions of the present study were performed within the same intensity domain (probably below the anaerobic threshold – Lan), it is not possible to reach the conclusion whether AIE performed in different intensity domains (for instance, alternating intensities above and below the Lan or between 65 and 85% of the HRR) may improve the PEH in relation to the steady intensity exercise. Moreover, it is even possible that our results have not showed evidence of intensity in the response between sessions due to the limited exercise time in intensities that could result in higher hypotensive effect (1 min at ~75% of the HRR), combined with longer time (2 min) in lower intensities (2 min at ~56% of the HRR).

The HR presented similar behavior in both exercises sessions, being higher after AIE. Such behavior was also demonstrated by McDonald *et al.*[8] who investigated the BP and HR response in normotensive subjects after exercise performed in different intensities (50% or 75% of the $\dot{V}O_2$peak). The HR was higher after exercise of higher intensity, being the increase more significant at 15 min post-exercise. Besides that, although the pre-exercise catecholamines indices have not been measured, it is possible that the increased HR after AIE is due to higher release of catecholamines during the alternations of intensities in this session (74,5 ± 4,0% and 55,9 ± 2,6% of the HRR). In the session of CIE though, the intensity was only kept at 60 ± 2,5% of the HRR. This behavior (increased HR in the rec) is also attributed to a reflex increase of the HR due to the post-exercise BP decrease, in the trial of keeping the cardiac debt during the PEH, as previously proposed by McDonald *et al.*[22].

## CONCLUSION

Although the PEH of SBP and CIE have been observed in both sessions, only the CIE resulted in PEH of DBP. Nonetheless, no difference was observed between the treatments for the absolute BP indices during the rec period. Therefore, we come to the conclusion that the sessions of AIE and CIE result in similar PEH, and that the AIE, within the intensities used in the present study, does not improve the post-exercise hypotensive effect when compared with the CIE. Finally, further studies should be conducted applying different variations of intensities and different duration times in the intensities studied in order to analyze and compare their hypotensive effects and their clinical applications in the prevention and non-pharmacological treatment of the arterial hypertension.


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