Original Article

Hypotensive Response Magnitude and Duration in Hypertensives: Continuous and Interval Exercise

Raphael Santos Teodoro de Carvalho, Cássio Mascarenhas Robert Pires, Gustavo Cardoso Junqueira, Dayana Freitas, Leila Maria Marchi-Alves

Escola de Enfermagem de Ribeirão Preto da Universidade de São Paulo, Ribeirão Preto, SP - Brazil

Abstract

Background: Although exercise training is known to promote post-exercise hypotension, there is currently no consistent argument about the effects of manipulating its various components (intensity, duration, rest periods, types of exercise, training methods) on the magnitude and duration of hypotensive response.

Objective: To compare the effect of continuous and interval exercises on hypotensive response magnitude and duration in hypertensive patients by using ambulatory blood pressure monitoring (ABPM).

Methods: The sample consisted of 20 elderly hypertensives. Each participant underwent three ABPM sessions: one control ABPM, without exercise; one ABPM after continuous exercise; and one ABPM after interval exercise. Systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), heart rate (HR) and double product (DP) were monitored to check post-exercise hypotension and for comparison between each ABPM.

Results: ABPM after continuous exercise and after interval exercise showed post-exercise hypotension and a significant reduction ($p < 0.05$) in SBP, DBP, MAP and DP for 20 hours as compared with control ABPM. Comparing ABPM after continuous and ABPM after interval exercise, a significant reduction ($p < 0.05$) in SBP, DBP, MAP and DP was observed in the latter.

Conclusion: Continuous and interval exercise trainings promote post-exercise hypotension with reduction in SBP, DBP, MAP and DP in the 20 hours following exercise. Interval exercise training causes greater post-exercise hypotension and lower cardiovascular overload as compared with continuous exercise. (Arq Bras Cardiol. 2015; 104(3):234-241)

Keywords: Blood Pressure; Hypertension; Exercise; Post-Exercise Hypotension; Blood Pressure Monitoring, Ambulatory.

Introduction

Systemic arterial hypertension (SAH) is a multifactorial clinical condition characterized by high and sustained blood pressure (BP) levels. Increased BP relates to age, the prevalence of SAH being higher than 50% among individuals aged 60-69 years[1].

Regarding the therapeutic approach, the treatment of SAH can be based on pharmacological and non-pharmacological measures, mainly aimed at reducing cardiovascular morbidity and mortality[1].

Non-pharmacological treatment comprises body weight reduction, sodium intake decrease, potassium intake increase, adhesion to a diet rich in fruits, vegetables and low-fat food, alcohol consumption decrease, smoking cessation and physical exercise practice, the latter being one of the most studied and used forms of non-pharmacological treatment of SAH[2,3].

Some studies have shown that one single session of physical exercise promotes post-exercise hypotension (PEH), which means BP reduction after physical exercise to levels lower than those measured prior to exercise[4,5].

Some studies have reported that, among hypertensives, physical exercise chronically reduces systolic blood pressure (SBP) and diastolic blood pressure (DBP) at rest, on average, 8.3 mmHg and 5.2 mmHg, respectively, the chronic reduction in BP being associated with a cumulative effect of acute reductions[6,7]. Therefore, in recent years, several studies have attempted to describe the benefits and peculiarities of physical exercise, mainly the aerobic one, to the SAH treatment[4,8].

Although the acute hypotensive effect of physical exercise and its mechanisms have been reported, so far there is no effective and consistent argumentation on the effects of the manipulation of the various components of training workload (intensity, duration, rest intervals, exercise types, training methods) on the hypotensive response magnitude and duration. The established propositions lack investigation and scientific evidence.

Correspondência: Raphael Santos Teodoro de Carvalho •
Escola de Enfermagem de Ribeirão Preto/USP - Departamento de Enfermagem Geral e Especializada - Av. Bandeirantes, 3900, Postal Code 14.040-902, Monte Alegre, Ribeirão Preto, SP - Brazil
E-mail: raphaelstcarvalho@gmail.com
Manuscript received July 07, 2014; revised manuscript September 03, 2014; accepted September 15, 2014.

DOI: 10.5935/abc.20140193

In addition, knowing the efficiency of each type of physical training can help defining and guiding the therapeutic approach capable of more effectively contributing to the SAH treatment.

Objective

To compare the effects of dynamic exercises (continuous and interval) on the hypotensive response magnitude and duration in hypertensive individuals by using ambulatory blood pressure monitoring (ABPM).

Methods

Sample

This study sample comprised 20 elderly hypertensives who diligently participated in activities provided by a philanthropic entity of a municipality of inner São Paulo state, during the data collection period. This study included all individuals aged 60 years and older, with no limitation to exercise, who had medical clearance for participation in physical activity, self-reported sedentary life style and unaltered pharmacological therapy for at least three months. Elderly individuals with the following characteristics were excluded from the study: disabling chronic cardiovascular, renal, pulmonary or psychological disorders. The present study was approved by the Committee on Ethics and Research of the Nursing School of Ribeirão Preto of the Universidade de São Paulo (protocol number 12116113.7.0000.5393), in accordance with the Brazilian Health Board 196/96 Resolution.

Anthropometric assessment

The anthropometric data of body weight, height and body mass index (BMI) were collected according to the World Health Organization recommendation[9].

Hemodynamic and cardiovascular measurements

Indirect BP measurements prior to exercise sessions were taken after a 10-minute rest according to the specifications of the VI Brazilian Guidelines on Hypertension[1].

Heart rate (HR) was measured before and during the exercise sessions by using a Polar® F6 heart rate monitor.

Cardiovascular overload was estimated based on the mean double product (DP) obtained from the results of each ABPM and calculated by using the formula: mean HR of 20 hours × mean SBP of 20 hours. Cardiovascular overload was compared under the following different situations: control, after continuous exercise, and after interval exercise.

The participants underwent three ABPM exams: control ABPM, ABPM after continuous exercise, and ABPM after interval exercise. All ABPM were performed during 20 hours of daily activities and in accordance with the V Brazilian Guidelines on Ambulatory Blood Pressure Monitoring and III Brazilian Guidelines on Home Blood Pressure Monitoring[10].

The Spacelabs® (model 90207) device was used, the cuff being appropriately sized for the participant's arm.

To prevent health damage, the routine use of anti-hypertensive drugs was maintained during ABPM.

Cardiorespiratory assessment

All participants underwent cardiopulmonary exercise test to assess cardiovascular health, to measure maximum oxygen consumption (VO_{2max}) and to determine ventilatory anaerobic threshold (VAT) and respiratory compensation threshold (RCT) for the prescription of continuous and interval exercises.

The modified Bruce protocol, which is reserved for individuals with physical limitations, such as older and sedentary individuals, was selected for this study[11]. The test was performed on a treadmill (Technogym®, Run model).

Participants underwent 12-lead electrocardiography at rest and continuous electrocardiography monitoring during the cardiopulmonary exercise test, which was performed in a temperature-controlled (21-23°C) environment, at least one hour and a half after the last meal. They were encouraged to exercise until muscle fatigue was achieved.

The VAT and RCT (expressed as oxygen consumption [VO_2] and treadmill velocity and inclination) corresponded to the points where the ventilatory response linearity was lost [ventilation (Ve), ventilatory equivalent of carbon dioxide (VCO_2)], while VO_2 continued to linearly increase regarding the power applied.

Exercise protocols

Participants randomly underwent two sessions of dynamic exercises in different days, at a minimum one-week interval between sessions, at which the 'training intensity' and 'specific exercise method' were manipulated. The exercise sessions were scheduled for the beginning of the morning and they preceded the installation of the ABPM equipment. In one session, the participants exercised continuously on the treadmill for 42 minutes at the VAT intensity. In the other, they exercised according to the interval exercise method.

The individuals exercised at the RCT for four minutes during the active phase, and, in the recovery phase, at 40% of VO_{2max} for two minutes. The total session duration was 42 minutes.

Ethical aspects

The present study was approved by the Committee on Ethics and Research with Human Beings of the Nursing School of Ribeirão Preto of the Universidade de São Paulo (research protocol number 12116113.7.0000.5393), in accordance with the Brazilian Health Board 196/96 Resolution.

Statistical analysis

Descriptive analysis with absolute and percentage frequencies of the qualitative variables, and means, standard deviation and medians of quantitative variables was performed by using the Statistical Package for the Social Sciences – SPSS software, version 15.0.

The Shapiro-Wilk test was used to assess the normality of the distribution of quantitative variables. To assess the statistically significant differences, Wilcoxon nonparametric test was used for variables with no normal distribution. The *t* test was used for paired samples of variables with normal distribution. In all analyses, the 5% statistical significance level was adopted ($p < 0.05$).

Results

Table 1 shows the clinical variables of participants, according to the values obtained before the first physical exercise program.

Tables 2 and 3 show the clinical variables obtained on ABPM recording (control and after continuous and interval exercise programs), considering wakefulness and sleep.

Comparing the control and post-continuous exercise ABPM results, a statistically significant difference was observed in SBP, DBP, mean arterial pressure (MAP) and DP during wakefulness and sleep, and in sleep HR.

Similarly, comparing the control and post-interval exercise ABPM results, a reduction in post-interval exercise values was observed, with a statistically significant difference in SBP, DBP, MAP and DP during wakefulness and sleep. No HR difference was observed between post-interval exercise and control ABPM values.

Comparing continuous and interval exercise, a statistically significant difference was observed in wakefulness and sleep SBP, MAP and DP, and in wakefulness DBP. No difference was observed in sleep DBP and in wakefulness and sleep HR.

Table 4 shows significant PEH for SBP and DBP after the continuous and interval exercise programs, during wakefulness and sleep, as compared with the pre-exercise resting period.

Discussion

Our results indicate that continuous and interval physical exercise promotes PEH, and that BP reduction persists during wakefulness and sleep, at least in the first 20 hours following exercise practice.

Similarly, PEH has been reported by several researchers. However, most of them have assessed the effect of physical exercise on BP for 60-120 minutes[12-14].

Few studies have assessed the effect of the manipulation of several training workload components (interval versus continuous training, exercise intensity and duration) on the hypotensive response magnitude and duration for 24 hours.

Ciolac et al[15] have been one of the first research teams to compare the effects of continuous and interval exercises on PEH for 24 hours using reserve HR as a criterion for physical exercise prescription. Those authors have reported a reduction in 24-hour mean SBP and DBP after continuous and interval exercise, with 2.6 mmHg and 2.3 mmHg reductions in SBP and DBP, respectively, after continuous exercise, and a significant 2.8 mmHg reduction in only SBP after interval exercise.

We found greater SBP and DBP reductions after both exercise modalities. Considering continuous exercise, reductions of 15.5 mmHg and 12.5 mmHg were found in SBP and DBP, respectively. Considering the interval modality, 18.5 mmHg and 14.5 mmHg reductions were observed in SBP and DBP, respectively. Differences were observed in wakefulness as compared with pre-exercise values.

Some methodological divergences might have contributed to the differences between our findings and those of the study by Ciolac et al[15]. We used other parameters for physical exercise prescription, such as VAT and RCT, because they are effective for exercise prescription and indicated by other researchers[16,17]. Heart rate is influenced by different factors, such as environment temperature, relative air humidity, hydration level, sleep, use of beverages that alter the sympathetic nervous system activity, exercise hour and psychological stress level[18].

Blood pressure levels before exercise practice also influence the PEH magnitude, because, the higher the BP level before physical exercise, the greater its reduction[19]. In the study by Ciolac et al[15], participants were hypertensives but had their BP under control. In our study, participants had high pre-exercise BP levels, despite all being on anti-hypertensive drugs.

Table 1 – Participants' mean values prior to the exercise program: minimum, maximum, median, mean and standard deviation of systolic and diastolic blood pressure (SBP, DBP, respectively), heart rate (HR), double product (DP), body mass index (BMI), abdominal circumference (AC), maximum oxygen consumption (VO_{2max}), ventilatory anaerobic threshold (VAT) and respiratory compensation threshold (RCT) (Ribeirão Preto, 2013)

Variable	Minimum	Maximum	Median	Mean	Standard deviation
SBP (mmHg)	113.00	160.00	144.50	143.45	10.18
DBP (mmHg)	72.00	103.00	88.50	88.50	7.11
HR (bat/min)	66.00	85.00	75.95	76.00	5.10
DP	8.50	12.70	10.95	10.87	1.04
BMI (kg/m^2)	22.20	39.70	28.44	29.36	3.84
AC (cm)	86.00	115.00	101.00	110.08	9.48
VO_{2max} (mL/kg.min)	17.50	27.00	23.30	22.84	2.58
VAT (mLl/kg.min)	12.20	18.20	15.64	15.35	1.74
RCT (mL/kg.min)	14.00	21.69	19.00	18.87	1.79

Muscle mass is another important factor that can determine greater magnitude and longer duration of PEH, because, the greater the muscle mass involved in exercise, the higher the production of vasodilator agents, such as adenosine, potassium, lactate, nitric oxide and prostaglandin[8]. Those vasodilator agents change peripheral vascular resistance, thus contributing to BP reduction[20]. We believe that the use of a treadmill for exercise training contributed to the greater PEH magnitude detected in our study, because that ergometer involves a larger number of muscle groups. On the other hand, the bicycle favors the use of lower limb muscles.

In addition, Cunha et al[13] have assessed PEH after continuous and interval exercise practice for 120 minutes, using 60% of reserve HR as the intensity for continuous exercise and 80% (during one minute) and 50% (during two minutes) of reserve HR as the intensity for interval exercise. However, those authors have reported that the intensity used was within the same domain, probably below the VAT, and

Table 2 – Mean values of minimum, maximum and median of systolic and diastolic blood pressure (SBP, DBP, respectively) and mean arterial pressure (MAP) recorded during wakefulness and sleep on ambulatory blood pressure monitoring (ABPM) of participants (n = 20) undergoing continuous and interval exercise programs (Ribeirão Preto, 2013)

Variable	Minimum	Maximum	Median	p
SBP (mmHg)				
Control				
Wakefulness	110.46	152.50	140.09	
Sleep	92.06	145.25	122.84	
Continuous exercise				
Wakefulness	109.31	138.00	129.79	0.001*
Sleep	99.13	141.67	113.59	0.001*
Interval exercise				
Wakefulness	101.35	130.19	124.63	0.001*/0.001†
Sleep	88.94	138.92	110.53	0.001*/0.01†
DBP (mmHg)				
Control				
Wakefulness	68.08	98.85	88.80	
Sleep	55.63	80.00	73.22	
Continuous exercise				
Wakefulness	64.96	91.35	77.56	0.001*
Sleep	58.13	73.08	64.53	0.001*
Interval exercise				
Wakefulness	63.35	84.46	73.08	0.001*/0.001†
Sleep	53.13	70.92	63.03	0.001*/0.079†
MAP (mmHg)				
Control				
Wakefulness	85.00	114.00	105.73	
Sleep	67.81	98.75	89.43	
Continuous exercise				
Wakefulness	83.00	107.00	93.56	0.001*
Sleep	74.00	96.00	80.97	0.001*
Interval exercise				
Wakefulness	76.54	98.46	89.56	0.001*/0.001†
Sleep	66.44	87.67	79.44	0.001*/0.017†

** Wilcoxon test compared to control. † Wilcoxon test compared to continuous exercise.*

Table 3 – Mean values of minimum, maximum and median of heart rate (HR) and double product (DP) recorded during wakefulness and sleep on ambulatory blood pressure monitoring (ABPM) of participants (n = 20) undergoing continuous and interval exercise programs (Ribeirão Preto, 2013)

Variable	Minimum	Maximum	Median	p
HR (beat/min)				
Control				
Wakefulness	69.00	89.00	76.27	
Sleep	57.81	72.75	63.09	
Continuous exercise				
Wakefulness	66.69	85.46	74.94	0.062*
Sleep	54.31	72.08	62.09	0.030*
Interval exercise				
Wakefulness	66.88	85.58	75.36	0.313* / 0.896†
Sleep	55.19	75.88	62.64	0.067* / 0.538†
DP				
Control				
Wakefulness	7.00	11.00	10.00	
Sleep	5.00	10.00	7.00	
Continuous exercise				
Wakefulness	8.21	11.35	9.67	0.002*
Sleep	5.80	9.80	7.05	0.001*
Interval exercise				
Wakefulness	8.05	11.22	9.12	0.001* / 0.019†
Sleep	5.59	10.28	6.63	0.001* / 0.001†

** Wilcoxon test compared to control. † Wilcoxon test compared to continuous exercise.*

Table 4 – Post-exercise hypotension (PEH) for systolic and diastolic blood pressure (SBP and DBP, respectively) during wakefulness and sleep as compared with values prior to continuous and interval exercise programs (Ribeirão Preto, 2013)

Variable	Minimum	Maximum	Median	p
Continuous exercise				
pre-exercise SBP (mmHg)	135.0	152.0	145.0	
wakefulness mean SBP (mmHg)	111.0	139.0	129.5	< 0.001
sleep mean SBP (mmHg)	100.0	138.0	113.5	< 0.001
pre-exercise DBP (mmHg)	75.0	102.0	90.0	
wakefulness mean DBP (mmHg)	65.0	88.0	77.5	< 0.001
sleep mean DBP (mmHg)	58.0	84.0	64.0	< 0.001
Interval exercise				
pre-exercise SBP (mmHg)	132.0	154.0	142.0	
wakefulness mean SBP (mmHg)	102.0	131.0	123.5	< 0.001
sleep mean SBP (mmHg)	90.0	137.0	109.5	< 0.001
pre-exercise DBP (mmHg)	75.0	97.0	87.5	
wakefulness mean DBP (mmHg)	64.0	85.0	73.0	< 0.001
sleep mean DBP (mmHg)	55.0	69.0	61.5	< 0.001

** Wilcoxon test comparing pre-exercise period with the wakefulness and sleep periods.*

both sessions were defined as low-intensity. Those authors could not conclude whether interval exercise (characteristically of high intensity) could generate higher PEH as compared with continuous exercise (characteristically of moderate intensity), but have found statistical significance in the SBP reduction in both training sessions and in the DBP reduction for 30 minutes only after continuous exercise.

To assess the effect of the manipulation of the exercise training workload on BP reduction, Lacombe et al.[14] have used a bicycle and a sample of individuals with a mean age of 57 ± 4 years, who had borderline BP levels or had been diagnosed with stage 1 SAH. The intensity of continuous exercise was 60% of VO_{2max} and that of interval exercise was 85% of VO_{2max} for two minutes, with recovery of 40% of VO_{2max} for two minutes. The continuous exercise sessions lasted 21 minutes and those of interval exercise, 20 minutes. The results indicated a significant reduction in only SBP for both sessions (3 ± 4 mmHg after continuous exercise and 4 ± 6 mmHg after interval exercise). However, that study has not provided a more comprehensive analysis of BP reduction, because BP was monitored for only 60 minutes after exercise training.

Considering the BP classification recommended by the V Brazilian Guidelines on Ambulatory Blood Pressure Monitoring and III Brazilian Guidelines on Home Blood Pressure Monitoring[10], the results of control ABPM revealed that, on the day participants practiced no physical exercise, their BP levels were compatible with borderline BP during wakefulness and ambulatory hypertension during sleep, despite the use of drug therapy for the disease; they were, thus, at high cardiovascular risk.

The ABPM after continuous exercise showed a reduction in SBP of 10.3 mmHg and in DBP of 11.24 mmHg as compared with control ABPM during wakefulness. Thus, wakefulness BP was classified as normal. Despite the significant reduction in SBP during sleep as compared with control ABPM (9.25 mmHg reduction), SBP was classified as borderline. During sleep, DBP decreased by 8.69 mmHg, being classified as optimal.

After interval exercise practice, the ABPM results during wakefulness indicated an SBP reduction of 15.46 mmHg and a DBP decrease of 15.72 mmHg as compared with those of the same period of control ABPM. Thus, SBP was classified as normal, and DBP, as optimal. During sleep, an SBP reduction of 12.31mmHg and a DBP decrease of 10.19 mmHg were observed as compared with control ABPM. Thus, SBP during sleep was classified as normal, and DBP as optimal, meaning a normalization in mean BP levels for 20 hours, for both wakefulness and sleep.

Other authors have found similar results comparing BP variation over the 24 hours following physical exercise training and that during a no exercise period[21,22]. However, we found no studies assessing the effects of the manipulation of the different training workload components on the PEH magnitude and duration of elderly hypertensives.

When comparing ABPM performed after interval exercise with ABPM after continuous exercise, we identified in the former a significant reduction in SBP, DBP and MAP during wakefulness, and in SBP and MAP during sleep.

Concerning DP, a significant reduction ($p < 0.05$) during wakefulness and sleep was observed in ABPM after continuous and interval exercise as compared with control ABPM. In addition, a higher reduction in DP was observed during wakefulness and sleep after interval exercise as compared with continuous exercise.

The lower DP observed after continuous and interval exercise training is of great clinical relevance, because it indicates lower cardiovascular overload, and, thus, a reduction in the risk for adverse events, such as ischemic heart disease[11,23-25]. In addition, we observed a higher benefit from interval exercise as compared with continuous, with lower cardiac overload in the 20 hours following exercise practice.

Heart rate was significantly reduced ($p < 0.05$) only after continuous exercise training and only during sleep. In addition, HR reduction in the 24 hours following physical exercise practice as compared with the control session was not identified in other studies[25,26]. We believe that acute HR reduction after continuous and interval aerobic exercise is not an expected response. Brandão Rondon et al[12] have shown that, after aerobic exercise training, HR remained significantly elevated for 60 minutes. According to those authors, that acute physiological HR response is due to the exacerbated sympathetic nervous activity for a few hours after exercise.

Our results showed that, the higher the exercise intensity, the greater the PEH magnitude over 20 hours. The hypotensive effects of continuous and interval exercises were sustained during daily activities, and BP decreased to normal levels. However, over 20 hours, we observed that interval exercise training determined a more significant reduction in BP and DP as compared with continuous exercise training.

Similarly to other researchers, we believe that the greater reduction in SBP, DBP, MAP and DP after interval exercise practice results from the high BP levels generated during the exercise session and from the total duration of BP elevation[27].

During more intense exercise training (interval exercise), BP levels are higher than during moderate intensity exercise (continuous exercise). Thus, there is greater pressure stress during interval exercise training with subsequent greater homeostatic imbalance[11].

Considering that the body systems are aimed at homeostasis, during the 20 hours following interval exercise, the physiological mechanisms of BP control would act more markedly than after continuous exercise to minimize the pressure stress generated during the exercise session and achieve homeostasis. Some of the mechanisms involved in that adjustment are as follows: baroreceptor action; vascular relaxation due to stress; fluid exchange through capillary walls; decrease in peripheral vascular resistance mediated by vasodilator agents produced during muscle contraction[18]; and decrease in systolic volume[12]. Thus, exercise sessions that induce greater acute BP increases, such as interval exercise, would also induce greater PEH in the following 20 hours.

We believe that working with reported morbidity might have limited the participation of individuals who ignored their hypertensive condition. In addition, the strategy adopted to recruit participants might represent a selection bias, because the sample was small and previously defined. In addition, all individuals could be submitted to neither the same dietary regimen nor to the same pharmacological prescription. To minimize that bias and to preserve the participants' clinical conditions, they were instructed to maintain, from the beginning to the end of data collection, their same dietary and pharmacological regimens.

Conclusion

In conclusion, continuous and interval exercise trainings promote PEH, with reductions in SBP, DBP, MAP and DP over the 20 hours following the physical activity. In addition, interval exercise generates greater PEH and smaller cardiovascular overload, measured as a smaller DP, as compared with continuous exercise.

Our results can also be useful to guide the appropriate therapeutic approach and BP reduction in elderly hypertensives. Exercise prescription for that population can be improved, eliminating the need for daily practice, which could contribute to better planning and to encourage patients' adherence.

We suggest that further studies be conducted with larger and more diversified samples to support our findings.

Author contributions

Conception and design of the research: Carvalho RST, Pires CMR, Marchi-Alves LM; Acquisition of data: Carvalho RST, Junqueira GC, Marchi-Alves LM; Analysis and interpretation of the data and Statistical analysis: Carvalho RST, Marchi-Alves LM; Writing of the manuscript: Carvalho RST, Freitas D, Marchi-Alves LM; Critical revision of the manuscript for intellectual content: Carvalho RST, Pires CMR, Freitas D, Marchi-Alves LM.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

This study was partially funded by Capes.

Study Association

This article is part of the thesis of master submitted by Raphael Santos Teodoro de Carvalho, from Universidade de São Paulo.

References

1. Sociedade Brasileira de Cardiologia; Sociedade Brasileira de Hipertensão; Sociedade Brasileira de Nefrologia. VI Diretrizes brasileiras de hipertensão. Arq Bras Cardiol. 2010;95(1 supl.1):1-51.
2. Dasgupta K, Quinn RR, Zarnke KB, Rabi DM, Ravani P, Daskalopoulou SS, et al; Canadian Hypertension Education Program. The 2014 Canadian Hypertension Education Program recommendations for blood pressure measurement, diagnosis, assessment of risk, prevention and treatment of hypertension. Can J Cardiol. 2014;30(5):485-501.
3. Pappachan JM, Chacko EC, Arunagirinathan G, Sriraman R. Management of hypertension and diabetes in obesity: non-pharmacological measures. Int J Hypertens. 2011;2011:398065.
4. Gomes Anunciação P, Doederlein Polito M. A review on post-exercise hypotension in hypertensive individuals. Arq Bras Cardiol. 2011;96(5):e100-9.
5. Veloso J, Polito MD, Riera T, Celes R, Vidal JC, Bottaro M. [Effects of rest interval between exercise sets on blood pressure after resistance exercises]. Arq Bras Cardiol. 2010;94(4):512-8.
6. Cornelissen VA, Smart NA. Exercise training for blood pressure: a systematic review and meta-analysis. J Am Heart Assoc. 2013;2(1):e004473.
7. Pescatello LS, Franklin BA, Fagard R, Farquhar WB, Kelley GA, Ray CA, et al; American College of Sports Medicine. American College of Sports Medicine position stand. Exercise and hypertension. Med Sci Sports Exerc. 2004;36(3):533-53.
8. Casonatto J, Polito MD. Hipotensão pós-exercício aeróbio: uma revisão sistemática. Rev Bras Med Esporte. 2009;15(2):151-7.
9. World Health Organization. (WHO). Obesity: preventing and managing the global epidemic. Report of a WHO consultation. Geneva;2000. (WHO Techical Report Series,894).
10. Sociedade Brasileira de Cardiologia. Sociedade Brasileira de Hipertensão, Sociedade Brasileira de Nefrologia. V Diretrizes de monitorização ambulatorial da pressão arterial (MAPA) e III Diretrizes de monitorização residencial da pressão arterial (MRPA). Arq Bras Cardiol. 2011;97(3 supl.3):1-24.
11. Negrão CE, Barretto AC. Cardiologia do exercício: do atleta ao cardiopata. 3ª ed. Barueri: Manole; 2010.
12. Brandão Rondon MU, Alves MJ, Braga AM, Teixeira OT, Barretto AC, Krieger EM, et al. Postexercise blood pressure reduction in elderly hypertensive patients. J Am Coll Cardiol. 2002;39(4):676-82.
13. Cunha GA, Rios AC, Moreno JR, Braga PL, Campbell CS, Simões HG, et al. Hipotensão pós-exercício em hipertensos submetidos ao exercício aeróbio de intensidades variadas e exercício de intensidade constante. Rev Bras Med Esporte. 2006;12(6):313-7.
14. Lacombe SP, Goodman JM, Spragg CM, Liu S, Thomas SG. Interval and continuous exercise elicit equivalent postexercise hypotension in prehypertensive men, despite differences in regulation. Appl Physiol Nutr Metab. 2011;36(6):881-91.
15. Ciolac EG, Guimarães GV, D'Avila VM, Bortolotto LA, Doria EL, Bocchi EA. Acute effects of continuous and interval aerobic exercise on 24h ambulatory blood pressure in long-term treated hypertensive patients. Int J Cardiol. 2009;133(3):381-7.
16. Denadai BS. Limiar anaeróbio: considerações fisiológicas e metodológicas. Rev Bras Ativ Fís Saúde. 1995;1(2):74-88.
17. Stefani L, Mascherini G, Galanti G. Aerobic threshold for exercise prescription. Int J Clin Med. 2010;1(1):6-9.
18. Guyton A, Hall J. Tratado de fisiologia médica. Rio de Janeiro: Elsevier; 2011.
19. Chen CY, Bonham AC. Postexercise hypotension: central mechanisms. Exerc Sport Sci Rev. 2010;38(3):122-7.
20. Nunes N, Navarro F, Bacura RF, Pontes Junior FL, Alvim RO. Hipotensão pós-exercício: mecanismos e influências do exercício físico. R bras Ci e Mov. 2008;16(1):99-105.
21. Blanchard BE, Tsongalis GJ, Guidry MA, LaBelle LA, Poulin M, Taylor AL, et al. RAAS polymorphisms alter the acute blood pressure response to aerobic exercise among men with hypertension. Eur J Appl Physiol. 2006;97(1):26-33.

22. Guidry MA, Blanchard BE, Thompson PD, Maresh CM, Seip RL, Taylor AL, et al. The influence of short and long duration on the blood pressure response to an acute bout of dynamic exercise. Am Heart J. 2006;151(6):1322. e5-12.

23. Simão R, Polito MD, Lemos A. Comportamento do duplo produto em diferentes posições corporais nos exercícios contra resistência. Fit Perform J. 2003;2(5):279-284.

24. Sociedade Brasileira de Cardiologia. Consenso Nacional de Reabilitação Cardíaca. Arq Bras Cardiol. 1997;69(4):267-91.

25. Taylor-Tolbert NS, Dengel DR, Brown MD, McCole SD, Pratley RE, Ferrell RE, et al. Ambulatory blood pressure after acute exercise in older men with essential hypertension. Am J Hypertens. 2000;13(1 Pt 1):44-51.

26. Brownley KA, West SG, Hinderliter AL, Light KC. Acute aerobic exercise reduces ambulatory blood pressure in borderline hypertensive men and women. Am J Hypertens. 1996;9(3):200-6.

27. Robert-Pires CM, Penão LA, Lopes G. Comparação da hipotensão pós-esforço em sessões de exercício resistido com distintos volumes e intensidades. EFDeportes.com.Revista Digital. Buenos Aires,Nov.2010;15(150). (Acesso em 2013 jan 12). Disponível em: http://www.efdeportes.com