



Extreme Conditioning Program Induced Acute Hypotensive Effects are Independent of the Exercise Session Intensity

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ABSTRACT

International Journal of Exercise Science 10(8): 1165-1173, 2017. The aim of the study was to determine the acute systolic (SBP) and diastolic (DBP) blood pressure, rating of perceived exertion (RPE) and heart rate (HR) responses following two intense training sessions (24 hours apart). Nine male extreme conditioning program (ECP) practitioners with more than 6 months of experience (age 26.7 ± 6.6 years; body mass 78.8 ± 13.2 kg; body fat 13.5 ± 6.2 %) completed two experimental ECP sessions. Cardiovascular variables were measured before, immediately after and every 15 min during a 45 min recovery following each experimental session. Compared with pre-exercise data, our results showed a SBP decrease at 30 min post exercise session 1 ($P \leq 0.05$) and at 45 min following exercise session 2. DBP decreased ($P \leq 0.05$) at 15 min and 30 min following exercise session 1 and at 30 min after the exercise session 2, respectively. HR remained significantly higher ($P \leq 0.05$) 45 min following the first and second exercise session compared with pre-exercise values. Exercise session 1 induced a higher increase in HR ($86 \pm 11\%$ of HR_{max} versus $82 \pm 12\%$ of HR_{max} , $p = 0.01$) and RPE (8.8 ± 1.2 versus 8.0 ± 1.2 , $p = 0.02$) when compared to exercise session 2. In conclusion, post-exercise hypotension occurs following strenuous exercise sessions, regardless of the session design, which may have an important role in the prevention of cardiovascular diseases.

KEY WORDS: Strenuous exercise, physical fitness, blood pressure

INTRODUCTION

Hypertension is considered a global public health problem, causing millions of deaths each year (7). This disorder has a multifactorial etiology, characterized by persistent elevation of blood pressure ($\geq 140/90$ mm Hg) combined with deleterious metabolic changes, increasing the risk of cardiovascular and metabolic disease progression (7). Age, obesity, insulin resistance, diabetes, race, smoking status, socioeconomic status and hyperlipidemia are common associated risk factors for hypertension (7).

It has been shown that lifestyle changes, reducing the consumption of alcohol and tobacco, appropriate dietary habits and body weight maintenance are recommended as preventative and non-pharmacological treatments for hypertension. In addition, to reduce the prevalence of hypertension, regular physical activity is strongly recommended (13). It has been shown that a single session of exercise induces an important phenomenon called post-exercise hypotension, characterized by systemic reductions in systolic (SBP) and/or diastolic blood pressure (DBP) to values below those observed at rest or pre-exercise (4, 8, 14, 16, 18, 20, 21). Significantly reductions on BP after exercise are seen in investigations with individuals with normal BP (18), hypertension (14) and metabolic syndrome (16, 20, 21). These reductions are showed following aerobic exercises (AE) (2), resistance exercises (RE) (14, 16, 18, 21) and combined aerobic and resistance exercises (10, 20).

Extreme Conditioning Program (ECP) is a growing fitness regimen characterized by functional movements performed at high intensity and constantly varied movements (15). Olympic weight lifting (snatch, clean and jerk), gymnastic movements (Pull-ups, push-ups, handstand and sit-ups) and aerobic training (rowing, biking and running) combined in an allotted time are typical within ECP workouts (15, 17, 19). Recently, investigators have demonstrated an additive post-exercise hypotensive (PEH) response following the combination of aerobic and RE when compared to a single type of exercise. Keese *et al.* has shown that adding aerobic exercise to resistance training resulted in a more pronounced PEH response than RE alone (10). Interestingly, Angadi *et al.* observed that aerobic interval exercise (4-minutes at 90-95% HRmax repeated by 4-bouts, separated by three minutes) induced greater duration in the PEH response (>2 hours) when compared with 30-minute steady-state exercise (75-80% maximum heart rate) and sprint interval exercise (30-second Wingate sprints repeated 6 times, separated by 4 minutes), respectively (2). These recent studies have sparked greater interest into cardiovascular adaptations following high intensity exercises.

Furthermore, recent studies identified low and/or nonresponders to BP after exercise, demonstrated that the training effects (health related and performance factors) varies widely. Interestingly, "responders" and "nonresponders" to BP were identified after different exercise types, including maximal exercise test (8), continuous moderate aerobic exercise (11), and resistance exercise (12, 18). On the other hand, to our knowledge, the effects of different ECP sessions on intraindividual variation in BP responsiveness has not yet been designed.

At a time when more individuals are practicing ECP, more studies need to be performed to evaluate the effect of this fitness regimen on the cardiovascular system for the control of blood pressure (BP). Thus, the purpose of the study was to evaluate the effects of two sessions on

subsequent days of ECP on BP, heart rate (HR), rating perceived exertion (RPE) and intraindividual variation in BP responsiveness between the sessions.

METHODS

Participants

Nine ECP practitioners for at least 6 months (age 26.7 ± 6.6 years) were recruited through advertisements. All participants were free of injury, known illness and were not using drugs to enhance performance. All training sessions were conducted in an official ECP Box (Brasilia, DF, Brazil), prescribed and accompanied by a coach with ECP certificate.

All participants signed an informed consent document and the study was approved by the University Research Ethics Committee for Human Use and conformed to the Helsinki Declaration on the use of human subjects for research.

Protocol

Assessment of aerobic fitness: The participants were instructed to run 1,600 m or four times around a 400 m track in the lowest possible time. The mean velocity was calculated (mV_{1600}) by dividing the distance by the time in which they completed the test. In order to characterize the sample, maximal oxygen uptake (VO_{2max}) was calculated using the equation proposed by Almeida et al. (1) [$VO_{2max} = (0.177 * 1600mV) + 8.101$; $R^2 = .89$].

The ECP sessions were independent variables, while the dependent variables were the changes in BP, HR and RPE after 45 minutes of ECP (session 1 and 2). The ECP consisted of strength and gymnastic exercises paired with aerobic conditioning, however, metabolic conditioning session 1 was predominantly based on Olympic lifting and metabolic conditioning session 2 on body weight exercises. The experimental design adopted in this study was the same used by Tibana *et al.* (17).

Participants completed 2 training sessions 24 hours apart, as described in Tibana *et al.* (16). The training sessions were described in table 1 and were divided into strength, gymnastic and metabolic conditioning exercises. The values of maximal strength were based off reported values from the participants, which were experienced in ECP and performed periodic maximal strength measurements. Even so, after strength and gymnastic exercises, 5 minutes of rest was allowed and then metabolic conditioning was performed, according to the exercises described in table 1 for each training session. The goal of the metabolic conditioning sessions was to complete the maximum number of repetitions in each training session, without compromising exercise technique.

All training sessions were performed between 10 and 11 am, and participants were instructed to have a meal at least 2 h before arriving at the ECP box (same meal in training session days). Participants were asked to refrain from alcohol, coffee, tea, cola or other stimulants. In addition, they were instructed to refrain from vigorous physical activity for the previous 48h of session 1 and from alcohol ingestion for the previous 24 h. Systolic and DBP were measured

with an oscillometric device (Microlife 3AC1-1, Widnau, Switzerland) according to the recommendations of the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (5). The cuff size was adapted to the circumference of the arm of each participant according to the manufacturer's recommendations. All BP measures were evaluated in duplicate (1 minute apart) and the mean value was calculated and used for analysis. An HR monitor (Polar S810i, Polar Electro Oy, Kempele, Finland) was used to evaluate HR. Blood pressure and HR measurements were performed after 15 min of seated rest (rest), immediately after ECP sessions (0) and 15, 30 and 45 min after the ECP sessions. During BP and HR measurements participants remained seated quietly under a controlled room temperature (~22° C). Subjects were instructed to not drink water during the recovery period to avoid the potential effect of hydration on the post exercise BP responses (6). According to the response of BP after training sessions, the participants were classified as: non-responders, no reduction in BP after training session; responders, greatest reduction in BP lower than 10 mmHg after training session; high responders, greatest reduction of BP higher than 10 mmHg after training session (18).

Table 1. Schematic representation of the training sessions.

	Strength	Gymnastic	Metabolic conditioning
WOD 1	1) 5X1 Snatch from blocks (just above knee) 80% of 1RM from blocks - 2-5 min of rest. 2) 3x5 Touch & Go Snatches (full) @ 75% of 5rm - 90 sec of rest.	3X60 second Weighted Plank Hold (plate on back) - heaviest possible, 90 sec of rest.	10 minute AMRAP of: 30 Double-Unders 15 Power Snatches
WOD 2	1) 5X1 Clean from blocks (just above knee) 80% 1RM - 2 min of rest. 2) 5X1 Jerk from blocks / 80% of 1RM from blocks - 2 min of rest. 3) 3X5 Touch & Go Cleans (full) / 70% of 5RM / 90 sec of rest.	3X10 Strict Hand Standing Push up (as fast as possible, lower the top of the head to ground and extend the arms (press) back to the starting position) - 2 min of rest.	12 minute AMRAP of: Row 250m 25 6" Target Burpees

AMRAP: as many round as possible; WOD: work of the day.

Participants were asked to rate their perceived exertion 5 min following the completion of each working set based on the CR-10 RPE scale (3). They were asked to use any number on the scale to rate their overall effort. A rating of 0 was to be associated with no effort (rest) and a rating of 10 was considered to be maximal effort and associated with the most stressful exercise.

Statistical Analysis

The data are expressed as mean \pm standard deviation (SD). Shapiro-Wilk test was used to check for normality distribution of the variables. A two way repeated measures ANOVA was used to compare blood pressure and heart rate between the sessions. Compound sphericity of the variables was verified by a Mauchley test. When the assumption of sphericity was not met, the significance of F-ratios was adjusted according to the Greenhouse-Geisser procedure. Tukey's post-hoc test with Bonferroni adjustment was applied in the event of significance. A paired sample t-test was used to compare RPE and HR immediately after the training sessions and area under the curve (AUC) of blood pressure at 45 min following the training sessions. A χ^2 test was used to compare the blood pressure responders between training sessions. The

power of the sample size was determined based on the SBP and DBP post-exercise hypotension. Considering the sample size of this study and an alpha error of 0.05, the power ($1 - \beta$) achieved for SBP was 0.99 for training session 1 and 2 and for DBP was 0.84 for training session 1 and 0.61 for training session 2. The level of significance was $p \leq 0.05$ and SPSS version 20.0 (Somers, NY, USA) software was used.

RESULTS

Table 2 shows the physical characteristics of the ECP practitioners used in the study. Systolic and diastolic blood pressures were considered to be within normal range. Exercise session 1 induced a significant increase in HR (166 ± 19 bpm, $86 \pm 11\%$ of HR_{max} versus 158 ± 21 bpm, $82 \pm 12\%$ of HR_{max} , $p = 0.01$) and RPE (8.8 ± 1.2 versus 8.0 ± 1.2 , $p = 0.02$) than exercise training 2 immediately after exercise.

Table 2. Subject's physical characteristics

	n = 9
Age, yr	26.8 ± 6.6
Weight, kg	78.8 ± 13.2
Body fat, %	13.5 ± 6.3
VO_{2max} , mL.(kg.min) ⁻¹	49.4 ± 3.3
Snatch, kg	82.7 ± 9.3
Clean and Jerk, kg	107.4 ± 10.1
Back Squat, kg	144.6 ± 20.6
Front Squat, kg	131.8 ± 15.5
Years of training, yr	2.5 ± 1.2
Systolic blood pressure, mmHg	128.6 ± 11.4
Diastolic blood pressure, mmHg	74.4 ± 6.9
Resting heart rate, bpm	73.4 ± 11.9

Figure 1 presents the HR during pre-intervention and 45 min following the training session. There was no statistically significant interaction between intervention sessions and time on HR, $F(4, 32) = 2.62$, $p = 0.06$. The HR remains significantly higher ($p \leq 0.05$) during the 45 min after the training sessions compared to rest values.

The SBP had no statistically significant interaction between training sessions and time, $F(4, 32) = 0.35$, $p = 0.84$ (figure 2). When the training sessions were evaluated separately, the SBP remains significantly lower ($p \leq 0.05$) than rest values in minute 30 after training session 1 and between minute 15 and 45 after training session 2. There was also no statistically significant interaction between training sessions and time for DBP, $F(4, 32) = 0.92$, $p = 0.46$ (figure 3). The DBP remains significantly lower ($p \leq 0.05$) than rest values in minutes 15 and 30 after exercise session 1 and in minute 30 after exercise session 2.

Figure 4 shows the AUC of blood pressure during 45 min after training sessions. There were no significant differences on AUC of SBP ($p = 0.07$) and DBP ($p = 0.56$) between training sessions.

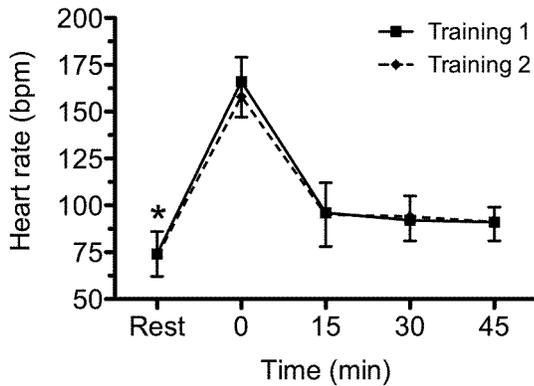


Figure 1. Mean \pm SD of heart rate prior and after training sessions. * $p \leq 0.05$ vs minute 0, 15, 30 and 45 after both training sessions.

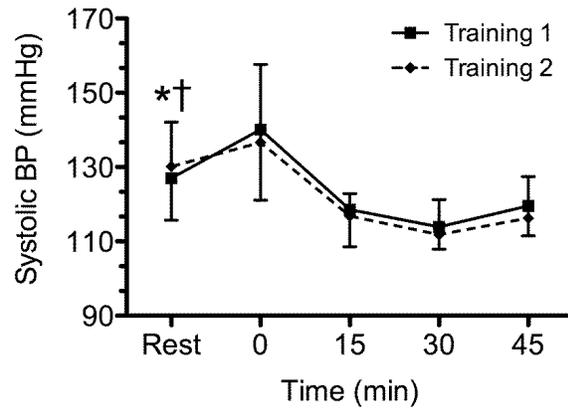


Figure 2. Mean \pm SD of systolic blood pressure (BP) prior and after training sessions. * $p \leq 0.05$ vs minute 30 for training session 1; † $p \leq 0.05$ vs minutes 15, 30 and 45 for training session 2.

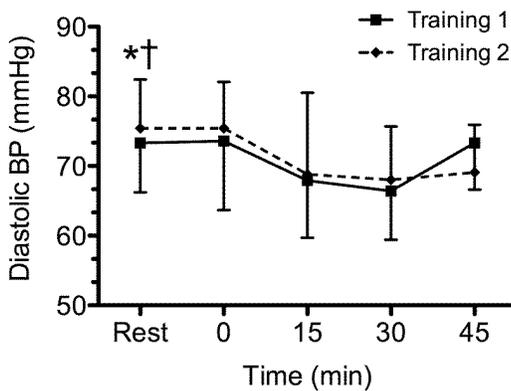


Figure 3. Mean \pm SD of diastolic blood pressure (BP) prior and after training sessions. * $p \leq 0.05$ vs minutes 15 and 30 for training session 1; † $p \leq 0.05$ vs minute 30 for training session 2.

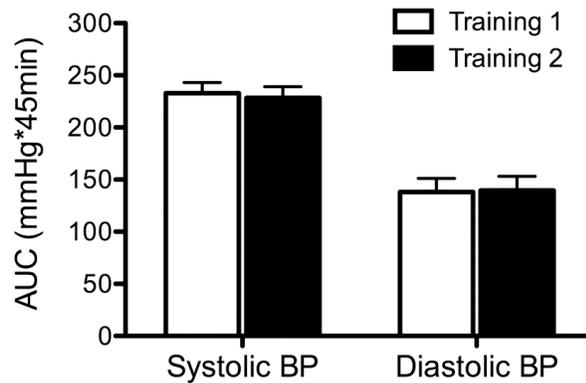


Figure 4. Mean \pm SD of systolic and diastolic blood pressure (BP) area under the curve (AUC) during 45 minutes after training sessions.

Considering the number of systolic blood pressure responders, there were no associations ($p > 0.05$) between training session and systolic or diastolic blood pressure responders (table 3), who indicates that individual BP response was similar between sessions. The BP responders were similar between training sessions, even though training session 2 did not present systolic BP non-responders. Two participants are classified as non-responders and seven as high responders for training 1. For training 2, no participants were classified as non-responders, one responder and eight as high responders. For diastolic blood pressure responders, two are classified as non-responders, three as responders and four as high responders to training 1. For training 2, two are non-responders, two are responders and five are high responders.

Table 3. Classification of post exercise hypotension magnitude after a single bout of exercise (absolute frequency, n).

	Training 1	Training 2
Systolic BP*		
Nonresponder	2	0
Responder	0	1
High responder	7	8
Diastolic BP†		
Nonresponder	2	2
Responder	3	2
High responder	4	5

BP, blood pressure. *Systolic blood pressure: $\chi^2 = 0.32$; degrees of freedom = 1; $p = 0.571$; †Diastolic blood pressure: $\chi^2 = 2.92$; degrees of freedom = 1; $p = 0.570$

Figure 5 shows the PEH magnitude for the training sessions separated by subject. When the PEH magnitude was compared between sessions, one subject displayed a SBP greater than 10 mmHg following exercise session 1 while four subjects recorded greater BP responses following session 2 (Figure 5 A). DBP showed a difference greater than 10 mmHg following exercise session 2 for three test subjects (Figure 5 B).

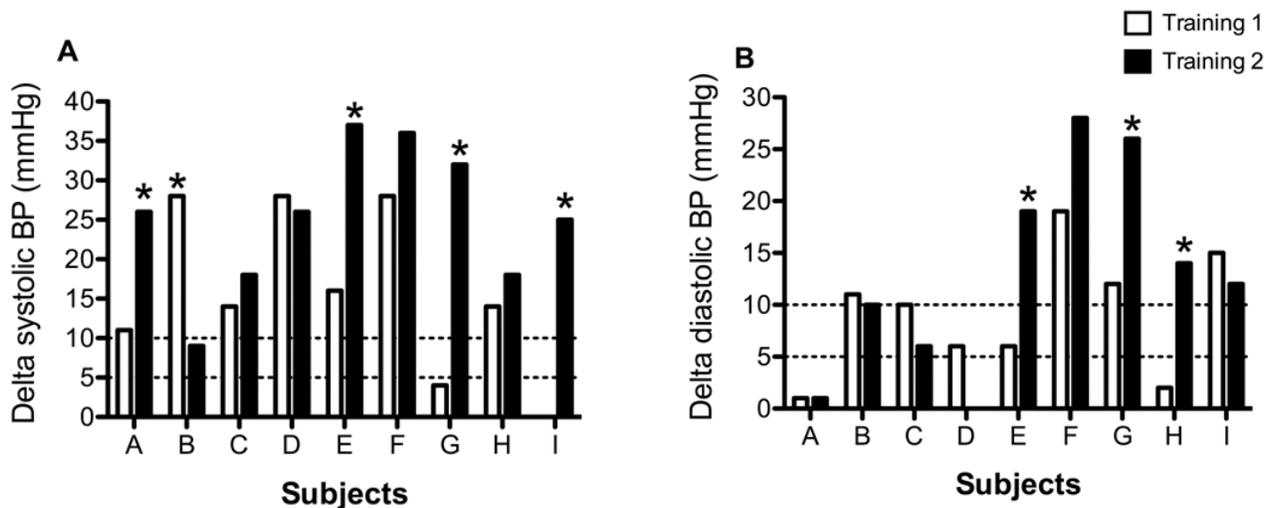


Figure 5. Heterogeneity of systolic (A) and diastolic (B) post exercise hypotension magnitude after a single bout of exercise. *Magnitude difference between training sessions greater than 10 mmHg. Delta systolic BP in training 1 for subject I and delta diastolic BP in training 2 for subject D were zero.

DISCUSSION

The purpose of this research was to compare two different ECP sessions on BP, heart rate, RPE and to determine the intraindividual variation in BP response between the protocols. The main findings of this study were: (a) a single session of ECP caused PEH in normotensive men; (b) the hypotensive effects are independent of the training session design; (c) the ECP employing Olympic weightlifting exercises during the metabolic condition induced a higher increase in HR ($86 \pm 11\%$ of HRmax versus $82 \pm 12\%$ of HRmax, $p = 0.01$) and RPE (8.8 ± 1.2 versus $8.0 \pm$

1.2, $p = 0.02$) as compared with a ECP session without Olympic weightlifting exercises during the metabolic condition and (d) high intraindividual variation in the magnitude of PEH in response to the training sessions.

For our knowledge, this is the first study to analyze the effects of two different ECP sessions on BP, heart rate, RPE and intraindividual variation in BP responsiveness, lending utility to the exercise prescription for cardiovascular health field. The results agree with several studies showing a decrease in SBP following aerobic exercise (AE) (2), resistance exercise (RE) (14, 16, 18, 21) and combined AE plus RE (10, 20). Keese *et al.* found that exercise session with RE plus AE (2 sets at 80% 1RM in six exercises plus 20 minutes of cycle ergometer at 65% of VO_{2peak}) induced similar hypotensive effects as compared with an AE session (50 minutes of cycle ergometer at 65% of VO_{2peak}) in young men (10). Systolic BP was decreased following AE (-6.3 mmHg), RE (-4.2 mmHg, 3 sets at 80% 1RM in eight exercises) and combined exercise (-5.1 mmHg) sessions in young subjects, with higher magnitudes for AE and combined sessions.

Furthermore, Angadi *et al.* found that aerobic interval exercise (4-minutes at 90-95% HRmax repeated by 4-bouts, separated by three minutes) induced a longer-lasting PEH response (>2 hours) when compared with 30-minutes of steady-state exercise (75-80% heart rate maximum) and sprint interval exercise (30-second Wingate sprints repeated 6 times, separated by 4 minutes), respectively (2). Similarly, in the present study, both ECP sessions, that were performed at $86 \pm 11\%$ (session 1) and $82 \pm 12\%$ of heart rate maximum (session 2), induced PEH.

It was recently shown that there is considerable interindividual variation in BP responses following a single bout of exercise, meaning that some individuals display PEH ("responders"), while others do not ("nonresponders") (9, 12, 18). Interestingly, "responders" and "nonresponders" were identified following different exercise types, including maximal exercise test (9), continuous moderate aerobic exercise (11), and resistance exercise (12, 18). Hecksteden *et al.* demonstrated that the PEH following maximal exercise (acute exercise) is associated with the chronic training-induced decrease of BP following a walking/running program (9). Moreover, Tibana *et al.* revealed that during RE the degree of BP reduction after acute exercise is correlated with the magnitude of change in resting BP observed after 8 weeks of resistance training in healthy untrained women (18). It is important to note that Whelton *et al.* (22) described that small decrements in BP had an important clinical benefit (2 mmHg reduce the risk of stroke by 14% and 17%, and the risk of developing coronary artery disease by 9% and 6%, respectively). When PEH magnitude was compared between sessions, different biological characteristics may be the cause of the variability in the BP responses. The mechanisms for the PEH was not observed in this study.

The present study recognizes limitations, such as the lack of a mechanistic approach and a control session without exercise was missing. The weight lifting during the exercise sessions were based on maximal strength self-reported, which could be a bias for the accurate %1RM used in the study. Finally, the acute response of BP was measured only 45 minutes following

exercise. Future studies might include different interventions (ex.: AE, RE or combined AE and RE) to determine the impact of each training modality on acute cardiovascular responses.

Extreme conditioning program induces PEH regardless of the training session design in adult trained men, thus, this type of training is effective in decreasing acute SBP and DBP, which can prevent possible cardiovascular risk factors. Due to increasing popularity, ECP may be a viable alternative to traditional exercise modalities for optimizing BP control in normotensive adults. Moreover, RPE after metabolic conditioning predominantly based on Olympic lifting was higher than after a metabolic conditioning with body weight exercises. More studies should be designed to investigate the acute and, specially, chronic effects of ECP in different populations. Moreover, it is possible that due to the different individual responsiveness to training, subjects may require different dose-response prescriptions to obtain optimal BP results. For example, those subjects who did not present acute PEH with training based on body weight exercises could have their training modified to Olympic lifting metabolic conditioning based to improve their metabolic results.

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