A COMPARATIVE STUDY OF CARDIOVASCULAR RESPONSES TO TWO REST INTERVALS BETWEEN CIRCUIT RESISTANCE EXERCISES IN NORMOTENSIVE WOMAN

EXERCISE AND SPORTS MEDICINE CLINIC

ORIGINAL ARTICLE

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ABSTRACT

Introduction: Hypertension is a cardiovascular disorder which occurs in approximately one billion individuals worldwide and represents an important risk factor for cardiovascular disease. Objective: To compare the cardiovascular responses during recovery after two protocols of circuit resistance exercises (CRE) with different rest intervals (RI). Twelve normotensive females (aged 21.3 ± 1.3, yrs; height 163.5 ± 5.9 cm and weight 57.5 ± 8.9 kg) performed two CRE with RI of 30 (RI30s) and 40 (RI40s) seconds between the exercises, randomly. Methods: The protocols consisted of three circuits of six exercises with 10 repetition maximum (10RM) and 2 minute rest between circuits, followed by a 60 minute recovery period. Measurements were taken before exercise, at the end of last exercise (R1) and each 10 min of post-exercise recovery (R10, R20, R30, R40, R50 and R60). Analysis of Variance (ANOVA) with Repeated Measures (group × time) was used to analyze data, followed by post-hoc Bonferroni test, for $p \leq 0.05$. Results: In comparison of rest values, systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR) and rate pressure product (RPP) at R1 after exercise trials with RI30s and RI40s increased significantly. Post-exercise hypotension (PEH) of SBP was observed after CRE with RI30s (at R20, R30, R40, R50 and R60) and RI40s (at R30, R40, R50 and R60), whereas PEH of DBP was observed only after CRE with RI30s at R60. Except for time after CRE with RI30s at R10, no significant change of HR was observed in all measured moments during recovery period of trials. RPP returned to the rest values after exercise trials at R10 and then decreased significantly after CRE with RI30s at R60 and after CRE with RI40s at R40, R50 and R60. Conclusion: In all measured moments, there were no significant differences between experimental sessions in post-exercise levels of SBP, DBP, HR and RPP. In conclusion, CRE with RI30s and RI40s between the exercises can lead to occurrence of PEH similarly in magnitude and duration and approximately provides same cardiovascular responses after exercise. Our findings suggest a potentially positive health benefit of strength training.

Keywords: post-exercise hypotension, systolic blood pressure, diastolic blood pressure, heart rate, rate pressure product.

INTRODUCTION

Hypertension is a cardiovascular disorder that affects approximately 1 billion individuals worldwide, represents an important risk factor for cardiovascular disease[1]. There are many options for treating hypertension and preventing risk factors associated with cardiovascular diseases[2], including physical exercise. Both acute and chronic exercises have been recommended as a non-pharmacological and less expensive treatment for hypertension[3]. It has been shown that a single physical exercise session has an important effect on reducing blood pressure (BP) to levels below those of pre-exercise resting[4, 5]. This phenomenon is named post-exercise hypotension (PEH) and has been widely investigated because of its importance for the treatment and prevention of arterial hypertension[6, 7.] The mechanisms responsible for PEH remain unclear and may be related to reduction in cardiac output and/or in peripheral vascular resistance[4, 5]. PEH may be associated with a shift in the baroreflex control and reduction in the alfa-adrenergic responsiveness, as well as to an increased secretion of humoral, hormonal, and local substances associated with vasodilation in response to exercise[4, 5]. PEH has been demonstrated after aerobic exercise[7] while after resistance exercise controversial results have been observed, such as increase[8], maintenance[9, 10], or even decrease[11, 12]. Although some studies demonstrate the occurrence of PEH in resistance exercises, there is still no consensus on an ideal protocol (frequency, intensity and volume) to enhance this effect[13.] In this sense, some researchers reported that RE intensity affects the duration (longer PEH in the protocol with the highest intensity), but not the magnitude of the post-exercise hypotensive response[14, 15,] and different training methodologies (set repetition vs. circuit format) do not affect the magnitude or duration of the post-RE hypotensive response[15]. In addition to the variables previously studied (exercise intensity, volume and sequence), other variables such as the amount of muscular mass involved, number of repetitions, type of training and rest interval (RI) between the exercise sets can affect the hemodynamic responses to a bout of resistance exercises[16, 17]. Although RI was considered one of the main variables of resistance exercise by Ratamess et al[18], there are as one of the main variables of resistance exercises, there are few studies in the literature regarding investigation and comparison of the effects of different RI on the cardiovascular responses to resistance exercises. Also, to our knowledge, there are no studies to date which have investigated the comparison of the effects of different rest intervals (RI) between circuit training exercises on the cardiovascular responses. RI length influences on the removal of metabolites produced during muscle contraction and contributes to the reduction of muscle fatigue. Thus, it can influence the cardiovascular responses to weightlifting training[18].

Therefore, the objective of the present study was to investigate and compare the effects of different RI between circuit training exercises (30s and 40s; the ratio of exercise to rest was approximately 1 to 1.5 and 1 to 2, respectively) on the cardiovascular responses in non-hypertensive young females.

MATERIALS AND METHODS

Subjects

Twelve healthy sedentary females volunteered to participate in this study. All of the participants were non-smokers, had no history of cardiovascular disease in themselves or their families, were not taking any medication, engaged in regular physical activity < 2 h per week, and were not in menstrual cycle. Subjects who presented body mass index (BMI) ≥ 24 kg/m^2 and fat mass > % were excluded. Complete advice about possible risks and discomfort was given to the participants, and all of them give their written informed consent to participate. Their physical and cardiovascular characteristics are shown in table 1. All procedures were in accordance with the Declaration of Helsinki and the study was approved by the Ethcis Committee of the School.

Table 1. Physical and cardiovascular characteristics of the participants

Age (y)	21.3 ± 1.3
Weight (kg)	57.5 ± 8.9
Height (cm)	163.5 ± 5.9
BMI (kg/m2)	21.4 ± 2.5
Body Fat (%)	19.8 ± 5.4
SBP (mmHg)	113.3 ± 5.7
DBP (mmHg)	74.8 ± 8.7
HR (bpm)	77.0 ± 6.4
10 RM leg press (kg)	46.3 ± 11.1
10 RM lat pull down (kg)	49.6 ± 8.6
10 RM knee flexion (kg)	20.4 ± 5.4
10 RM bench press (kg)	9.2 ± 4.7
10 RM knee extension (kg)	23.3 ± 5.4
10 RM cable biceps curl (kg)	40.0 ± 4.8

*data are presented as means ± standard error of mean (SEM).

PROCEDURES

Before initiating the tests, the participants underwent an anamnesis, a clinical evaluation and BP, body fat mass, body mass index, weight and height measurements. Subsequently all of them underwent familiarization session and participated in 10RM test. Afterwards, participants carried out two experimental sessions on distinct days and with a minimum of 72 h intervals: (1) circuit resistance exercises (CRE) with 30s RI between exercises (RI30) and (2) CRE with 40s RI between exercises (RI40). The RI30 and RI40 sessions were performed in a randomized order. Pre and post-exercise values of BP, HR and rate pressure product (RPP: an index of myocardial oxygen consumption) were measured and analyzed.

The participants were instructed not to ingest alcoholic or caffeinated drinks, not to perform strenuous physical activity in the previous 48 h and to have their last meal 2 h before the beginning of the experimental sessions, which occurred at 2:00-4:00 PM to control diurnal BP variation. The laboratory had mean temperature of 20.6 ± 0.8^{0}C and mean relative air humidity of 79 ± 5%

Blood pressure measurements

After a 5-min rest in seated position, BP was measured three times during two different visits to the laboratory. On the occasion of each visit, BP was measured by the same experienced observer using a standard mercury sphygmomanometer (ALPK2, Japan), taking the first and the fifth phases of Korotkoff sounds as SBP and DBP values, respectively. Participants were excluded if the average of the last two values obtained during each visit for SBP and DBP was greater than 139 and 89 mmHg, respectively.

10RM test

At least 7 days prior to the experiments, participants performed a maximal 10 repetitions test (10RM) in the leg press, lat pull-down, knee flexion, bench press, knee extension, and biceps curl after 15 min warm-up consisting of 5 minutes of slow running, 5 minutes of static stretching, and 5 minutes of dynamic exercise. Each individual was given up to five tries, in order to determine the load, with a five minute interval between them. Additionally, before the 10RM tests, participants underwent familiarization session and became familiar the standard exercise techniques.

Exercise protocols

Initially, the volunteers remained seated on a comfortable chair for 20 min, with BP and HR being measured each 5 min from 10th min to obtain average resting values. Experimental session was postponed to another day, if the pre-exercise BP of volunteers were abnormal. Then, the subjects who were randomly selected for one of the two protocols underwent 15 min warm-up consisting of 5 minutes of slow running, 5 minutes of static stretching, and 5 minutes of dynamic exercise and performed CRE with 30s (The ratio of exercise to rest ~ 1 to 1.5) or 40s (The ratio of exercise to rest ~ 1 to 2) active and passive RI between each exercise in which time the participant moved between each station and then began the next exercise. In each session, the circuit of resistance exercises was performed in the following sequence: leg press, lat pull-down, knee flexion, bench press, knee extension, and biceps curl. The subjects performed 3 circuits of 10 repetitions (1 complete movement in ~ 2s) with 2 min passive rest in the sitting position after each complete circuit. After exercise trials, participants rested in the sitting position for 60 min, with BP and HR being measured at the end of last exercise (R1) and each 10 min of post-exercise recovery (R10, R20, R30, R40, R50 and R60). BP was recorded by the same observer in all exercise trials, using a standard mercury® sphygmomanometer. HR was monitored during recovery with a Polar pulse meter (T31, Finland). Simultaneously to BP and HR measurements, as well as at pre-exercise resting, the RPP was calculated (systolic blood pressures × heart rate), as it is considered a reliable predictor of myocardial oxygen demand[19, 20].

Statistical analysis

Analysis of Variance (ANOVA) with repeated measures (group × time) was used to analyze data and when the difference presented was significant, the Bonferroni pos-hoc test was used for multiple comparisons, with a value of p≤0.05.

RESULTS

In all measured time, no significant differences were was observed between experimental sessions in pre and post-exercise level of SBP, DBP, HR and RPP.

Blood pressure

BP responses during the different experimental sessions are shown in Figure 1. Regarding SBP measurements compared to rest values, there was significant increase at R1 after exercise trials with RI30s and RI40s, and then significant decrease at R20, R30, R40, R50 and R60 for RI30s and at R30, R40, R50 and R60 for RI40s.

DBP increased significantly at R1 after two trials and decreased significantly only at R60 after RI30s. Post-exercise DBP at R10, R20, R30, R40 and R50 after two trials and at R60 after trials with RI40s did not differ from that measured at rest.

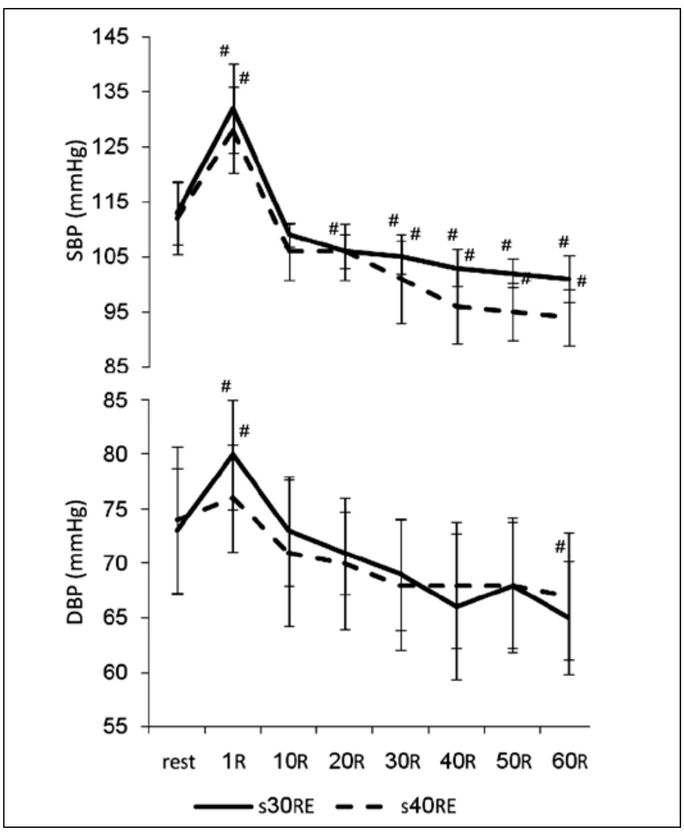

Figure 1. Changes in systolic and diastolic. blood pressure during recovery after exercise trials with RI30s and RI40s. # $p < 0.05$ *vs.* rest.

Heart rate

HR responses during the different experimental sessions are shown in Figure 2. Compared to the pre-exercise values, HR was significantly higher than baseline values at R1 and R10 after exercise trial with RI30s and at R1 after RI40s. Exercise trials decreased HR levels less than the rest values during the recovery period (R40, R50, R60), although this decrease was not statistically significant.

Rate pressure product

RPP responses during the different experimental sessions are shown in Figure 2. Compared to the pre-exercise values, RPP was significantly higher than baseline values at R1 after exercise trials. RPP levels decreased less than the rest values significantly during the recovery period of exercise trial with RI30s at R60 and after exercise trial with RI40s at R40, R50 and R60.

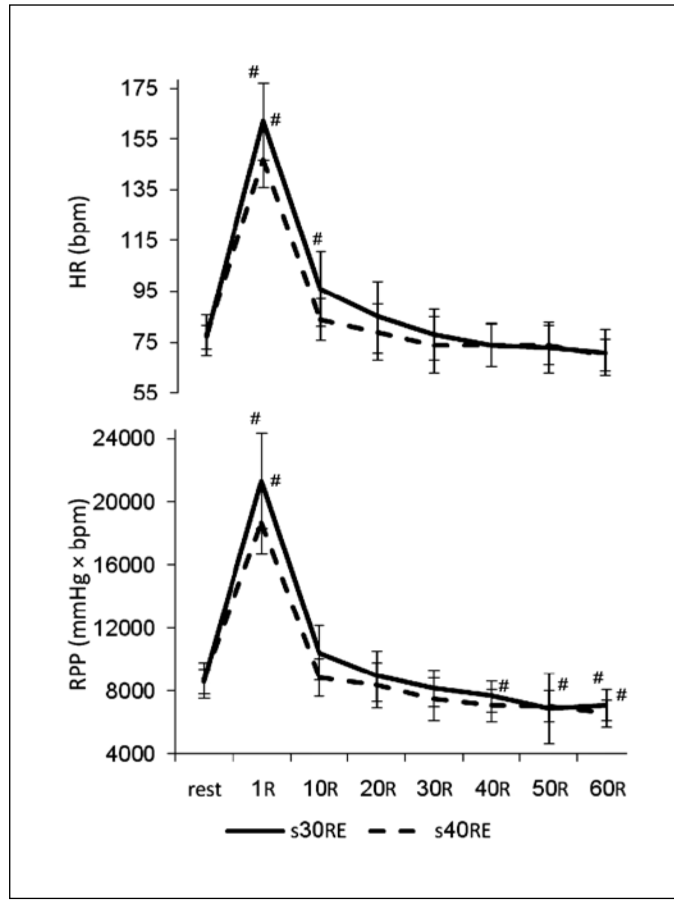

Figure 2. Changes in heart rate and rate pressure product during recovery after exercise trials with RI30s and RI40s. # $p < 0.05$ *vs.* rest.

DISCUSSION

The present study compared the SBP, DBP, HR and RPP during recovery after a single bout of CRE with different RI between them (30s and 40s; the ratio of exercise to rest was approximately 1 to 1.5 and 1 to 2, respectively) in non-hypertensive young females. The main findings of this study were: a) significant increase in the SBP, DBP, HR and RPP at R1 after exercise trials with RI30s and RI40s compared to rest values; b) A single bout of CRE provoked PEH of SBP with RI30s (at R20, R30, R40, R50 and R60) and RI40s (at R30, R40, R50 and R60). c) PEH of DBP was observed only at R60 after; exercise trial with RI30s; d) Compared to the pre-exercise values; except for time after exercise trial with RI30s at R10, no significant change in HR was observed in any of the measured moments during recovery period of trials; e) RPP returned to the rest values after exercise trials at R10 and then decreased significantly after exercise trial with RI30s at R60 and after exercise trial with RI40s at R40, R50 and R60; f) In all measured moments, there were no significant differences between experimental sessions in post-exercise levels of SBP, DBP, HR and RPP. Based on previous studies, the data about PEH and resistance exercise are still scarce and controversial results have been reported. Increase[8], maintenance[9, 10] or even decrease[11, 12] in post-resistance exercise BP has been observed. The present study found a significant PEH of SBP compared to pre-exercise measurements in the protocols tested. The reduction in blood pressure levels after a single exercise session is in agreement with the results obtained by other studies that observed PEH after resistance exercises[3, 11, 12, 15]. Simão et al[15] compared the effect of intensity, volume and session format on post-resistance exercise hypotensive response and observed significant post exercise reduction of SBP after the protocols. Mohebbi et al[11] and Rezk et al[12] also reported significant post-exercise reduction in SBP after two RE sessions with different intensities in normotensive young individuals. Mota et al[3] observed PEH of SBP after circuit model for resistance exercise composed by 13 resistance exercises performed with 20 repetitions at 40% 1RM and 30 seconds rest interval between exercises. In contrast to the results of the present study, Veloso et al[10] observed no change in SBP after resistance exercise with different rest intervals between resistance exercise sets and reported no significant differences between the protocols in the SBP responses. Raglin et al[21] evaluated university athletes (15 men and 11 women) after performance of a resistance exercise session at 70% to 80% of 1RM and did not find significant differences between post-exercise measurements and rest measurements of SBP. Rodriguez et al [22] observed no significant variance in the SBP after both traditional multiple set and tri-set methods where six upper limb exercises were used for two distinct muscular groups (chest and back). Moreover, Polito et al[23] failed to induce a hypotensive response in SBP following three series of 12 maximal repetitions of knee extension unilaterally and bilaterally.

The differences between the results found in the present study and those reported by Veloso et al[10] and Raglin et al[21] may be attributed to the differences in the protocols used as well as differences between subjects. Veloso used a protocol in which the load decreased at each set, with the purpose of maintaining the same work volume (load × repetitions) in all protocols. On the other hand, the differences between the results found in the present study and those reported by Rodriguez et al[22] and Polito et al[23] may be related to the involvement of muscle mass in exercise. In the present study that performed 3 circuit of 6 exercises for upper and lower limbs, exercising muscle mass was higher than in Rodriguez et al[22] and Polito et al[23] studies that used lower and upper limb exercises, respectively. One of the physiological mechanisms that could explain the influence of muscle mass on blood pressure after resistance exercise is the reduction in vascular resistance, caused by the liberation of vasodilating endothelial substances (e.g., nitric oxide and prostaglandins).

Regarding DBP, compared to pre-exercise values, except for time after exercise trial with RI30s at R60, no significant PEH of DBP was observed in all measured moments during recovery period of trials.

In Simão et al[15] study, significant post-exercise decrease in DBP was also observed 10 minutes after completion of a protocol of 12 repetitions with a load of 50% of 6RM. Rezk et al[12] also found significant post-exercise decrease in DBP; however, the duration of PEH was longer (30 minutes) than that found by Simão et al[15]. In contrast, Rodriguez et al[22] and Polito et al[23] did not observe significant variance in the DBP after resistance exercise. Also, Veloso et al[10] observed no changes in DBP after resistance exercise with 2 min RI between resistance exercise sets but, significant reduction in DBP occurred after 1 and 3 min RI, and no significant differences were reported between the protocols in the DBP responses.

Similarly to the results of the present research, Mohebbi et al[11], Polito et al[24] and MacDonald et al[25] observed significant PEH of SBP and no changes of DBP following resistance exercise. One of the possible explanations for SBP's higher sensitivity to PEH would be the posture subjects adopt after the exercise. Although all mentioned studies have chosen the seated position to assess arterial pressure, it was observed that the post-exercise SBP declines more soundly in the seated position rather than in the supine position[26].

Possible mechanisms involved in mediating post-exercise reduction in arterial blood pressure include decreased stroke volume and cardiac output; reduction in limb vascular resistance, total peripheral resistance, and muscle sympathetic nerve discharge[4, 5]. Rezk et al[12] assessed some mechanisms of BP control such as systolic volume, peripheral vascular resistance, and cardiac output after a resistance exercise session and observed decrease in the systolic volume and cardiac output, no change of the peripheral vascular resistance and, consequently, a reduction in BP. According to these authors, the systolic volume remained below resting levels for 90 minutes.

In this study, HR returned to rest value after exercise trials with RI30s and RI40s, respectively from R20 and R10. In relation to post-resistance exercise heart rate (HR) responses, the results are also controversial and less conclusive. Some investigators have observed increase[11, 12] while no change[9, 23] of HR during the recovery period was reported either. It seems that reduction in cardiac output due to decrease in the systolic volume and no change of HR has been the main cause of PEH in this study.

The present study demonstrated that the RPP returned to rest value after exercise trials from R10 and then decrease below the rest value significantly. It has been suggested that HR is the most important factor to determine RPP[27], and because in all measured moments RPP changes were consistent with HR, tthis fact was confirmed by the present study.

Additionally, there may be reduction in vascular resistance influenced by accumulation of metabolites produced in muscle contraction, which, according to MacDonald et al[5], is one of the factors accounting for vasodilation and subsequent decrease in peripheral vascular resistance. A greater accumulation of metabolites in the protocol with lower RI (30s) that had been demonstrated by Ratamess et al[18] and Crisafulli et al[28] could explain the longer post-exercise decrease in SBP and DBP that was found in the present study.

CONCLUSION

The present findings have shown that the CRE with RI30s and RI40s led to significant post-exercise decrease in SBP. Also, in addition to that, post-exercise DBP was only observed trial with RI30 at R60. Different RIs between the exercises did not influence on the heart rate responses and reduced double product significantly below the rest value after exercise trials. Although it has been suggested that RI length influences on the removal of metabolites produced during muscle contraction and contributes to the reduction of muscle fatigue and it can influence on the cardiovascular responses to weightlifting training[18], we found no significant differences between experimental sessions in post-exercise level of SBP, DBP, HR and RPP in all measured moments. However, levels of all cardiovascular variables after exercise trial with RI30s were over RI40s.

We suggest further studies to evaluate the effects of other RE variables on PEH in different populations such as those of elderly and hypertensive individuals. Additionally, the physiological mechanisms involved in post resistance exercise hypotension need to be better explained.

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