Effect of Different Resistance Exercise Methods on Post-Exercise Blood Pressure

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ABSTRACT

Int J Exerc Sci 1(4) : 153-162, 2008. The aim of the present study was to evaluate the post-exercise blood pressure (BP) responses to two different methods of resistance exercise (RE, traditional multiple set and tri-set). Young adult men (n = 30, 19.6 ± 0.7 years old; 76.0 ± 2.7 kg; 178.2 ± 6.7 cm; 90.5 ± 5.8 MBP) with six months of previous experience in RE were selected. The volunteers were randomly assigned into three groups (n = 10, each group): non-exercised control group (CON); multiple set group (MS); and a tri-set group (TRI). The TRI group performed three consecutive exercises (3 sets of 10 repetitions with 70% of 1RM and 1 minute of rest interval after the three exercises for the same muscle group) in the following order: bench press, cross-over and peck-deck and lat pull-down, seated cable row and barbell row. The multiple set group performed 3 sets of 10 repetitions for the same exercises, but with 1 minute rest interval between each set and exercise. After the exercise sessions and control situation, individuals remained seated for BP measure every 5 minutes up to 90 minutes. The repeated measures analysis of variance (ANOVA) (2 groups by three time points) was used, followed by *post-hoc* Bonferroni test, for $p \leq 0.05$. There were no significant alterations for systolic and diastolic blood pressure compared with the CON group and in the moments after exercise. Heart rate was increased after exercise for both exercised groups in all post-exercise measures compared with baseline. RE method (MS or TRI) exerted no influence on post-exercise blood pressure. Post-exercise induced hypotension may require the recruitment of larger muscle groups, such as those of the lower limbs.

KEY WORDS: Strength training, tri-set, multiple set, systolic blood pressure, diastolic blood pressure

INTRODUCTION

Scientific evidences in the literature demonstrate that regular resistance training can be an important instrument in blood pressure (BP) control, both for normotensive and hypertensive individuals (7, 19). Additionally, it has been shown that one single session of resistance training can induce the post-exercise hypotension (PEH) effect, considered as an important strategy in the control and reduction of BP (9, 21, 25, 28). Nevertheless, the American College of Sports and Medicine (1) and the American Heart Association (2) recommend resistance exercise (RE) in association with an aerobic-based exercise program in the prevention, treatment and control of hypertension (14, 25). However, there is paucity of available data about resistance training and PEH.

In this sense, Roltsch et al. (27) found no significant differences in post-exercise BP after a RE session of 8-12 maximum repetitions (RM) in normotensive subjects. Studies comparing two different RE intensities show no post-exercise hypotensive response. In a comparison between 50% (12-20 repetitions per set) and 80% (4-8 repetitions per set) of 1RM, no significant post-exercise hypotensive response was shown immediately after 180 minutes after RE and no significant difference in the BP response was shown between intensities (10). Similarly, intensities of 40, 60 and 80% of 1RM performed in 3 sets of 10 repetitions showed no significant hypotensive response for a time period of 120 minutes post-exercise and no difference was shown between intensities. (24) On the other hand, Simão et al. (28) verified that a single bout of resistance training, performed in a conventional regimen (6RM) or in circuit (50% of 6RM), induced significant PEH in normotensive subjects. Fisher (9) observed a decrease in systolic blood pressure (SBP) for 60 minutes after a session of five resistance exercises performed in a circuit with 50% of 1 RM in normotensive and hypertensive women.

A possible explanation for these results concerns the physiological mechanisms involving PEH. Probably, endothelium vasodilator agents, such as nitric oxide, prostaglandins, adenosine, potassium, among others are released as a consequence of physical effort (11, 18), inducing a lowering in vascular peripheral resistance. As regards aerobic exercise, due to a relatively simple control of performing exercises, previous research has identified values of volume and intensity that can induce PEH (6, 23).

With regard to the RE, the many possibilities of manipulating the volume and intensity produced controversial results. Additionally, further studies are necessary to test different forms of RE methods on the PEH. Because of the rising popularity of the fitness industry, with resistance training machines and the inclusion of RE in overall fitness programs for many populations, more precise knowledge regarding the possible benefits of resistance training on BP and investigation of different methods of resistance training on PEH are warranted (7, 14). However, to the authors' knowledge no other studies have investigated the effects of the tri-set method on PEH. Since this type of resistance training regimen widely applied in training centers, it was resolved to analyze this method.

In view of these considerations, the purpose of this study was to investigate the effect of two different methods of RE (traditional multiple set and tri-set) on the post-exercise hypotension, considering equal values of load and numbers of repetitions.

METHOD

Subjects

To investigate the effect of different resistance exercise training sessions on post-effort cardiovascular behavior, 30 healthy male volunteers (19.6 ± 0.7 years old; 76.0 ± 2.7 kg; 178.2 ± 6.7 cm; 90.5 ± 5.8 MBP) with at least 6 months of previous experience in resistance exercise training were selected, all of them students of the UniFMU School of Physical Education (Table 1). All participants trained at least three times per week, with three sets of 10RM in the six months before the beginning of the study intervention. According to the American College of Sports Medicine (1) the individuals were considered "trained". The subjects were randomly assigned into three groups: non-exercised control group (CON, n = 10); multiple set group (MS, n = 10); and a tri-set group (TRI, n = 10).

Acute resistance exercise sessions

The 1RM tests were performed in three different days separated by 72h to avoid influences in the maximal determination. Two exercises for different muscle groups were tested in the same day, with 10 minutes of rest between them. In the first evaluation day bench press and lat pull-down were tested for 1RM. In the second evaluation (after 72h) cross-over and seated cable row were tested. In the third evaluation 1RM was determined for peck-deck and barbell row. All evaluations were conduced in the same period of the day, including the measures of heart rate, blood pressure and acute resistance exercise sessions, at 11:00 am, in February. The study was conducted in 45 days with a 3 non-consecutive day week frequency for the familiarization period, before the 1RM tests, this guaranteed that subjects were tested after learning the correct movement of the exercises.

In the fourth evaluation day, the control (CON) group did not exert any effort, remaining seated for the time corresponding to the performance of the exercise protocol; the multiple set (MS) group performed only one acute session of the exercises in a traditional manner, with a load corresponding to 70% of 1RM and three sets of 10 repetitions for each exercise and 1 minute rest between sets and exercises; the tri-set group (TRI) performed only one acute session of the exercises in accordance with the Tri-set method with 70% of 1RM, consisting of performing three exercises for the same muscular group in sequence without a rest interval between them. Thus, the TRI group performed three sets of bench-press, cross-over and peck-deck together, followed by the lat pull-down, seated cable row and barbell row exercises with a one-minute interval after each set in the three exercises. All sessions were individually supervised by experienced strength and conditioning specialists who directly monitored training sessions. The average duration for the training sessions was 30 minutes and for the repetitions was 3-4s, taking into account the concentric and eccentric phases of the movement.

In the fourth evaluation day, before the exercises were performed, the systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) values were measured at 5-minute intervals for 20 minutes at rest (the mean value of three measures was considered the rest value).

After the effort, the same measurements were made at 5 minute-intervals for 90 minutes. All blood pressure measures were performed by the same experienced evaluator.

The experimental procedures were approved by the UNIFESP Research Ethics Committee for Human use. All volunteers were informed of all the experimental procedures and gave their informed, written consent before participation. The procedures were in accordance with guidelines for use of human subjects set forth by the American College of Sports Medicine. As exclusion criteria were considered: BP values above the pre-hypertensive scores (5); use of any inotropic or chronotropic substance; smoking or orthopedic limitations that could compromise performance of the exercises.

Body Composition

Anthropometric data were collected before and after the training periods. Height was measured without shoes with a Harpender stadiometer. Body composition was measured by the skinfold thickness method with a Lange® skinfold caliper. The equation of Jackson and Pollock (17) for men was used to estimate body fat percentage. In this equation the sum of chest, abdominal and thigh skinfolds are used. After this procedure, fat mass (Kg) and fat-free mass (Kg) were estimated.

Maximum strength test (1RM)

Maximal strength was assessed for 6 exercises using the one-repetition maximum test (1RM) technique in custom-designed resistance equipment (Life Fitness, USA). These machines were also used during the acute exercise training session. Subsequent to a general warm-up (10 minutes of low intensity treadmill running), individuals performed eight repetitions with estimated 50% of 1RM (according to each participant's previous training experience), after one minute of rest, three repetitions with estimated 70% of 1RM were accomplished. The subsequent trials were performed for one repetition with progressively heavier weights until the 1RM was determined within three attempts, using 3- to 5-min rest periods between trials. (22) The standardization of range of motion and movement of the exercises was conducted according to the descriptions of Brown and Weir (4). To obtain reliable baseline strength values, the pre-training 1RM was performed on three separate days with several days between them. A high interclass correlation was found between the second and the third 1RM trials (R = 0.97). The highest 1RM determined from the last two trials was used for the baseline measure.

Heart Rate and Blood Pressure Assessments

SBP and DBP were measured on the left upper arm by the auscultation method using a mercury manometer (Tycos®) and a stethoscope (Sprague®). An evaluator assessed the SBP (first Korotkoff sound) via auscultation and the DBP (fifth Korotkoff sound) at rest after the subject had been seated and calm for 10 minutes. Mean blood pressure (MBP) was also estimated. The measuring procedure was in accordance with the recommendations of the American Heart Association (2) and was conducted by an experienced evaluator. Heart rate was measured by telemetry with the use of an electronic heart hate monitor (Polar® F92ti, Finland). On arrival at the laboratory (11:00 to 12:00 a.m.)

Table 1. Subjects' baseline anthropometric and cardiovascular measures.

Variables	Control (CON)	Multiple set (MS)	Tri-set (TRI)
Age (years)	22.22 ± 2.17	19.67 ± 0.75	18.80 ± 0.72
Mass (Kg)	75.33 ± 8.17	76.3 ± 6.22	76.07± 6.89
Height (cm)	180.20 ± 6.14	177.27 ± 2.52	176.28 ± 2.60
BMI (Kg/m²)	23.31 ± 1.71	24.33 ± 2.40	24.52 ± 2.69
Body Fat (%)	14.36 ± 6.38	14.97 ± 4.40	15.57 ± 4.76
Fat Mass (Kg)	11.46 ± 8.38	11.57 ± 4.36	12.02 ± 4.79
Fat-free Mass (Kg)	63.89 ± 8.29	64.77 ± 3.95	64.04 ± 3.99
HR (bpm)	63.70 ± 4.99	62.50 ± 6.22	61.83 ± 5.19
SBP (mmHg)	115.50 ± 5.50	122.50 ± 8.80	125.83 ± 5.85
DBP (mmHg)	71.50 ± 4.17	74.17 ± 8.01	76.67 ± 5.16
MBP (mmHg)	86.15 ± 3.60	93.32 ± 9.13	93.64 ± 2.56

Values are presented as means ± standard deviation of the mean (SD). BMI = body mass index; HR = heart hate; SBP =systolic blood pressure; DBP = diastolic blood pressure and MBP = mean blood pressure, p≤0.05.

subjects were instructed to remain seated and stayed in this position for 5 minutes. Blood pressure was measured in accordance with the AHA procedure three times and the average values were adopted (2). There was a significant correlation between the measures (R = 0.96) and they did not differ significantly from each other (dependent Student's t-test, p≤0.05). Subjects did not perform any physical activity for at least 48 hours before evaluations. The measurements were performed in a quiet and comfortable place, 20 minutes before (rest) and after (5, 15, 30, 45, 60, 75, 90 minutes) exercise bouts in a seated position. Heart rate (HR) was continuously measured and recorded, on a beat-by-beat basis, during the exercise bouts by using a Polar Vantage NV (Polar Electro Oy, Oulu, Finland) HR recorder.

Statistical Analysis

The statistical analysis was performed using statistical software Statistics 6.0 for Windows (Statsoft, Tulsa, OK, USA). The sample size was calculated considering 1.8 mmHg as minimum difference in the resting SBP value between the groups, the residual standard deviation was 0.75 and the statistical potency was 0.80. The Shapiro-Wilk test was used to verify the data normality and the Levene test to verify homogeneity of the variance, so that all data were classified as parametric. The repeated measures analysis of variance (ANOVA) (3 groups by different time points) was used, 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

No significant differences were observed between experimental groups for the

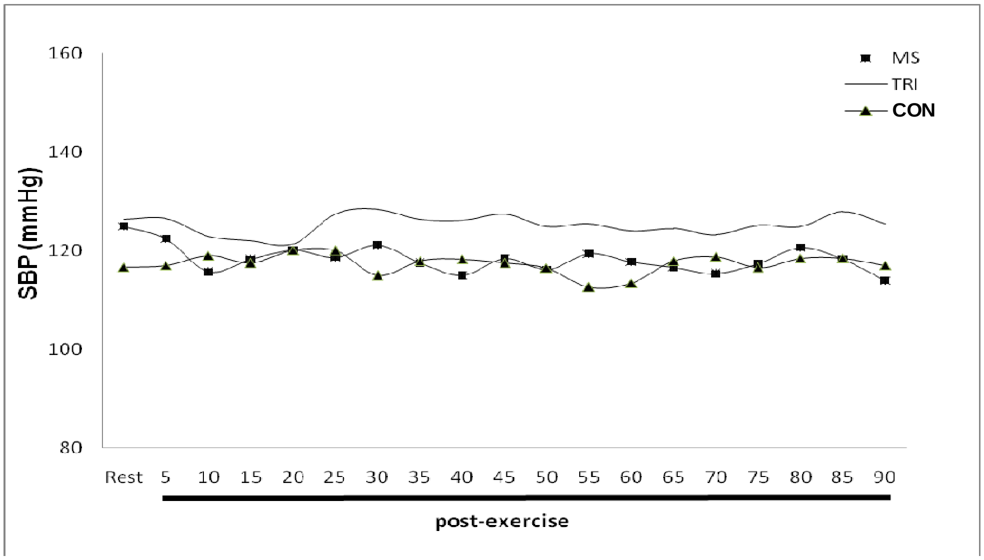

Figure 1. Systolic blood pressure (SBP), for the control group (CON); multiple set group (MS); and tri-set group (TRI). The values were obtained at rest and after each 5 minutes after the exercise until 90 minutes after the protocol. Values are presented as means, p≤0.05.

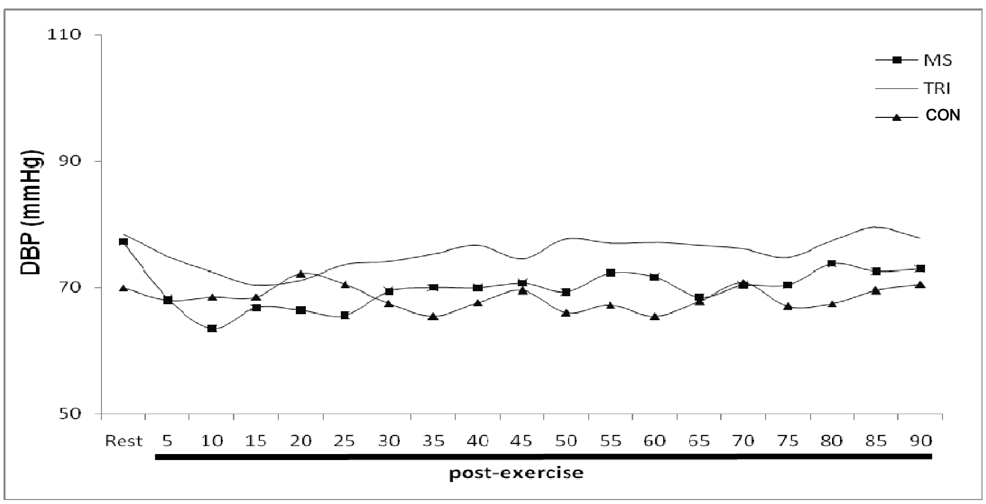

Figure 2. Diastolic blood pressure (DBP), for the control group (CON); multiple set group (MS); and tri-set group (TRI). The values were obtained at rest and after each 5 minutes after the exercise until 90 minutes after the protocol. Values are presented as means, p≤0.05.

anthropometric and cardiovascular measures before exercise intervention (Table 1) according to Student's t-test, (p≤0.05). Figures 1 and 2 present the behavior of the rest SBP and DBP, respectively, after the different RE methods. For both, there was no significant difference in MS and TRI groups compared with the control group (CON). Nevertheless, a tendency towards decrease in SBP and DBP was observed after 15 minutes of exercise. As demonstrated in Figure 3, the MBP was

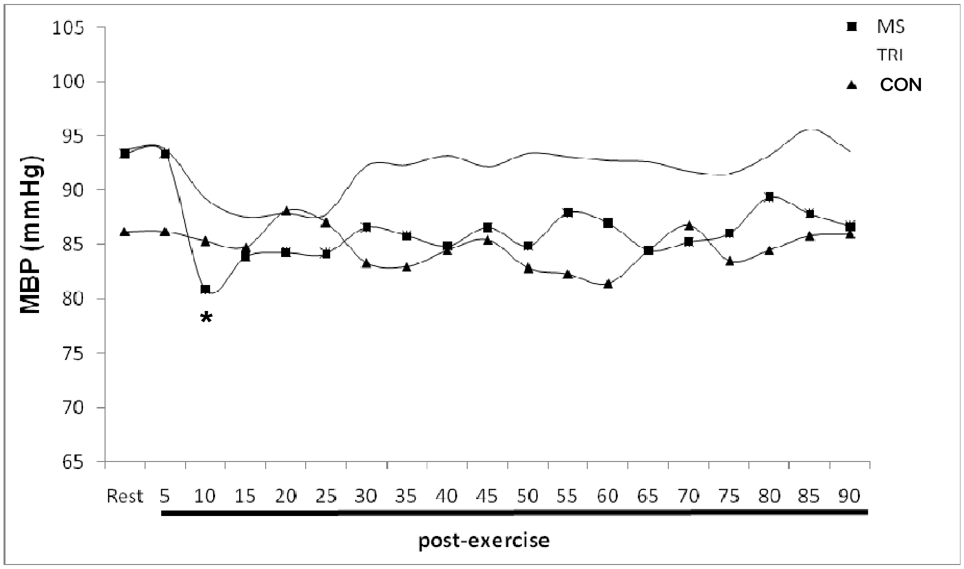

Figure 3. Mean blood pressure (MBP), for the control group (CON); multiple set group (MS); and tri-set group (TRI). The values were obtained at rest and after each 5 minutes after the exercise until 90 minutes after the protocol. Values are presented as means. *Significant difference compared with the baseline value, p≤0.05.

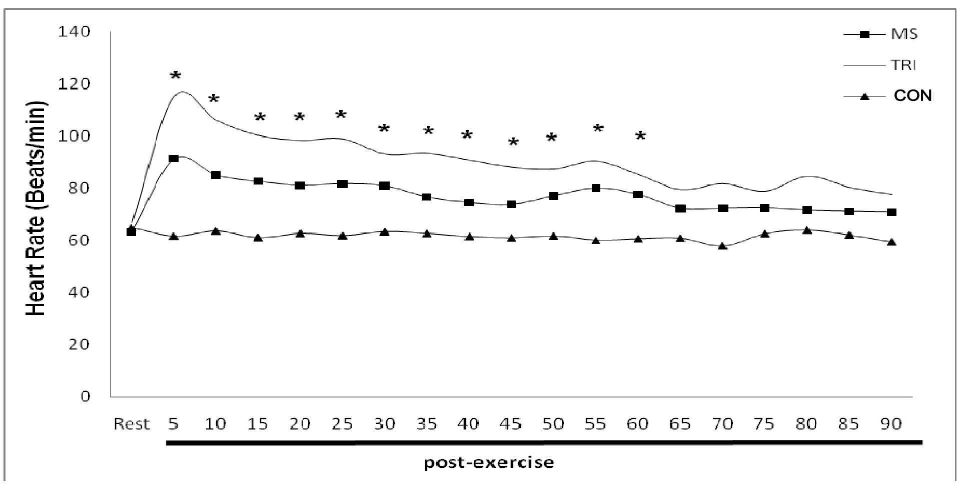

Figure 4. Heart rate (HR), for the control group (CON); multiple set group (MS); and tri-set group (TRI). The values were obtained at rest and after each 5 minutes after the exercise until 90 minutes after the protocol. *Significant difference compared with the baseline value. Values are presented as means, p≤0.05.

significantly lower after 15 minutes when compared with the baseline values for the MS group. With regard to HR, both exercised groups showed significantly higher post-effort than baseline values also when compared with the control group, in all measured moments (Figure 4).

DISCUSSION

The hypothesis of the present study was not confirmed, as the expected result of this study would be a higher PEH for the Tri-set method, using 10 repetitions with 70% of 1RM, since performing three resistance exercises without rest between sets, induces a more pronounced stress in the cardiovascular system. The results of the present study failed to show significant variance in the SBP and DBP after the RE, irrespective of the method used: traditional multiple set or tri-set. In fact, the literature about PEH and strength exercise is still sparse and it is difficult to make comparisons. However, some aspects can be pointed out. Six exercises were used for two distinct muscular groups (chest and back). Other studies observed reductions in the SBP and/or DBP using exercises for the whole body (generally, one exercise for each muscle group). For example, Simão et al. (28) used five or six exercises, but each one targeting a specific muscle group, involving upper and lower limbs. A possible explanation could be related to PEH depending on endothelial vasodilator agents that would be released at higher levels after effort, involving larger muscle groups, such as those of the lower limbs (11). The study conducted by MacDonald et al. (21) observed PEH up to 60 minutes, using only one exercise (leg-press) performed for 15 minutes uninterruptedly and with limb alternation.

Nevertheless, one can hypothesize that the trigger mechanism of PEH is not dependant on the RE methods used: traditional multiple set or tri-set. In other studies, PEH was observed using the traditional multiple set method (26, 28) or circuit (9, 16, 26, 28), but no differences were observed in PEH between multiple set and circuit training.

Similarly to the results of the present research, other studies failed to observe significant PEH following resistance exercise. (3, 10, 24) When comparing loads of 50% (12–20 repetitions per set) and 80% (4–8 repetitions per set) of 1RM, no significant post-exercise hypotensive response was observed up to 180 minutes after the resistance training, and no significant difference in the BP response was observed between intensities (10). In another research that compared different intensities, no significant hypotensive response was found after 3 sets with 10 repetitions of RE performed with loads of 40, 60, and 80% of 1RM for a time period of 120 minutes post-exercise, and no differences were found between intensities (24).

Another point about the present study concerns the clinical state of the volunteers. The volunteers were people without any type of cardiovascular diseases and were normotensive. The PEH tends to occur more frequently in subjects with high blood pressure values (8). However, significant reduction in the MBP was verified for the multiple set group in the first post-exercise measure. This result was probably influenced by minimal isolated changes in the SBP and DBP that may not represent important clinical implications.

On the other hand, the HR was higher in both groups that performed the RE when compared with the control group, for all post-exercise measures. When the subjects are not in the supine position (in the present study the post effort BP was measured with the subjects in a seated position) gravity provides an elevated BP in regions distant from the heart (29). After the exercise, HR values tend to be higher than at rest, irrespective of a PEH event (13).

One of the causes of PEH is the reduction in peripheral vascular resistance, which could increase the blood flow. This increase is directly related to the blood flow to the veins which, without the "muscle pump", induces pre-load reduction. On the other hand, the systolic volume remains the same due the reduction of the post-load and the rise in HR (12, 15). The rise in HR post-effort was related to aerobic (8) or resistance exercise (20). Between the possible limitations of the present study are: the limited number of participants in each group (n = 10) and the use of resistance exercises only for upper body.

In the present study, no differences were observed in the post exercise HR between the RE groups (traditional multiple set and Tri-set), although the values of this variable for both groups were significantly higher than at rest.

In summary, the method of the resistance exercise used (traditional multiple set or Tri-set) seems to exert no or minimal influence on the post-exercise hypotension behavior. Possibly, to induce a more significant PEH, the performance of exercises recruiting larger muscle groups, such as those of the lower limbs, would be necessary.

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