Original Article

Effects of Rest Interval between Exercise Sets on Blood Pressure after Resistance Exercises

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Abstract

Background: Although studies have demonstrated the occurrence of postexercise hypotension (PEH) in resistance exercises, there is still no consensus on an ideal protocol.

Objective: To evaluate the effects of different rest intervals (RI) between resistance exercise (RE) sets on postexercise blood pressure (BP).

Methods: Sixteen sedentary non-hypertensive young men performed three RE protocols with RI of 1 (P1), 2 (2) and 3 (P3) minutes between the sets, as well as a control protocol (CON), in a counterbalanced manner. The RE protocols consisted of three sets of eight repetitions in six exercises. The loads used in the 1st, 2nd, and 3rd exercise sets were 80%, 70% and 60% of one repetition maximum (1RM), respectively. Measurements were taken at rest (RES), 15 (T15), 30 (T30), 45 (T45), 60 (T60), 75 (T75), and 90 (T90) minutes after the session. Factorial analysis of variance (Anova) was carried out, followed by post hoc LSD.

Results: No significant change was found in systolic BP after the protocols. A significant increase in diastolic BP was verified after CON at timepoints T45 and T90. Significant reduction in diastolic BP occurred after P1 and P3, with duration of 30 and 15 min, respectively. No significant differences were found in the systolic and diastolic BP responses between the protocols with different RI.

Conclusion: RI does not seem to influence systolic BP reduction after an RE session. However, reductions in diastolic BP (P1 and P3) lasting up to 30 minutes were observed. (Arq Bras Cardiol 2010; 94(4):482-487)

Key words: Exercise; hypotension; cardiovascular physiological phenomena.

Introduction

Physical exercises can reduce blood pressure at rest, during exercise with submaximal workload, and after physical exercises. However, this reduction is probably greater in hypertensive in comparison to normotensive individuals[1].

The decrease in blood pressure below resting levels that occurs after physical exercises is called postexercise hypotension (PEH). PEH may be attributed to a decrease in peripheral vascular resistance and/or cardiac output; however controversies still exist as regards its mechanisms[2-4]. PEH following aerobic exercises has been studied by several researchers[5,6]. In a review article, Kenney and Seals[7] reported that only dynamic exercises such as walking, running, leg cycling, and swimming performed at submaximal intensities would lead to PEH. Contradicting this statement, studies have demonstrated that this effect also occurs after resistance exercises[8-19].

Although these 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[20]. In this sense, Polito et al[11] and Simão et al[19] compared PEH after two different intensities of resistance exercises. The authors reported the same magnitude of reduction in systolic blood pressure in both cases; however, PEH lasted longer in the protocol with the highest intensity. In addition to the variables previously studied (exercise intensity, volume and sequence), the hemodynamic responses to a bout of resistance exercises also depend on other variables such as the amount of muscular mass involved, number of repetitions, type of training and rest interval (RI) between the exercise sets[21-24]. RI is frequently neglected; however, it is considered by Ratamess et al[25] as one of the main variables of resistance exercises. RI length influences 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[25]. Therefore, the objective of the present study was to compare the effects of different RI (1, 2, and 3 min) between resistance exercise sets on the cardiovascular responses to resistance exercises in non-hypertensive young individuals.

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Methods

The sample comprised 16 young males (23 ± 3 years) who had experience with resistance exercises, but had not engaged in regular physical activities at least for the past three months. Individuals diagnosed with chronic diseases, those with alterations in neuromuscular parameters that could compromise the study, systolic blood pressure (SBP) at rest equal to or higher than 140 mmHg and diastolic blood pressure (DBP) equal to or higher than 90 mmHg were excluded from the sample. Individuals being treated with inotropic or chronotropic agents were also excluded. All voluntarily participated in the study and gave a written informed consent. The research project was approved by the ethics committee of *Faculdade de Ciência da Saúde da Universidade de Brasília* (Protocol no. 123/2007).

In order to determine the loads used in the protocols, the one-repetition maximum test (1RM) was performed in the following exercises: inclined leg press, seated row, bench press, leg curl, arm extension (triceps press), and arm curl (barbell curl). Two tests were administered by the same trained examiner following Kraemer and Fry's recommendations[26], in different days with an interval of at least 48 h (test/retest).

The individuals performed four test protocols in the following counterbalanced manner: one control (CON) and three resistance exercise protocols with rest intervals of 1, 2 and 3 min (P1, P2, and P3) between the sets. The protocols were administered at the same hour on different days, at least 48 hours apart. The individuals were advised not to take alcoholic beverages, medicines or stimulating beverages in the 24 hours prior to the beginning of the protocols.

Upon arrival at the laboratory, the individuals remained seated at rest for 15 minutes, for resting (RES) blood pressure (BP) measurement. After the resting measurement was taken, they would start the assigned protocol. In the control protocol (CON), after the resting measurement, the individuals remained seated for BP and heart rate (HR) measurements every 15 minutes, for 90 minutes.

In the resistance exercise protocols, the individuals performed a warm-up set of eight repetitions with 50% of the load used in the protocol in the leg press, bench press and seated row exercises. After the warm-up, three sets of eight repetitions were performed for each exercise. The loads used in the leg press, bench press, seated row and leg curl exercises in the 1st, 2nd, and 3rd sets were 80%, 70%, and 60% of 1RM, respectively. In arm extension (triceps press) and arm curl (barbell curl) exercises, the loads used in the 1st, 2nd, and 3rd sets were 70%, 60% and 50% of 1RM, respectively. Previous studies[25,27,28] demonstrated that rest intervals shorter than three minutes promote a decrease in the total volume (load x repetitions) of the subsequent set. For this reason, the loads were reduced in the subsequent sets, with the purpose of minimizing the reduction in the number of repetitions and keeping the same total volume in all protocols.

The rest intervals between the sets of the protocols were 1, 2, and 3 minutes (P1, P2, and P3). The protocols were performed in a random sequence, in different days, at least 48 hours apart. The interval between the exercises was two minutes. The velocity of performance of the repetitions was one to two seconds in the concentric phase and two seconds in the eccentric phase and was controlled by an observer during the tests. After completing the protocol, the individuals remained seated for BP and HR measurements every 15 minutes for 90 minutes.

BP was measured using an oscillometric device (Microlife 3AC1-1, Widnau, Switzerland) validated by the European Society of Hypertension's international protocol[29]. Heart rate was measured using an electronic frequency meter (Polar RS800, Finland). The measurements were taken with the individual in the sitting position, with the cuff secured to the right arm supported at heart level. HR, SBP, DBP, and mean blood pressure (MBP) were assessed, the latter as calculated by the sum of DBP and one third of the pulse pressure (SBP - DBP). The measurements were taken at the following timepoints: at rest (RES), 15 minutes after rest in the sitting position; 15 minutes after the session (T15); 30 min after the session (T30); 45 min after the session (T45); 60 min after the session (T60); 75 min after the session (T75); and 90 min after the session (T90).

Statistical analysis

Normality of the data was checked using the Kolmogorov-Smirnov normality test. A 4 x 7 factorial analysis of variance was conducted with repeated measures (protocols P1, P2, P3 and CON x blood pressure measurements at RES, T15, T30, T45, T60, T75, and T90). Post-hoc multiple comparisons with correction of the confidence interval were made using the Least Significant Difference (LSD) method. The data were analyzed using the Statistical Package for the Social Sciences software - SPSS (version 13.0). The significance level was set at 0.05 for all assessments.

Results

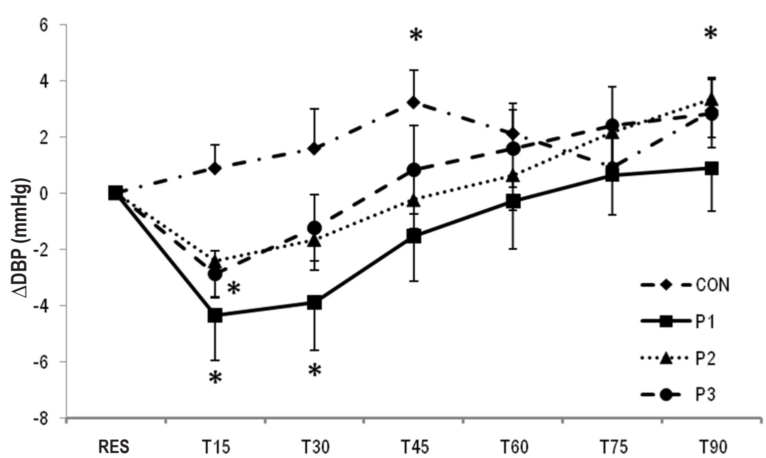
No significant differences were found between SBP measurements taken at rest and those taken after the exercise protocols (P1, P2, and P3). However, the comparison between protocols showed SBP significantly higher in CON at T60 in comparison to P1 ($p = 0.004$), P2 ($p = 0.011$) and P3 ($p = 0.004$). At T90, SBP measured in P2 was significantly lower than in CON ($p = 0.036$) and in P3 ($p = 0.048$). The results of the comparisons of SBP between the protocols are shown in Table 1.

DBP was significantly increased after CON at timepoints T45 ($p=0.001$) and T90 ($p=0.02$) in comparison to rest. Significant PEH was observed in P1 at timepoints T15 ($p = 0.012$) and T30 ($p = 0.03$). After P3, significant PEH was observed at T15 ($p = 0.007$), and significant increase at T90 ($P = 0.018$) in comparison to rest. This significant increase was also observed at T90 in P2 ($p = 0.017$). The comparison between protocols showed significantly higher DBP ($p < 0.05$) in CON at T15 and T30 when compared to P1, P2, and P3. Additionally, at T45, DBP measurement in CON remained significantly high in comparison to P1 ($p = 0.012$) and P2 ($p = 0.01$). The results of the comparison of ΔDBP (post-exercise DBP - RES DBP) between the protocols are shown in Graph 1.

Table 1 - **Systolic blood pressure (SBP) and diastolic blood pressure (DBP) responses to the different protocols (n = 16)**

	RES	T15	T30	T45	T60	T75	T90
SBP (mmHg)							
CON	116 ± 7	115 ± 7	118 ± 7	117 ± 8	120 ± 8	117 ± 8	119 ± 9
P1	115 ± 8	113 ± 10	112 ± 11	115 ± 9	112 ± 9*	114 ± 8	115 ± 9
P2	116 ± 7	117 ± 7	115 ± 8	115 ± 7	115 ± 8*	115 ± 4	115 ± 6*
P3	116 ± 8	114 ± 7	114 ± 6	115 ± 7	114 ± 9*	117 ± 9	118 ± 9
DBP (mmHg)							
CON	62 ± 6	63 ± 5	64 ± 5	66 ± 6‡	65 ± 6	63 ± 6	65 ± 7‡
P1	62 ± 6	57 ± 6*†	58 ± 6*†	60 ± 6*	62 ± 6	63 ± 6	63 ± 5
P2	61 ± 5	59 ± 5*	60 ± 4*	61 ± 4*	62 ± 5	64 ± 4	65 ± 5
P3	61 ± 6	59 ± 5*†	60 ± 6*	62 ± 6	63 ± 6	64 ± 6	65 ± 6‡

*RES - at rest; T15 to T90 - period after the protocol up to 90 minutes; CON - control; P1: RI of 1 min; P2: RI of 2 min; P3: RI of 3 min. *p < 0.05 lower than CON. †p < 0.05 lower than RES. ‡ p < 0.05 higher than RES.*



*Graph 1 - Comparison of the DBP (Δ) responses between the different rest intervals. RES - rest; T15 to T90 - period after the protocol up to 90 minutes; CON - control; P1 = 1 min; P2 = 2 min; P3 = 3 min. *p < 0.05 in relation to RES; ΔDBP = (post-exercise DBP - RES DBP).*

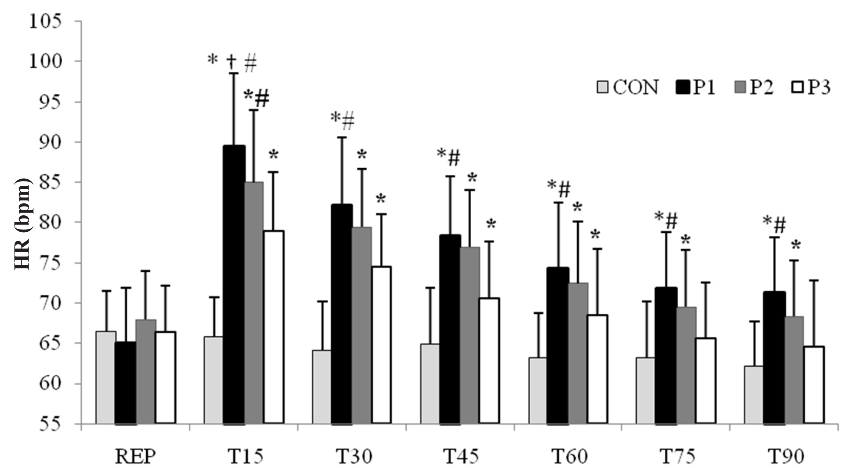
A significant decrease was observed in the HR responses to the CON protocol in relation to rest at timepoints T60 (p = 0.009), T75 (p = 0.019) and T90 (p = 0.002). After P1, HR remained significantly high in relation to rest from T15 (p < 0.001) to T90 (p = 0.001). This increase in HR in relation to rest was also observed after P2; however, HR remained significantly high from T15 (p < 0.001) to T60 (p = 0.002). After P3, HR remained significantly high from T15 (p < 0.001) to T45 (p = 0.012). The results of the comparisons of HR between the protocols are shown in Graph 2.

Discussion

The main results found were: a) none of the protocols tested led to significant postexercise reduction of SBP; b) PEH of greater magnitude and longer duration was found after the protocol that used an RI of 1 min; c) no significant differences were found in the postexercise responses of SBP and DBP using different RI.

Studies demonstrate that after performance of only one resistance exercise (RE) bout, BP may be elevated[14], reduced[9,11,13-19] or unchanged[30-32] in comparison to pre-exercise measurements. The present study did not find a significant postexercise reduction of SBP in any of the protocols tested. The results found do not support the studies that reported postexercise reduction of SBP after an RE session[9,11,18,19]. However, they are similar to those reported by Hill et al[8], Raglin et al[31], and De Van et al[15].

MacDonald et al[33] used direct BP measurement and reported significant postexercise reduction of SBP of up to 20 mmHg. This PEH started 10 min after protocol completion and was sustained up to 60 min. The RE protocol used comprised 15 min of exercise in unilateral leg press at 65%



*Graph 2 - Comparisons of HR responses between the different rest intervals. RES - at rest; T15 to T90 - period after the protocol up to 90 minutes; CON - control; P1 = 1 min; P2 = 2 min; P3 = 3 min. *p < 0.05 higher than CON. †p < 0.05 higher than P2. # p < 0.05 higher than P3.*

of 1RM in normotensive young individuals. No significant differences between the protocols were found regarding duration or magnitude of this effect. The results found in MacDonald et al's study[9] are different from ours, possibly because the exercise was performed in a continuous manner, thus making it work like an aerobic exercise session in which PEH has been more frequently reported. Polito et al[11] also reported significant postexercise reduction in SBP of up to 15 mmHg after two RE sessions with different intensities in a sample comprising individuals who had been practicing RE for at least 6 months. No significant differences between the protocols were found regarding the magnitude of PEH; however, PEH lasted longer after the most intense protocol (6RM). In a similar study, Simão et al[19] compared the effect of intensity, volume and session format on post-resistance exercise hypotensive response. Significant postexercise reduction of SBP lasting for 50 to 60 minutes was found after the protocols. No significant differences between the protocols were observed regarding the magnitude of this effect. The differences between the results found in the present study and those reported by Polito et al[11] and Simão et al[19] may be attributed to the differences in the protocols used as well as to the difference in the level of physical fitness of the sample. The present study used a protocol in which the load decreased at each set, with the purpose of maintaining the same work volume (load x repetitions) in all protocols, thus isolating the effects of the RI on the variables analyzed. Accordingly, the combination of the total load with the RI of the protocol may have been insufficient to provoke a significant reduction in SPB. The studies that demonstrated postexercise reduction in SBP after training sessions at lower intensities used a greater number of repetitions and shorter RI, thus compensating the lower intensities[11,18,19].

Rezk et al[18] evaluated the effect of two RE sessions at different intensities on PEH in a sample comprising 17 normotensive young individuals who did not regularly engage in any physical activity. The protocols tested consisted of three sets of 10 repetitions with a load of 80% of 1RM and RI of 1 minute between the sets, and three sets of 20 repetitions with 40% of 1RM and RI of 45 seconds between the sets. Significant PEH was found as from 30 minutes after completion of the two protocols; this effect was sustained up to 90 min, as opposed to the results demonstrated by Polito et al[11] and Simão et al[19], in which the intensity influenced PEH duration.

Other studies found results similar to those of the present study, in which no significant changes in SBP after an RE session were verified. Hill et al[8] observed a decrease in SBP only immediately after completion of a protocol with three sets of a circuit of four exercises with interval of 30 seconds between each exercise, with load of 70% of 1RM until onset of volitional fatigue in normotensive individuals. Raglin et al[33] evaluated university athletes (15 men and 11 women) after performance of an RE session at 70% to 80% of 1RM and did not find significant differences between postexercise measurements and rest measurements of SBP. De Van et al[15] did not find significant changes in SBP for 150 minutes after an RE session with one set up to fatigue in nine exercises using a load of 75% of 1RM. The authors evaluated a sample of sedentary young men (n = 11) and women (n = 5)

In relation to DBP, after the protocol using RI of 1 minute (P1) between the sets, significant PEH with duration of 30 minutes was observed. The mean decrease in DBP was 5 ± 2 mmHg at timepoint T15, and 4 ± 1 mmHg at timepoint T30. The results of the present study corroborate previous findings demonstrating the occurrence of post-resistance exercise decrease in DBP with duration ranging from 10 to 60 minutes[8,11,15,16,18,19]. Hill et al[8] found significant postexercise decrease in DBP lasting 60 minutes after the end of an RE protocol. Their study sample comprised six normotensive individuals with experience in RE and age between 22 and 33 years. Focht and Koltyn[16] evaluated 84 volunteers (51 men and 33 women) after performance of three protocols: 1.

three sets of 12 to 20 repetitions with a load of 50% of 1RM and RI from 45 to 75 seconds between the sets; 2. three sets of 4 to 8 repetitions with a load of 80% of 1RM and RI from 120 to 150 seconds between the sets; 3. control protocol. Postexercise decrease in DBP lasting 20 minutes was found after the protocol using 50% of 1RM. In Polito et al[11] and Simão et al[19] studies, significant postexercise 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[18] and De Van et al[15] also found significant postexercise decrease in DBP; however, the duration of PEH was longer (30 minutes) than that found by Polito et al[11] and Simão et al[19], and similar to that observed in the present study. Despite the differences in the protocols used, the magnitude and duration of postexercise decrease in DBP in the present study were similar to those found in previous studies[15,16,18].

The causes of post-resistance exercise hypotension have not been fully explained; this effect is possibly related to a decrease in the systolic volume, while the peripheral vascular resistance remains unchanged. Thus, there is a reduction in cardiac output and, consequently, a reduction in BP. This effect was reported by Rezk et al[18], in one of the few studies found that assessed some mechanisms of BP control such as systolic volume, peripheral vascular resistance, and cardiac output after an RE session. According to these authors, the systolic volume remained below resting levels for 90 minutes. This explanation seems to be the most plausible, because the heart rate remains high after the end of the exercise, possibly to compensate the decrease in systolic volume. Increase in HR was observed in the present study after the three RE protocols, thus corroborating previous studies[9,15,18,25,34]. The decrease in systolic volume may be influenced by the reduction in venous return caused by the decrease in plasma volume because, apparently, after performance of RE, there is blood fluid extravasation into the interstitial space, thus reducing blood volume[35]. Additionally, there may be a reduction in vascular resistance influenced by an accumulation of metabolites produced in muscle contraction, which, according to MacDonald et al[36], is one of the factors accounting for vasodilatation and subsequent decrease in peripheral vascular resistance. This may occur so that BP is regulated in a way that permits an adequate circulation for metabolite buffering and supply of the required nutrients[37,38]. This could explain the postexercise decrease in DBP found in the present study, because the protocol with the lowest RI promoted longer PEH. This effect possibly occurred because of a greater accumulation of metabolites in the 1-minute RI protocol, as had already been demonstrated by Ratamess et al[25] in previous studies.

Recently, Crisafulli et al[39] verified a relationship of blood lactate levels and decreased peripheral vascular resistance to BP after an exercise bout in athletes. The use of shorter RI may lead to increased accumulation of metabolites produced in muscle contraction, and this can influence the reduction in peripheral vascular resistance[36]; however, this effect was not observed in the present study. According to Ratamess et al[25], the interaction between intensity and volume is decisive for metabolic responses to RE. In the present study, the total volume (repetitions x load) was the same in the three protocols. Thus, the effect of RI alone was not sufficient to cause differences in PEH between the protocols tested.

At timepoints T45 and T90 after CON, and at timepoint T90 after P2 and P3, a significant increase in DBP was found in comparison to the rest measurement. This increase in DBP after the control protocol has already been reported in previous studies[15,18] and may have occurred due to the orthostatic stress caused by the sitting position. Possibly, the sitting position led to a reduction in venous return, thus modifying the cardiopulmonary baroreflex control, and consequently increasing peripheral vascular resistance and DBP[40].

Conclusion

Based on the results obtained, we can conclude that none of the protocols tested led to significant postexercise decrease in SBP. Additionally, BP responses after the protocols were not influenced by the different rest intervals tested (1, 2, and 3 minutes).

RE sessions lead to a postexercise decrease in DBP that lasts up to 30 minutes. However, the different rest intervals tested (1, 2, and 3 minutes) did not influence the magnitude of PEH after an RE session with the same total workload (repetitions x load).

The rest interval between the sets influenced the heart rate and double product responses after an RE session, and shorter intervals led to greater elevation of these variables.

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.

Potential Conflict of Interest

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

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Study Association

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