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Effect of Agonist-Antagonist Paired Set Training *vs.* Traditional Set Training on Post-Resistance Exercise Hypotension

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ABSTRACT

Paz G, Maia M, Bentes CM, Figueiredo T, Salerno V, Simão R, Miranda H. Effect of Agonist-Antagonist Paired Set Training vs. Traditional Set Training on Post-Resistance Exercise Hypotension. **JEPonline** 2014; 17(6):13-23. This study investigated the effect of agonist-antagonist paired sets (PS) training *vs.* traditional sets (TS) training on systolic (SBP) and diastolic blood pressure (DBP) responses. Fourteen men performed two experimental protocols: TS, three bench press sets were performed followed by three repetitions to failure sets of seated row exercise; and PS, three paired sets of bench press and seated row. Rest intervals of 4 min each were used between sets and exercises for both protocols. Training volume (repetitions x sets x loads) was computed for each protocol. Blood pressure was measured before and every 5 min of the 40-min post-exercise period. Training volume was significantly higher under PS (1625.1 kg ± 210.5) compared to TS (1493.7 kg ± 115.6) for seated row ($P = 0.018$). No differences were noted between PS (1435.8 kg ± 218.4) and TS (1373.6 kg ± 198.1) for bench press. Significant reductions in SBP were noted at 35 and 40-min post-exercise under PS compared to rest values. No hypotensive effect was noted in SBP after the TS protocol. Significant reductions in DBP were observed between 5 min and 40 min post-exercise under TS and PS protocols, respectively. Thus, PS training may increase the magnitude of the hypotensive effect on SBP compared to TS for upper body exercises.

Key Words: Blood Pressure, Strength Training, Hypotension

INTRODUCTION

Resistance training (RT) is a key component of exercise programs with the goal to develop physical fitness for health and/or athletic performance (11). Additionally, RT promotes significant effects on the endothelial function in practitioners with or without cardiovascular disease (32). Furthermore, the endothelial dysfunction is one of the primary causes of hypertension, and it has been suggested that resistance exercise should be adopted as a non-pharmacological treatment for hypertension (6,7, 12).

Blood pressure (BP) increases dramatically during RT (13,17). However, at the end of session, BP has been reported to be lower than the pre-exercise value (4,22,28). This phenomenon is usually referred to as the hypotensive effect (31), which may play an important role in controlling hypertension and cardiovascular risk (5). A small reduction in BP of 4 mmHg reduces the possibility of stroke and coronary arterial disease in normotensive or hypertensive subjects. Therefore, RT may represent a useful tool in altering BP during the day and over time (5).

The magnitude and duration of hypotensive responses after RT sessions are related to differences in training volume (repetition x sets x loads) (28), the muscle group exercised (22,30), and/or training intensity (30). Rezk et al. (24) found systolic blood pressure (SBP) hypotension in normotensive subjects after low intensity RT (40% of 1 repetition maximum - RM) and after high intensity RT (80% of 1RM), while only low intensity exercise decreased diastolic blood pressure (DBP). Prista et al. (23) observed that a single session of eight resistance exercises for different muscles groups (1 set of 10 to 15 repetitions of 30 to 60% of 1RM) did not decrease BP measured after exercise in the clinical condition, but did reduce ambulatory BP during sleep. Moreover, Bentes et al. (4) compared the hypotensive effect and performance responses between different RT intensities and different exercise orders in 13 apparently healthy women. They reported significant decreases in SBP and DBP after different RT sessions with the manipulation of intensity and exercise sequence.

Several training methods have been applied by practitioners and coaches with the goal to increase the training volume, and also to improve the strength performance (5). One method is the agonist-antagonist paired set (PS) that consists of paired sets between exercises for an agonist muscle group followed an exercise for the antagonist muscle group with or without limited rest interval length (16). Paired set training is usually accompanied by important metabolic activity that could promote muscle arterial vasodilation, decrease systemic vascular resistance, and decrease BP (26). The major difference between PS training and traditional set (TS) training is the rest interval length. Shorter rest intervals between sets and exercises improve relative intensity during RT, thus enabling higher levels of perceived exertion (29,35). In addition, longer rest intervals allow for a longer recovery and the capacity to maintain the strength performance (10,29). Paired set training is usually associated with a higher training volume in a time-efficient manner (volume/time) (25,26).

Nonetheless, De Salles and colleagues (9) noted which 2-min rest interval length between sets promoted a longer post-exercise hypotensive magnitude than 1-min rest interval length. Conversely, Veloso et al. (36) observed three different rest intervals (1 *vs.* 2 *vs.* 3 min) between sets and exercises in young normotensive untrained men and found no differences were between the rest intervals. Moreover, to our knowledge, no study has investigated the post-resistance exercise hypotension response after PS training compared to TS training.

Thus, the purpose of the present study was to evaluate the acute effect of PS versus TS in post-resistance exercise hypotension and training volume. It was hypothesized that PS would have a pronounced and longer effect on BP associated to a greater volume during the RT session. Thus, post-exercise hypotension might have clinical relevance in hypertensive subjects. The study was conducted with healthy participants with the goal to understand the BP responses without pathological interference.

METHODS

Subjects

Fifteen normotensive trained men (mean ± standard deviation: age = 22.2 ± 2.3 yrs; height = 173 ± 7.6 cm; weight = 82.5 ± 5.6 kg; and body fat percentage = 13.3 ± 3.1%) participated as subjects in this study. All subjects had previous RT experience (mean 4.5 ± 1.2 yrs) that averaged four 60-min sessions·wk^{-1} using 1- to 2-min rest intervals between sets and exercises.

Although the subjects were matched for age, height, and weight, the following exclusion criteria were also used: (a) smoking history; (b) use of ergogenic substances or drugs that could affect the cardiovascular responses; (c) bone, joint, or muscle impairments that could limit the execution of the exercises; (d) resting BP higher than 140/90 mmHg; and (e) cardiovascular or metabolic disease, especially hypertension and diabetes.

The current study was approved by the Institutional Human Experimental Committee at Federal University of Rio de Janeiro. Written informed consent was obtained from the subjects prior to participation, in accordance with the Declaration of Helsinki. Also, prior to participation in the study, the subjects completed a Physical Activity Readiness Questionnaire (PAR-Q) (34).

Procedures

The first two testing sessions focused on measures of strength and anthropometry. At each of the sessions, strength was assessed using a 8RM test for bench press and wide-grip seated row exercises on machines (Life Fitness, IL, USA) (2). If the subject did not attain 8 repetitions in the first attempt, the weight was adjusted by 4 to 10 kg followed by a minimum of 5 min of rest prior to the next attempt. Only three trials were allowed per testing session and 10 min of rest was required between exercises. The test and retest were conducted with an interval of 48 to 72 hrs. Bench press and seated row exercises were alternated during testing and retesting.

The following strategies were used to reduce the margin of error in the data collection procedures (18): (a) standardized instructions were given before the tests such that the person being tested would be aware of the entire routine involved in the data collection; (b) the individual being tested was instructed on the proper technique of the exercise execution; (c) all subjects were given standardized verbal encouragement throughout the tests; and (d) all tests were conducted at the same time of the day.

The current study employed a randomized crossover design. To investigate the effects of multiple sets of PS versus TS on post-resistance exercise hypotension, the subjects performed four visits carried out on non-consecutive days. Two visits for test and retest of 8RM, following assessment of 8-RM loads for the for wide-grip seated row and bench press exercises. At the third and fourth visits, subjects were assigned to the TS protocol or the PS group in a randomized crossover design with 48- to 72-hr recovery between sessions and retest. Before each protocol, BP was measured before (following 10-min rest upon arrival at the lab). All subjects were encouraged to report for workout sessions fully hydrated and to be consistent in their food intake throughout the duration of the study.

The subjects performed two RT sessions with 48 to 72 hrs recovery between sessions. Subjects performed a warm-up set of 15 repetitions using 50% of 8RM loads, followed by a 2-min rest interval before beginning the TS (33) or PS protocols. The TS subjects performed 3 sets of bench press exercises with 8RM loads, followed by 3 sets of seated row exercises repetition to failure, with a 2-min rest interval between sets and exercises. The PS subjects performed 1 set repetition to failure on the bench press exercise with 8RM loads, immediately followed by 1 set repetition to failure with 8 RM loads on the seated row exercise. The same rest interval (2 min) was adopted before the next paired sets (bench press and seated row exercises). The subjects performed 3 sets of paired sets. Blood pressure was measured before (following a 10-min rest upon arrival at the lab) and at 5-min intervals for 40 min following the two different sessions.

The subjects' BP was assessed by an automatic device (PM50 NIBP/Spo2 CONTEC - EUA) at the left arm. Mean arterial pressure (MAP) was calculated by the equation: MAP = DBP + [(SBP – DBP) ÷ 3]. For sessions 3 and 4 of resistance exercise, BP was measured before RT and immediately after exercise and each 5 min during a period of 40 min post-exercise. All measurements were taken with the subject in the seated position. All subjects were requested to have their last meal 3 hrs before data assessment. They were also asked not to use alcohol or perform physical effort during the previous 24 hrs. The measurements were made between 8 a.m. and 10 a.m. at a temperature of 23 to 25°C.

Statistical Analyses

The data for all variables were analyzed using the Shapiro-Wilk normality test and homocedasticity (Bartlett criterion). Data are presented as mean ± SD. A repeated measures analysis of variance was applied for comparison within sessions for the results of the post-exercise BP response to pre-exercise resting. Repeated-measures analysis of variance (ANOVA) one-way was used to determine possible changes in SBP, DBP and MAP for each exercise session. Bonferroni post hoc least significant difference test was applied to delineate between significant differences. The level of significance was set at $P \leq 0.05$, and all statistical analyses were done using the SPSS 20.0 software.

RESULTS

Training volume was significantly higher under PS (1625.1 kg ± 210.5) compared to TS (1493.7 kg ± 115.6) for the seated row exercise ($P = 0.018$). However, no differences were found under PS (1435.8 kg ± 218.4) and TS (1373.6 kg ± 198.1) for the bench press exercise ($P = 0.225$). Significant reductions in SBP were observed 35 and 40 min post-exercise under PS protocol compared to rest BP (Figure 1).

However, there was no hypotensive effect on SBP under TS protocol. Significantly lower values of SBP were also noted between 35 and 40 min post-exercise under PS protocol compared to TS condition (Table 1). Significant reductions in DBP were observed between 5 and 40 min post-exercise under TS and PS protocols compared to rest BP.

Similarly, significantly lower values of DBP were noted between 30 and 40 min post-exercise under PS protocol compared to TS protocol (Table 2). In regards to MAP, no significant differences were found between both protocols (Table 3).

Table 1. Systolic Blood Pressure Results (Significant Difference for *Rest Values and for †TS).

SBP (mmHg)	Traditional Set	Agonist-Antagonist Paired Sets
Rest	122 ± 9.6	124 ± 8.1
Post	136 ± 24	134.1 ± 17.7
5	128 ± 19	122.7 ± 16
10	125 ± 14	120 ± 13
15	125 ± 13.8	121 ± 13
20	123.2 ± 14.4	121.8 ± 20.1
25	127 ± 17	120.7 ± 15.7
30	126 ± 16.4	121.1 ± 16
35	129.1 ± 22.5	116 ± 13.1*†
40	127.1 ± 15.1	116 ± 16.2*†

Table 2. Diastolic Blood Pressure Results (Significant Difference for *Rest Values and for †TS).

DBP (mmHg)	Traditional Set	Agonist-Antagonist Paired Sets
Rest	75.8 ± 7.2	68.9 ± 7.2
Post	62.5 ± 10.7	67.2 ± 11.2
5	60.3 ± 8.3*	60.4 ± 9.1*
10	58.7 ± 8.4*	58.7 ± 9.5*
15	58.2 ± 9.8*	58.2 ± 7.5*
20	58.4 ± 5.4*	58.3 ± 7.6*
25	60.7 ± 6.6 *	58.3 ± 11.7*
30	62.3 ± 8.4*	59.9 ± 8.1*†
35	63.3 ± 9.0*	60.2 ± 6.5*†
40	67.7 ± 8.9*	63.7 ± 8.6*†

Table 3. Mean Arterial Pressure Results.

MAP (mmHg)	Traditional Set	Agonist-Antagonist Paired Sets
Rest	91.2 ± 7.1	87.4 ± 8.9
Post	87.0 ± 8.4	89.5 ± 7.6
5	82.8 ± 9.4	81.2 ± 7.8
10	80.8 ± 7.6	79.3 ± 8.9
15	80.6 ± 9.2	79.3 ± 8.7
20	80.0 ± 11.2	79.5 ± 7.6
25	82.7 ± 8.7	79.1 ± 8.7
30	83.6 ± 9.1	80.3 ± 7.6
35	85.2 ± 7.8	78.8 ± 9.1
40	87.5 ± 5.9	81.3 ± 7.6

DISCUSSION

The purpose of this study was to compare the post-exercise hypotensive response in normotensive, apparently healthy men between TS and PS for bench press and seated row resistance exercises. The key findings of the current study were higher post-exercise hypotension on SBP and DBP under PS compared to TS protocol. The decrease in SBP and DBP observed in the present study after RT is in agreement with previous research (4,14,22,24). However, the significant decrease in SBP was observed after PS training.

Significantly higher training volume was observed during PS compared to TS protocol for the seated row exercise. However, the training volume was similar between each protocol for the bench press exercise. Previous studies (3,8,26) have shown a potential effect of PS on agonist muscle performance due to the possible reduction in antagonist coactivation, storage of elastic energy, and alteration of the triphasic pattern of muscle activation. On the other hand, several researchers (1,21,25) have not explained the mechanisms responsible for the increase in muscle activation (1,21,25). Bentes et al. (4) showed in their results that the total work does not influence the decrease in BP and that the manipulation of the intensity, rest intervals, and the exercise orders may be more important.

No studies were found that investigated the BP response after PS versus TS training. According to Robbins et al. (26) PS may induce a peripheral fatigue status, given the increase in blood flow due to the PS performed for opposite muscle groups in the same body segment. Significant hypotensive effect was noted for SBP after PS between 35 min and 40 min post-exercise. This condition was not observed during the TS protocol. Previous researchers (4,14,19,20,22,24) have shown the hypotensive effect after ~15 to 30 min after RT. Simão et al. (30) reported a greater decrease in SBP up to the 50-min mark after a RT session composed by 3 sets for 5 exercises performed with 6RM loads compared to a session composed of 12 repetitions at 50% of 6RM during a circuit format with the same exercises. These results indicate that intensity of RT is a key component in the duration of the hypotensive effect.

Bentes and colleagues (4) reported that, while different intensities and different exercise orders resulted in a significant hypotensive effect in SBP and DBP in 13 apparently healthy women who performed 4 RT sessions in randomized order, the manipulation of intensity and exercise sequence did not generate significant changes in the duration and magnitude of the hypotensive effect. However, Simões et al. (31) found significant hypotensive effect on SBP and MAP (between 90 and 120 min post-exercise) after a circuit training composed by leg extension, bench press, leg press, leg curl, and lat pull down with 43% of 1RM performed by trained men with and without type 2 diabetes mellitus compared to circuit training with 23% of 1RM. Probably, the moderate workload (8RM) combined with a 2-min rest interval was not sufficient to induced a post-exercise hypotension, considering that training volume was lower for seated row during the TS training.

Significantly higher training volume performed during PS training in short period of time may be the responsible factor for decreasing SBP between 35 min and 40 min post-exercise. The significant decrease in DBP was also noted for the TS and PS protocols between 5 min and 40 min post-exercise. Additionally, significantly lower values of DBP were observed in PS compared to TS protocol between 30 and 40 min post-exercise. These results have been observed by researchers with normotensive subjects (9,22,24) and hypertensive subjects (19,20,28) in many different exercise protocols. Hence, it is reasonable to conclude that the results of the current study are similar to the available data on the BP responses to RT.

As to the RT exercises, relatively few studies have examined possible mechanisms for the post-exercise hypotensive response (27). One plausible explanation has been associated with a reduction in cardiac output (Q) followed by the increase in peripheral vascular resistance (PVR) and heart rate (HR). The underlying cause for the decrease in PVR has not yet been determined. Rezk et al. (24) reported that the decrease in Q that was not compensated by vascular resistance may be responsible for the decrease in BP. There is also the hypothesis that vasodilators or vasoconstrictions agents, which do not last for many hours may modify vascular sensitivity and decrease BP. In agreement, MacDonald et al. (15) observed that the amount of substances liberated after RT exercises was one of the main factors responsible for muscle arterial vasodilation and, therefore, the decrease in PVR that renders the subjects' blood pressure hypotensive during post-resistance exercise.

As to the findings, there are several limitations of this study: (a) it is not possible to extrapolate the results obtained for people with different training levels or clinical conditions; (b) variables possibly related to post-exercise hypotension mechanisms (such as sympathetic activity, blood flow, Q, and nitric oxide production) were not evaluated; (c) this study did not have a control group; and (d) RT exercises allow for a considerable manipulation of volume and intensity, the possible interaction between the number of sets and repetitions, and recovering intervals to produce post-exercise hypotension should be considered in future research.

CONCLUSIONS

In conclusion, the post-exercise hypotension observed in the current study may have positive impacts on early phases of high BP development. However, the results of this study are likely to apply only to trained, male adults and further research testing with other populations including hypertensive individuals is warranted. Thus, the PS protocol performed at moderate workload (8RM) for only two resistance exercises for upper body muscles may be an interesting alternative to induce a significant decrease in SBP and DBP versus the TS protocol.

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