International Journal of EXERCISE SCIENCE

Original Research

Hypotensive Responses of Reciprocal Supersets versus Traditional Resistance Training in Apparently Healthy Men

CLAUDIO M. BENTES†[1,2], PABLO B. COSTA‡[3], VICTOR G. CORRÊA NETO†[1], ROBERTO SIMÃO‡[1], GABRIEL A. PAZ†[1], MARIANNA F. MAIA†[1], TIAGO FIGUEIREDO†[1,4,5], GABRIEL R. NETO†[6], JEFFERSON S. NOVAES‡[1], and HUMBERTO MIRANDA‡[1]

[1]Federal University of Rio de Janeiro. School of Physical Education and Sports. Rio de Janeiro – BRAZIL; [2]Oswaldo Cruz Foundation. Fernandes Figueira Institute, Graduate Program in Applied Clinical Research On Women's Health, RJ, BRAZIL; [3]Department of Kinesiology, California State University, Fullerton, California, UNITED STATES; [4]Estácio de Sá University. Physical Education School. Macaé, RJ, BRAZIL; [5]Department of Sport Science Universidade de Trás-os-Montes e Alto Douro, Exercise and Health, Vila Real, PORTUGAL; [6]Department of Physical Education, Associate Graduate Program in Physical Education UPE / UFPB, João Pessoa, Paraíba, BRAZIL

†Denotes graduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 10(3): 434-445, 2017. The purpose of this study was to compare the hypotensive responses of reciprocal supersets (SS) versus traditional training (TRAD) methods. Thirteen men with at least five years of recreational experience in resistance training (RT) volunteered for the study. When completing the TRAD protocol, participants performed the following exercises separately in sequence: chest press (CP), low row (LR), leg extension (LE), leg curl (LC), pull down (PD), and shoulder press (SP). The SS method required participants to complete the same exercises as in the TRAD protocol, but exercises were coupled such that muscles sequentially served both as an agonist for lift one and then antagonist for lift two and vice versa. Exercise order used was CP and LR, LE and LC, and PD and SP with 10 repetition maximum loads. Blood pressure (BP) was measured before and for every 10 minutes for one hour after training. There was significantly more total work (TW) done in the TRAD condition compared to SS. Post exercise hypotension was evident only after the TRAD session at minutes 30 and 40 for systolic BP. Significant differences between the TRAD and SS methods were found at 20 minutes, 30 minutes, and 40 minutes for systolic BP. There was no significant two-way interaction for group × time for diastolic BP. There was a significant two-way interaction for group × time for mean arterial pressure. Significant reductions for mean arterial pressure (MAP) occurred only in the TRAD method after 30 to 40 minutes compared to the baseline values. Therefore, a TRAD RT method was sufficient to cause a hypotensive effect after the training session whereas the SS method did not reveal significant decreases in BP after the session. However, these findings are important to elucidate concerns regarding the post-exercise hypotension after RT and showed that TW might be the key to promote these changes because the volume of training was shown to be an important training variable to manipulate and might be associated with BP hypotension after RT.

KEY WORDS: Strength training, hypotension, blood pressure, systolic blood pressure, diastolic blood pressure, post-exercise hypotension

INTRODUCTION

The blood pressure (BP) reduction after a resistance training (RT) session is called post-exercise hypotension (PEH). This has been an important strategy to control BP to promote cardiovascular health in normotensive participants, in addition to traditional pharmaceutical interventions (33). Recently, a meta-analysis demonstrated significant reductions in BP after a single bout of RT that might promote PEH lasting up to 24 hours. Moreover, the RT are capable of promoting significant chronic effect in BP (5). Although RT was previously contraindicated for hypertensive individuals, studies have shown that this type of exercise may be safe and can result in a clinically relevant BP reduction (6). In addition, studies have examined the PEH response after RT sessions adopting different strategies to manipulate the methodological variables of training prescription such as different numbers of sets (10), load intensity (11), exercise order (2), and rest interval length (34).

Fitness professionals often employ RT methods to manipulate volume and intensity of training in order to pursue specific outcomes (e.g., strength, muscle hypertrophy, power, and muscle endurance), and are characterized by the manipulation of the aforementioned variables (3). In this sense, reciprocal supersets (SS), also known as agonist-antagonist superset training, incorporates different exercises performed consecutively while limiting the rest interval duration between the exercises (30, 31). Evidence supports performing RT on antagonistic muscle pairs in order to increase training volume and fatigue (23, 27). The traditional (TRAD) method is characterized by completing sets and repetitions, to failure or not to failure, followed by adequate rest interval period between sets and exercises (17).

The interaction between volume and intensity during RT sessions with PEH is still an area to be investigated. The intensity may influence the duration and magnitude of the hypotensive response after RT sessions because it affects heart rate, post-exercise cardiac vagal modulation (25), and cardiac output (4). Currently, no studies have examined PEH comparing the SS to a TRAD method. These methods differ from each other by the rest interval duration between sets, and this difference might increase exercise intensity (defined by work per time) because greater fatigue follows a shorter local muscle recovery (17).

This research may help strength and conditioning coaches and practitioners during the prescription and selection of training methods with the goal of improving the hemodynamics responses in healthy individuals. Therefore, it is necessary to obtain a better understanding of the effects of different common training methods (SS vs. TRAD) of RT on BP responses. Accordingly, the purpose of this study was to compare the PEH of reciprocal SS versus TRAD in recreationally active adults. We hypothesized that the TRAD method would result in a greater and longer hypotensive effect compared with the SS method.

METHODS

Participants

Thirteen men with at least five years of recreational experience in RT volunteered for the study (Table 1).

All participants had experience with RT at least three times per week, with typical rest interval durations (less than 1 minute to 3 minutes between sets and exercises). Prior to data collection, all participants answered the Physical Activity Readiness Questionnaire and signed an informed consent form according to the Declaration of Helsinki. The exclusion criteria for the study were: (a) use of medication affecting their cardiovascular responses and (b) existence of musculoskeletal or cardiovascular problems that might influence the performance of the proposed exercises. All participants were asked to not ingest caffeine or alcohol during the 24-hour period, and to not perform any vigorous physical activity during the 48 hours prior to any testing protocols. None of the participants had any recent history of upper or lower body injury. During the experiment, participants were instructed to continue their typical diet in order to maintain their individual routines and not cause abrupt changes in resting metabolism. The research project was approved by the University Ethics Committee for the Protection of Human Participants (protocol number 213/693 - CAAE: 11176113.0.0000.5257).

Table 1. General characteristics of participants.

Age (years)	20 ± 1.3
Height (centimeters)	179 ± 0.03
Body Mass (kg)	79 ± 4.3
Body Mass Index (kg/m^2)	24 ± 0.7
Systolic Blood Pressure (mmHg)	123 ± 5.2
Diastolic Blood Pressure (mmHg)	76 ± 9.0
Mean Arterial Pressure (mmHg)	92 ± 6.6

Mean ± standard deviation.

Protocol

A repeated measures design was used to investigate the hypotensive effects of different RT methods (SS vs. TRAD). The participants visited the Strength Training Laboratory four times. In the first visit, anthropometric measurements and ten-repetition maximum strength testing (10RM) were performed. In the second visit, re-tests of 10RM in each exercise were carried out to analyze reliability. Intraclass correlation coefficients (ICC) results showed high reliability: Chest Press (CP; r = .94); Low Row (LR, r = .91); Leg Extension (LE, r = .90); Leg Curl (LC, r = .89); Pull Down (PD, r = .99); and Shoulder Press (SP, r = .97). Participants were then randomly assigned to the SS or TRAD training conditions. On the third session, participants performed one of the experimental protocols (SS or TRAD, Figure 1). In the fourth visit, participants performed the last condition, completing both experimental protocols. Blood Pressure was measured after the RT session for 60-minutes.

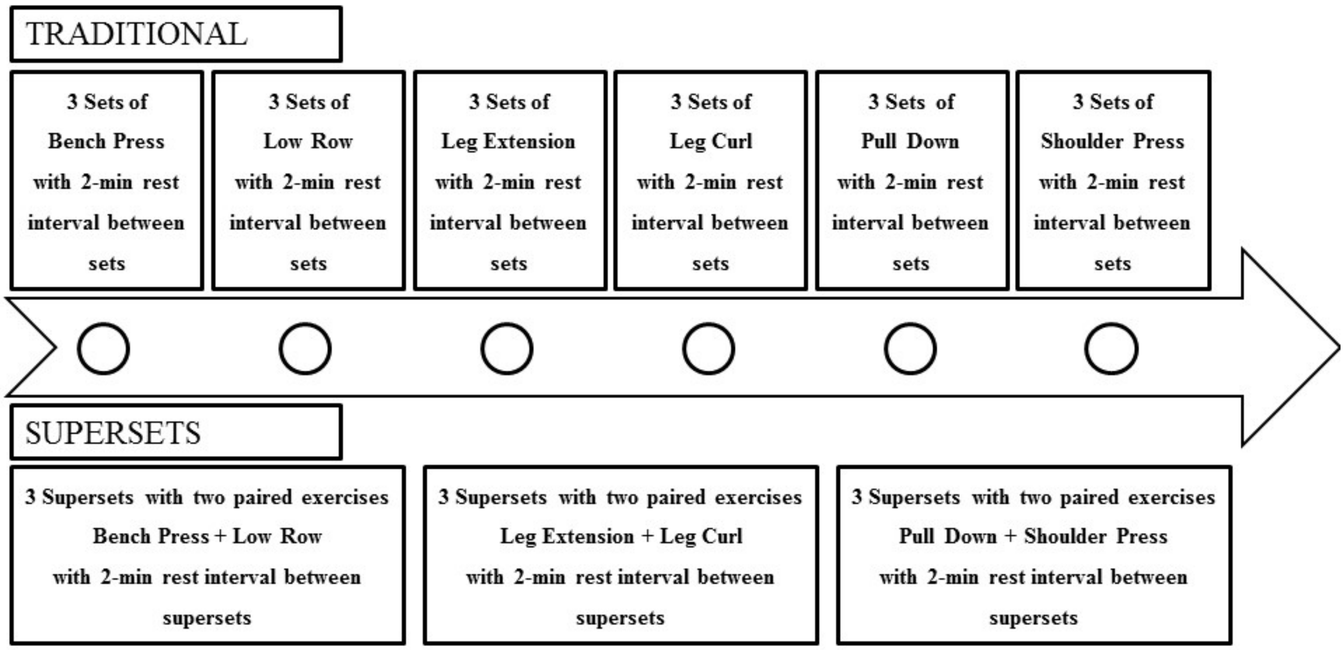

Figure 1. Schematic representation of the traditional (TRAD) and reciprocal supersets (SS) research designs.

All the exercises were performed with 10RM load in both protocols. The TRAD adopted 2-min rest periods between sets and exercises. The SS design adopted 2-min rest periods between supersets.

The 10RM tests were performed in two nonconsecutive days to obtain reliable loads in the following exercise sequence: CP, LR, LE, LC, PD, and SP. During all 10RM tests, before the first attempt, participants warmed up by performing 10 repetitions with 40% of their estimated 10RM (based on their reported training load) followed by three 10RM sets for each exercise were performed, and if the subject did not achieve 10RM in the first attempt, the weight was adjusted by 4–10 kg. Only three trials were allowed per testing session to minimize neuromuscular fatigue. The rest interval lengths adopted during the test were 5 minutes between sets and 10 minutes between exercises. During the exercises, the participants were instructed to maintain correct movement techniques, and the highest load completed was considered the 10RM (35).

The two RT sessions were performed on nonconsecutive days with at least 48 hours between experimental sessions. In all experimental conditions, a warm-up set of 10 repetitions of each exercise at 40% of 1RM was performed, followed by each experimental design (SS or TRAD), depending on random assignment. The TRAD design progressed with each exercise performed separately. Three sets were performed for each exercise and rest interval periods of 2 min between sets and exercise were provided with the followed sequence: CP, LR, LE, LC, PD, and SP (Figure 1). The SS method used the same approach as the TRAD, with three sets of each exercise, however, using supersets with the combination between two exercises of antagonist movements: CP and LR, LE and LC, and PD and SP. A rest interval period of 2 min was used between supersets (Figure 1). During the movement, no pauses were permitted between the eccentric and concentric phase. Velocity of repetitions were controlled by a metronome set to 60 beats per minute, thus allowing for one second concentric phase and a three second eccentric phase per repetition (Wittner Taktell Eletronic Metronome, Germany). During all RT sessions, participants were asked to avoid performing a Valsalva maneuver to minimize any potential risks during the exercise session (13). Training sessions of individual participants were performed at approximately the same time of the day (within ± 1 hr). All sets were performed bilaterally and until momentary muscle failure.

Measurements of BP [systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP)] were performed using an automatic oscillometric device (PM50 NIBP/SpO2. CONTEC - EUA). The equipment was auto calibrated before each use. All participants rested quietly before the experimental session. They rested in a seated position during 15 minutes, after which baseline BP was measured. Intraclass coefficient correlation (ICC) results from our laboratory indicate high reliability (SBP, $r = .99$; DBP, $r = .97$; MAP, $r = .998$). After each experimental session the participants stayed seated in the laboratory in an isolated and quiet environment with controlled temperature between 22-24 degrees Celsius. Blood pressure was assessed at rest and at 10, 20, 30, 40, 50, and 60 minutes after the training session, resulting in seven measurements. All participants remained seated during the BP assessments. Recommendations by the American Heart Association (28) were followed to ensure the accuracy of the BP monitor. In the resting condition, all participants were tested at the start of the monitoring period (26), and this equipment was used for all pre- and post-session BP measurements and was compared with a sphygmomanometer and auscultation methods. The cuff size followed the recommendations of the American Heart Association (28). Measurements were performed on the left arm for every assessment (20, 28). The MAP was calculated with the followed equation: MAP = DBP + [0.333 × (SBP - DBP)] (24).

Statistical Analysis

Statistical analysis was performed using the Shapiro–Wilk normality test and the homoscedasticity test (Bartlett criterion). The results of BP displayed normal distribution and homoscedasticity ($p > .05$). Two-way repeated measures ANOVAs (group [SS vs. TRAD] × time [rest vs. 10 min vs. 20 min vs. 30 min vs. 40 min vs. 50 min vs. 60 min]) followed by Tukey's post hoc test were used for the analyses of possible differences in SBP, DBP, and MAP. Total work (TW) was calculated by multiplying the total repetitions (1st set + 2nd set + 3rd set) by the workload (kg) and paired tests were used to examine possible differences between groups (TRAD vs. SS). The level of significance was set at $p < .05$. All statistical analyses were carried out using SPSS statistical software package version 20.0 (SPSS Inc., Chicago, IL).

RESULTS

Figures 3, 4, and 5 display mean and standard deviation values. The TW results showed significant differences between exercise groups TRAD vs. SS (TRAD = 8277.38 ± 1399.90 kg versus SS = 7594.90 ± 1624.51 kg; $p = .0303$, Figure 2).

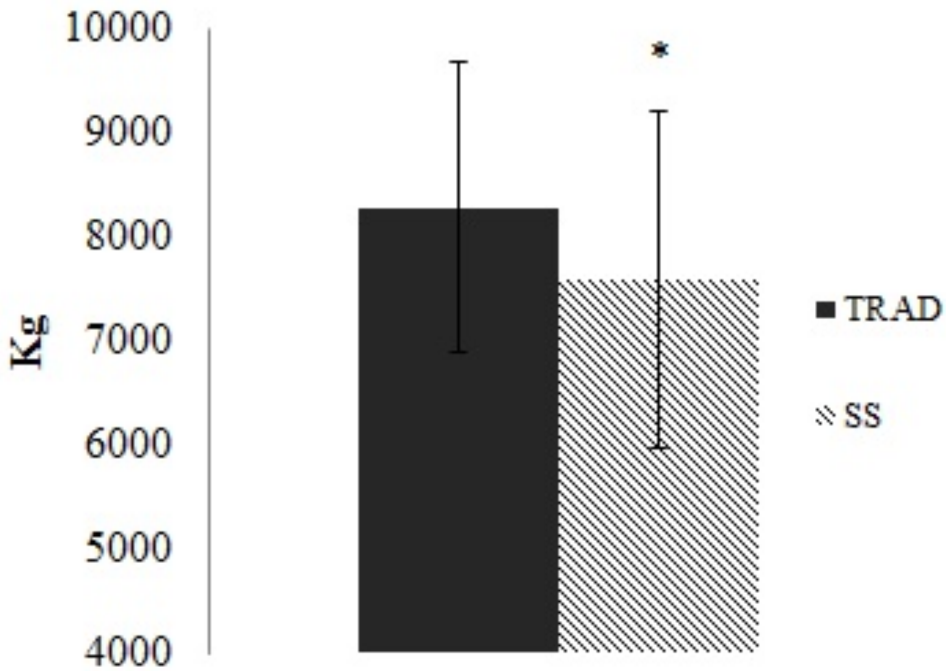

Figure 2. Total work results. * - Significant differences between TRAD vs. SS.

For SBP, there was a significant two-way interaction for group × time ($p < .001$). In addition, there were main effects for time ($p < .001$) and group ($p < .001$). However, on timeline measurements, compared with the baseline values, there were significant differences after 30 to 40 minutes for the TRAD method (30 minutes [$p < .001$] and 40 minutes [$p < .001$], Figure 3) or the mean changes between each post-exercise value versus baseline (mmHg) (TRAD - 10-minute =-2.85; 20-minute = -7.23; 30-minute = -11.31; 40-minute = -14.23; 50-minute = -5.62; 60-minute = -5.15 and SS - 10-minute = -2.87, 20-minute = -6.40; 30-minute = -8.00; 40-minute = -6.13; 50-minute = -6.73; 60-minute = -2.80). There were no significant differences in timeline measurements compared with baseline values for the SS method ($p > .05$). There were significant differences between protocols (TRAD vs. SS) at 20 minutes ($p < .001$), 30 minutes ($p < .001$), and 40 minutes ($p < .001$).

For DBP, there was no significant two-way interaction for group × time. In addition, there were no main effects for group or time (Figure 4) or the mean changes between each post-exercise value versus baseline (mmHg) (TRAD- 10-minute = -3.46; 20-minute = -6.00; 30-minute = -8.31; 40-minute = -10.00; 50-minute = -4.92; 60-minute = -4.85 and SS- 10-minute = -3.46; 20-minute = -5.92; 30-minute = -8.15; 40-minute = -9.77; 50-minute = -4.85; 60-minute = -4.77).

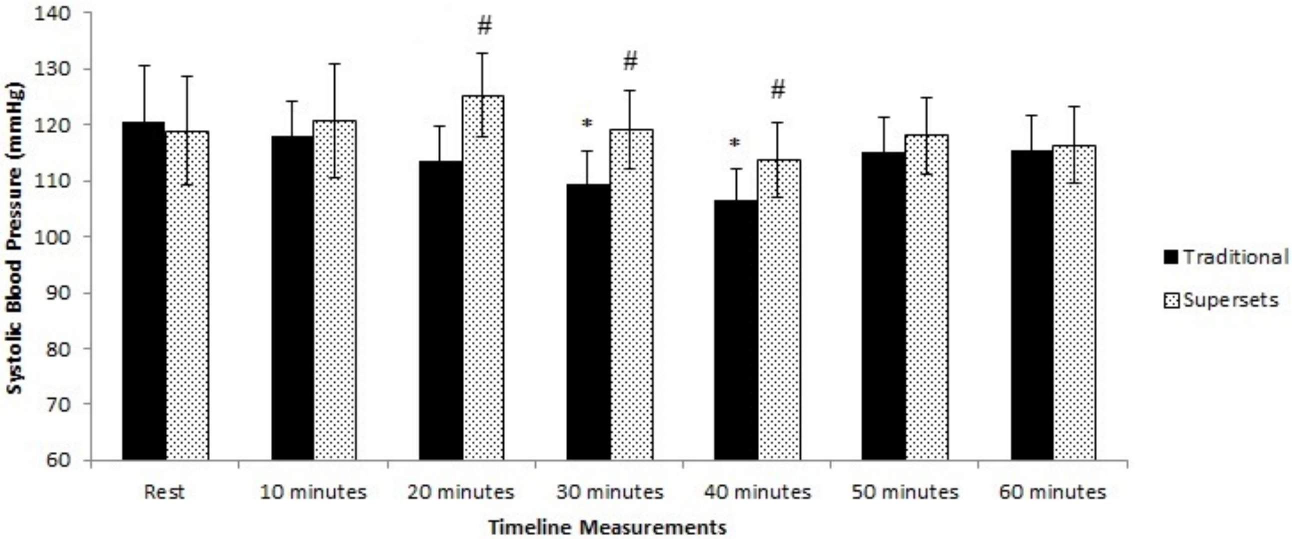

Figure 3. Mean ± standard deviation for systolic blood pressure results (mmHg). * - Significant difference from rest ($p < .05$); # - Significant differences between methods (traditional vs. supersets, $p < .05$).

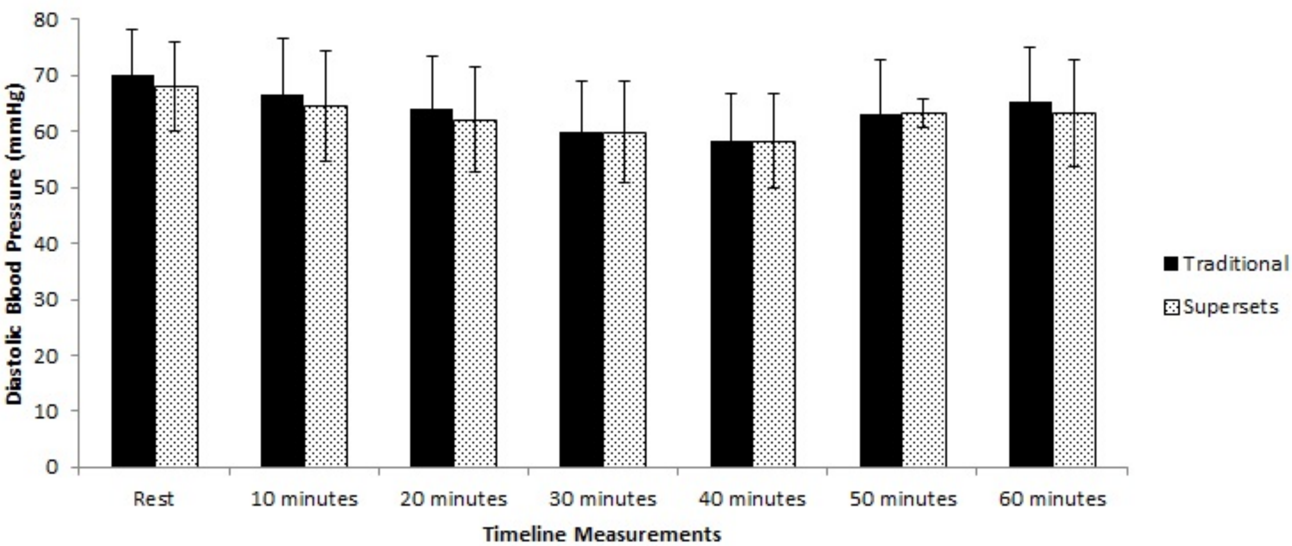

Figure 4. Mean ± standard deviation for diastolic blood pressure results (mmHg).

For MAP, there was a significant two-way interaction for group × time ($p < .001$). In addition, there were main effects for time ($p < .001$) and group ($p < .001$). On timeline measurements, compared with the baseline values, there were significant differences after 30 to 40 minutes for TRAD (30 minutes [$p = .028$] and 40 minutes [$p = .03$], (Figure 5), or the mean changes between each post-exercise value versus baseline (TRAD- 10-minute = -3.23; 20-minute = -6.38; 30-minute = -9.31; 40-minute = -11.31; 50-minute = -5.08; 60-minute = -4.85 and SS- 10-minute = -1.39; 20-minute = -1.77; 30-minute = -5.23; 40-minute = -8.08; 50-minute = -3.46; 60-minute = -3.92). There were no significant differences in timeline measurements compared with baseline values for the SS method. There were significant differences between protocols (TRAD vs. SS) at 50 minutes post-session assessment ($p < .001$).

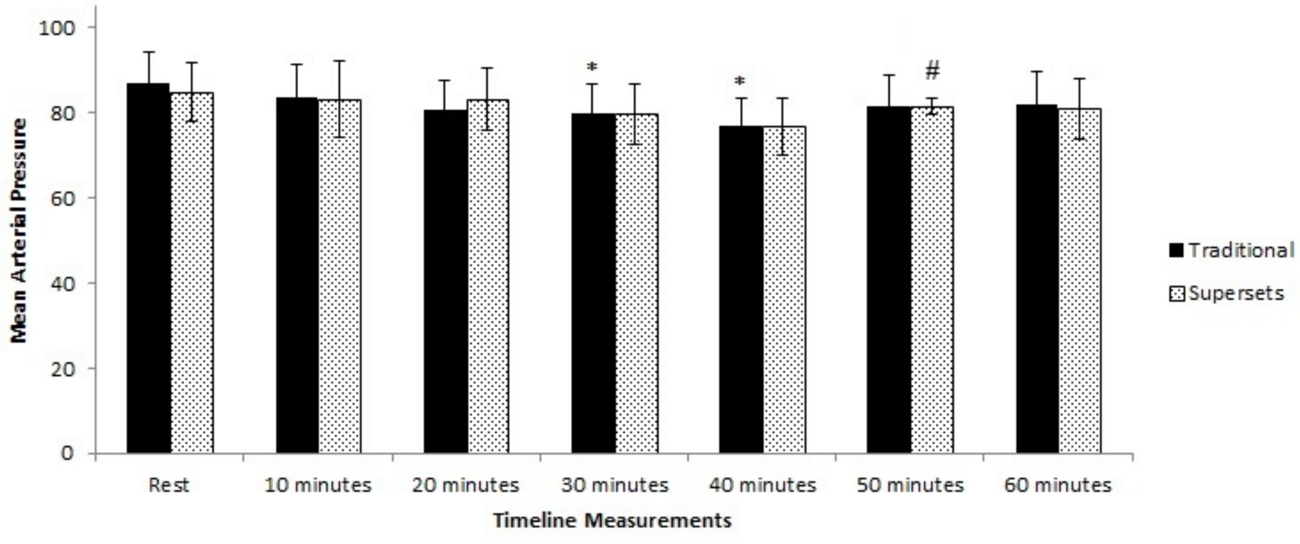

Figure 5. Mean ± standard deviation for mean arterial pressure Results (mmHg). * - Significant difference from rest ($p < .05$); # - Significant differences between methods (traditional vs. supersets, $p < .05$).

DISCUSSION

The present study compared the hypotensive effects of the SS vs. TRAD resistance exercise in apparently healthy men. Currently, no studies have compared the PEH effects of both TRAD and SS methods of training. Thus, the main findings of the present study showed decreases in SBP with the TRAD compared to the SS method (after 20, 30, and 40 minutes), which was not found with the SS method. Nevertheless, there are natural elevations in BP during a RT exercise (37). These increases can rise to high levels during the training session (22), which makes it interesting to understand and to develop strategies to manage this elevation in BP after the end of the RT session (15).

There was a significant difference in TW between groups where TW was lower following SS compared to TRAD. Although in the present study we did not measure perceived exertion (PSE) levels , these differences could be associated with high levels of PSE during a SS session and modify the total time between the sessions (18, 19). The main cause of the differences in TW might be shorter rest periods with the paired agonist-antagonist exercises providing higher intensity levels. Unfortunately, total time in each training session was not measured. Perhaps, this could be examined in future research studies. Thus, the rest interval length is an important variable of prescription in RT that can have a direct influence on the magnitude of BP responses by modifying the training volume. Similar to our results, Polito et al. (29) reported that 2-minute rest intervals were more effective in promoting PEH after a training session than 1-min rest intervals. These results are quite relevant and could potentially be extrapolated to hypertensive and cardiac populations. Regarding intensity, short rest intervals lead to a higher PSE (8), indicating rest interval duration can be inversely associated with the perception of intensity during a RT session (17). In addition, Bentes et al. (2) have previously demonstrated similar responses comparing two different intensities (60 and 80%1RM) and showed a significant hypotensive effect after a training session with both intensities. These results demonstrate it is not necessary to prescribe exhaustive training routines to promote BP reductions, since both intensities were able to lower BP. Thus, our results suggest training with TRAD method could be more efficient for BP decreases than higher levels of intensity in RT sessions using supersets methods.

Some investigations diverged with our results. For instance, Simões et al. (36) and Duncan et al. (7) compared different exercise intensities and training designs and reported higher intensity RT sessions were more effective in reducing BP after the training session. However, the conflicting results could be because in this aforementioned investigation, the intensity control was in overload (percentage of one maximal repetition test), whereas in the present study, the intensity was controlled by different rest interval length (SS and TRAD). Nevertheless, comparing these methods of training, methods without rest intervals or short rest interval duration could have less influence compared to methods with traditional rest intervals in inducing PEH. Hence, this information highlights the importance of the rest interval duration on hemodynamics involved in cardiovascular responses.

Hypotension after RT compared with aerobic exercise presents conflicting results. After an aerobic session, large decreases in BP seem to occur (15, 21). Changes in SBP after RT session have been reported as increasing (14), providing similar values (32), or decreasing (12, 16, 34). The possible explanation for the inconsistent findings could be associated with the participant´s experience, different exercise intensities, or different enzyme polymorphisms such as the angiotensin converting enzyme (ACE) gene, and these differences might have a direct impact in BP decreases after a RT session (9).

Our results demonstrated greater decreases in BP after the training session with the TRAD method, whereas the SS method did not show significant decreases in BP after training, but showed significant decreases in TW. These results for TW may be a key to explain the large decreases in TRAD on the present study's SBP results. Moreover, the TRAD method demonstrated significant differences in SBP from 20 to 40 minutes after the training session compared with the SS method. Figueiredo et al. (10) compared the acute responses of RT prescribed with different numbers of sets (1, 3, and 5 sets) on heart rate variability and PEH in men. The results showed that sessions with high volumes (five sets) were capable of producing significant and extended PEH. According to our results, the volume of training is an important training variable to manipulate and might be associated with BP hypotension after RT. In the present study's research design, we did not equate the total work in order to not disfigure the research design, the training volume is an importance variable of the training to elucidate a PEH, and this might be an important limitation of the study. However, the participants in the present study were classified with BP within normal levels. Thus, research studies with similar methodologies are suggested in hypertensive populations.

In conclusion, the TRAD method of RT (three sets of 10RM, using upper and lower body exercises, and performed with 2-min rest intervals between sets and exercises) promoted a significant and short-term PEH in apparently healthy men and showed relevant information for the fitness professional. These results demonstrate higher decreases in BP after the training session with the TRAD method, whereas the SS method did not show significant decreases in BP after the training. Moreover, the TRAD method compared with a SS method demonstrated significant differences in SBP from 20 to 40 minutes after the training session. These findings are important to elucidate concerns regarding the PEH after RT and showed that TW might be the key to promote these changes. Hence, the results of the present study are important for strength and conditioning coaches and personal trainers to be aware of when prescribing SS training methods regarding BP responses during and after a training session, particularly in pre-hypertensive or those with diagnosed hypertension. Moreover, safety during and after RT is important, in addition to helping to reduce the risk of cardiovascular incidents. Strength and conditioning professionals can prescribe exercises with TRAD methods if the aim is to acutely reduce BP after training. Furthermore, short-term decreases in BP after a RT session could have positive impacts on early phases of hypertension (1).

REFERENCES

1. ACSM. Exercise and hypertension. Med Sci Sports Exerc 36: 533-553, 2004.

2. Bentes CM, Costa PB, Rodrigues Neto G, Costa e Silva GV, De Salles BF, Miranda HL, Novaes JS. Hypotensive effects and performance responses between different resistance training intensities and exercise orders in apparently health women. Clin Physiol Funct Imaging 35(3): 185–190, 2015.

3. Bentes CM, Simão R, Bunker T, Rhea MR, Miranda HL, Gomes TM, Novaes JS. Acute effects of dropsets among different resistance training methods in upper body performance. J Hum Kinet 34(1): 105-111, 2012.

4. Caruso FR, Arena R, Phillips SA, Bonjorno JC, Mendes RG, Arakelian VM, Bassi D, Nogi C, Borghi-Silva A. Resistance exercise training improves heart rate variability and muscle performance: a randomized controlled trial in coronary artery disease patients. Eur J Phys Rehabil Med 51(3): 281-289, 2015.

5. Casonatto J, Goessler KF, Cornelissen VA, Cardoso JR, Polito MD. The blood pressure-lowering effect of a single bout of resistance exercise: A systematic review and meta-analysis of randomised controlled trials. Eur J Prev Cardiol 23(16): 1700-1714, 2016.

6. Cornelissen VA, Smart NA. Exercise training for blood pressure: a systematic review and meta-analysis. J Am Heart Assoc 2(1): e004473, 2013.

7. Duncan MJ, Birch SL, Oxford SW. The effect of exercise intensity on postresistance exercise hypotension in trained men. J Strength Cond Res 28(6): 1706-1713, 2014.

8. Farah BQ, Lima AHRA, Lins-Filho OL, Souza DJCA, Silva GQM, Robertson RJ, Cyrino ES, Ritti-Dias RM. Effects of rest interval length on rating of perceived exertion during a multiple-set resistance exercise. Percept Mot Skills 115(1): 273-282, 2012.

9. Fernandes MO, Azevêdo LM, Dolabella SS, Pardono E. Influence of I/D polymorphism of the ace gene on PEH in normotensive young men. Rev Bras Med Esporte 21(4): 308-312, 2015.

10. Figueiredo T, Rhea MR, Peterson M, Miranda HL, Bentes CM, Reis VMR, Simão R. Influence of number of sets on blood pressure and heart rate variability after a strength training session. J Strength Cond Res 29(6): 1556-1563, 2015.

11. Figueiredo T, Willardson JM, Miranda HL, Bentes CM, Reis VM, Simão R. Influence of load intensity on postexercise hypotension and heart rate variability after a strength training session. J Strength Cond Res 29(10): 2941-2948, 2015.

12. Fisher M. The effect of resistance exercise on recovery blood pressure in normotensive and borderline hypertensive women. J Strength Cond Res 15(2): 210-216, 2001.

13. Fleck SJ, Kraemer WJ. Designing Resistance Training Programs. 6th ed: Human Kinetics 2014.

14. Focht BC, Koltyn KF. Influence of resistance exercise of different intensities on state anxiety and blood pressure. Med Sci Sports Exerc 31(3): 456-463, 1999.

15. Forjaz CL, Tinucci T, Ortega KC, Santaella DF, Mion D, Negrão CE. Factors affecting post-exercise hypotension in normotensive and hypertensive humans. Blood Press Monit 5(5-6): 255-262, 2000.

16. Hardy DO, Tucker LA. The effects of a single bout of strength training on ambulatory blood pressure levels in 24 mildly hypertensive men. Am J Health Promot 13(2): 69-72, 1998.

17. Kelleher AR, Hackney KJ, Fairchild TJ, Keslacy S, Ploutz-Snyder LL. The metabolic costs of reciprocal supersets vs. traditional resistance exercise in young recreationally active adults. J Strength Cond Res 24(4): 1043-1051, 2010.

18. Kraft JA, Green JM, Gast TM. Work distribution influences session ratings of perceived exertion response during resistance exercise matched for total volume. J Strength Cond Res 28(7): 2042-2046, 2014.

19. Kraft JA, Green JM, Thompson KR. Session ratings of perceived exertion responses during resistance training bouts equated for total work but differing in work rate. J Strength Cond Res 28(2): 540-545, 2014.

20. Kurtz TW, Griffin KA, Bidani AK, Davisson RL, Hall JE. Recommendations for blood pressure measurement in humans and experimental animals part 2: blood pressure measurement in experimental animals. A statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Arterioscler Thromb Vasc Biol 25(3): e22-e33, 2005.

21. MacDonald JR. Potential causes, mechanisms, and implications of post exercise hypotension. J Hum Hypertens 16(4): 225-236, 2002.

22. MacDougall JD, Tuxen DSDG, Sale DG, Moroz JR, Sutton JR. Arterial blood pressure response to heavy resistance exercise. J Appl Physiol 58(3): 785-790, 1985.

23. Maia MF, Willardson JM, Paz GA, Miranda HL. Effects of different rest intervals between antagonist paired sets on repetition performance and muscle activation. J Strength Cond Res 28(9): 2529-2535, 2014.

24. McArdle WD, Katch FI, Katch VL. Exercise physiology: nutrition, energy, and human performance: Lippincott Williams & Wilkins; 2010.

25. Nicolino J, Ramos D, Leite MR, Rodrigues FMM, de Alencar Silva BS, Tacao GY, Toledo AC, Vanderlei LCM, Ramos EMC. analysis of autonomic modulation after an acute session of resistance exercise at different intensities in chronic obstructive pulmonary disease patients. Int J Chron Obstruct Pulmon Dis 10: 223-229, 2015.

26. O'Brien E, Parati G, Stergiou G, Asmar R, Beilin L, Bilo G, Clement D, Sierra A, Leeuw P, Dolan E. European Society of Hypertension position paper on ambulatory blood pressure monitoring. J Hypertens 31(9): 1731-1768, 2013.

27. Paz GA, Robbins DW, Oliveira CG, Bottaro M, Miranda HL, Janeiro RJ, Robbins D. Volume load and neuromuscular fatigue during an acute bout of agonist-antagonist paired-set versus traditional-set training. J Strength Cond Res, In Press doi: 10.1519/JSC.0000000000001059.

28. Pickering TG, Hall JE, Appel LJ, Falkner BE, Graves J, Hill MN, Jones DW, Kurtz T, Sheps SG, Roccella EJ. Recommendations for blood pressure measurement in humans and experimental animals part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Circulation 111(5): 697-716, 2005.

29. Polito MD, Simão R, Nóbrega ACL, Farinatti PTV. Pressão arterial, frequência cardíaca e duplo-produto em séries sucessivas do exercício de força com diferentes intervalos de recuperação. Rev Port Cien Desp 4(3): 7-15, 2004.

30. Robbins DW, Young WB, Behm DG, Payne WR. Agonist-antagonist paired set resistance training: A brief review. J Strength Cond Res 24(10): 2873-2882, 2010.

31. Robbins DW, Young WB, Behm DG, Payne WR. The effect of a complex agonist and antagonist resistance training protocol on volume load, power output, electromyographic responses, and efficiency. J Strength Cond Res 24(7): 1782-1789, 2010.

32. Roltsch MH, Mendez T, Wilund KR, Hagberg JM. Acute resistive exercise does not affect ambulatory blood pressure in young men and women. Med Sci Sports Exerc 33(6): 881-886, 2001.

33. Rossi AM, Moullec G, Lavoie KL, Gour-Provençal G, Bacon SL. The evolution of a Canadian Hypertension Education Program recommendation: the impact of resistance training on resting blood pressure in adults as an example. Can J Cardiol 29(5): 622-627, 2013.

34. Salles BF, Maior AS, Polito MD, Novaes J, Alexander J, Rhea M, Simão R. Influence of rest interval lengths on hypotensive response after strength training sessions performed by older men. J Strength Cond Res 24(11): 3049-3054, 2010.

35. Simão R, Farinatti PTV, Polito MD, Maior AS, Fleck SJ. Influence of exercise order on the number of repetitions performed and perceived exertion during resistance exercises. J Strength Cond Res 19(1): 152-156, 2005.

36. Simões GC, Moreira SR, Kushnick MR, Simões HG, Campbell CSG. Postresistance exercise blood pressure reduction is influenced by exercise intensity in type-2 diabetic and nondiabetic individuals. J Strength Cond Res 24(5): 1277-1284, 2010.

37. Sousa NMF, Magosso RF, Dipp T, Plentz RDM, Marson RA, Montagnolli AN, Martins RAS, Perez SEA, Baldissera V. Continuous blood pressure response at different intensities in leg press exercise. Eur J Prev Cardiol 21(11): 1324-1331, 2014.