Influence of Number of Sets on Blood Pressure and Heart Rate Variability After a Strength Training Session

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Abstract

Figueiredo, T, Rhea, MR, Peterson, M, Miranda, H, Bentes, CM, Machado de Ribeiro dos Reis, V, and 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—The purpose of this study was to compare the acute effects of 1, 3, and 5 sets of strength training (ST), on heart rate variability (HRV) and blood pressure. Eleven male volunteers (age: 26.1 ± 3.6 years; body mass: 74.1 ± 8.1 kg; height: 172 ± 4 cm) with at least 6 months previous experience in ST participated in the study. After determining the 1 repetition maximum (1RM) load for the bench press (BP), lat pull down (LPD), shoulder press (SP), biceps curl (BC), triceps extension (TE), leg press (LP), leg extension (LE), and leg curl (LC), the participants performed 3 different exercise sequences in a random order and 72 hours apart. During the first sequence, subjects performed a single set of 8–10 repetitions, at 70% 1RM, and with 2-minute rest interval between exercises. Exercises were performed in the following order: BP, LPD, SP, BC, TE, LP, LE, and LC. During the second sequence, subjects performed the same exercise sequence, with the same intensity, 2-minute rest interval between sets and exercises, but with 3 consecutive sets of each exercise. During the third sequence, the same protocol was followed but with 5 sets of each exercise. Before and after the training sessions, blood pressure and HRV were measured. The statistical analysis demonstrated a greater duration of postexercise hypotension after the 5-set program vs. the 1 set or 3 sets ($p \leq 0.05$). However, the 5-set program promoted a substantial cardiac stress, as demonstrated by HRV ($p \leq 0.05$). These results indicate that 5 sets of 8–10 repetitions at 70% 1RM load may provide the ideal stimulus for a postexercise hypotensive response. Therefore, ST composed of upper- and lower-body exercises and performed with high volumes are capable of producing significant and extended postexercise hypotensive response. In conclusion, strength and conditioning professionals can prescribe 5 sets per exercises if the goal is to reduce blood pressure after training. In addition, these findings may have importance, specifically in the early phase of high blood pressure development, but more research is needed in hypertensive populations to validate this hypothesis.

Key Words resistance exercises, hypotension, autonomic control, resistance training

Introduction

Exercise training has been recommended as a nonpharmacological behavioral intervention to prevent and treat cardiovascular disorders (1,2). Strength training (ST) is an important component of exercise programming and is known to promote acute reductions in blood pressure, a phenomenon called postexercise hypotension, which may play an important role in controlling hypertension and cardiovascular risk (1,2). A small reduction in blood pressure (i.e., 3 mm Hg) reduces the possibility of stroke and coronary arterial disease in normotensive or hypertensive subjects; therefore, ST may represent a useful tool in altering blood pressure during the day and over time (1,2).

Several studies have examined postexercise hypotension after acute ST sessions with varying modalities (16), intensities (12,16), rest intervals (5), and exercise orders (7), but only 2 studies have analyzed this phenomenon after ST was performed with different number of sets. Polito and Farinatti (11) analyzed the effect of the number of sets (6 sets vs. 10 sets) on 2 exercises (leg press [LP] and biceps curls [BC]) on normotensive trained men. They demonstrated that high-volume multiple-set training (i.e., 10 sets) promoted significantly greater postexercise hypotension, and

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that the muscle mass involved in an ST had an influence on the extent of postexercise hypotension. Conversely, Scher et al. (14) analyzed the effect of 1 and 2 sets, performed in a circuit format, in sedentary, hypertensive older men and women. The results of their study showed that acute ST performed in circuit format with different volumes reduced blood pressure during the first 60 minutes after exercise; however, higher volume (i.e., 2 sets) promoted a reduction of mean 24-hour blood pressure. To date, no previous study has analyzed the effect of 3 different volumes of total body ST on blood pressure and heart rate variability (HRV). Continued research related to this topic has important professional value, as we attempt to better define the most appropriate ST prescription for individuals with, or at risk for, cardiovascular disease (11).

Heart rate variability is a reflection of changes in the autonomic nervous system that exert influence on the heart. The study of this variable is very important to examine the integration of the autonomic nervous system and the cardiovascular system. In addition, decreased HRV in apparently healthy subjects or after myocardial infarction is a risk factor for mortality (18). There is ample evidence to demonstrate the role of aerobic exercise in improving HRV among high-risk patients (3). However, at present, few studies have investigated the effect of ST on HRV (7,12), and there is virtually no evidence to compare differing volumes of ST on HRV. This study serves an important role in delineating the effects of ST on blood pressure and HRV and can assist the exercise professional in choosing the appropriate prescription among healthy and at-risk populations.

Thus, it is necessary to better understand the influence of differing volumes of ST on both blood pressure control and HRV. Such evidence will provide insight into alternative options to complement or replace traditional aerobic exercise for preventing or treating cardiovascular risk and the mechanisms of blood pressure control. Therefore, the purpose of this study was to compare the effects of 1, 3, and 5 sets in an ST session on the blood pressure and HRV in trained men. It was hypothesized that higher volumes of ST would have a pronounced and longer effect on blood pressure and HRV.

Methods

Experimental Approach to the Problem

Blood pressure and HRV were measured before (after 10-minute rest on arrival at the laboratory) and at 10-minute intervals for 60 minutes after the 3 different sessions. After assessment of 1RM loads for the bench press (BP), lat pull down (LPD), shoulder press (SP), BC, triceps extension (TE), leg press (LP), leg extension (LE), and leg curl (LC), subjects performed 3 sessions with 72-hour recovery between sessions. During sequence 1 set (S1), subjects performed 1 set of 8–10 repetitions at 70% of 1RM, with 2-minute rest intervals between sets and exercises, and in the following order: BP, LPD, SP, BC, TE, LP, LE, and LC. During sequence 3 sets (S3) and sequence 5 sets (S5), subjects performed the same protocol but with 3 sets or 5 sets, respectively. The procedures were the same other than different training number of sets performed.

Subjects

Eleven normotensive men with previous experience in ST participated in this study (age: 26.09 ± 3.56 years; body mass: 74.11 ± 8.12 kg; height: 172 ± 4 cm; BMI: 25 ± 1.96 $kg \cdot m^{-2}$; % body fat: 18.26 ± 6.35%; experience >6 months). Their regular ST program before the study generally involved multiple-set ST programs performed 3 times per week with moderate to high intensity and 1- to 2-minute rest intervals. According to the criteria established by the Seventh Joint National Committee (4), the following criteria were adopted for subject recruitment: (a) nonsmokers, (b) absence of any kind of cardiovascular or metabolic disease, (c) no articular or bone injury, and (d) absence of any medication that could influence the cardiovascular response. The subjects were informed about the study procedures, possible risks, and benefits, and they signed a consent form. This study was reviewed and approved by the Ethics Committee of the Rio de Janeiro Federal University for research with human subjects. Before the start of each session, subjects were instructed not to consume any caffeinated or alcoholic beverage and were encouraged to maintain their usual activities and eating habits throughout the study period.

Procedures

One Repetition Maximum Testing. During the first laboratory visit, the subjects' height and weight were measured by means of an analogical scale and a stadiometer (Toledo, Brazil) followed by 1RM testing. The 1RM testing began with a warm-up with 50% of the predicted 1RM. After 5-minute rest, each subject was encouraged to perform 1 repetition with a heavier load if possible. If the attempt was successful, the load was increased and the attempt repeated to achieve the 1RM load. After 72 hours, a second visit occurred and the 1RM test was repeated; the highest successful lift was recorded as the 1RM (17). The exercises performed were the BP, LPD, SP, BC, TE, LP, LE, and LC. The 1RM assessments were divided over a 4-day period. On the first and third days, BP, LE, BC, and LC were tested and retested, on second and fourth days, LPD, LP, SP, and TE were performed. To minimize the error during 1RM tests, the following strategies were adopted: (a) standardized instructions concerning the testing procedure were given to participants before the test; (b) participants received standardized instructions on exercise technique; (c) verbal encouragement was provided during the testing procedure; and (d) the mass of all weights and bars used were determined using a precision scale. The 1RM was determined in fewer than 3 attempts with a rest interval of 5 minutes between 1RM attempts and 10 minutes was allowed before starting the 1RM assessment of the next exercise. The range of motion of exercises used was similar to that by Simão et al (17). The 1RM data were analyzed using intraclass correlation coefficients (BP, $r = 0.99$; LPD, $r = 0.96$; SP, $r = 0.98$; BC, $r = 0.94$; TE, $r = 0.97$; LP, $r = 0.97$; LE, $r = 0.90$; and LC, $r = 0.97$) and showed high reliability.

Exercise Sessions. Seventy-two hours after the 1RM assessment, the subjects performed one of the 3 exercise sequences in a randomized design. The second session was performed 72 hours after the first session, and the same interval procedure was applied for the third session. The 3 sessions used the same exercises performed with 3 different numbers of sets. S1 was performed with 1 set of each exercise, S3 was performed with 3 sets of each exercise, and S5 was performed with 5 sets of each exercise. Exercises were performed in set/repetition format, where the prescribed number of sets was completed for each exercise before moving to the next exercise. The exercise order for all sequences was BP, LPD, SP, BC, TE, LP, LE, and LC. Bench press, SP, and BC were performed with free weights, and LPD, TE, LP, LE, and LC were performed with Life Fitness exercise machines (Optima Series, USA). The rationale for performing lower-body exercises last in sequence was related to the muscle mass involved in lower-body exercises as muscle mass can influence the postexercise hypotension response (11). The warm-up procedure for each sequence consisted of 1 set with 10 repetitions of BP and LP for all sequences at 40% of 1RM. A 2-minute rest interval was allowed after the warm-up and before subjects performed the assigned exercise sequence. All exercise sequences were performed with 70% of 1RM loads, with 2-minute rest intervals between sets and exercises. During the exercise sessions, subjects were verbally encouraged to perform 8 to 10 repetitions in all sets. Successful repetitions used a complete range of motion as defined during 1RM testing. No pause was allowed between the eccentric and concentric phase of each repetition. During all training sessions, participants were asked to avoid the Valsalva maneuver. No attempt was made to control the velocity with which repetitions were performed. The total number of repetitions for each set of each exercise was determined to calculate the total volume of work performed.

Measures of Heart Rate and Heart Rate Variability. A heart rate (HR) monitor (Polar, Polar RS800CX, Finland) was used for 10 minutes before and for 60 minutes after the sessions for monitoring HR and HRV. Data were recorded on the equipment and then immediately downloaded to the computer to be analyzed. After this procedure, the data were digitized in Matlab (Matlab version 6.0; MathWorks, MA, USA) for analysis on time domain and frequency. The spectral analysis in the frequency domain was performed using the Fourier transform algorithm. The HRV parameters were analyzed according to the components of low frequency in normalized units (LF-nu), which provides information about sympathetic nervous system, high frequency in normalized units (HF-nu), which provides information about parasympathetic nervous system, and the *SD* of differences between adjacent normal R-R intervals (RMSSD), which provides information about the predominance of sympathetic or parasympathetic nervous system, after Fourier transformation and noise filtering (18). Data were collected at rest

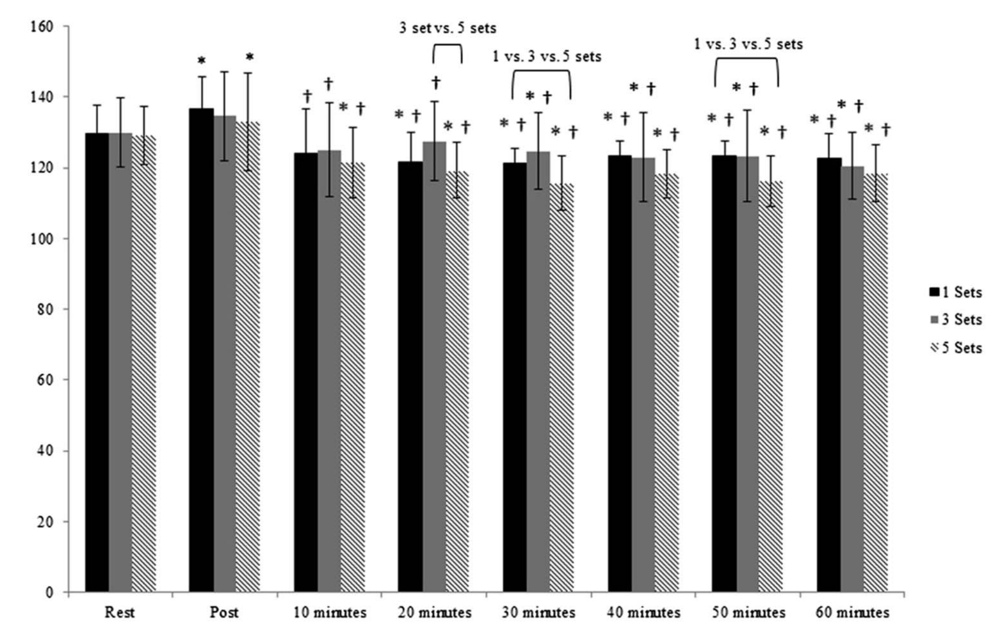

Figure 1. Systolic blood pressure response to 3 strength training exercise sessions (mean ± *SD*). *Significant difference from rest in the same session ($p \leq 0.05$). †Significant differences from postsession in the same session ($p \leq 0.05$).

and before and after an ST session. Subjects remained at rest in a seated position in a quiet room with temperature maintained between 20° and 22° C.

Arterial Blood Pressure Assessment. Systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were measured using an automatic oscillometric device (Contec PM50 NIBP/Spo2, Contecmed, Qinhuangdao, China). The equipment was auto calibrated before each use. The resting blood pressure value was averaged over 2 consecutive measurements with an interval of 5 minutes after the individual remained in a seated position for 10 minutes in a quiet environment. After the ST bout, blood pressure was assessed every 10 minutes over a 60-minute period, in a calm environment with temperature (22° C), and relative humidity recorded resulting in a total of 6 measurements after each training session. Measurements were performed in the left arm, following the recommendations of the American Heart Association (2).

Statistical Analyses

Data for all variables were analyzed using the Shapiro-Wilk normality test and homocedasticity (Bartlett criterion). For normally distributed variables, 1-way analysis of variance was applied to compare the following parameters: 1RM test and retest and total number of repetitions performed in S1, S3, and S5, the resting values of SBP, DBP, MAP, HR, RMSSD, LF-nu, and HF-nu. Subsequently, the resting values and postexercise measures were compared within and between sessions for multivariate analysis of variance with repeated measures. In all cases, the post hoc Tukey was used to locate statistically significant differences. Additionally, to determine the magnitude of the findings, effect sizes (ESs; the difference between pretest and posttest scores divided by the pretest SD) were calculated for the SBP, DBP, MAP, and RMSSD for all exercise sequences. The scale proposed by Rhea (13) was used to determine the magnitude of the ES. Alpha was set at $p \leq 0.05$, and all tests were performed with the SPSS (version 19.0; Graphpad).

Results

All tested variables followed a normal distribution. There were significant differences between S3 and S5 at 20 minutes post-ST and the 3 exercise sequences on 30 and 50 minutes in SBP ($p \leq 0.05$). In addition, significant reductions were

Table 1. Effect size: SBP, DBP, MAP, and RMSSD after 3 sequences of strength training.*

		10 min	20 min	30 min	40 min	50 min	60 min
SBP							
S1	Magnitude	0.7	1.02	1.03	0.77	0.77	0.85
	Classification	Sm.	Mod.	Mod.	Sm.	Sm.	Mod.
S3	Magnitude	0.5	0.26	0.54	0.71	0.68	0.96
	Classification	Sm.	Sm.	Sm.	Sm.	Sm.	Mod.
S5	Magnitude	0.92	1.18	1.61	1.30	1.54	1.28
	Classification	Mod.	Mod	Large	Mod.	Large	Mod.
DBP							
S1	Magnitude	1.55	1.69	1.51	1.23	0.44	0.63
	Classification	Large	Large	Large.	Mod.	Sm.	Sm.
S3	Magnitude	2.01	1.53	2.08	1.63	1.59	0.97
	Classification	Large	Large	Large	Large	Large	Mod.
S5	Magnitude	0.91	1.35	1.29	0.79	1.02	0.51
	Classification	Mod.	Mod.	Mod.	Sm.	Mod.	Sm.
MAP							
S1	Magnitude	1.55	1.55	1.44	1.14	0.65	0.81
	Classification	Large	Large	Mod.	Mod.	Sm.	Mod.
S3	Magnitude	1.51	1.09	1.57	1.37	1.33	1.07
	Classification	Large	Mod.	Large	Mod.	Mod.	Mod.
S5	Magnitude	1.05	1.49	1.62	1.12	1.39	0.9
	Classification	Mod.	Mod.	Large	Mod.	Mod.	Mod.
RMSSD							
S1	Magnitude	−1.01	−0.69	−0.62	−0.05	−0.38	−0.49
	Classification	Mod	Sm.	Sm.	Trivial	Sm.	Sm.
S3	Magnitude	−1.43	−0.74	−0.47	−0.42	−0.29	0.31
	Classification	Mod	Sm.	Sm.	Sm	Trivial	Trivial
S5	Magnitude	−1.07	−1.02	−0.82	−0.74	−0.58	−0.18
	Classification	Mod	Mod	Mod	Sm.	Sm	Trivial

*SBP = systolic blood pressure; S1 = 1 set; Sm = small; Mod = moderate; S3 = 3 sets; S5 = 5 sets; DBP = diastolic blood pressure; MAP = mean arterial pressure; RMSSD = *SD* of differences between adjacent normal.

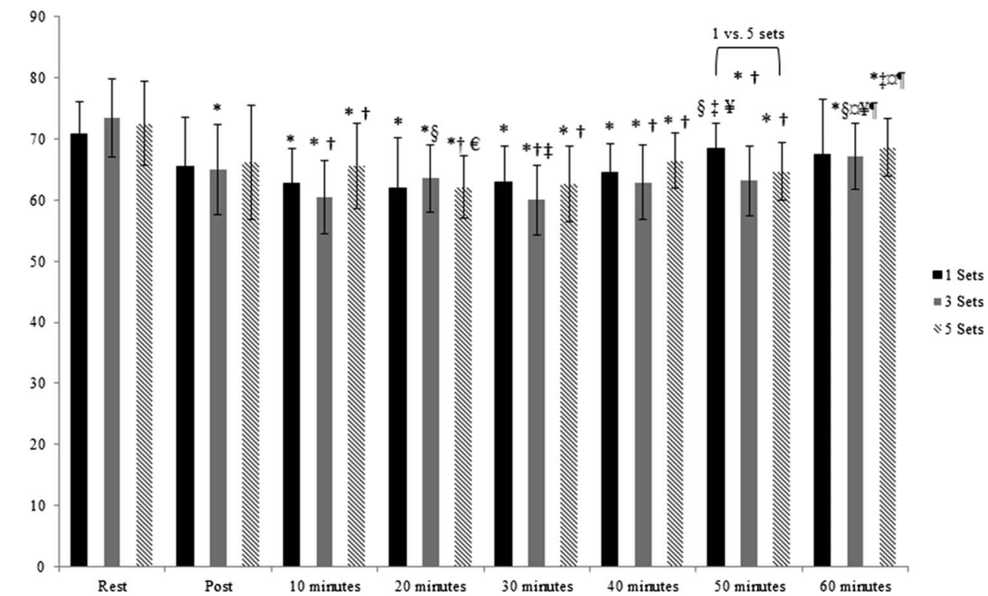

Figure 2. Diastolic blood pressure response to 3 strength training exercise sessions (mean ± *SD*). *Significant difference from rest in the same session ($p \leq 0.05$). †Significant differences from postsession in the same session ($p \leq 0.05$).

found at all time points when compared with the rest period for all training volumes with greater magnitude of S5 (Figure 1 and Table 1). For DBP, there were significant differences in the resting values and all time points for the 3 exercise sequences ($p \leq 0.05$), and significant differences were also found between S1 and S5 at 50 minutes time point (Figure 2). The ES data showed a greater reduction on DBP for S1 and S3 from 10 to 30 minutes (Table 1). Significant reductions

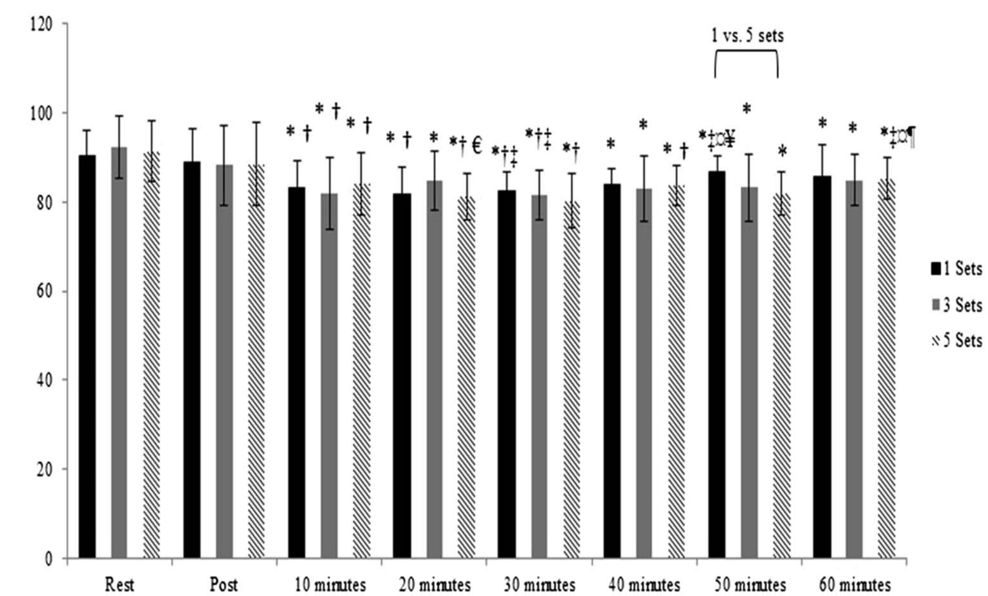

Figure 3. Mean arterial pressure response to 3 strength training exercise sessions (mean ± *SD*). *Significant difference from rest in the same session ($p \leq 0.05$). †Significant differences from postsession in the same session ($p \leq 0.05$).

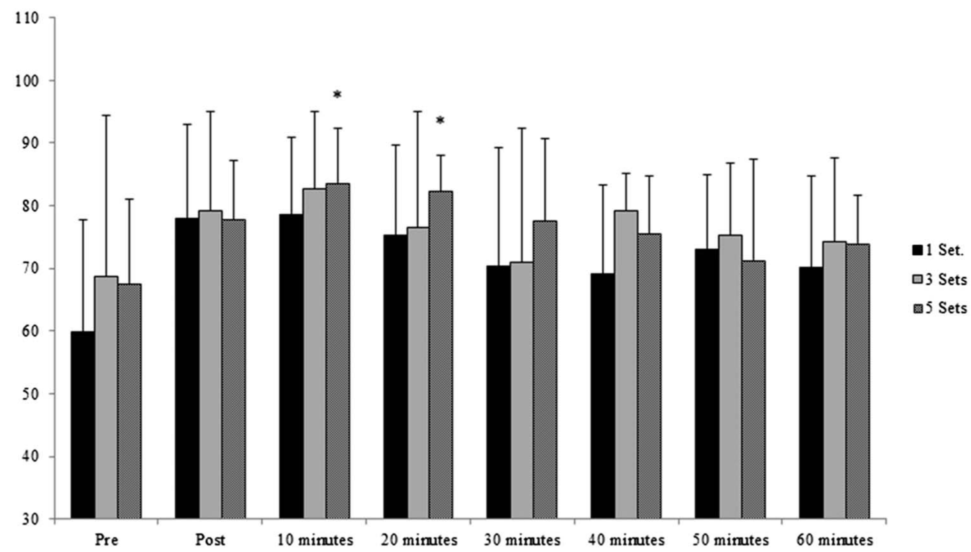

Figure 4. Low frequency response to 3 strength training exercise sessions (mean ± *SD*). *Significant difference from rest in the same session.

were also found in postexercise MAP at all times points for all groups. Mean arterial pressure was significantly different between S1 and S5 at 50 minutes ($p \leq 0.05$) (Figure 3). The ES data showed a greater reduction on MAP for S3 and S5 at all time points (Table 1).

Significant differences were found in LF-nu only when subjects performed 5 sets at 10 and 20 minutes (Figure 4). In relation to HF-nu, significant differences were found at 10 and 20 minutes after the S5, and between S1 and S5 were found at 20-minute time point (Figure 5). The RMSSD value was reduced throughout the 1-hour period after S3 and S5 ST sequences, with significant differences ($p \leq 0.05$) at 10, 20, and 30 minutes after session. The ES showed a greater magnitude of RMSSD reduction at 20 and 30 time points (Table 1).

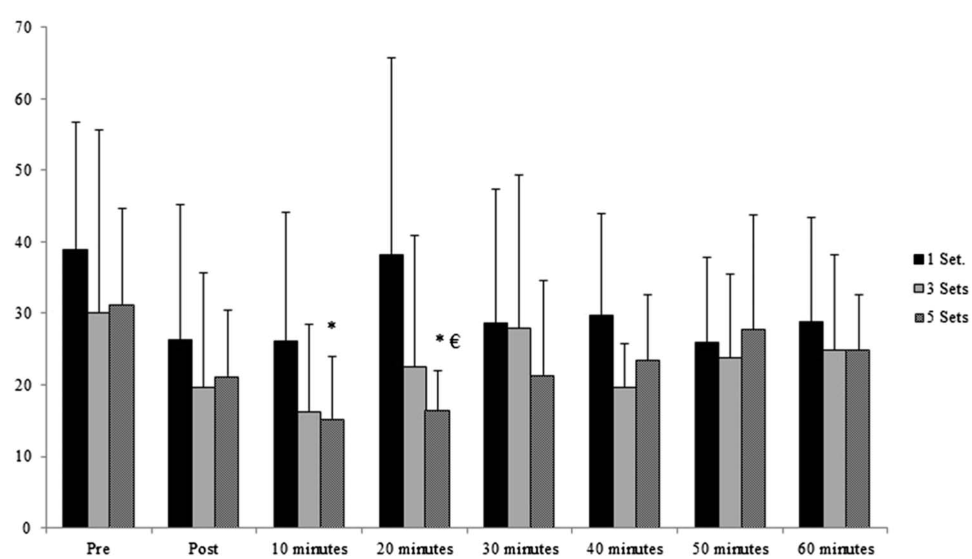

Figure 5. High frequency response to 3 strength training exercise sessions (mean ± *SD*). *Significant differences from rest. €Significant differences between groups from 1 set.

Discussion

The purpose of this study was to compare the effects of 1, 3, and 5 sets during ST on blood pressure and HRV after an ST session. The primary findings of this study were that ST acutely reduces SBP, DBP, and MAP, and the magnitude and duration of the postexercise hypotension are dependent of ST volume. The magnitude and duration of the post-exercise hypotension was found to be contingent on volume such that the 5 sets program induced the greatest effect as compared with the 1- and 3-set programs. Our results demonstrate that higher volume training can elicit a significant postexercise hypotension for 60 minutes, even in recreationally trained men. Our results also revealed a strong influence of higher volume ST on HRV, and thus cardiac autonomic control, after only a single session. Therefore, we have confirmed the hypothesis that higher training volume can elicit a longer postexercise hypotension and exert more influence on HRV.

Our findings showed that the highest volume ST session (5 sets) promoted the greatest alterations on blood pressure and cardiac autonomic control when compared with lower volumes. A large reduction in SBP, DBP, and MAP was found in the 5-set training protocol and can be attributed to the total volume performed in a session. However, a greater increase in sympathetic tonus and a reduction parasympathetic tonus observed in 5-set training protocol when compared with 1-set training protocol and 3-set training protocol may be attributed to the high total volume combined with significant muscular fatigue. It is possible that the high training volume could have elicited an acute cardiovascular imbalance by affecting plasma volume, and thus cardiac output and systolic volume (8,12). Additionally, since concentric failure occurs more frequently when training volume increases, recruitment of additional motor units requires a progressive activation of the sympathetic nervous system to maintain training volume and intensity (15). Finally, these findings may have been caused by greater activation of metaboreceptors, mechanoreceptors, and arterial baroreflex, due to a reduction in blood flow to the active muscles and an increase in peripheral vascular resistance induced by a mechanical occlusion of blood flow (12).

The results of this study are partially in agreement with 3 previous studies (11,14,16). All studies showed greater and longer postexercise hypotension with programs with higher volumes (i.e., 5 vs. 6 exercises in a sequence; 6 vs. 10 sets in only 1 exercise; and 1 vs. 2 sets in a circuit approach). However, no previous studies have analyzed the influence of ST volume in sessions performed in traditional approach on blood pressure and HRV. Simão et al., (16) investigated the effect of 2 different training volumes (5 and 6 exercises in the sequence) on postexercise hypotension in young normotensive trained men and found a longer effect when the ST session was performed with higher volumes and in circuit format. Moreover, Polito and Farinatti (11) compared the effects of 2 different training volumes (i.e., 6 and 10 sets) and the total amount of muscle mass involved in ST session. Their study revealed that the muscle mass activated during ST had an influence in postexercise hypotension, especially in high-volume multiple-set training sessions (i.e., 10 sets in LP). Scher et al., (14) also evaluated the effect of different volumes (1 set vs. 2 sets) of acute low intensity ST, performed in a circuit format, among hypertensive elderly men and women. The results of this study showed significant reductions in blood pressure during the first 60 minutes after exercise, and the highest volume (i.e., 2 sets) promoted a more consistent SBP reduction over 24 hours after training. The differences in total training volume potentially influenced the magnitude and duration of postexercise hypotension after ST; however, studies analyzing the cardiac response after ST performed with different volumes are not reported.

In relation to SBP, DBP, and MAP, this study demonstrated that training volume influenced both the magnitude and duration of blood pressure response. Our data demonstrated a greater magnitude and duration of SBP decrease in 5-set training, when compared with 1-set or 3-set training. However, 3-set ES data presented a greater and longer duration of hypotensive response in DBP for 3 sets compared with 1 set and 5 sets. The results also show a greater and longer decrease in SBP when 5 sets were performed and a greater and longer decrease in DBP when 3 sets were performed. In relation to MAP, greater and longer decreases were found more frequently in multiple-set programs (i.e., 3 and 5 sets). Previous studies that have examined different aspects of postexercise hypotension have demonstrated that ST is capable of reducing SBP, DBP, and MAP (14,16). As observed in this study, the SBP response after ST, specifically in 5 sets, demonstrated a significant reduction in male subjects with previous experience in ST, although other studies demonstrated a hypotensive response after single bouts of training in normotensive and hypertensive subjects (14,16). A possible explanation for the postexercise hypotension after 5 sets is that the high volume, and in consequence, the high intensity of training, at the end of the ST session may result in plasma reduction and an increased cardiac contractile effort to maintain cardiac output (12). However, the influence of the parasympathetic nervous system in 1 set and 3 sets can explain a greater ES in DBP reduction (Figure 5).

The results relative to HRV showed that greater number of sets (i.e., 5 sets) promote a greater cardiac stress (Figures 4 and 5). Recently, Lima et al. (10) demonstrated that cardiac sympathetic activation remains higher than resting values after an upper-body ST session. Their results partially corroborate the current study's results. For example, in the 5-set training protocol, there was an increase in sympathetic activation; however, the reduction of parasympathetic activity observed by the HF-nu band and RMSSD index as compared with the 1-set and 3-set protocols has important practical application. For instance, an increase in sympathetic activation combined with a reduction of parasympathetic activity increases the risk of cardiovascular events in both healthy individuals and patients with cardiovascular disease (18). These findings have clinically significant relevance, as very high volume training may be contraindicated for patients at elevated cardiovascular risk.

Other studies found differences in isolated sessions, and there were some methodological dissimilarities that may have influenced the results. For example, greater changes and longer hypotensive responses to ST were found in individuals who had previous experience in ST with sessions that were performed with greater volume at moderate to high intensity (i.e., 6RM, 12RM, 70% of 10RM and 80% of 1RM) (11,16). Therefore, it is possible that moderate- to high-intensity training (70% of 1RM) performed with multiple sets (3 and 5 sets), and with moderate rest interval between sets and exercises (2 minutes), contributes to a greater and longer postexercise hypotension in trained subjects, but that with 5 sets promotes a major cardiac stress.

Ultimately, it is important to consider some limitations of this study. The SBP can be affected during a supine position after an ST session (6). However, the HRV can be affected during a prolonged seated position, which can lead to a reduction in venous return and increased baroreflex activity (9). Because of a lack of studies reporting the influence of number of sets on blood pressure and HRV after an ST session, a seated position was adopted. We did not directly analyze cardiac variables closely related to postexercise hypotension, such as cardiac output and blood flow, and we did not have a control group. Additionally, because this study used normotensive young subjects, the results presented here may not be generalizable to other populations, such as hypertensive subjects. Further research is certainly needed to examine the postexercise hypotension response related to the manipulation of ST methodological variables like rest interval between sets, training intensity, and exercise order.

Practical Applications

The findings of this study demonstrated a significant postexercise hypotensive response to ST in trained men. The extent of the cardiac response was directly related to training volume such that higher volumes of ST elicited a greater response in blood pressure and HRV. Therefore, ST composed of upper- and lower-body exercises performed with higher volumes are more likely to produce a greater and longer postexercise hypotensive response, as compared with routines with 1 or 3 sets. In conclusion, strength and conditioning professionals can prescribe at least 5 sets per exercises if the goal is to reduce blood pressure after training. Consistent postexercise hypotension may have a positive impact on early phases of high blood pressure development. However, the results of this study are likely to apply only to trained male adults, and further research testing other populations, including hypertensive individuals, is warranted.

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