INFLUENCE OF THE NUMBER OF SETS IN CARDIOVASCULAR AND AUTONOMIC ADJUSTMENTS TO RESISTANCE EXERCISE IN PHYSICALLY ACTIVE MEN

ORIGINAL ARTICLE

Alexandre Correia Rocha (Physical Educator)[1]
Michelle Sartori (Physical Educator)[2]
Bruno Rodrigues (Physical Educator)[3]
Kátia De Angelis (Physical Educator)[4]

1. Fefis/Unimes, Santos, SP, Brasil.
2. InCor – HCFMUSP, São Paulo, SP, Brasil.
3. Universidade São Judas Tadeu (USJT), São Paulo, SP Brasil.
4. Universidade Nove de Julho (UNINOVE), São Paulo, SP, Brasil.

Mailing address:
UNINOVE - Rua Vergueiro 235/249
2º subsolo Mestrado 01504 001
São Paulo – SP. Brazil.
prof.kangelis@yahoo.com.br

ABSTRACT

Objective: To evaluate the influence of the number of sets on cardiovascular changes and heart rate variability (HRV) in resistance exercise (RE) recovery period in physically active men. Methods: The sample was composed of 13 (27.38 ± 1.59 years) normotensive men, practitioners of RE. Two RE routines were performed: routine 1 (R1) consisted of two sets of 10RM with 1 minute between sets and 2 minutes between exercises; and routine 2 (R2) was similar to R1; however, with three sets of each exercise. Blood pressure (BP), pulse interval (PI) and HRV were measured at rest and during recovery (60 minutes) from the RE. Results: RE induced reduction in systolic BP after R1 (pre: 119.4 ± 1.70 vs. post: 110.8 ± 1.80 mmHg) and R2 (pre: 121.6 ± 2.20 vs. post: 110.3 ± 1.11 mmHg). However, diastolic BP (pre: 71.2 ± 1.80 *vs.* post: 64.3 ± 2.40 mmHg) and mean BP (pre: 88.0 ± 1.60 vs. post: 80.7 ± 1.60 mmHg) reduced only after the R2, and heart rate (HR) was increased at this time. The R2 promoted variance of PI reduction in the recovery when compared to the R1. Furthermore, only the R2 induced increase in low frequency band and reduction in high frequency band of PI compared to rest values. Conclusion: BP reduction was associated with higher number of sets, but not with reduction in HR and/or cardiac sympathetic modulation in RE practitioners.

Keywords: resistance training, post-exercise hypotension, heart rate control.

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INTRODUCTION

Systemic hypertension (SHT) reaches more than 30% of the people in some Brazilian cities and can be present in up to 75% of the older population[1]. This disease is a multicausal and multifactorial syndrome characterized by the presence of high pressure levels and is normally associated with metabolic and hormone disturbs and cardiac and vascular hypertrophy[2]. Thus, the search for alternatives to deal with the risk factors and dysfunctions associated with SHT has increasingly become more important.

Therefore, one of the alternatives to control and prevent this disease is regular practice of physical exercises. Due to the easy control of intensity and lack of information about the blood pressure (BP) alterations during a resistance exercise training program (RE), the aerobic exercises have been the most studied and are more recommended. Until the beginning of the 1990's, the resistance exercises (RE) were not recommended by international guidelines[3]. In the last years, the increase in the number of published investigations corroborates the RE role as an important complementary measure for prevention and treatment of chronic-degenerative diseases for all the populations, including hypertensive subjects[4]. There is evidence that a single session of RE promotes BP reduction in hypertensive[5] and normotensive individuals[6] and these responses may be related to the sessions volume/intensity[7]. Among the mechanisms associated with the BP reductions are alterations in cardiac sympathovagal modulation. Thus, Rezk *et al.*[6] demonstrated reduction of systolic blood pressure (SBP) and diastolic blood pressure (DBP) after an RE session. Such findings are associated with the cardiac output (CO) decrease mediated by systolic volume (SV) reduction, despite the heart rate (HR) increase in the recovery period from the RE in normotensive individuals. Corroborating these findings, Abad *et al.*[8] also observed increase of sympathetic modulation, indicated by the increase of sympathovagal balance post- RE (LF/HF).

It is worth mentioning that the HR fluctuations, which may be assessed by the heart rate variability (HRV) in the time and frequency domain, reflect the interaction between the sympathetic and parasympathetic nervous systems. Thus, alteration in the HRV provide a sensitive and early indicator of compromising to health and have been associated with many diseases, among which, systemic hypertension and early death[9]. However, the majority of the studies have as parameter the HRV assessment in response to aerobic exercises, while few studies have investigated the HRV before, during or after RE. In this investigation we tested the hypothesis that post-exercise cardiovascular and HRV alterations may be influenced by the volume/intensity of the RE session. Thus, the aim of the present study was to assess the influence of the number of sets (two or three sets) in the cardiovascular and in HRV alterations in the recovery period from the RE in normotensive and physically active subjects.

METHODS

The sample was composed of 13 male subjects, aged between 20 and 30 years, body mass index (BMI) lower than 30 kg/m^2, blood pressure (BP) below 140/90 mmHg, obtained in two different occasions, besides not being smokers. All of the subjects have regularly practiced bodybuilding for at least six months, with minimum frequency of three weekly times. The participants who had injury, pain or recent orthopedic surgery in upper or lower limbs, or any other pathologies, such as cardiac, metabolic, neurological or rheumatologic nature, or if they participated at competitive level in any sports modality (state or national level) were excluded.

The present study was approved by the Ethics Committee of the São Judas Tadeu University, São Paulo, SP, Brazil (075/2010). Before the resistance exercise protocol, all subjects of the research signed the Free and Clarified Consent Form.

The volunteers were submitted to two distinct routines of bodybuilding separated by a minimal 48-hour interval. Routine 1 (R1) consisted of two sets of 10 repetitions maximum (10RM) with one-minute interval between sets and two minutes between exercises, while routine 2 (R2) was similar to R1; however, the subjects performed three sets for each exercise. It is worth mentioning that the performance order of the routines was drawn. Load was adjusted for 10 repetitions maximum (RM) in all exercises involved in the routines. The exercises performed were: bench press, abdominal crunch, leg press lat pull dow, shoulder press, incline bench press, biceps curl, squat, and triceps pulley.

Assessments

Body weight (BW) was evaluated on a digital scale (G Tech Glass), with precision of 0.1 kg and height was checked with a WISO stadiometer with precision of 0.01 cm. Cardiovascular and autonomic assessments applied a Polar frequency meter (model RS800), a sphygmomanometer (Becton, Dickinson) and a stethoscope (Littman). The SBP, DBP and HR were checked in a non-invasive manner at rest and at recovery (60 min post-test). The instruments used as reference standard for the BP and HR measurement in this study had been previously inspected by the National Institute of Metrology (Inmetro) and were accordingly calibrated. All the hemodynamic measurements were performed by the same evaluator and according to the guidelines of the Brazilian Society of Hypertension for measurements at rest[1]. All the measurements of the volunteers were performed at sitting position and the upper limb was kept at heart height.

The HRV was measured by the record of the R-R interval (ms), through the Polar frequency meter, model RS800. In that HR monitor, the transmitter belt detects the electrocardiographic signal beat-by-beat and transmits it through an electromagnetic wave to the Polar wrist receptor, where this information is digitalized, displayed and stored. This system detects the ventricular depolarization corresponding to the R wave of the electrocardiogram, with sampling frequency of 500 Hz and time resolution of 1 ms which was previously validated against standard electrocardiograph by Holter[10]. The recording files were transferred to the *Polar Precision Performance Software* through the *Interface Infrared*, or IrDA, which allows the exercise data birectional exchange with a microcomputer for subsequent analysis of the interval variability of cardiac pulse in the different recorded situations. The R-R intervals (PI) originated from the frequency meter were converted and stored in an Excel file and it was visually verified to identify and/or correct some incorrect marking. The data were analyzed and charted through the MATLAB program in the format of the Fast Fourier Transform (FFT). After this mathematical remodeling, the absolute potencies were obtained in the respective pre-set frequency bands: low frequency (LF, 0.04-0.15 Hz) and high frequency (HF, 0.15-0.4 Hz). The data are expressed in normalized units. The LF component is used as an index of sympathetic modulation. The HF component is used as an index of the parassympathetic modulation. The LF/HF ratio indicates the sympathovagal balance. The detection of the R-R intervals obtained in the frequency meter will follow the same criteria previously described for the design of the time sets of the variability in the frequency domain. For this study, the standard deviation (SD), total variance (VAR) and square root of the mean of the square of the differences between the successive RR intervals (RMSSD) were used as indices in the time domain.

The BP and HR assessments were performed with the subjects sitting after 30 minutes of rest and after 60 minutes of recovery after the end of the RE protocols. The analysis of the HRV was performed in two pieces of approximately five minutes of the rest period (between 15 and 25 minutes of rest) and in two pieces of the recovery period (between 50 and 60 minutes). Thus, the value of each HRV parameter of a given subject was the mean of two pieces in each situation.

Statistical analysis

The results are presented in mean ± standard error of the mean. ANOVA followed by Newman Keuls Student's *post hoc* was used for statistical analysis. The significance level adopted was of 5%.

RESULTS

Table 1 presents the anthropometric measures (height, body weight and BMI) and hemodynamic measures (systolic blood pressure, diastolic blood pressure and heart rate) of the volunteers at rest.

Figure 1 demonstrates the SBP (A), DBP (B), MBP (C) and PI (D) alterations after 60 minutes of recovery from routines 1 and 2 of RE. The RE, regardless of the routine (two or three sets) generated significant reduction of SBP after 60 minutes compared with the rest period (figure 1A). However, the DBP and MBP values reduced only after 60 minutes of routine 2 (three sets of RE) (figures 1B and 1C). The PI was lower after 60 minutes of RE following routine 2 (three sets of RE) compared with the respective rest period, which was not observed in the recovery period of routine 1 (two sets of RE) (figure 1D). Differences have not been observed between routines concerning the assessed cardiovascular parameters.

According to the results from table 2, the SD and RMSSD values were not changed at 60 minutes of recovery by any of the routines performed. Concerning the VAR of PI, reduction at the 60 minutes of recovery of R2 (three sets of RE) was observed when compared

Table 1. Sample's characteristics.

Age (years)	27.4 ± 1.59
Height (m)	1.74 ± 0.02
Body weight (Kg)	76.9 ± 3.12
BMI (Kg/m^2)	27.4 ± 0.75
SBP (mmHg)	120 ± 1.41
DBP (mmHg)	70.1 ± 1.19
HR (bpm)	74.0 ± 1.79

Values representing ± standard error; body mass index (BMI) systolic blood pressure (SBP); diastolic blood pressure (DBP); and heart rate (HR).

with the same moment of R1 (two sets of RE). The R1 and R2 of RE induced increase of the LF/HF balance at 60 minutes of recovery. However, only the routine with higher number of sets (R2) induced, at 60 minutes of recovery, increase of the normalized values of the LF band (%LF), representative of the cardiac sympathetic modulation, and reduction of the normalized values of the HF band (%HF), representative of the cardiac parasympathetic modulation, concerning the rest period (table 2). Differences have not been observed between routines concerning the parameters assessed of HRV in the frequency domain.

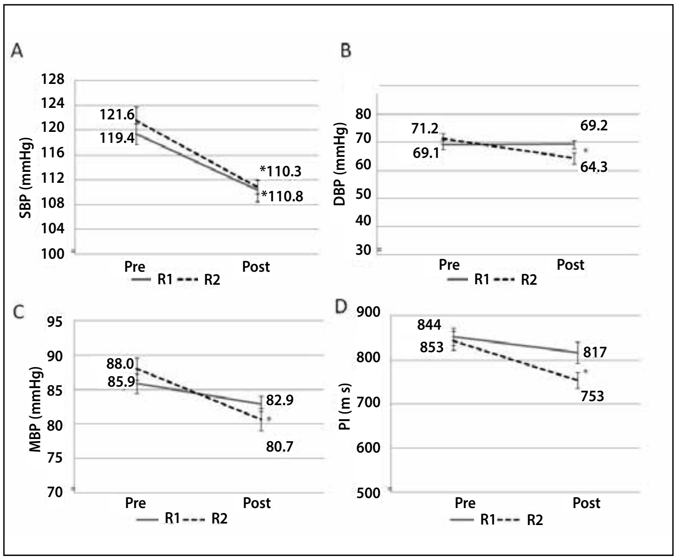

Figure 1. Systolic blood pressure (A), diastolic blood pressure (B) mean blood pressure (C) and pulse interval (D), pre and post-routines 1 (R1) and 2 (R2). *p < 0.05 *versus* rest.

Table 2. Heart rate variability assessed in the time and frequency domains pre and post-routines 1 and 2.

	Routine 1		Routine 2	
	Pre	Post	Pre	Post
SD (ms)	83.0 ± 6.0	89.5 ± 5.8	83.7 ± 4.5	71.1 ± 4.4
VAR (ms²)	7028 ± 1043	8664 ± 960	6911 ± 697	5291 ± 658#
RMSSD (ms)	49.2 ± 5.3	47.0 ± 5.2	49.8 ± 5.8	34.0 ± 3.4
%LF (n.u)	75.1 ± 2.3	83.4 ± 2.3	76.4 ± 3.7	85.4 ± 1.7*
%HF (n.u)	24.9 ± 2.3	16.6 ± 2.3	23.6 ± 3.7	14.6 ±1 .7*
LF/HF	3.6 ± 0.4	6.8 ± 1.1*	4.3 ± 0.5	6.9 ± 0.8*

Values representing mean ± standard error. Normalized low frequency band (%LF), sympathovagal balance (LF/HF), mean standard deviation (SD), variance (VAR) and square root of the mean of the square of the differences between the normal RR intervals (RMSSD). *p<0.05 vs Pre ; # p<0.05 vs Routine 1.

DISCUSSION

The RE role in cardiovascular parameters and in the cardiac autonomic control is not totally elucidated yet, perhaps due to the fact the total intensity of the RE session be dependent on many variables which when combined directly interfere in the intensity of the training session[11], making it difficult to standardize the research protocols. In this investigation, we studied the influence of the number of sets (two or three sets-10RM) in the cardiovascular and autonomic adjustments in men who practice bodybuilding. Our sample was composed of regular resistance training practitioners (at least three times per week, for at least six months) who were normotensive, but who according to the BMI classification criteria were with overweight. Probably, the increase of muscle mass, rather than fat mass in the subjects who participated in this research is related to the BMI above the normality range[12].

The assessment of the cardiovascular adjustments to the RE evidenced that the exercise routine with higher number of sets triggered significant reduction for all the cardiovascular variables assessed (SBP, DBP, MBP and PI) at 60 minutes of recovery compared with the pre-intervention period. However, these changes were not observed in the routine with lower number of sets. In the study carried out by Polito *et al.*[13], in which the BP post-RE in physically active young subjects have been investigated, longer post-exercise hypotension time was observed (PEH) for the SBP in the RE routine with higher intensity (6RM *versus* 12 repetitions with 50% of 6RM). However, the magnitude of this alteration was not different between programs, as observed in the present study when we evaluated the influence of the number of sets in the RE session. Still in the study by Polito *et al.*[13], the DBP presented reduction only after 10 minutes of exercise, returning to its baseline value on the 20th minute. Such result is different from the ones observed in the present study for the routine with three sets, since it has been observed that the DBP remained reduced until one hour after the R2. Nevertheless, we cannot exclude the possibility that there has been reduction of DBP in a recovery period prior the 60 minutes both in the routine with two sets and in the routine with three sets.

Corroborating our results of more consistent BP reduction post-RE with higher number of sets (higher session total intensity), Santos and Simão[14] report that more intense sessions could influence the PEH magnitude as well as its duration. In the study by Mediano *et al.*[15], in which the post-RE BP alterations in 20 subjects with mean age of 61 ± 12 years with controlled hypertension have been investigated. More expressive reduction in the SBP and especially in the DBP post-routine with higher volume/intensity (1 x 10RM *versus* 3 x 10RM) was observed. Similar results were observed by Melo *et al.*[16], where the speculated mechanism in this research for the PEH was a possible muscle vasodilatation caused by the metabolites accumulation post-RE[17], causing decrease of the peripheral vascular resistance (PVR) and/or a possible reduction of the plasma volume due to its overflowing to the interstitial fluid due to the RE performance, inducing decrease of systolic volume as well as CD[17]. Some studies suggest that reduction of vascular sympathetic activity could contribute to reduction of PVR, contributing hence to the PEH after RE performance[18].

Rezk *et al.*[6] observed SBP reduction after RE session of high (80% 1RM) and low (40% 1RM) intensities in normotensive individuals; however, the DBP only reduced after low-intensity protocol. The BP reduction in this study was associated with CO reduction, mediated by reduction of the systolic volume SV, despite the increase of HR determined by the increase of cardiac sympathetic activity and reduction of the cardiac vagal activity in the recovery period in both protocols (40% 1RM and 80% 1RM). Therefore, it is worth mentioning that the higher number of sets applied in our study resulted in higher number of movement repetitions; similarly to investigations performed at 40% of 1RM which allow higher number of repetitions than the ones performed at 80% of 1RM. Thus, it seems that the higher number of repetitions, regardless of the intensity, could modulate the post-RE DBP response in normotensive men. Moreover, corroborating with Rezk *et at.*[6], we observed PI reduction in the present study; in other words, increase of HR, associated with increase of sympathetic modulation and reduction of cardiac vagal modulation, in the recovery period from RE; however, this result was observed only after the routine with higher number of sets. Interestingly, the cardiac sympathovagal balance increased after the two RE routines, suggesting hence that even the routine with two sets performed at 10RM is associated with increase in the cardiac sympathetic modulation until the 60 minutes of the recovery period.

It should be highlighted that the comparison of the two RE routines in the present study evidenced increase of VAR of PI in the routine with two sets compared with the routine with three sets, suggesting faster reestablishment of cardiac autonomic modulation. Similarly, Lima *et al.*[19] observed increase in the indicators of sympathetic modulation (%LF and LF/HF) and reduction in the indicator of parasympathetic modulation (%HF) post-RE of higher intensity (70% of 1RM) when compared with the ones with lower intensity (50% of 1RM). Similar results have also been observed by Maior *et al.*[18] when compared the effects of RE sessions performed with 6RM *versus* 12RM in trained and healthy subjects. According to the authors, there was no difference in any of the HRV domains when the 6RM and 12RM protocols were compared; however, the sympathovagal balance (LF/HF) increased only after the protocol with higher intensity (6RM), indicating higher cardiac sympathetic modulation.

Despite the relatively small and of convenience sample, our results stress the idea that higher training volume (number of sets) could cause increase of total intensity of the training session, and consequently, would promote higher hypotensive effects[14], but these would not be associated with the reduction of the cardiac sympathetic modulation[9,18,19]. In that aspect, it is worth mentioning that the training volume is many times named without accuracy, taking in consideration only the session duration[20]. Nevertheless, the strength training session volume comprehends the total number of sets and repetitions per session or per week, and also the number of performed exercises[11]. Therefore, the total intensity of the strength training session can also be influenced by alterations in the volume, which is one of the most important training components[20].

CONCLUSION

The results of the present study evidenced that the PEH was related to the higher number of sets, and hence with the higher total intensity of the RE session in normotensive men resistance training practitioners. The reduction in SBP and DBP after the RE session performed with higher number of sets was not associated with the HR and/or cardiac sympathetic modulation reduction and can be related to reduction of SV (inducing reduction of CO) and/or of PVR. Future studies should assess if the responses observed in the present study are similar in sedentary hypertensive or physically active subjects, as well as increase the understanding on the mechanisms involved in the post-RE PEH, trying to obtain greater magnitude and duration of the hypotensive responses associated with better cardiovascular autonomic response.

All authors have declared there is not any potential conflict of interests concerning this article.

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