Acute cardiovascular responses in strenght training conducted in exercises for large and small muscular groups

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ABSTRACT

The aim of this study was to compare the behavior of the systolic blood pressure (SBP); diastolic blood pressure (DBP); heart rate (HR) and double product (DP) during the unilateral performance of three sets of 10RM in two exercises involving distinct muscular groups. Eighteen normotense men (22.4 ± 2.7 years; 76.2 ± 9.8 kg; 175.4 ± 6.0 cm) experienced in resisted exercises participated in the study. The volunteers were submitted to the experimental procedure in four non-consecutive days. On the first day, the 10RM tests were applied in the biceps curls with dumbbells (BC) and extensor bench (SB). After 48 hours, a re-test of 10RM was performed. After the loads were obtained, three sets of 10RM were performed in the selected exercises. The performance rhythm in both exercises was controlled by a metronome, with an established time of two seconds for each of the eccentric and concentric phases. The HR was measured though a cardiofrequency meter and the SBP and the DBP through the auscultatory method. The two-way ANOVA with repeated measurements, followed by the *post-hoc* test by Tukey did not find differences ($p > 0.05$) for intra-exercises SBP. Therefore, at least in the present study, the muscular mass involved in the strength training did not influence the acute cardiovascular responses in trained normotensive subjects.

Keywords: Resisted exercises. Muscular mass. Heart rate. Blood pressure. Double product.

INTRODUCTION

Regular practice of exercises has been efficient as one possibility of intervention for the blood pressure control (BP)[1-2]. Within this context, resisted exercises (RE) are recommended as a complementary activity in the treatment of diseases such as hypertension and chronic cardiac insufficiency, helping to promote favorable adaptations in the cardiovascular function[2]. Nevertheless, RE require careful prescription in order to be safe during their practice[3-4]. Thus, the cardiovascular stress indicators may provide important background for the exertion monitoring in RE[3,5-9].

Acute cardiovascular responses vary concerning kind, intensity and exercise duration[8,10-11]. RE performed at high intensity have a considerable static component[12-13], causing increase of the peripheral vascular resistance[11,13-14]. Moreover, the occlusion of the vascular bed promotes accumulation of metabolites which trigger the muscular chemoreceptors[7,11], stimulating the sympathetic nervous system in the release of catecholamines[4,11]. Consequently, an increase of the heart rate (HR) occurs, especially of the systolic blood pressure (SBP), during exertion[4,12], leading to an increase of the double product (DP), another important indicator of cardiac stress[14].

Other factors which can cause the increase of the HR, SBP and DP during RE are: muscle mass involved[15], respiratory pattern[15] and number of performed sets[4,12]. Specifically concerning muscle mass involved, theoretically, exercises which recruit small muscle groups would tend to provide smaller responses of HR than exercises performed by large groups. However, some investigations did not verify differences in this relationship[5,19]. It was confirmed that the investigations in this context are scarce, which makes it difficult to predict the behavior of the cardiovascular responses in exercises which recruit muscle groups of different sizes.

Therefore, the aim of this study was to compare the behavior of the SBP, DBP, HR and DP cardiovascular variables during the unilateral performance of three sets with loads for 10 maximal repetitions (10RM) in exercises involving small and large muscle groups.

MATERIALS AND METHODS

Eighteen normotensive men were studied (22.4 ± 2.7 years; 76.2 ± 9.8 kg; 175.4 ± 6.0 cm). All of them had previous experience in RE for at least 12 months and presented negative Par-Q questionnaire. The following aspects were chosen as exclusion criteria: consumption of substances which would alter the cardiovascular responses in resting and exertion; use of ergogenic products; use of alcohol or caffeine before the essay; besides osteomioarticular complications which would restrict the performance of the selected exercises. The individuals voluntarily participated in the experiment and signed a free and clarified consent form according to the 196/96 resolution from the National Health Committee.

The volunteers were submitted to the experimental procedure in four non-consecutive days. In the two first days, the 10RM tests were applied, which were unilaterally performed on the right limb for the seated biceps curls with dumbbells (BC) and extensor bench (EB) (Buick®) exercises. The detection of the maximal load for 10RM occurred in up to three trials, with recovery interval of at least three minutes between each of them. The intervals between the exercises were of 20 minutes. The BC exercise was performed with the volunteer seated on a bench which allowed chest posterior inclination at approximately 15°, performing then elbow complete flexion with the forearm supinated in all movement's breadth. In the EB, the movement would start at 90°, ending at knee total extension. In both cases, the left arm was not used as an aid to the movement, being positioned in abduction at shoulder level and rested on a board for BP measurement.

After obtaining the maximal loads in the 10RM test, the individuals would rest for 48 hours and were reevaluated in order to have the test reproducibility obtained (test and re-test). The load estab-

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lished in both days with difference lower than 5% was considered as 10RM. Exercises performance was not allowed between tests sets to avoid interference in the obtained results.

On the third day, at the site of the tests performance, the volunteer remained seated for five minutes in order to have his HR and resting BP values measured. Later, three sets with load for 10 RM in the first exercise and with 2-minute intervals were performed. The performance rhythm was controlled through a metronome (*Dolphin*®), with 2 seconds being established for each contraction phase, with a total of 4 seconds in each repetition. The HR was measured through a cardiofrequency meter (*Polar*® *Acurex Plus*) and the BP through the auscultatory method, with the use of aneroid sphygmomanometer(*Bic*®), previously calibrated and stethoscope from the same brand name. The BP measurements were performed by a single experienced evaluator, on the left relaxed arm, between the one before the last and the last repetitions[(5,20)], in order to minimize the limitations concerning the adopted technique[(13,15,20)]. On the fourth day of data collection, the same procedure was conducted for the second exercise. The entrance order for each individual in the different exercises was alternated.

The data collection occurred between 14 and 17 hours, with the purpose to restrict possible influences of the circadian cycle of the individuals over the cardiovascular variables. During the tests, the volunteers were instructed about the importance of not performing the Valsalva maneuver, since the increase of the intrathoracic pressure caused by it would associate with higher pressure levels[(4,12,15,17)].

The statistical analysis of the data was performed through a two-way ANOVA (exercise x sets) with repeated measurements in the second factor, followed by the Tukey post-hoc test, considering as significance level $p < 0.05$. The data were treated in the *Statistica*® 5.5 software (*Statsoft*®, USA).

RESULTS

Table 1 shows the mean and standard deviation values of the studied variables in the resting and exercise situations for the different sets in the EB. As can be seen in the SBP, HR and DP variables, significant differences were verified from rest to exertion, which did not occur for the DBP. Concerning the intra-sets behavior, significant difference was verified only in the SBP responses between the first and third sets.

TABLE 1
Results of the cardiovascular variables for the extensor bench

Situation	SBP	DBP	HR	DP
Resting	115.2 ± 6.7*	70.6 ± 7.0	68.6 ± 8.3*	7,919.9 ± 1,222.6*
1st set	140.3 ± 12.0#	73.7 ± 7.9	113.5 ± 20.2	16,004.4 ± 3,456.7
2nd set	148.6 ± 13.9	74.2 ± 8.4	112.4 ± 20.7	16,779.9 ± 3,790.5
3rd set	156.4 ± 15.0	75.3 ± 9.3	117.4 ± 24.3	18,521.1 ± 4,842.2

* significant difference for the remaining sets;
\# significant difference for the 3rd set.

Table 2 shows the mean and standard deviation values of the studied variables in the resting and exercise situations for the different sets performed in the BC. The SBP, DBP, HR and DP behavior was similar to the one observed in the EB. The intra-sets data for the BC showed significant differences between the first and second sets and in the first and third sets for the SBP.

TABLE 2
Results of the cardiovascular variables for the biceps curls

Situation	SBP	DBP	HR	DP
Resting	113.0 ± 8.6*	69.2 ± 6.2	71.7 ± 10.3*	8,126.3 ± 1,438.3*
1st set	134.7 ± 15.6†	69.9 ± 4.4	117.2 ± 18.4	15,767.8 ± 2,926.0
2nd set	144.2 ± 16.0	71.7 ± 6.2	120.6 ± 18.9	17,383.6 ± 3,278.2
3rd set	152.3 ± 17.0	72.0 ± 6.2	124.4 ± 22.2	18,885.9 ± 3,538.4

* significant difference for the remaining sets;
† significant difference for the 2nd and 3rd sets.

Figures 1 to 4 show the behavior of the cardiovascular variables observed in the resting and exercise situations. Significant differences were not verified in the absolute values of the variables between each set, when the distinct exercises were compared.

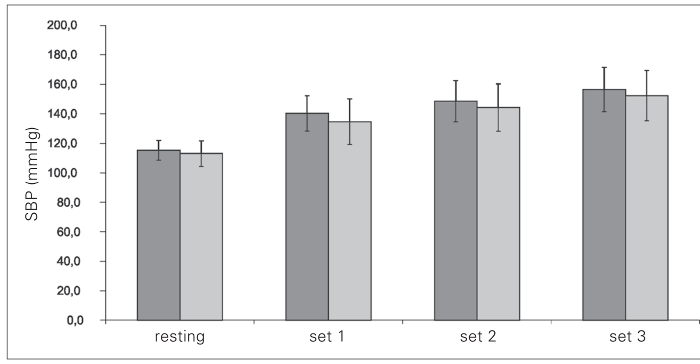

Figure 1 *– Mean and standard deviation for the systolic blood pressure in the extensor bench (dark column) and biceps curl (light column)*

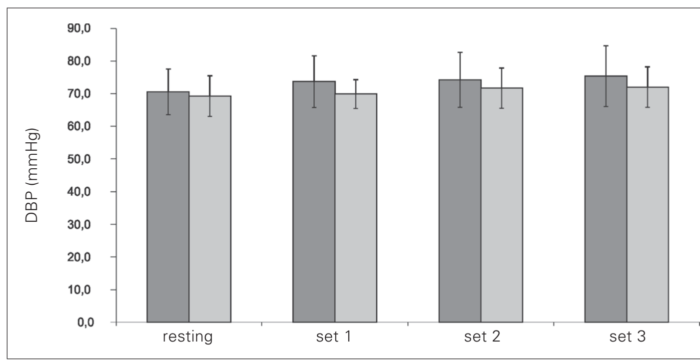

Figure 2 *– Mean and standard deviation for the diastolic blood pressure in the extensor bench (dark column) and biceps curl (light column)*

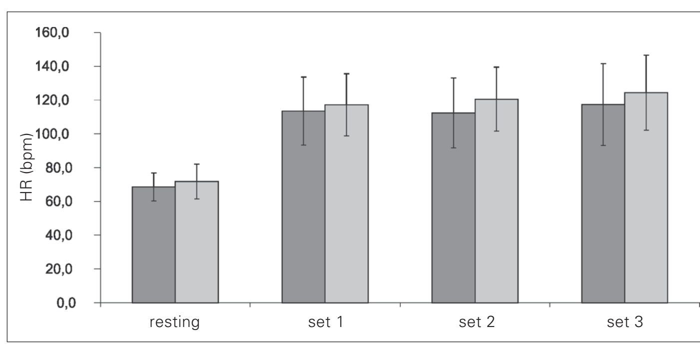

Figure 3 *– Mean and standard deviation for the heart rate in the extensor bench (dark column) and biceps curl (light column)*

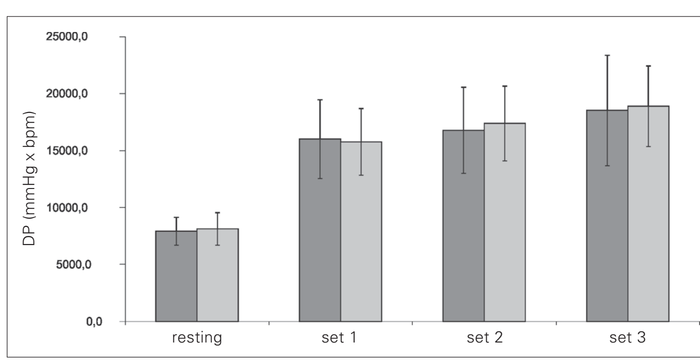

Figure 4 *– Mean and standard deviation for the double product in the extensor bench (dark column) and biceps curl (light column)*

DISCUSSION

Favorable recommendations to strength training for healthy individuals[21] as well as for cardiovascular disease patients[2-3]. are observed in the literature. Thus, there is a considerable appreciation concerning the ideal dose-response relationship for exercise[13]. The cardiovascular stress monitoring, therefore, allows the verification of the suitability and safety of the applied programs[4,6,8-9] in groups with different needs. This study compared the acute cardiovascular responses in exercises involving distinct muscle groups.

There is no consensus in the literature about the effects of the size of the muscle group involved in the exercise as well as its influence in the acute cardiovascular responses to the RE. The outcomes of the present study show that the size of the involved muscle mass would not influence in the acute cardiovascular responses, once significant differences over the cardiovascular indicators were not observed in the performance of the EB and BC. Other studies described in the literature corroborate with this premise. For instance, Fleck and Dean[19], when applying intra-arterial catheterism, did not verify higher cardiovascular stress in unilateral exercises for upper and lower limbs with loads between 100% and 50% of 1RM until exhaustion. Similarly, Polito *et al.*[5], when comparing knee extension uni and bilaterally performed in three sets of 12RM, did not observe significant differences between performance ways. Nonetheless, MacDougall *et al.*[17] and Seals *et al.*[18] identified that the increase of the pressure levels is associated with the size of the recruited muscle mass, due to the increase of peripheral vascular resistance.

Although the cardiovascular control to exertion involves a complex chain of mechanisms, it is considered that they may be divided into central and peripheral[7,18]. The central mechanism is concerned with the irradiation of the motor cortex impulses for the cardiovascular control center[18], while the peripheral one is linked with the release of metabolites in the active muscle[11]. However, the degree of relative contribution of these mechanisms over the modulation of the cardiovascular responses is still obscure. Thus, the equivalence obtained in the results could occur due to the following factors: a) smaller vascular tree involved in the BC exercise, an aspect which would imply in greater accumulation concerned with metabolites (lactate and K^+, for example); b) the degree of exertion required in the BC would occur in the synergetic action of other muscles for the maintenance of the motor pattern causing greater central stress.

The BC exercise demands higher degree of intermuscular coordination, a condition which would influence greater stimulus for the motor cortex. Therefore, the synergetic action of other muscles could reverberate over the cardiovascular responses. Fatigue of agonist muscles would cause relatively greater exertion, activating an additional muscle group as well as the nociceptors[22], favoring hence, the increase of the central stress. According to Ramos *et al.*[23], the pressure response is proportional to the recruitment of the synergetic muscle during the static contraction. Thus, these variables could minimize the differences observed in the cardiovascular response in muscle actions with high static component, regardless of the size of the muscle group.

Other elements would be also able to interfere in the magnitude of the cardiovascular response. For instance, Petrofsky *et al.*[24] observed in an experiment using cats, higher concentrations of K^+ in the type II fibers during exertion. Such condition would increase the stimulation of the muscular chemoreceptors, reflecting in the neural inflow for the cardiovascular control center[18] and, consequently, would increase the sympathetic activity[11]. Greater vascularization observed in the red fibbers would cause lower peripheral resistance. Therefore, muscle groups with their predominance would occur in lower cardiovascular demand; however, this study did not control this variable.

The contribution of the present study is the analysis of the cardiovascular stress in a group of asymptomatic individuals submitted to a protocol with volume and intensity suggested by the *American College of Sports Medicine*[21] for uniarticular exercises. Therefore, the participants were not submitted to exercise models which could excessively reflect over the analyzed variables. Thus, we tried to reproduce the conditions usually found in the prescription of programs for development of muscular strength.

The obtained outcomes for the absolute values of the SBP, HR and DP variables observed during exertion are according to the ones proposed by the literature[7-8]. The SBP presented significant difference between the three sets of BC, while in the EB the difference occurred only between the first and the third sets. This intra-exercise behavior was described by Gotshall *et al.*[22], who verified progressive increase of the SBP in each one of the three sets of 10RM in the leg press exercise (bilateral). Thus, an additional effect of the cardiovascular stress was observed concerning the performance of repetitive sets. Consequently, such data presents relevance in the prescription of exercises for individuals in special conditions, since it allows the modulation of the application of the training volume.

Nevertheless, the HR increase was not associated with the number of sets performed. Polito *et al.*[7], when using the photopletismographic method, did not observe a progressive response of HR in trained individuals. The group performed four sets of 8RM in the EB (unilateral) with different recovery intervals. The outcomes indicated that intervals of up to two minutes would not influence this variable. Te present essay corroborates with this assertive. Similarly, Polito *et al.*[5], in an experiment which involved three sets of 12RM in the EB uni and bilaterally performed, with trained individuals, did not verify increase of HR in repeated sets. Therefore, this isolate indicator does not constitute an efficient way to verify the cardiovascular stress in strength training. Moreover, at least in the present study, the size of the muscle group did not cause differentiated effect in the HR responses (figure 3). Such fact may be accepted from the moment in which the different exercises followed the same performance velocity, totalizing the same time for performance of the sets.

Another variable investigated in the present study was the DP. The literature highlights that in intermittent exercises the DP does not present validity for the estimation of oxygen pick up by the myocardium[6,9]. However, higher values for it during exertion represent higher cardiovascular stress, since they imply in higher values of HR, systolic volume, cardiac debt and, in some situations, increased systemic resistance[4,6,9]. According to the *American College of Sports Medicine*[14], it constitutes one of the main indicators of cardiac stress in training with weight. In the present study, in both investigated exercises, the mean values obtained for the DP were below the cutting point suggested for *angina pectoris* (30.000 mmHg.bpm)[9], identifying a low risk in the conduction of the RE. In addition, the size of the muscle group did not cause differentiated impact in the studied exercises (figure 4). Since the performance time was identical for the exercises with different sizes of muscle groups, it is suggested that the total time of exercise performance represents an important influencing aspect in the acute cardiovascular responses to exertion, especially in the SBP, which directly reflects in the DP.

However, the DBP measurements do not reflect the values during exercise, since they were performed a few seconds after the end of each set. Such procedure was necessary due to the used BP measurement technique (auscultatory method). Therefore, the SBP measurement was conducted in order to agree with the exercise ending and the DBP, consequently, it occurred a few seconds later. This small time interval may be sufficient to significantly reduce the BP responses. Data which supported such premise are presented by Baum *et al.*[15]. These authors observed that the relaxing interval of only three seconds would be sufficient to allow an immediate recovery in the BP, due to the mechanical effect (immediate) caused by the reduction of the peripheral resistance, as well as by the metabolic recovery which attenuates the chemoreceptor action. Corroborating with this premise, Wiecek *et al.*[25] obtained similar results when measuring the BP after the ending of 15RM stimuli.

It is important to highlight a limitation which involved the present study. The BP was measured through the auscultatory method. This procedure during high intensity and short duration exercise has important limitations[13], since it underestimates the values during the exercise[6,9,15,20,22], especially in the diastolic levels[13]. This situation occurs because this method is not sensitive to detect fast increments in the BP values. Nevertheless, the auscultatory method allows to verify the BP behavior trend[6,9,13,20], presenting hence higher applicability[20], lower risk[6] and high correlation with the photopletismography, which is the main non-invasive method[9,20], and justifies its application.

In conclusion, the outcomes of the present study showed that the muscle mass involved in the RE does not influence in the acute cardiovascular responses to the exertion in normotensive subjects for equivalent interval values, volume and training intensity. However, the behavior of the analyzed indicators may differ in specific populations, as well as in different conditions of exertion (tension time, body position and recovery intervals). Therefore, further studies with different outlining are needed in order to verify the behavior of these indicators under different training stimuli.

All the authors declared there is not any potential conflict of interests regarding this article.

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