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Effect of Acute Resistance Exercise in Different Intensities and Body Segments on Cardiovascular Variables

ORIGINAL

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Abstract

Background: An acute session of resistance exercise changes cardiovascular parameters according to the type of prescription. The objective this study to evaluate the heart rate, systolic and diastolic blood pressure and myocardial oxygen consumption behaviors during execution of resistance exercise applied in acute and isolated way, with different intensities and body segments.

Methods: 52 healthy and active young performed the experimental protocol with five stages. In the first stage, it was carried out the one-repetition maximum test (1RM) for knee extension (LL) and elbow flexion (UL) and, in the following phases, four resistance exercise protocols were applied, on different days with random order execution: endurance protocol (2 series, 20 reps and 40% of 1RM) and strength protocol (2 series, 8 reps and 80% of 1RM) for upper and lower limbs. Heart rate (HR) was monitored by Polar S810i heart rate monitor, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured by auscultation in the left arm, and MVO_2 was calculated from SBP and HR. All these measurements were measured immediately after the execution of the first (M1) and second (M2) series.

Finding: There were significant increases in M1 and M2 in comparison to their respective rest in HR ($p < 0.001$), SBP ($p < 0.05$) and MVO2 ($p < 0.001$) in all protocols applied. For DBP there were significant decreases in M1 of endurance ($p = 0.028$) and force lower limbs ($p = 0.022$) protocols compared to the resting values. There are no significant changes among the proposed protocols.

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Conclusion: Strength and endurance protocols, run with upper and lower limbs, applied in acute and isolated way, were able to promote changes in cardiovascular variables in relation to their respective resting value. However, lower limbs endurance protocol stands out in their differences among them, due to the longer execution period and larger muscle group.

Keywords
Muscle strength, heart rate, blood pressure, oxygen consumption.

Introduction

Among the specific benefits of resistance training can highlight the increase in cross-section and strength muscular, improves the quality of bone density, improved self-esteem and general welfare of the weight practitioner [1-5]. And aiming these benefits, the use of this modality has been widely recommended by the American College Sports of Medicine (ACSM) and Americam Heart association (AHA), due to the prominence he has gained over the years for their safety and effectiveness even in patient populations and debilitadas [3-5].

During the execution of resistance exercise, can generate important changes in the cardiovascular system, characterized by the increase of variables such as venous return, stroke volume (SV), cardiac output (CO), blood pressure (BP) and heart rate (HR) even during his acute application or even under systematic training [5-9]. And the magnitude of these changes appears to be dependent on factors specific to this type of prescription: intensity, duration of activity and muscle group involved [1, 5], presence of Valsalva maneuver, pauses between repetitions [5, 7-9].

However, most studies evaluating the acute effects of resistance exercise on the cardiovascular system are controversial or inconclusive, which seems to be related to their various methodological designs [7-12]. Mainly based on the intermittent characteristic of this execution mode, the studies try to apply greater volume of exercise, either associating or by performing them as circuit, in order to mobilize more significantly the cardiovascular system [11, 12].

Based on the benefits promoted by resistance exercise in rehabilitation processes of different specialties (orthopedics, neurology, gynecology, pediatrics, and others) has used this modality aimed at restoring functions of specific muscle groups [1, 2, 7], in addition, the behavior the cardiovascular variables before a single application of this method is a gap in the literature that should be studied in order to ensure implementation of this method in different intensities and muscle groups safely to all types of populations.

Therefore, it is expected to find with this study that acute responses of the cardiovascular variables during the execution of resistance exercise are dependent on the intensity and muscle groups involved in the exercise, that is, the greater the intensity and the muscle group exercícitado, the greater the cardiovascular responses throughout its execution. Thus, the aim of this study is to evaluate the heart rate, systolic and diastolic blood pressure and myocardial oxygen consumption behaviors during execution of resistance exercise applied in acute and isolated way, with different intensities and body segments.

Methods

Subjects

This transversal investigation is comprised of 52 male volunteers, aged between 18-30 years old, healthy and active, classified from the Questionnaire of Physical Activity Readiness (PAR-Q) [3] and the

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International Activity Questionnaire physics (IPAQ) [13], respectively.

We did not include smokers, drinkers, medication users that interfere in the behavior of blood pressure and heart rate, individuals with cardiovascular, pulmonary or metabolic pathologies known and those with clinical conditions that contraindicate the performance of resistance exercise. Were excluded volunteers who had no assiduity to the proposed protocol.

From the 60 volunteers interviewed initially, 52 completed all phases of the experimental protocol. At the initial assessment a volunteer was not included by presenting mitral valve insufficiency diagnosed by echocardiography, and along the study period, seven volunteers were excluded due to lack of assiduity in the days of the protocol.

Volunteers were informed about the procedures and aims of this study and, after agreeing, they signed an informed consent, constituting the sample. All procedures performed in our study were approved by the Ethics Committee in Research of the Universidade do Oeste Paulista – UNOESTE, Presidente Prudente, SP, Brazil (Proc No. CAAE: 34303014.6.0000.5515).

Experimental protocol

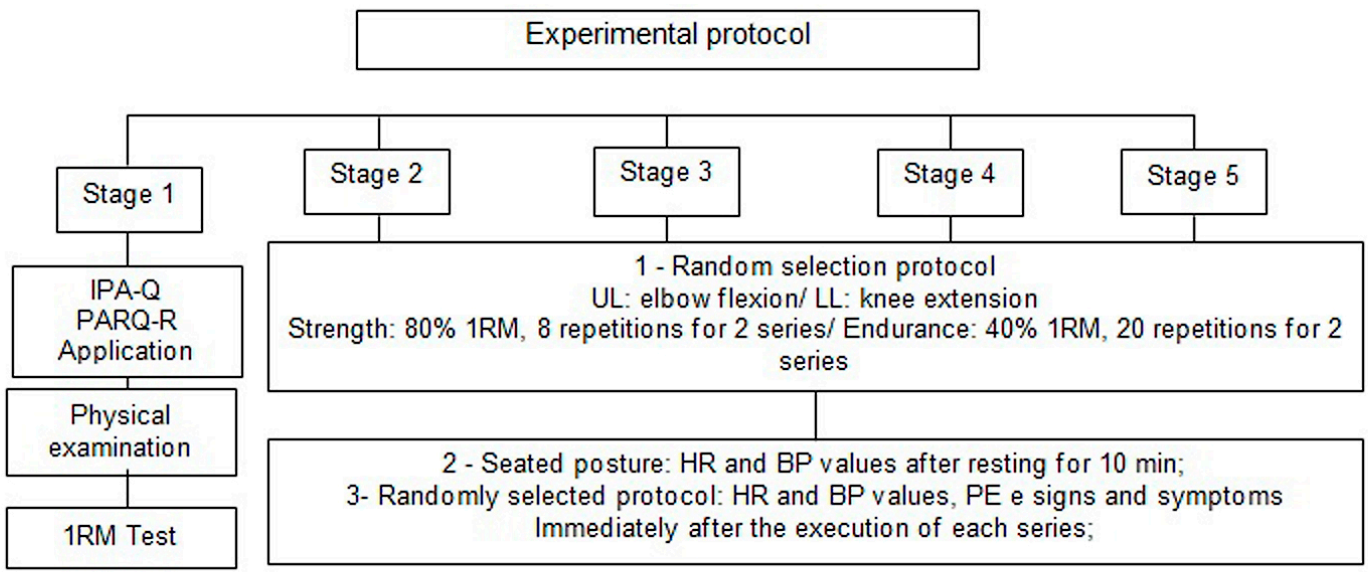
Experimental procedure was performed in a room with controlled temperature (21 to 23°C) and humidity (40 to 60%), during the afternoon to avoid the influence of circadian cycle on variables cardiovascular [1]. All equipments were prepared before the subjects arrived and, during the tests, only people who were related to the research could remain in the room to reduce the anxiety of volunteers.

All volunteers were instructed about the importance of abstinence from some drinks (coffee, soda, chocolate and tea) and the maintenance of the usual practice of physical activity during the protocols [1, 6]. We also oriented them to avoid talking during data collection except when asked.

The experimental protocol was divided in five stages with a minimum interval of 48 hours among them [14], whose sequence is in the following flowchart **(Figure 1)**. At first the following procedures were performed: volunteers's identification, questions regarding the inclusion criteria, application of PAR-Q[3] and IPAQ [13] and physical examination.

Early in the second day of evaluation, we randomly selected the order of resistance exercise protocols through a manual raffle. We performed the following protocols: 1) upper limb endurance proto-

Figure 1: Sequence of experimental protocol (minimum intervalo f 48 hours).



col; 2) lower limb endurance protocol; 3) upper limbs strength protocol 4) lower limbs strength protocol.

Initial assessment

Before beginning the experimental procedure, the volunteers were identified (age, sex, phone, profession, current medication), and answered all PAR-Q[3] and IPAQ [13] questions and was conducted physical examination consists of determining the values of blood pressure (BP) [15], anthropometric evaluation (weight, height and calculation of body mass index [BMI]) [16], heart rate (HR) [17] and one-repetition maximum test (1RM) [9, 18-22] for knee extension (LL) and elbow flexion (UL). All these amounts were recorded in the individual participant's record and used to characterize the sample.

BP measured by auscultation in the left arm, according to the criteria established by the VI Brazilian Guidelines on Hypertension [15], using an aneroid sphygmomanometer and stethoscope (WelchAllyn ®, Germany).

The measurement of weight (Balmak, Brazil) and height (Sanny, Brazil) with an accuracy of 0.1 g and 0.1 cm, respectively, for determination of body mass index (BMI = kg/m^2) [16], and HR [17], which was measured using a Polar S810i heart rate monitor (Polar Electro Oy, Finland) using a recording strap the heart rate receiver of this HR monitor.

At the end of initial assessment, for prescribing the intensity of protocols, the 1RM [9, 18-22] test for upper and lower limbs was performed. For the LL test, we used an extension table in a pulley system Ipiranga (Hard Academy in 2009, Brazil) and the upper limb test [9], a simple pulley attached to a pulley system Ipiranga (Hard Academy in 2009, Brazil) and an adapted Scott preacher were used to control the execution of elbows flexion.

During the execution of both tests the movement has been fully realized in a controlled manner and good posture [18-22]. Futhmore, verbal stimuli were given to the volunteers and mechanical failure (compensation and incomplete amplitude of movement), or Valsalva maneuver [14] were not allowed.

The Valsalva maneuver was controlled at each repetition of the 1RM test or even during the course of the suggested protocols. This control was performed by observing the evaluator during the execution of each attempt in the case of 1 RM test. The volunteer was oriented prior during the test would attempt to control the breath, with the inspiration when the volunteer was performed at rest and during exhalation the concentric and eccentric phase of the movement [14].

To carry out these tests was set an initial charge of 50% of body weight to lower and 15% of body weight for arms, and the subject was instructed to perform the exercise and grade the level of effort made in very easy, easy, medium or heavy [21]. It was then given a 5 minute rest interval, the interval between each test was repeated attempt [22, 23].

For the next attempts were added, the load value, according to the perception of effort informed by voluntary for both upper limbs and for lower limbs. The test was terminated when the volunteer reached a load causing mechanical failure of implementation, thereby becoming established as the maximum load the last charge carried out the proper way [18, 21, 23]. Was allowed no more than six attempts to establish the maximum load [22].

The following strategies was not done on adaptation of volunteers to weight machine or movement to be evaluated in the 1 RM test, but, in order to reduce the possibility of misunderstandings were adopted: a) instructions regarding the whole routine of tests were previously supplied to all components of the sample; b) The subject was instructed on the execution technique; c) the researcher was aware at all times of the executions, in order to prevent any mistake that could interfere with data collection. Like this strategy was applied by Miranda et al. [9].

Endurance and strength protocol

Two different protocols have been applied: endurance and strength protocol, according to the in-

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tensities of 40 and 80% load obtained in the 1RM test, respectively, for the upper and lower limbs. The execution of the protocols followed the same conditions of the 1RM tests and used the same equipment.

Endurance protocol consisted of a intensity of 40% of 1RM, two series, 20 repetitions and the resistance protocol, 80% of 1RM, two series, 8 repetitions, both with one minute of interval between each series [24, 25]. The volunteer was instructed to perform the concentric activity within one second and the eccentric activity in another, the periods were controlled by an external observer [7].

For the implementation of these protocols have been observed this activity sequence in the experimental procedure: 1) At the beginning of each stage was placed on the chest of volunteers with recording strap on your wrist, HR receiver S810i heart rate monitor; 2) After 10 minutes at rest, the initial values of HR and BP were measured; 3) Then the subject was forwarded to weight machines to perform the protocol; 4) Immediately after the execution of each series, the values of BP and HR were measured, and volunteers were asked to indicate their perceived exertion (PE) [23] using the modified Borg scale (0-10 point), and the presence of signs and symptoms, to control the activity.

Cardiovascular variables analysis

To analyze the cardiovascular variables were measured HR, SBP DBP and MVO_2 at baseline and immediately after the first (M1) and second (M2) series of each exercise protocol. For all these measures, there was the standardization of the seated posture for volunteers.

HR was measured by a Polar S810i heart rate monitor [17], and the identification of values for each selected period, was obtained by the Polar software precision performance (heart rate monitor's own), and thus exported to Excel spreadsheet.

The BP measured according to the criteria established by the VI Brazilian Guidelines on Hypertension [15] using an aneroid sphygmomanometer and stethoscope (WelchAllyn®, Germany), as previously described.

To obtain MVO_2, we used a mathematical function developed by Hellerstein and Wenger7 which is based on a high correlation between the double product (DP=SBP x HR) and MVO_2, ie MVO_2 = (DP x 0.0014) - 6.37.

Statistical analysis

Data analysis of the population profile descriptive statistics was used, through mean, standard deviation, median and confidence interval. Comparisons of the HR, SBP, DBP and MVO_2 values between protocols (strength, endurance, upper and lower limbs) and moments [rest and during the protocols (after the first and second series)] we applied the analysis of variance (ANOVA) for repeated measurements. Assumption of sphericity was tested using Mauchly's test and, where necessary, was employed. In all analyzes, when necessary, the Greenhouse-Geisser corrections were effective and, thus, there was no need to resort to non-parametric procedures for processing the data.

Understanding that the experimental unit (volunteer) was the same in the different conditions tested (UL, LL, endurance and strength), and that these different measures are not influenced by each other (48h separation between them), we used ANOVA for repeated measures with 12 moments (Rest, M1 and M2 for upper and lower limbs, endurance and strength).

This structural configuration enabled by the use of a single test (and its respective post hoc, Bonferroni test) comparing (i) four moments at rest (equality between the groups is a basic assumption for this type of experiment), (ii) definition of the variables behavior within each of the four groups and, finally, (ii) the four groups within their different moments. Measures of effect size were expressed by Eta-Squared values (Large effect size was Eta-Squared ≥0.140; Medium effect size was Eta-Squared <0.140 and ≥0.06; Small effect size was Eta-Squared <0.06 and >0.01; Trivial effect size was Eta-Squared <0.01

[26]. Significance level was set at p-value <0.05 for all tests.

Results

Table 1 characterizes the population of this study in terms of age, body composition, cardiovascular variables at rest and peak force in 1RM tests for knee extension and elbow flexion.

Table 2 shows the results for the heart rate behavior at rest and immediately after the execution of the first (M1) and the second series (M2) of endurance and strength protocols using with upper and lower limbs.

It is observed a significant increase in heart rate at M1 and M2 in comparison to their respective rest for all protocols (p <0.001). No significant differences were observed between the resting values p = 1) and in M1 (p> 0.05), while for the M2, the strength value of the LL showed a significant difference compared to the moments M1 (p = 0.002) and M2 (p = 0.001) of the endurance protocol of LL.

Systolic and diastolic blood pressure results at rest and immediately after the first (M1) and the second series (M2), for the endurance and strength protocols, performed with upper and lower limbs, can be observed in **table 3** and **4**, respectively.

No significant differences among moments at rest of different protocols applied (p = 1) were observed **(table 3)**. Significant increase in the values of M1 and M2 in relation to their respective resting values was observed in all protocols (p <0.05). Furthermore, the M1 of the strength protocol with

Table 1. Decision-making operations/operators, their sensitivity and probable molecular signatures.

Personal characteristics	Mean ± standard deviation	Minimum - Maximum
Age (years)	21.78 ± 2.6	17 - 29.88
Weight (Kg)	72.01 ± 9.16	54.8 - 94.2
Height (meters)	1.74 ± 0.07	1.63 - 1.93
BMI (Kg/m^2)	23.80 ± 2.72	17.69 - 32.03
HR (bpm)	79.02 ± 11.67	60 - 105
SBP (mmHg)	108.5 ± 11.67	90 - 140
DBP (mmHg)	67.92 ± 9.55	50 - 92
MR - UL (Kg)	37.23 ± 10.34	20 - 65
MR - LL (Kg)	97.32 ± 19.55	60 - 130

Abbreviations: kg: kilograms; Kg/m^2: kilograms per meter squared; bpm: beats per minute; mmHg: millimeters of mercury MR: maximum resistance.

Table 2. Average values, standard deviations, median and confidence interval at 95% of heart rate during endurance and strength protocols carried out with upper and lower limbs.

Moments	Endurance		Strength	
	UL	LL	UL	LL
Rest	78.35 ± 12.11	77.23 ± 11.27	77.17 ± 13.17	78.71 ± 11.67
	(79)	(78)	(76.5)	(77)
	[74.97- 81.72]	[74.01- 80.37]	[73.5 - 80.84]	[75.46 - 81.96]
M1	93.85 ± 20.74*	105.86 ± 21.39*†	97.71 ± 21.89*	99.67 ± 19.36*
	(91)	(105.5)	(93.5)	(99)
	[88.06-99.63]	[99.90 - 111.83]	[91.6 - 103.81]	[94.27 - 105.07]
M2	99.88 ± 24.80*	106.83 ± 24.65*†	96.34 ± 24.02*	93.17 ± 20.42*
	(100.5)	(111.5)	(98.5)	(95.5)
	[92.97 - 106.79]	[99.96 - 113.69]	[89.65 - 103.04]	[87.48 - 98.86]

* Significant difference compared to resting values; † Significant difference from the moment M2 of the strength protocol of lower limbs (Data were compared using ANOVA for repeated measures followed by Bonferroni test, p <0.05). Large effect size for “Moments” (Eta-Squared= 0.464), small effect size for “Protocol/Limbs” (Eta-Squared= 0.027) and medium effect size for “Moment x Protocol/Limbs” (Eta-Squared= 0.065).

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UL was significantly lower compared to M2 of the endurance protocol with LL (p = 0.013).

As well as in systolic blood pressure for diastolic blood pressure no significant differences between resting values in different protocols (p = 1) were observed. Significant decrease was observed at M1 of endurance (p = 0.028) and strength (p = 0.022) of LL compared to their respective resting protocols. Also, there was difference between the M1 strength in LL when compared to: resting endurance LL (p = 0.041), M2 of endurance of UL (p = 0.001) and M2 of strength of UL (p = 0.027).

Table 3. Average values, standard deviations, median and confidence interval at 95% of systolic blood pressure during endurance and strength protocols carried out with upper and lower limbs.

Moments	Endurance		Strength	
	UL	LL	UL	LL
Rest	105.19 ± 12.63	107.32 ± 10.06	106.35 ± 12.06	106.88 ± 10.91
	(102)	(109)	(104)	(109)
	[101.67 - 108.71]	[104.52 - 110.13]	[102.99 - 109.71]	[103.84 - 109.92]
M1	113.94 ± 16.14†	120.73 ± 16.73*	115.11 ± 15.63‡§	120.69 ± 15.5*
	(110)	(120)	(110)	(120)
	[109.44 - 118.44]	[116.07 - 125.39]	[110.76 - 119.47]	[116.37 - 125.01]
M2	118.38 ± 16.76*	125.15 ± 18.99*†	118 ± 15.83*	121.57 ± 18.75*
	(120)	(120)	(118)	(120)
	[113.71 - 123.05]	[119.86 - 130.44]	[113.59 - 122.41]	[116.35 - 126.80]

* Significant difference compared to resting values of the applied protocols; †Significant difference compared to the respective rest; ‡ Significant difference compared to rest of strength and endurance protocols with lower limb; § Significant difference from the M1 of strength protocol of the upper limbs (Data were compared using ANOVA for repeated measures followed by Bonferroni test, p <0.05). Large effect size for "Moments" (Eta-Squared= 0.381), small effect size for "Protocol/Limbs" (Eta-Squared= 0.028) and small effect size for "Moment x Protocol/Limbs" (Eta-Squared= 0.023).

Table 4. Average values, standard deviations, median and confidence interval at 95% of diastolic blood pressure during endurance and strength protocols carried out with upper and lower limbs.

Moments	Endurance		Strength	
	UL	LL	UL	LL
Rest	68.23 ± 9.46	69.81 ± 9.14	68.52 ± 8.14	69.96 ± 9.41
	(70)	(70)	(70)	(70)
	[65.59 - 70.87]	[67.26 - 72.35]	[66.25 - 70.79]	[67.34 - 72.58]
M1	69.23 ± 9.63	63.81 ± 10.29*	67.69 ± 8.93	63.10 ± 10.69*†
	(70)	(62)	(70)	(61)
	[66.55 - 71.92]	[60.94 - 66.67]	[65.20 - 70.18]	[60.11 - 66.07]
M2	72.03 ± 9.43‡	65.77 ± 8.77§	68.98 ± 9.08§	66.42 ± 10.47
	(71)	(67)	(70)	(65)
	[69.41 - 74.67]	[63.32 - 68.21]	[66.45 - 71.51]	[63.50 - 69.34]

* Significant difference compared to the respective rest; † Significant difference from the rest of endurance of LL, the M2 of endurance of UL and the M2 of strenght of UL; ‡ Significant difference compared to M1 of endurance of LL; § Significant difference from the M2 of endurance protocol of the UL (Data were compared using ANOVA for repeated measures followed by Bonferroni test, p <0.05). Small effect size for "Moments" (Eta-Squared= 0.049), small effect size for "Protocol/Limbs" (Eta-Squared= 0.036) and medium effect size for "Moment x Protocol/Limbs" (Eta-Squared= 0.066).

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Table 5. Average values, standard deviations, median and confidence interval at 95% of MVO_2 during endurance and strength protocols carried out with upper and lower limbs.

Moments	Endurance		Strength	
	UL	LL	UL	LL
Rest	5.26 ± 2.3	5.29 ± 1.95	5.18 ± 2.22	5.48 ± 2.18
	(5.6)	(5.3)	(5.37)	(5.61)
	[4.61 - 5.89]	[4.75 - 5.84]	[4.56 - 5.80]	[4.88 – 6.09]
M1	8.74 ± 4.36*†	11.82 ± 5.39*	9.64 ± 5.11*	10.69 ± 4.6*
	(7.76)	(10.86)	(8.25)	(9.57)
	[7.52 - 9.95]	[10.31 - 13.32]	[8.21 - 11.06]	[9.41 - 11.97]
M2	10.42 ± 5.52*	12.69 ± 6.12*	9.84 ± 5.27*	9.79± 5.22* ‡
	(8.96)	(12.37)	(9.13)	(9.14)
	[8.88 - 11.96]	[10.99 - 14.39]	[8.37 - 11.31]	[8.34 - 11.25]

*Significant difference compared to resting values of the applied protocols; †Significant difference compared to M2 of endurance of UL and to M1 and M2 of endurance of LL; ‡ Significant difference compared to M2 of endurance of LL (Data were compared using ANOVA for repeated measures followed by Bonferroni test, p <0.05). Large effect size for "Moments" (Eta-Squared= 0.505), small effect size for "Protocol/Limbs" (Eta-Squared= 0.037) and medium effect size for "Moment x Protocol/Limbs" (Eta-Squared= 0.064).

Myocardial oxygen consumption (MVO_2) values in rest and after the first (M1) and the second series (M2) for the studied protocols can be viewed in **Table 5**. Comparing the moments M1 and M2, differences were observed between M2 endurance of UL and M1 endurance of LL ($p = 0.002$). It was also observed difference between the M2 of strength protocol of UL and M2 endurance of UL ($p = 0.037$).

No significant differences were observed in the resting values of the protocols ($p = 1$). MVO_2 values at M1 and M2 were higher compared to their respective resting values for all protocols ($p <0.001$). There were significant differences in M1 of endurance protocol of UL in comparison to the M2 of endurance of UL ($p = 0.001$) and the M1 ($p = 0.02$) and M2 ($p = 0.03$) of endurance LL. Significant differences were also observed between the M2 of strenght protocol of LL compared to the M2 of endurance protocol of LL ($p = 0.001$).

Discussion

Strength and endurance protocols, run with upper and lower limbs, were able to promote changes in cardiovascular variables, as well as after the execution of the first and the second series in relation to their resting values; however lower limb endurance protocol showed differences relative to other protocols.

In our results, the heart rate has increased along the implementation of both protocols, compared to baseline. This response confirms the data published in the literature [27-30] and initially occur by rapid vagal withdrawal and, subsequently, by increased sympathetic activity in response to muscle contraction induced by performing the exercise [27].

HR behavior during exercise is dependent on some characteristics of the prescription of resistance exercise, such as: muscle mass involved in exercise, intensity and time of exercise performance [28]. These factors may be related to higher values for the HR in moments M1 and M2 of endurance protocol of LL compared to the moment M2 strength protocol of LL.

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Protocols used in this study differ in the intensity and runtime. Endurance protocol consists of 2 sets of 20 repetitions at 40% 1RM and the strenght of 2 sets of 8 repetitions at 80% 1RM, therefore, besides the difference in intensities also the running time of the endurance protocol is greatest.

Similarly to the HR, were also observed significant increases in moments M1 and M2 relative to resting values for SBP, the most pronounced increase occurred in lower limb endurance protocol. It is known that the autonomic control mechanisms of BP and HR are similar, which makes congruent these results.

Recently published studys [29, 30] comparing the HR, DP and SBP responses induced by resistance exercise performed with different numbers of repetitions and intervals between sets, found similar results to this study. The protocol with the highest number of repetitions and lowest intensity (3 series of 12RM) promoted major changes in the cardiovascular system when compared to the one with highest intensity and less repetitions (3 series of 6RM) [29]. Also in the study of Lamotte et al. [30] higher values of HR and BP were observed in cardiac patients in the protocol consisting of a highest number of repetitions and lowest intensity [40% 1RM (4 series of 17 repetitions) vs 70% of 1RM (4 series of 10 repetitions)].

The cumulative effect of the series seems to be related the answers obtained. The longer duration of the exercise promotes greater maintenance of muscle tension and increase local vascular resistance, indicating a greater decrease in cardiac output and, consequently, a compensatory baroreflex response of positive inotropic effect, which increases cardiac sympathetic activity responsible for increase in HR and SBP [29, 30].

Regarding DBP, we observed declines in their M1 and M2 values in relation to their respective resting values, except for the upper limb endurance protocol, which showed an increase of DBP value at M2 compared to rest.

Comparing the application of resistance exercise in relation to different body segments [7], the lower limbs due to their larger demand of perfused capillaries, promote greater decrease in vascular peripheral resistance [7], however, with upper limb exercises, because they have less muscle cross-sectional, induce increased vascular peripheral resistance [9]. Our results corroborate these statements, since the values of DBP of the lower limbs (endurance and strength protocols) reached more pronounced drop and the endurance protocol of upper limbs showed a significant increase in M2.

We have observed increased MVO_2 during the execution of protocols, with more pronounced increase in lower limb endurance protocol. Also, significant differences were also observed between the M2 of strength protocol of LL compared to the M2 endurance protocol of LL.

Heart metabolism is influenced by both chronotropism as the inotropism, which influence the overload on the myocardium and its need for oxygen in various situations, including the exercise7. As noted, both HR and SBP increased with exercise performance relative to their resting values, which explains the observed increase in the MVO_2 values.

Factors such as body position [10], the interval among the series of exercises8, the type of activity [10] and the form of exercise performance9 also influence MVO_2 values. In addition, longer duration of exercise tends to keep the higher overhead on myocardium [7].

In this study the periods of rest intervals between sets of repetitions and body position were controlled and equal in all protocols; however the protocols were performed with different body segments (upper and lower limbs) and had different duration, which can be involved in higher values and statistical differences observed for M1 and M2 of endurance protocol of lower limbs in relation to other protocols [7].

Our results indicate that resistance exercise acutely applied in different intensities and in isolated

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and different muscle groups, was able to promote significant changes, which seem to be more exacerbated for protocol longer period of execution and higher muscle group. The protocols used in this study were designed to isolate the cardiovascular responses to different body segments and intensities, since this type of exercise is a disseminated feature in various physiotherapy specialties and usually utilized in isolation.

HR, SBP, DBP and MVO_2 behaviors in response to applied acutely resistance exercise in different body segments in healthy and active young were physiological. It is emphasized that the protocols were safe from the cardiovascular standpoint, since they did not promote abnormal behaviors and/or signs and symptoms that indicate abnormalities. Absence of unusual changes in respondse to acute application of this type of exercise has also been described in the literature [7, 11-13, 16].

Regarding the limitation of the study, during the period of data collection, there was resistance from volunteers to accept the guidelines, such as the deprivation of the use drinks that might interfere with autonomic activity, which contain caffeine or alcohol, 24 hours before realization of protocols. This fact contributed to extend the collection period, since they had to be rearranged. Thus, for some volunteers that exceeded more than seven days between the execution period of the protocols, we had to exclude them, justified by absence of attendance.

In conclusion, strength and endurance protocols, run with upper and lower limbs, applied in acute and isolated way, were able to promote changes in cardiovascular variables in relation to their respective resting value. However, lower limbs endurance protocol stands out in their differences among them, due to the longer execution period and larger muscle group.

Competing Interest

The authors declare have no competing of interest.

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List Of Abbreviations

1RM: one-repetition maximum test
ANOVA: analysis of variance
BMI: body mass index
DBP: diastolic blood pressure
DP: double product
HR: heart rate
IPAQ: International Activity Questionnaire physics
LL: knee extension
M1: after first series
M2: after second series
MVO_2: myocardial oxygen consumption.
PAR-Q: Questionnaire of Physical Activity Readiness
PE: perceived exertion
Reps: repetitions
SBP: systolic blood pressure
UL: elbow flexion

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