Blood pressure responses to resistive exercise in trained female athletes: Influence of velocity of movement

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(Received: August 15, 2014; Accepted: September 29, 2014)

Abstract: The purpose of this study was to examine post-exercise hypotension (PEH) responses to three different resistance exercise velocities in female athletes. The 13 female subjects with experience of resistance training performed a series of resistance exercises with 80% of one repetition maximum for 3 sets with differing in velocity of movements: fast movement (FM; 1-second eccentric and 1-second concentric actions), moderate movement (MM; 1-second eccentric and 2-second concentric actions) and slow movement (SM; 2-second eccentric and 4-second concentric actions). After completing each training session, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken every 10 min for a period of 60 min of recovery. The results indicated significant increases in SBP at 10th min post-exercise in comparison to baseline. After 60-min recovery, all conditions showed statistically significant decreases in SBP when compared with pre-exercise. In all measured moments, there were no significant differences among experimental sessions in post-exercise levels of SBP and DBP. Therefore, resistance training with FM, MM, and SM can induce increases in SBP after exercise, whereas, after 60-min recovery, can induce decreases in SBP or post-exercise hypotension.

Keywords: force, speed movement, SBP, DBP

Introduction

It appears that only a session of resistance exercise induced reducing blood pressure to level below pre-exercise. This phenomenon is called post-exercise hypotension (PEH) [1, 2] and has been widely investigated because of its importance for the treatment and prevention of arterial hypertension [3, 4]. PEH has been demonstrated after resistance exercise controversial results have been observed, such as increase [5], maintenance [6, 7], or even decrease [8, 9]. Although, some studies addressed the positive effects of resistance training on the management of blood pressure, there is still no consensus on an optimal resistance training design [10].

Success of a resistance training protocol to management of blood pressure relies on the manipulation of the acute variables such as volume, exercise selection, exercise order, and speed of muscle action [11]. In addition to the variables previously studied (exercise intensity, volume and sequence), other variables such as the amount of muscular mass involved, number of repetitions, type of training, and rest interval between the exercise sets and velocity of movement in resistance exercise can affect the responses to a bout of resistance exercise [12, 13]. Although velocity of movement was considered one of the main variables for resistance exercise [11, 14], there is few knowledge in the literature regarding investigation and comparison of the effects of different velocity of movements on cardiovascular responses to resistance exercises and the data about the effects of velocity of movement on cardiovascular responses especially in female athletes is scarce. Also, to the authors’ knowledge, there are no studies to date which have investigated the comparison of the effects of different velocity of movements in resistance exercise on the cardiovascular responses. Velocity of movement influenced on the metabolic productions during muscle.
contraction, and it can be affect on the cardiovascular responses to weightlifting training [14, 15]. Therefore, the purpose of the present study was to investigate and compare the effects of different velocity of movements in resistance exercise on cardiovascular responses in female athletes.

Materials and Methods

Participants

The subjects were 13 healthy females with at least 1 year experience in resistance training. All subjects were trained and well accustomed to heavy-resistance exercise. The subjects were free from any upper and lower body injuries and cardiovascular problems, had no cardiovascular disease, and did not use smoke and alcohol. Complete advice about possible risks and discomfort was given to the participants, and subsequently, their written informed consent was obtained. The study was conducted in full accordance with the statement of protection for human subjects in the Declaration of Helsinki. The subjects’ physical and cardiovascular characteristics are presented in Table I.

| Table I | Subjects’ physical and cardiovascular characteristics (mean ± SD) |
|-------------------|---------------------------------------------------------------|
| Age (year)         | 26.1 ± 4.7                                                    |
| Height (cm)        | 163.6 ± 6.8                                                   |
| Body mass (kg)     | 60.2 ± 5.9                                                    |
| BMI (kg/m²)        | 22.8 ± 2.5                                                    |
| SBP (mmHg)         | 104.8 ± 7.3                                                   |
| DBP (mmHg)         | 63.8 ± 3.4                                                    |
| 1RM leg press (kg) | 75.6 ± 18.1                                                   |
| 1RM lat pull down (kg) | 38.2 ± 12.2                                                |
| 1RM knee flexion (kg) | 34.9 ± 11                                                   |
| 1RM bench press (kg) | 14.17 ± 4.3                                                  |
| 1RM knee extension (kg) | 31.4 ± 11                                                   |
| 1RM standing biceps extension (kg) | 22.1 ± 4.5                                                  |

Study design

A randomized, crossover experimental design was used, with each subject performing 3 velocities of movements of resistance exercise. The data collection was performed on 6 nonconsecutive days. At least 48 h before starting of study, athletes were recruited to laboratory for assessing age, body mass, and height. During this session, each athlete was familiarized with resistance exercises (familiarization session, day 1). During the familiarization visit, participants were instructed on how to properly time the eccentric and concentric actions for each condition with the use of a metronome. At days 2 and 3, the one repetition maximum of each resistance exercise was determined (day 1: leg press, bench press, and standing biceps extension; day 2: knee extension, lat pull down, and knee flexion). All athletes underwent, in a random order, three exercise conditions: resistance exercises with fast movement velocity (FM), resistance exercises with moderate movement velocity (MM), and resistance exercise with slow movement velocity (SM), with 48 h rest in between conditions. All treatment sessions were performed in the afternoon at the same time for deceasing circadian rhythm. Pre and 60 min post each condition (every 10 min), SBP and DBP were measured. Athletes were instructed to avoid any strenuous physical exercise and alcohol for at least 72 h before performing each condition and to avoid smoking, caffeine, and medications for 12 h. The ambient temperature was fixed at 27 ± 1 °C, and the air humidity during the tests ranged between 60% and 70%.

Resistance exercise

In each training session, the athletes performed 10-min warm-up including light running, static stretching, and ballistic movements, and then remained seated for 5 min, and then blood pressure was measured at rest. After measuring rest blood pressure, the athletes moved to exercise room and performed resistance exercises in order to leg press, lat pull down, knee flexion, bench press, knee extension, and standing biceps extension with differing in velocity of movement at 80% of one repetition maximum for 3 sets and 8 repetitions [11, 14, 15]. The velocity of movements in resistance exercises for each exercise session was controlled by metronome. The rest interval between sets and exercise was 1.5 and 2 min, respectively.

Blood pressure measurement

Blood pressure was assessed after 5 min of rest following 10-min warm-up in a seated position (rest value). Also, after performing each condition, athletes reported to laboratory and seated for 60 min in a quiet and comfortable place, to measure the post-exercise blood pressure every 10 min (post-intervention period). On the occasion of each visit, blood pressure was measured by the same experienced observer using a standard mercury sphygmomanometer (Missouri®) and stethoscope (Rappaport® GF Health Products, Northeast Parkway Atlanta), taking the first and the fifth phases of Korotkoff sounds as SBP and DBP values, respectively. An experienced appraiser performed the measurements during rest and after exercise for all subjects.
Statistical analyses

Data are presented as mean ± standard deviation. Prior to analysis, data normality was checked with the Kolmogorov–Smirnoff test. A repeated-measures ANOVA followed by the Bonferroni post hoc test, where indicated, was used to analyze SBP and DBP. The level of significance was set at $p \leq 0.05$ for all statistical procedures. All analyses were conducted using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA).

Results

The SBP and DBP responses during the different treatment sessions are presented in Figs 1 and 2, respectively. In comparison to rest value, SBP increased significantly at 10th min of recovery following all conditions or velocity of movements ($p = 0.001$). The MM and SM conditions indicated significant decreases in SBP at 30th, 40th, and 50th min of recovery when compared with pre-exercise value. Also, after 60 min recovery, all conditions shown decrease in SBP rather than pre-exercise value ($p < 0.05$). In addition, DBP did not differ from that measured at rest and after resistance exercise with differing in velocity of movement. Also, in all measured time, there were no significant differences among conditions.

Discussion

To the authors’ knowledge, this was the first study that examined the influence of velocity of movements during resistance exercise on blood pressure responses in women athletes. The main findings of the current study are as follows:
follows: a) significant increases in SBP after all velocities of resistance exercise; b) decreases in SBP (PEH) for SM and MM conditions at 30th, 40th, and 50th min of post-exercise; c) decreases in SBP for all the conditions after 60-min recovery in comparison to pre-exercise value. The reduction in blood pressure after a session of resistance exercise is in agreement with the results obtained by previous studies that reported PEH after resistance exercise [2–4, 8, 9]. In contrast, Veloso et al. [7] and Polito et al. [16] observed no changes in blood pressure or PEH after resistance exercise. One of the possible physiological mechanisms for the PEH after resistance exercise could be the influence of muscle mass on blood pressure. It appears that blood pressure affected muscle mass in reduction of vascular resistance, caused by the liberation of vasodilating endothelial substances such as nitric oxide, prostaglandins, and adenosine [17]. Other possible mechanisms that involved in reduction of blood pressure could be decreases in stroke volume and cardiac output, reduction in limb vascular resistance, total peripheral resistance, and muscle sympathetic nerve discharge [1, 2, 17], but because no physiological measurements were made, only speculations are possible, and these responses were strongly supported with previous studies [1, 2, 8, 9, 17].

In the SM trial, the continuous force output and concomitant sustained restriction of blood flow might cause a marked and persistent reduction of muscle oxygenation level. Therefore, we believed that a sustained exposure of intramuscular hypoxic condition might be a more important factor for increasing blood pressure after resistance exercise, and these mechanisms continued to 40th min of post-exercise where PEH occurred [15, 18]. Similar to SM condition, MM trial indicated significant increases in SBP at 10th of post resistance exercise. Time under tension refers to the total time a muscle is performing work, either in eccentric or concentric portion of an exercise. All MM repetition movement velocity sets were long, and it seems that this time to work could increase exposure of intramuscular hypoxic, consequently increasing SBP where these increases were continued to 40th of post-exercise [11, 15, 18]. Similar to SM and MM conditions, participants after FM resistance exercise indicated significant increases in SBP at 10th min of post-exercise. Fast motor units recruited during fast training velocity [11, 15, 18]. This type of exercise can produce higher forces after a period of training utilizing faster velocity movements involves the greater use of the stretch shortening cycle, and it has been supported that it could induce more metabolic stress and muscle sympathetic nerve charge resulting increases in SBP until 60th min of post-exercise [15, 19–22].

Compared with pre-exercise value, no significant PEH of DBP was occurred in all measurement moments after resistance exercise for all the conditions. These findings are in line with previous studies [10, 16] and are in contrast to another studies [8, 9]. The mechanism(s) responsible for unchanged DBP could be interaction between increases in cardiac output and decreases blood vessels resistance, but because no physiological measurements were made, only speculations are possible.

The findings of the present study revealed that resistance exercise led to significant decreases in SBP. Also, no statistically changes in DBP were observed for all the conditions. These findings are in agreement with literature that detected non-pharmacological effects of exercise for the management of BP. Moreover, with regard to these findings, it is recommended that PEH after FM resistance exercise needs more time in comparison to SM and MM conditions and strength and conditioning professionals must keep this note in their mind.

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Funding sources: None.

Authors’ contribution: HA designed the study, wrote the manuscript and made revisions; VA assisted the study design, performed the statistical analysis, wrote the manuscript and made revisions to make revisions and to elaborate the graphics; VA assisted the study design, contributed to take the data.

Conflict of interest: None.

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