Revista Brasileira de Prescrição e Fisiologia do Exercício
ISSN 1981-9900 ***versão eletrônica***

Periódico do Instituto Brasileiro de Pesquisa e Ensino em Fisiologia do Exercício

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ACUTE EFFECT OF HEAVY RESISTANCE EXERCISE ON VERTICAL JUMP PERFORMANCE IN YOUNG BASKETBALL PLAYERS

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ABSTRACT

The purposes of the study were to investigate whether HRE induces increase in vertical JP, and to compare the effects of different HRE volumes and recovery periods on vertical JP. Nine volunteers (six men and three women), young basketball players in the juvenile category (16±1 year-old age, height of 1,72±0,09 m, body mass of 69,2±15,1 kg, fat percentile of 15,6±4,2%), performed one set of five countermovement vertical jump (CMJ) and after four minutes of interval they executed one or three set of 5RM back half-squat exercise. Four and 10 minutes after the end of the squat exercise, the individuals performed a second set of five CMJ. No significant statistical differences (f=1.26, p=0.301) were observed among conditions (one or three set of 5RM back half-squat exercise) in CMJ performance four minutes after the end of the squat exercise. The condition 3x5RM significantly (p<0,01) reduced the height of CMJ 10 minutes after the HRE (f=3.54, p=0.040). Based on the results, we can conclude that low (1X5RMs) or high (3X5RMs) volume of HRE does not improve CMJ performance after four or 10 minutes of recovery. Besides, high volume of HRE (3X5RMs) induced decrease of CMJ performance in recreationally trained young.

Key words: Conditioning contractile activity. Countermovement jump. Postactivation potentiation.

RESUMO

Efeito agudo do exercício resistido intenso no desempenho do salto vertical em jovens jogadores de basquetebol

O propósito do estudo foi comparar diferentes volumes de exercício contrarresistência intenso (ECI) e períodos de recuperação no desempenho do salto vertical de jovens atletas de basquetebol. Nove voluntários saudáveis (seis homens e três mulheres), jogadores de basquete na categoria infanto-juvenil (16±1 anos, altura de 1,72±0,09 m, massa corporal de 69,2±15,1 kg, percentual de gordura de 15,6±4,2%) realizaram cinco saltos contramovimento (SCM) e a após quatro minutos de pausa ele realizaram uma ou três séries de cinco repetições máximas no meio agachamento (1X5RM ou 3X5RM, respectivamente). Quatro ou dez minutos após o fim do exercício de agachamento os indivíduos realizaram novamente cinco SCM consecutivos. Não foi observada diferença estatística entre as condições 1x5RM e 3X5RM no desempenho do SCM após quatro minutos do fim do exercício de agachamento. A condição 3x5RM reduziu significantemente a altura do SCM 10 minutos após exercício de agachamento (f=3.54, p=0.040). Os resultados sugerem que o ECI de baixo (1X5RM) ou alto (3X5RM) volume não melhora o desempenho do salto vertical contra movimento realizados após quatro ou 10 minutos de pausa em jovens atletas de basquetebol.

Palavras-chave: Exercício de aquecimento. Salto contramovimento. Potencialização pós-ativação.

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INTRODUCTION

The muscular power is a key element to successful outcomes in a number of athletic events, such as the high jump. Thus, the capacity to maximize muscular power is a field of constant research.

Several studies have reported that a previous heavy resistance exercise (HRE) promotes acute improvements in jump performance in young and adults, men and women, probably due to the post activation potentiation (PAP) phenomenon (Chiu, et al., 2003, Kotzamanidis, et al., 2005, Weber, et al., 2008, Esformes, et al., 2010, Linder, et al., 2010, McCann and Flanagan, 2010, Mitchell and Sale, 2011, Requena, et al., 2011a). PAP is defined as an increase in muscle contractile capacity after a conditioning activity (i.e. HRE).

Several mechanisms are proposed to explain PAP, such as the phosphorylation of myosin light chain which would increase the interaction between the contractile proteins and the sensibility of the myofibers to calcium ions; the modification of the muscle architecture, reducing muscle fibers angle in relation to the axis of force generation allowing better force transmission, and finally the alteration in neural activation pattern which increases motor unit recruitment to the subsequent maximal voluntary contraction (Sale, 2002, Aagaard, 2003, Docherty, et al., 2004) .

Improvements in jumping and sprinting performance after maximal isometric or dynamic muscle contractions are frequently used as an indicator of PAP occurrence (Radcliffe and Radcliffe, 1996, Sale, 2002, Docherty, et al., 2004, Chatzopoulos, et al., 2007, Weber, et al., 2008, Yetter and Moir, 2008, Khamoui, et al., 2009, Bevan, et al., 2010, Comyns, et al., 2010, Linder, et al., 2010, Mitchell and Sale, 2011).

For instance, Mitchell and Sale (Mitchell and Sale, 2011) reported significant increase in CMJ height four minutes after 1x5RM in the back squat exercise. Weber et al. (Weber, et al., 2008) also reported a ~5% significant increase in vertical jump height three minutes after one set of five repetitions with 85% of 1RM in the back squat exercise.

Even though several studies have observed increases in jump performance after the accomplishment of HRE, others have not found the same outcome (Radcliffe and Radcliffe, 1996, Sale, 2002, Jensen and Ebben, 2003, Docherty, et al., 2004, Chatzopoulos, et al., 2007, Yetter and Moir, 2008, Bevan, et al., 2010, Comyns, et al., 2010, Linder, et al., 2010).

For instance, in NCAA Division I athletes, Jensen and Ebben (Jensen and Ebben, 2003) did not find significant augmentation in countermovement vertical jump (CMJ) height four minutes after performing one set of five repetitions maximal (1x5RM) in the back squat exercise.

Similarly, Khamoui et al., (Khamoui, et al., 2009) also did not observe increase in CMJ height five minutes after recreationally trained men executed one set of two, three or four repetitions with 85% of 1RM in the back squat exercise.

Many factors may affect the PPA were identified, but there is no clear agreement regarding the ideal combination of conditioning activity variables to optimize PAP, especially in young athletes. The efficacy by which a conditioning activity can stimulate PAP mechanisms depends on the balance between fatigue and potentiation (Sale, 2002).

Thus, the interaction between volume and recovery interval may be critical when prescribing an intervention designed to induce PAP. Although some studies have evaluated different regimens of low volume, there seems to be a trend towards higher volumes (single vs. multiple sets) to trigger PAP (Chiu, et al., 2003, Docherty, et al., 2004, McBride, et al., 2005, Saez Saez de Villarreal, et al., 2007).

On the other hand, longer periods of recovery between the end of the HRE and the beginning of jump performance have been recommended to minimize the negative effects of fatigue over PAP mechanism (Sale, 2002, Docherty, et al., 2004).

Therefore, the purposes of the study were to compare the effects of different HRE volumes and recovery periods on vertical jump performance in young basketball players.

METERIALS AND METHODS

Subjects

Fifteen volunteers were selected and throughout the study there were six dropouts. Thus, nine volunteers (six men and three women), free from medication, nutritional supplements, or any type of ergogenic aid,

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completed the study. All volunteers were healthy (age 16±1 years, height 1.72±0.09 m, body mass 69.2±15.1 kg, body fat 15,6±4,2%) and characterized young basketball players, training at least 3 days per week (>4 years), 6 hours per week, with no experience in resistance training.

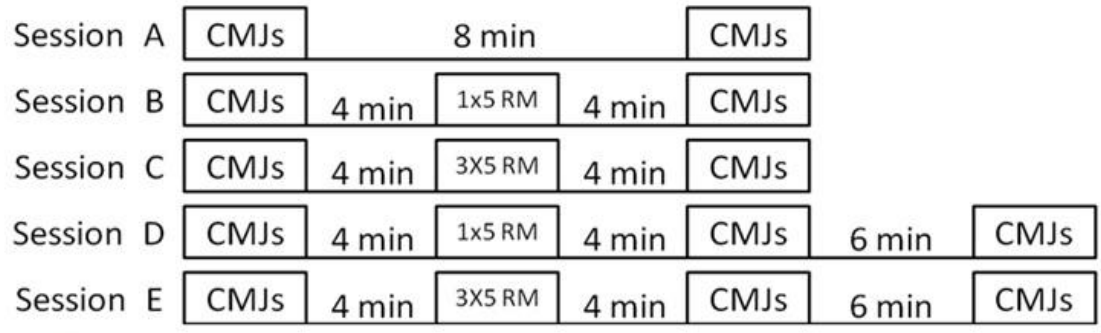
Legal guardian signed a term of informed consent for their adolescents to participate in this study, which was approved by the Ethics and Human Research Committee of the Federal University of Triangulo Mineiro (protocol No. 1990).

Experimental Approach

The volunteers accomplished seven visits to the laboratory. The first visit was to assess body composition and anthropometric variables and to familiarize them to the resistance exercise (5RM half-squat exercise) and vertical jump procedures. After 24 and 48 hours, they returned to the laboratory for the assessment of 5RM maximum dynamic strength, test and re-test respectively. The next five visits were organized in sessions A, B, C, D, and E with an interval of at least 24 hours among them.

Figure 1 depicts a general overview of the study design. Session “A” was the control session, in which the individuals performed one set of five CMJ, and after eight minutes of rest they performed again one set of five CMJ. In session "B" the subjects performed one set of five CMJ and after four minutes of interval they executed one set of 5RM back half-squat exercise. Four minutes after the end of the squat exercise, the individuals performed a second set of five CMJ. Session "C" was similar to “B”, except that the HRE was composed of three sets of 5RM back half-squat. Session "D" consisted of one set of five CMJ, four minutes of interval followed by one set of 5RM back half-squat. Four minutes after the squat exercise, the individuals performed a second set of five CMJ and six minutes after a third set of five CMJ was done. The last visit (session "E") was similar to the session "D", except that the HRE was composed of three sets of 5RM. The highest jump (HJ) and the mean of five jumps (MJ) were used for statistical analyses.

Figure 1 – General overview of the study design



General overview of the study design. **CMJs –** countermovement jumps; 1x5RM – one set of five repetitions maximum; 3x5RM – three sets of five repetitions maximum.

Anthropometric assessment

Body mass was measured with platform type anthropometric scales with capacity up to 150kg and 0,1kg precision. Subjects were barefoot and with minimum clothing. Height was determined with the use of the portable stadiometer with a 0,1cm accuracy. Later on body mass index was calculated (BMI = body mass (kg) / height $(m)^2$).

Body composition assessment

The body composition was determined by bioelectrical impedance (model 450, Biodynamics, USA) through the equation proposed by Houtkooper et al (Houtkooper, et al., 1989) as follows: Fat-free mass (FFM) (kg) = 0.61(height (m^2)/resistance) + 0.25 (body mass (kg)) + 1.30. Body fat percentage (G%) = [(body mass (kg) - FFM) / body mass (kg)] x 100.

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Countermovement jump test

The subjects were submitted to a countermovement vertical jump (CMJ) test. Countermovement jump height was determined through the use of a contact platform (Jump System Pro1.0, Cefise, Brazil). Subjects were allowed to perform a preparatory downward movement (knee flexion) followed by an upward trust. The individuals started from a standing position, with hands on the waist and parallel feet shoulder distance apart. They were asked to execute a coordinated movement of the hip, knee and ankle joints flexion and freely determine the amplitude of the countermovement to avoid changes in jumping coordination. The transition of the downward to the upward phase was characterized by a continuous movement, in which all joints were extended as fast as possible. All individuals warmed up in a cycloergometer for five minutes and soon afterwards they performed five jumps with a 5second interval between jumps.

Test of five repetitions maximum (5RM) in the back half-squat exercise

Previously to the test, all subjects participate in a familiarization session with the equipment and the back half-squat exercise technique. Each subject took part in two exercise sessions: 1 testing sessions and 2 re-testing. All sessions were conducted at the same time of day.

Three minutes after a warm-up composed of five minutes on a cycloergometer, subjects attempted one set of five half-squats with their self-selected 5RM load. In case of under- or overestimation they rested three to five minutes before the next attempt with a new 5RM load. On average, this procedure was repeated three to five times until the individual 5RM was obtained. They were instructed to perform each repetition to 90^{o} of knee flexion.

Statistical analysis

Data normality and homogeneity were evaluated by the tests of Kolmogorov & Smirnov and Levene, respectively. Results are presented as means ± standard deviations. Interaction moment (pre- and post HRE) × Session (A, B and C or D and E) effect was assessed by the repeated measures ANOVA. Whenever a significant F value was obtained, a post hoc test with Tukey's adjustment was performed to determine differences. Pearson correlation coefficient was used to determine relationship among variables of force (5RM) and the difference (delta = after - before) in the jump performance before and after the HRE. Significance level was set at 5% ($p<0.05$).

RESULTS

The mean value of MJ and HJ, before and after the conditions 1x5RM, 3x5RM, and control (CT), are presented in Graphics 1 and 2, respectively. No significant statistical differences were observed among conditions (Interaction Moment x Session: HJ - $f=1.30$, $p=0.288$ and MJ - $f=1.26$, $p=0.301$).

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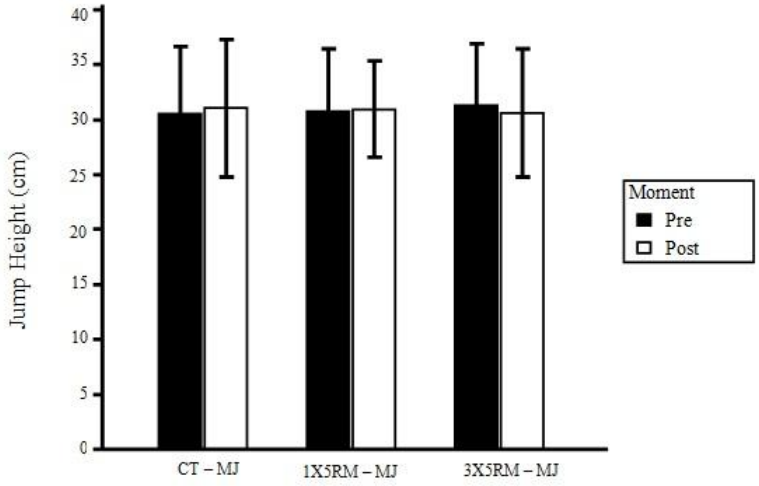
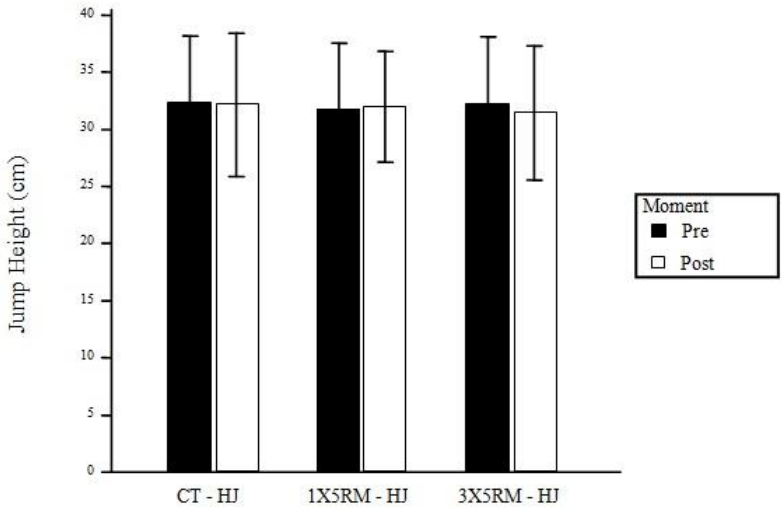
Graphic 1. Mean values of five jumps



Jump height (mean ± SD) in the moment pre- and post HRE-. CT-Control; MJ- Mean jump ; 1x5RM- composed by HRE with one set of 5RM; 3x5RM- composed by HRE with three sets of 5RM.

Graphic 2. Mean values of highest jump



Presents the mean values of the higher jumps in the pre and post HRE. CT-Control; HJ-Higher jumps; 1x5RM- composed by HRE with one set of 5RM; 3x5RM- composed by HRE with three sets of 5RM.

Graphics 3 and 4 present the mean values of MJ and HJ, respectively, evaluated before and after (four min and 10 min) the conditions 1x5RM and 3x5RM. The condition 3x5RM significantly ($p<0,01$) reduced the height of MJ and HJ 10 minutes after the HRE (Interaction Moment x Session: HJ – $f=4.25$, $p=0.022$ and MJ – $f=3.54$, $p=0.040$).

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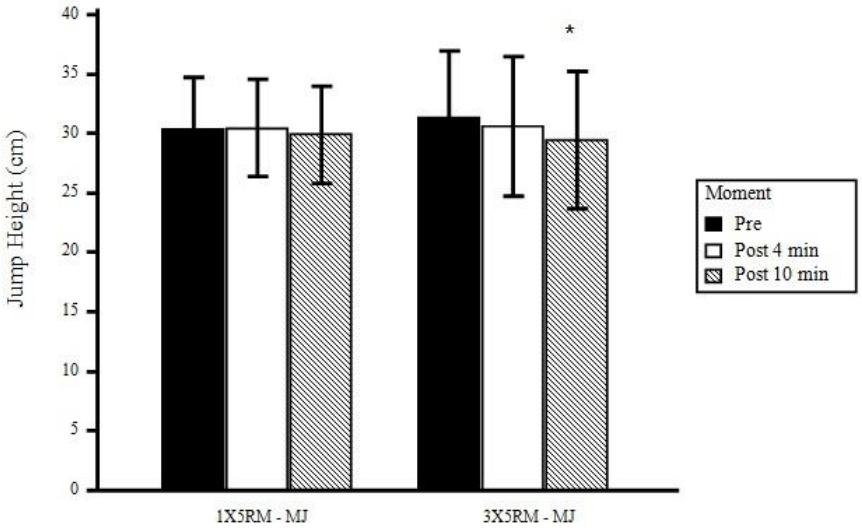
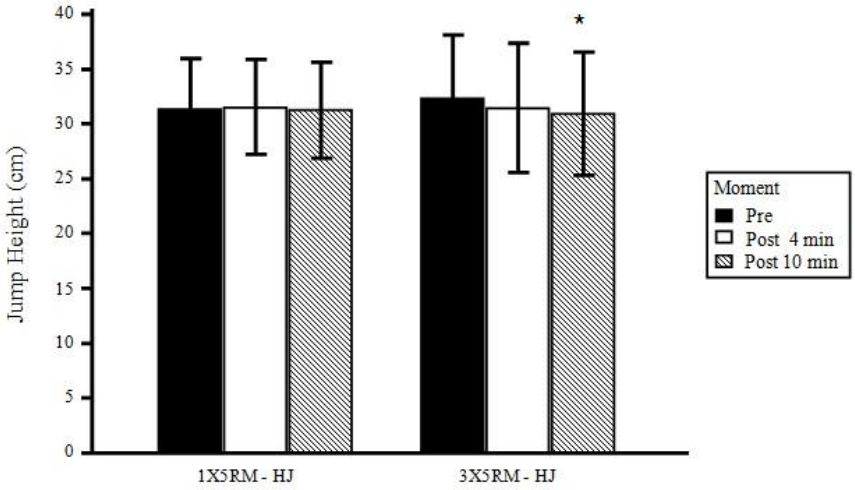
Graphic 3. Values of the mean of the jumps in the moment pre and post 4 and 10 minutes of HRE interval



Presents the values of the mean of the jumps in the moment pre and post 4 and 10 minutes of HRE interval. MJ-means jump; 1x5RM- HRE composed by one set of 5RM; 3x5RM- HRE composed by three sets of 5RM.

Graphic 4. Means values of the higher jumps pre and post 4 and 10 minutes of HRE interval



Presents the means values of the higher jumps pre and post 4 and 10 minutes of HRE interval. HJ-Higher jumps; 1x5RM- HRE with one set of RM; 3x5RM- HRE with three sets of 5RM.

There was not significant correlation between the load (in kg found in 5RMs) and the delta in CMJ performance [1X5RM-HJ, r = -0.41 (p=0.27); 1X5RM-MJ, r = -0.31 (p=0.45); 3X5RM-HJ, r = 0.01 (p=0.98) and 3X5RM-MJ, r = 0.41 (p=0.27)].

DISCUSSION

The present study did not find PAP induced by the resistance exercise of high intensity (5RMs) in recreational basketball players, as shown for the absence of significant improvements in CMJ performance

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after back half-squat exercise. In fact, a higher volume of the HRE (i.e., 3x5RM) induced fatigue after 10 minutes.

These results are similar to other studies that failed to find PAP in vertical jump after the application of a resistance exercise load (Jensen and Ebben, 2003, Scott and Docherty, 2004, Gonzalez-Rave, et al., 2009, Khamoui, et al., 2009).

For example, Scott and Docherty (Scott and Docherty, 2004) did not detected PAP in jumping performance (vertical and horizontal) five minutes after 1x5RMs in the back squat exercise in strong men (5RM = 196,9±23 kg; body mass = 79,3±7 kg). Khamoui et al., (Khamoui, et al., 2009) also did not find PAP in CMJ performance five minutes after 2, 3, 4, or 5RMs in the back half-squat in men with lower strength level compared to the above study (1RM = 124,7±17 kg; body mass 84,6±14 kg).

Jensen and Ebben (Jensen and Ebben, 2003) did not observe PAP in CMJ height and ground reaction force after 5RM squat exercise in NCAA (Division I) athletes, independent of the individuals' level of strength (high and low performance). Similarly, we found no PAP and significant correlation between the force level and potentiation of the CMJ (delta = after - before). Collectively, the data suggest that the level of muscle strength of young athletes was not liable for failure of individuals to produce PAP.

On the other hand, Mitchell and Sale (Mitchell and Sale, 2011) reported PAP in CMJ performance four minutes after 1x5RM squat exercise in rugby players with one year of experience in the resistance exercise.

Similarly, Webber et al. (Weber, et al., 2008) reported PAP in vertical jump performance and in the ground reaction force three minutes after five repetitions with 85% of 1RM squat exercise in NCAA (Division I) sprinters and jumpers with 1-year experience in strength and power training. The authors suggest that the adaptations promoted by the type of athlete's training (sprinters and jumpers) could provide PAP (Sale, 2002, Aagaard, 2003).

Corroborating with Webber et al. (Weber, et al., 2008), other studies showed PAP in athletes who participated in sports and physical activities with explosive characteristics (Chiu, et al., 2003, Esformes, et al., 2010, McCann and Flanagan, 2010, Requena, et al., 2011b).

Therefore, the specific adaptations to the training program, mainly explosive type training, seem to facilitate PAP occurrence (Chiu, et al., 2003).

The subjects of the present study did not have previous experience with either resistance training or explosive exercises, which may have affected negatively jumping performance after the HRE.

Concerning the recovery time between HRE and jump performance the literature shows disagreement. Gullich and Schmidtbleicher reported that PAP arose from three to five minutes after HRE (5RM) (Güllich and Schmidtbleicher, 1996).

However, Jensen and Ebben (Jensen and Ebben, 2003) did not find PAP in the height of CMJ and ground reaction force one, two, three and four minutes after 5RM squat. Corroborating with Jensen and Ebben (Jensen and Ebben, 2003), we did not find PAP four minutes after 1X5RM. The PPA likely dissipates by 30 minutes following a HER(Rixon, et al., 2007).

Therefore, the time period of recovery between HRE and jump performance has varied from 15 seconds to 20 minutes (Docherty, et al., 2004). The longest period of recovery would provide larger time for dissipation of the fatigue (probably in a faster rhythm than PAP´s decline)(Sale, 2002, Docherty, et al., 2004).

Assuming that more than four minutes would be necessary to increase the jump performance (PAP) (Sale, 2002, Docherty, et al., 2004) we assessed the jump after 10 minutes and we did not find difference after 1X5RM in CMJ performance.

In order to verify the effect of larger volume of HRE on PAP (Sale, 2002, Docherty, et al., 2004), we used three series of 5RM. The vertical jump performance was significantly decreased after 10 minutes of recovery, probably due to the fatigue or damage muscle induced by the high exercise volume (Sale, 2002, Docherty, et al., 2004, Porto, et al., 2008).

As a limitation of the study, the small sample size influenced negatively in the statistical power and may have left out some important differences as well as statistically significant.

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CONCLUSION

Therefore, the present study suggests that low (1X5RMs) or high (3X5RMs) volume of HRE does not improve CMJ performance after four or 10 minutes of recovery. Besides, high volume of HRE (3X5RMs) induces decrease of CMJ performance in recreationally trained young.

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The study was approved by the Ethics and Human Research Committee of the Federal University of Triângulo Mineiro (protocol No. 1990).

The authors thank FAPEMIG for the fellowships granted (CMB).

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Recebido para publicação 15/01/2014
Aceito em 15/03/2014