Post-exercise energy expenditure of half squat and bench press at different load percentages and controlled cadence

Gasto de energía pós-ejecercicio de media sentadilla y press de banco a diferentes porcentajes de carga y cadencia controlada

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ABSTRACT  
The aim of this study was to analyze the effect of movement velocity and intensity on EPOC fast component in bench press and half squat exercises performed to concentric failure. Twelve healthy recreational bodybuilders performed 10 days of experimental procedures: the 1st and 2nd days were to load determination (1RM test and re-test), the 3rd to 10th days performing the bench press and half squat exercises with 60 and 80% 1RM performed in slow (1s/1s) and high (2s/2s) movement velocity cadence 52 beats. Oxygen consumption was continuously measured in the first 20-min post-exercise using Cosmed K4 b2 portable device. A multivariate analysis compared the EPOC averaged in each minute post-exercise according to the different exercises, intensities and movement velocities. Was observed that EPOC declines fast from the 1st to 2nd minute and attains almost 100% of the decline near resting VO2 values at the 3rd minute of recovery both exercises. Greatest EPOC accumulated, during the eight minutes, was to exercise that involved the largest muscle group (half squat) with high intensity (80% 1RM) and greater movement velocity (1s/1s). In the full 20-min interval, the half squat had an energy equivalent of almost 80% more compared with the bench press. The higher velocities enhance energy expenditure to a greater extent than a more fatiguing slower exercise.

Keywords: energy cost, post-exercise oxygen consumption, strength training.
RESUMO
O objetivo deste estudo foi analisar o efeito da velocidade e intensidade do movimento no componente rápido do EPOC em exercícios de pressão de bancada e semiagachamento realizados para falha concêntrica. Doze fisiculturistas recreativos saudáveis realizaram 10 dias de procedimentos experimentais: o 1º e 2º dias foram para determinação de carga (1RM teste e re-teste), o 3º ao 10º dias realizando a prensa de bancada e exercícios de meia agachamento com 60 e 80% 1RM realizada em lento (1s/1s) e alta (2s/2s) cadência de velocidade de movimento 52 batimentos. O consumo de oxigênio foi medido continuamente no primeiro pós-exercício de 20 minutos usando o dispositivo portátil Cosmed K4 b2. Uma análise multivariada comparou a média do EPOC em cada minuto após o exercício, de acordo com os diferentes exercícios, intensidades e velocidades de movimento. Observou-se que o EPOC decresce rapidamente do 1º ao 2º minuto e atinge quase 100% do declínio próximo dos valores de VO2 em repouso no 3º minuto de recuperação ambos os exercícios. Maior EPOC acumulado, durante os oito minutos, foi o exercício que envolveu o grupo muscular maior (meio agachamento) com alta intensidade (80% 1RM) e maior velocidade de movimento (1s/1s). No intervalo completo de 20 minutos, o meio agachamento teve uma energia equivalente a quase 80% a mais em comparação com a prensa de bancada. As velocidades mais elevadas aumentam as despesas de energia em maior medida do que um exercício mais lento e fatigante.

Palavras-chave: custo de energia, consumo de oxigênio pós-exercício, treinamento de força.

RESUMEN
El objetivo de este estudio fue analizar el efecto de la velocidad de movimiento y la intensidad sobre el componente rápido EPOC en ejercicios de press de banca y media sentadilla realizados para evitar el fallo concéntrico. Doce culturistas recreativos sanos realizaron 10 días de procedimientos experimentales: el 1er y 2do días fueron para determinar la carga (prueba de 1RM y re-prueba), el 3er a 10mo días realizando el press de banco y ejercicios de media sentadilla con 60 y 80% 1RM realizados en lentos (1s/1s) y altos (2s/2s) velocidad de movimiento cadencia 52 latidos. El consumo de oxígeno se midió continuamente en los primeros 20 minutos después del ejercicio utilizando el dispositivo portátil Cosmed K4 b2. Un análisis multivariado comparó el EPOC promediado en cada minuto después del ejercicio de acuerdo con los diferentes ejercicios, intensidades y velocidades de movimiento. Se observó que el EPOC disminuye rápidamente del minuto 1 al 2 y alcanza casi el 100% de la disminución cerca de los valores de VO2 en reposo en el minuto 3 de la recuperación de ambos ejercicios. El mayor EPOC acumulado, durante los ocho minutos, fue el ejercicio que involucró el grupo muscular más grande (media sentadilla) con alta intensidad (80% 1RM) y mayor velocidad de movimiento (1s/1s). En el intervalo completo de 20 minutos, la media sentadilla tenía un equivalente de energía de casi un 80% más en comparación con la prensa de banco. Las velocidades más altas aumentan el gasto de energía en mayor medida que un ejercicio más lento y fatigante.
1 INTRODUCTION

The acute metabolic demands of resistance training (RT) exercise have been investigated by previous studies depending on variables, such as muscle mass (Mazzetti et al., 2007), lifting velocities (Barreto et al., 2010), number of sets (Heden et al., 2011), number of repetitions (Roberson KB, Jacobs KA, White MJ, Signorile JF., 2017), workload, training volume (Cesar et al., 2013), rest intervals (Arazi H, Ghiasi A, Afkhami M., 2013), and exercise order (Abrantes et al., 2021). Their results have shown significantly larger increases in oxygen uptake (VO$_2$) and energy expenditure, during and after exercise (EPOC). Performance of RT can significantly disrupt the body’s homeostasis, with the EPOC being dependent on the specific combination of prescriptive variables. There are many possibilities in how these prescriptive variables might be combined to influence energy expenditure and oxygen consumption during and following a RT bout (João et al., 2020).

The speed of muscle action has been shown to elicit different neural and the metabolic responses to RT. When lifting with maximal exertion, repetition velocity is inversely related to the relative load being lifted and follows the force/velocity curve (Newton et al., 2002). When the intent is to purposefully move at a slower repetition velocity (often with a lower intensity load), the increased time under tension appears to be an important stimulus to elicit improvements in localized muscular endurance (Bompa, Tudor O., Buzzichelli, Carlo., 2019). Ballor et al. (1987) demonstrated that a slower repetition velocity with a lighter load was more metabolically demanding versus moderate and faster repetition velocities. However, it is difficult to perform a large number of repetitions using a slower repetition velocity, which limits training volume.

Previous RT studies have demonstrated that faster repetition velocities with moderate to high loads were more effective versus traditional slower repetition velocities for absolute strength increases (Ratamess, 2007). However, there is another study showing a relatively slower repetition velocity produced similar energy expenditure.
during and following RT as a relatively faster repetition velocity, as long as the total volume is equal between resistance exercise bouts (Barreto et al., 2010). Other studies that measured EPOC demonstrated a positive association between resistance exercise intensity (Cesar et al., 2013; Haddock and Wilkin, 2006; Borsheim and Bahr, 2003; Osterberg and Melby, 2000).

Presently, the effect of different repetition velocities in different intensities on VO₂ and caloric expenditure during and following resistance exercise has not been completely elucidated. Thus, it would be useful, for exercise prescription purposes; to determine whether moving the resistance relatively faster or slower enhances caloric expenditure. Hence, the purpose of the current study was to analyze the effect of movement velocity and intensity on EPOC fast component in bench press (BP) and half squat (HS) exercises performed to concentric failure.

2 MATERIAL AND METHODS

2.1 SUBJECTS

Twelve male (34.5 ± 9.1 years; 176 ± 7.4 cm; 80.5 ± 12.0 kg) with at least six months of recreational RT experience to participate in the current study. All subjects answered the Physical Activity Readiness Questionnaire - PAR-Q (Sherpard, 1988), and signed an informed consent according to the committee of UFPB number 6.577.398/2023. The following additional exclusion criteria were adopted: a) use of drugs that could affect the cardio-respiratory responses; b) bone, joint or muscle diagnosed problems that could limit the execution of the RT; c) systemic hypertension (≥140/90 mmHg or use of antihypertensive medication); and d) metabolic disease.

2.2 ONE REPETITION MAXIMUM TESTING

Prior to pre-testing, all participants underwent three days on week for one week (three sessions on week) familiarization period, during which the subjects performed the same exercises as used in the 1RM tests, with the aim of standardizing the technique of each exercise. The sessions were performed for three sets of 10 repetitions, using a light weight.
After the familiarization period, all participants completed two sessions, in nonconsecutive days, of the 1RM test and retest. The 1RM tests were then performed on the same day for a barbell bench press and half squat (Rotech, Goiás, Brazil), with a 10 minute rest interval between exercises, using a randomized and counterbalanced order. The 1RM loads were determined in fewer than five attempts with a rest interval of five minutes between attempts.

The test and retest of 1RM to determine test-retest reliability were separated by 72 hours as described above in the timeline of testing. The heaviest resistance achieved on either of the test days was considered the 1RM resistance of a given exercise. No exercise besides the other tests performed as described in the timeline was allowed in the period between 1RM test sessions, so as not to interfere with the test-retest reliability results.

To minimize error during the 1RM tests, the following strategies were adopted (Simão et al., 2012): a) standardized instructions concerning the testing procedure were given to the participants before the test; b) participants received standardized instructions on specific exercise technique; and c) verbal encouragement was provided during the testing procedure. The 1RM was determined in fewer than five attempts, with a rest interval of five minutes between 1RM attempts, and a 10 minute recovery period was allowed before the start of the 1RM testing of the next exercise.

2.3 TRAINING PROCEDURES

After 48 hours pre-testing, the subjects were randomly assigned to investigate the effect of two different repetition velocities (one second concentric and eccentric; and two second concentric and eccentric) in different intensities (60% and 80% 1RM) on oxygen consumption during and after BP and HS exercises. The movement velocity during exercise was marked by a sound issued by a metronome (Tagima, Japan). All bouts performed one set until concentric fatigue.

Each subject performed eight bouts separated by 48 hours in a randomized counter-balanced cross-over design. The bouts differed in the velocity of repetitions and intensities (Figure 1).
2.4 EXPERIMENTAL SESSIONS OF THE STUDY.

The subjects underwent three training sessions over a week.

Day 1 tests: 1 repetition maximum (1RM) of bench press and squat exercises.
Day 2 tests: retest (1RM) of bench press and squat exercises.

the experimental procedures were randomly defined and counterbalanced order.

Day 3: 60% bench press (1RM), one/one cadence
Day 4: 80% bench press (1RM), one/one cadence
Day 5: 60% bench press (1RM), cadence two/two
Day 6: 80% bench press (1RM), cadence two/two
Day 7: half squat 60% (1RM), one/one cadence
Day 8: half squat 80% (1RM), one/one cadence
Day 9: 60% half squat (1RM), cadence two/two
Day 10: half squat 80% (1RM), cadence two/two

2.5 MEASURES THE ENERGY EXPENDITURE DURING THE EPOC

Energy expenditure were continuously measured in the first 20-min post-exercise using a previously validated, portable, open-circuit indirect calorimetry system (K4 b2, Cosmed USA Inc., Chicago, IL, USA) that measures breath-by-breath ventilation, expired oxygen, and carbon dioxide with averaged in 20 second intervals (McLaughlin et al., 2001). Before each test, the Cosmed was turned on 30 min prior to calibration according to manufacturer specifications. After 30 min the calorimeter was calibrated with known gases. The flow turbine was calibrated using a 3.00-L syringe. After tests bout, the participant breathed into a face mask that directed air into the unit housing the O2 and CO2 gas analyzers.

2.6 STATISTICAL ANALYSIS

Data were expressed as the mean ± standard deviation (M ± SD). After normality and sphericity assumptions were checked respectively with the Shapiro-Wilk tests. A two-way analysis of variance with repeated measures a multivariate analysis to compare the EPOC averaged in each minute post-exercise (up to 20 min) according to the different
exercises, intensities and movement velocities. Tukey least significant difference post hoc analyses were used where was appropriated to determine specific pairwise differences. Separate one-way ANOVA were used to test for group differences at kcal and volume of training for each variable and for conditions in exercise. Significance in this study was defined as p < 0.05. All statistical analyses were performed using SPSS 18.0 for Windows.

3 RESULTS

The rates of EPOC for exercise in each condition are shown in figure 1 and 2 during the 20 minutes post-exercise. There was a fast decline the expenditure energetic, immediately after stopping the movement of resistance exercise, for both upper and lower limbs exercise from 4th minute, stabilized from the 10th minute between 10 and 11 ml/kg/min, approximately, for bench press (Figure 1) and from the 8th minute between 11 and 13 ml/kg/min for half squat (Figure 2). There is no significant difference among mean of VO$_2$ in each condition (movement velocity and intensity) in bench press during the 20 minutes, except in 14th minute between BP e HS at 2s/2s with 80% of 1RM and 1s/1s with 60% of 1RM (p=0.023) (Table 1). From half squat during all time post exercise, not found significant differences among conditions.

Figure 1 - Mean energy expenditure in the 20-min post-exercise of bench press on movement velocities and intensity difference.
3.1 TYPE EXERCISE VS. MOVEMENT VELOCITY

The multivariate tests (Table 1) showed that when compared, individually, every two minutes by the type exercise and movement velocity differences are at the 4th, 10th and 14th minute EPOC.

3.2 TYPE EXERCISE VS. INTENSITY

When compared the type exercise and intensity there is differences of significantly better only in EPOC 16th minute. (Table 1)

3.3 MOVEMENT VELOCITY VS. INTENSITY

There was no difference when compared movement velocity and intensity every two minutes. (Table 1)

3.4 TYPE EXERCISE VS MOVEMENT VELOCITY VS. INTENSITY

When it examined concomitantly the EPOC by type of exercise, movement velocity and intensity, just the 14th minute, indicated significant differences. (Table 1)
Significant differences in the total number of repetitions achieved between BP vs. HS were browse, with higher volume de repetitions for HS 60%1RM in high velocity (1sec/1sec) and HS 80% 1RM in high (1sec/1sec) and slow (2sec/2sec) velocity (p < 0.01) (Table 2). The HS required increased oxigen uptake at the end of the period of 20 minutes (EPOC accumulated) in relation to BP (p < 0.01) (Table 2, figure 4). The greatest value of EPOC accumulated at the final 20 minutes post-exercise, was to HS with 80% 1RM and greater movement velocity (1s/1s) (Table 2). The greatest value of EPOC accumulated, during the 20 minutes, was to exercise that involved the largest muscle group (HS), high intensity (80%) and greater velocity (Figure 3). The HS has an EE of almost 80% more than the BP.

<table>
<thead>
<tr>
<th>EPOC (minute)</th>
<th>Type exercise vs. movement velocity</th>
<th>Type exercise vs. intensity</th>
<th>Movement velocity vs. intensity</th>
<th>Type exercise vs movement velocity vs. intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Post 2</td>
<td>0.978</td>
<td>0.434</td>
<td>0.545</td>
<td>0.820</td>
</tr>
<tr>
<td>4</td>
<td>0.939</td>
<td>0.335</td>
<td>0.013</td>
<td>0.910</td>
</tr>
<tr>
<td>6</td>
<td>6.740</td>
<td>0.011*</td>
<td>0.047</td>
<td>0.828</td>
</tr>
<tr>
<td>8</td>
<td>0.420</td>
<td>0.519</td>
<td>0.014</td>
<td>0.908</td>
</tr>
<tr>
<td>10</td>
<td>1.149</td>
<td>0.287</td>
<td>0.513</td>
<td>0.476</td>
</tr>
<tr>
<td>12</td>
<td>6.531</td>
<td>0.012*</td>
<td>1.117</td>
<td>0.293</td>
</tr>
<tr>
<td>14</td>
<td>3.211</td>
<td>0.077</td>
<td>2.380</td>
<td>0.126</td>
</tr>
<tr>
<td>16</td>
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<td>0.046*</td>
<td>0.032</td>
<td>0.858</td>
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<tr>
<td>18</td>
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<td>0.112</td>
<td>4.907</td>
<td>0.029*</td>
</tr>
<tr>
<td>20</td>
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<td>0.090</td>
<td>4.506</td>
<td>0.120</td>
</tr>
<tr>
<td></td>
<td>2.076</td>
<td>0.072</td>
<td>4.608</td>
<td>0.148</td>
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</table>

* Significant difference between situation (p < 0.05). Source: own authorship.
Figure 4 - Accumulated energy expenditure in the 20-min post-exercise of half squat and bench press on movement velocities and intensity difference.

```
<table>
<thead>
<tr>
<th>Exercise</th>
<th>MV</th>
<th>Intensity</th>
<th>Repetitions</th>
<th>O2 debt (ml.kg^-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP_1x_60%</td>
<td>1/1</td>
<td>60% 1RM</td>
<td>30 ±(5.0)</td>
<td>113.76</td>
</tr>
<tr>
<td>BP_1x_80%</td>
<td>2/2</td>
<td>80% 1RM</td>
<td>23(±2.8)</td>
<td>127.79</td>
</tr>
<tr>
<td>HS_1x_60%</td>
<td>1/1</td>
<td>60% 1RM</td>
<td>13(±4.2)</td>
<td>115.99</td>
</tr>
<tr>
<td>HS_1x_80%</td>
<td>2/2</td>
<td>80% 1RM</td>
<td>17(±3.5)</td>
<td>123.73</td>
</tr>
<tr>
<td>BP_2x_60%</td>
<td>1/1</td>
<td>60% 1RM</td>
<td>38(±5.2)*</td>
<td>130.11*</td>
</tr>
<tr>
<td>BP_2x_80%</td>
<td>2/2</td>
<td>80% 1RM</td>
<td>29(±2.4)</td>
<td>127.79*</td>
</tr>
<tr>
<td>HS_2x_60%</td>
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<td>60% 1RM</td>
<td>30(±3.2)*</td>
<td>132.33*</td>
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<tr>
<td>HS_2x_80%</td>
<td>2/2</td>
<td>80% 1RM</td>
<td>24(±4.2)*</td>
<td>124.39</td>
</tr>
</tbody>
</table>
```

* Significant difference compared between bench press and half squat (p < 0.05). Source: own authorship.

4 DISCUSSION

This study aimed to analyze the effect of movement velocity (1 sec / 1 sec and 2 sec / 2 sec) and intensity (60 and 80% 1RM) on EPOC fast component in BP and HS exercises performed to concentric failure. The main findings were to observation the rapid decline of EPOC in response of BP and HS exercises, also the movement velocity and intensity ratio did not cause difference of VO₂ within 20 minutes after both exercises, when compared each two minutes. The end of 20 minutes post-exercise, the energy expenditure and VO₂ was better in the HS vs. BP, with 80% 1RM.

Studies showed that exercises with large muscle groups increase the total work involved (Lagally et al., 2009; Robergs et al., 2007) and, consequently, metabolic responses resulting in greater caloric expenditure during the activity (VO₂ during) as well
as a high EPOC (Cesar et al., 2013; Almeida et al., 2011; Farinatti and Castinheiras Neto, 2011). In this study was found that the exercise that involved larger muscle group (HS) was that accumulated and presented greater energy expenditure with a accumulated of EPOC more than the BP.

Studies using the resistance exercise demonstrated their role on the magnitude of energy expenditure during the recovery period by finding different results ranging from 6 to 114 kcal on average over 60 min to 15 h after exercise (Richmond and Godard, 2004; Sforzo and Touey, 1996; Willardson and Burkett, 2005; Willardson and Burkett, 2006a; Willardson and Burkett, 2006b). In this research, was observed that the HS has an energy expenditure of almost 80% more than the BP (Figure 3), whereas the static component of the repetition may be a factor in the increase of this variable aspect. The energy expenditure caused by anaerobic exercise becomes two times greater than the resting condition (de Lira et al., 2007). In our study, it was found among the isolated exercises that with greater active muscle mass had the highest energy consumption in EPOC over the eight minutes. The sum of accumulated between the exercises conditions showed that the HS consumed 16% more energy compared to the sum of BP (Figure 3).

The movement velocity is one of variable prescription of training leading to improvements in neuromuscular performance. Repetitions performed at high velocities with moderate to high loads more suitable than low velocities for increases in muscle strength (Hunter et al., 2003). In this study the velocity was significantly different from the type of exercise, with higher consumption in the first minute for the exercise involving larger muscle groups in an activity performed at higher velocities. Contractions performed in an explosive manner may have an important role in oxygen consumption, thereby increasing energy expenditure during and after RT. The greatest EPOC in HS with fast movement velocity (one sec concentric and one sec eccentric) can be explained by the fact that the contractions involve greater threshold motor units composed of cells specifically are more energy faster expensive (Mazzetti et al., 2007).

It is worth mentioning that probably the similar results of the two speed sequences used in the training and the adopted training volume did not allow significantly different muscular responses. On the other hand, João et al., (2020) In a review and meta-analysis
article, analyzed energy expenditure according to the intensity of work and repetitions used in resistance training, the selected studies pointed out that the intensity can be manipulated using high loads and low volume (1 series - 3-6 repetitions at 85 -90% 1RM) and studies used resistance training with low load and super slow execution (25% 1RM) and both resulted in significant energy expenditure, on the other hand, high loads were superior in comparison with low loads. Pointing out that energy expenditure can be manipulated through the speed of execution of the exercise.

Studies report that the EPOC is composed of three components: fast, slow and ultra-slow, which can last for up to 39 hours after the session (Bangsbo, 1998; Borsheim & Bahr, 2003; Matsuura et al., 2006). In a review article, Castinheiras Neto et al. (2009) cites that the duration of EPOC in response to RT, varies between 15 minutes and 48 hours, this can be explained by methodological differences among the studies analyzed. In literature, the time of duration of fast component of the EPOC is still controversial. However, it has been suggested that duration occurs within the first minutes after the effort (Bertuzzi et al., 2010; Meirelles and Gomes, 2004). In this period, the process of rephosphorylation of stocks of energy substrates is responsible for approximately 10% of the total volume of the EPOC (Brooks et al., 1971).

The intensity of training did not influence on the fast component of the EPOC. A significant difference was found only in the 8th minute between the type of exercise (BP and HS) can be explained by the stabilization time is longer in HS compared to BP. These data support previous evidence regarding the influence of intensity in RT, suggesting that the volume of training can be an aspect more relevant to the caloric expenditure during the EPOC when compared with the intensity of training (Thornton et al., 2011).

The intensity and repetitions volume on RT are the variables that stand out most in the scene of the studies on EPOC (Castinheiras Neto et al., 2009). Surveys say that the magnitude of EPOC is significantly greater for the higher intensity protocol with equivalent duration (> 15 min) (Ratamess et al., 2007; Thornton and Potteiger, 2002). The increase in EPOC in high-intensity exercise is, probably, caused by an increased metabolic response during exercise in one bout until failure, mainly concentric, which requires increased energy and expense needed to reverse several physiological processes.
back home. The highest EPOC values, in this study, were measured in the exercises involving high loads, when the exercise is performed up to exhaustion caused by maximal number of repetitions.

The largest energy consumption occurs during the fast phase of EPOC (Bahr, 1992), in our study we observed a dramatic decrease immediately after the first minute, stabilizing in the 16th minute in exercise with greater muscle mass involved (HS) (Table 1). According to results reported by Bertuzzi et al. (2010) and Thornton et al. (2011), the EPOC was significantly different in the first five minutes after exercise compared to pre-exercise. These results indicate that the greatest demand energetic after exercise is in fast component of the EPOC. Therefore, it represents relevant settings for the prescription of RT programs that aims are to increase the energy balance.

There was a decline in the first minutes of EPOC for the two types of exercises being stabilized in the 6th minute with a drop in spending of approximately 100% from the first minute to the fourth minute. The largest decline of the EPOC was the first to the fourth minute, in all situations, continuing at lower levels of the 12th to 16th minute, however there is stability from the 10th minute (Table 1). Castinheiras Neto et al. (2009) reported that methodological limitations do not allow for trends, especially regarding the duration of EPOC.

5 CONCLUSION

In summary, our results showed that greatest value of EPOC accumulated was to exercise that involved the largest muscle group (HS) with high intensity (80% 1RM) and higher movement velocity. Explosive contractions enhance energy expenditure to a greater extent than a more fatiguing slower exercise. That RT in slow execution is not the most effective technique for optimal energy expenditure; the HS has energy expenditure bigger than the BP. Thus, the greater muscular mass involved seems the best way to promote increased energy expenditure in the post-exercise period.

We can conclude that from the viewpoint of analysis of isolated exercises, higher velocities and greater muscles involved performed until failure are extremely relevant to compose sequences of exercises of training programs driven to an increase in adaptations
that lead to weight loss. These findings have useful implications for recreational exercises and personal fitness trainers, because they suggest that the combination between higher velocities and greater muscle mass in higher loads may provide the most effective combination of resistance exercise techniques to increase energy expenditure for weight loss.
REFERENCES


