Energy Expenditure during Multiple Sets of Leg Press and Bench Press

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ABSTRACT

Magosso RF, da Silva Junior AJ, Neto AP, Neto JC, Baldissera eV. Energy Expenditure during Multiple Sets of Leg Press and Bench Press. \textbf{JEPonline} 2013;16(5):57-62. The purpose of this study was to quantify energy expenditure (EE) during multiple sets of leg press (LP) and bench press (BP) exercises in 10 males with at least 1 yr of resistance training (RT). The subjects underwent two sessions to determine 1 repetition maximum (1RM) on the BP and LP and one protocol consisting of a warm up and 4 sets for 10 repetitions at 70\%\ 1RM with a 3-min rest period between sets for each exercise. Energy expenditure was calculated as the sum of oxygen uptake (aerobic component), EPOC, and lactate production (anaerobic component). There were no significant differences in EE between exercises for sets 1 to 4 and the total energy expended. However, statistical analysis revealed a significant difference (P<0.05) between exercises in RT economy (BP, 0.0206 ± 0.0044 kcal·kg\textsuperscript{-1} vs. LP, 0.0051 ± 0.0015 kcal·kg\textsuperscript{-1}). Within exercise comparison showed set 4 was significantly different from sets 1 and 3 for BP, and for LP a significant difference was found between set 4 and sets 1, 2 and 3. Our results point to an increase in EE during multiple sets at 70\%\ 1RM and show that in spite of the difference in muscle mass involved and total work done during each type of exercise, EE was not different due to greater economy during the LP.

Key Words: Bench Press, Leg Press, Energy Expenditure, Ratings of Perceived Exertion, Resistance Training
INTRODUCTION

Resistance training (RT) is recognized as a valid exercise modality for improving health and overall fitness. It also helps to produce favorable changes in body composition by increasing fat free mass and decreasing body fat (1). Given the increase in the number of overweight adults who participate in RT programs and the metabolic responses during RT that have an influence on body composition, it is important to quantify the energy expenditure (EE) during RT (3).

For body weight management or weight loss, EE during exercise sessions plays an important role. Unlike steady-state aerobic exercise where EE can be quantified by oxygen uptake, the occlusion of blood flow during intense muscular contraction that results in an oxygen deficit, the analysis of oxygen uptake and EE during RT is inadequate (12). Yet, it is important to recognize that EE during RT is dependent on oxygen uptake, lactate contribution, and EPOC (13).

Studies of EE during RT include sets to fatigue (14,15), the effect of rest interval length (2,11), the exercise order (3), the number of repetitions per set (13), the contraction speed (8), and the muscle mass recruited (2). Most of the studies used few or only one exercise to understand the mechanisms of EE during RT (9,10). Thus, the purpose of this study was to quantify EE during a multiple set program on the leg press (LP) and the bench press (BP) exercises as well as to compare EE for both exercises.

METHODS

Subjects
Ten male subjects (mean ± SD = age 20.3 ± 4.2 yrs, body weight = 74.1 ± 10.2 kg, height = 177.2 ± 4.6 cm, and BMI = 23.8 ± 3.2 kg·m⁻²) from the Federal University of São Carlos volunteered to participate in this study. It was required that the subjects have at least 1 yr of RT without the use of ergogenic aids. Also, it was required that the subjects have no orthopedic problems that may interfere with the performance of LP and BP exercises. The subjects signed an informed consent that informed them of any potential risks. This study was approved by the local ethics committee.

Experimental Approach to the Problem
In order to quantify EE during the LP and BP exercises, the subjects underwent four sessions as follows: (a) the first two sessions were taken to determine 1 repetition maximum (1RM); and (b) in the third and fourth sessions a LP and BP protocol were carried out on a randomized order.

1RM Testing
The subjects instructed to perform each repetition for 3 sec (1.5 sec for concentric phase and 1.5 sec for eccentric phase). Verbal commands were given to ensure that the movement velocity was maintained. The warm up consisted of 8 repetitions with 50% of the estimated 1RM, and a set of 3 repetitions with 70% of estimated 1RM after a 2-min rest period. Following stages were single lifts with 5-min rest period and 1RM was found in a maximal of 5 lifts for all subjects. The next test was taken at least 48 hrs later and began with the weight lifted on the first test. The highest value was considered as the subjects' 1RM.

Exercise Sessions
Seventy-two hours after the 1RM test, the subjects were randomly assigned to participate in the LP protocol and the BP protocol. Each protocol consisted of a warm up and 4 sets for 10 repetitions with 70% 1RM and a 3-min rest period between sets. Repetition time consisted of 3 sec. Each set lasted for 30 sec, which was controlled by verbal commands. This protocol was chosen due to its use by
recreational trainers (7). After each set, the subjects reported their ratings of perceived exertion (RPE) with the scale OMNI (6) and a blood sample of 25 µl was taken from the ear lobe for blood lactate concentration (BLC) analysis using a lactate analyzer (YSI 1500 Sport, Yellowsprings®). Throughout the protocol ventilatory parameters (VO$_2$, VCO$_2$ and VE) were collected using a portable gas analyzer (VO2000, Medgraphics®) previously calibrated according to manufacturer’s manual. The subjects were instructed to breathe normally until all values reached normality. The first 2 min of the protocol were collected as resting values. Ventilatory data were averaged every 10 sec and recorded using the Aerograph® software during the session and 3 min post-exercise to account for recovery from set 4.

Total energy expenditure (TEE) was calculated as the sum of oxygen uptake (aerobic component), EPOC, and lactate production (anaerobic component) (13). Aerobic exercise energy expenditure was recorded as 1 L of O$_2$ = 21.1 kJ (5.05 kcal); excess post-exercise oxygen consumption was converted to energy expenditure as 1 L of O$_2$ = 19.6 kJ (4.7 kcal) to dismiss the glycolytic component from the oxygen uptake measure, and anaerobic exercise energy expenditure was calculated as the difference between resting and peak lactate values multiplied by body weight (kg), then by 3.0 ml of O$_2$. This oxygen equivalence measure was converted to joules as 1 L of O$_2$ = 21.1 kJ (5.05 kcal). Total work (TW) was calculated as the product of the number of sets and repetitions and the amount of weight lifted (sets $\times$ rep $\times$ kg). Resistance training (RT) economy was calculated as the ratio between EE and TW (RT economy = kcals consumed/total work) (5).

**Statistical Analysis**

The data were statistically analyzed for between-exercises and within-exercises using ANOVA with Bonferroni post-hoc when necessary. The significance level was set at $P \leq 0.05$.

**RESULTS**

ANOVA showed no difference in EE between the exercises for sets 1 to 4 and total kcals. However, the analysis revealed a significant difference between exercises in RT economy for the energy expended during the BP versus the LP. Within exercise comparison showed set 4 was significantly different from set 1 and set 3 for BP and for LP a significant difference was found between set 4 and sets 1, 2, and 3. EE data are presented in Table 1.

**Table 1. Energy Expenditure during Four Sets on Bench Press (BP) and Leg Press (LP).**

<table>
<thead>
<tr>
<th></th>
<th>Total work (kg)</th>
<th>EE set 1 (kcal)</th>
<th>EE set 2 (kcal)</th>
<th>EE set 3 (kcal)</th>
<th>EE set 4 (kcal)</th>
<th>Total EE (kcal)</th>
<th>EE (kcal·min$^{-1}$)</th>
<th>EE/TW (kcal·kg$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP</td>
<td>2349.2 ± 568</td>
<td>10.4 ± 1.7</td>
<td>11.6 ± 1.9</td>
<td>11.3 ± 1.2</td>
<td>13.2 ± 1.9</td>
<td>46.4 ± 4.7</td>
<td>3.3 ± 0.3</td>
<td>.0206 ± .0044*</td>
</tr>
<tr>
<td>LP</td>
<td>10010 ± 3345</td>
<td>10.5 ± 1.3</td>
<td>11.3 ± 2.2</td>
<td>11.4 ± 2.4</td>
<td>13.5 ± 2.7</td>
<td>46.7 ± 8.1</td>
<td>3.3 ± 0.6</td>
<td>.0051 ± .0015</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± standard deviation. Total work calculated as (sets $\times$ rep $\times$ kg); EE = energy expenditure (Kcal); TW = total work. *Indicates a significant difference between exercises ($P \leq 0.05$).

RPE values are presented in Table 2. For BP and LP, RPE increased significantly throughout the protocol from set 1 to set 4. Between exercises comparison showed no significant difference.
Table 2. Ratings of Perceived Exertion (OMNI Scale) Values during Four Sets on Bench Press (BP) and Leg Press (LP).

<table>
<thead>
<tr>
<th>Set</th>
<th>BP</th>
<th>Set</th>
<th>BP</th>
<th>Set</th>
<th>BP</th>
<th>Set</th>
<th>LP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2.6 ± 1.1</td>
<td>4.5 ± 1.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.4 ± 1.3&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.4 ± 1.6&lt;sup&gt;abc&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set 1</td>
<td>3.5 ± 2.0</td>
<td>4.9 ± 2.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.9 ± 2.8&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>6.6 ± 2.7&lt;sup&gt;abc&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data are expressed as mean ± standard deviation. <sup>a</sup>Indicates a significant difference from set 1; <sup>b</sup>Indicates a significant difference from set 2; <sup>c</sup>Indicates a significant difference from set 3. Significance level was set at (P≤0.05).

DISCUSSION

The main findings of this study are that: (a) during 4 sets of 10 repetitions with 70% 1RM, EE is not equal for all sets of BP and LP exercises; and (b) following statistical comparison of the exercises, EE was not significantly different. Gorostiaga et al. (4) showed that the final 5 repetitions of a 10RM set in the LP exercise led to higher EE than the first 5 repetitions, due to a loss in mechanical efficiency during exercise. Similarly, Scott and colleagues (14) reported that with two sets performed to failure, there was a greater cost (kcal/TW) and loss of efficiency in the 2nd set. Although our study was not conducted to muscular failure, the significant increase in RPE and the values reported by our subjects in set 4 (BP, 7.4 ± 1.6 and LP, 6.6 ± 2.7) may indicate that the subjects were in fact close to fatigue, which in turn is the cause for the loss of efficiency and the increase in EE during the last of the 4 sets.

The comparison between BP and LP showed no difference in total EE or for any of the sets in spite of the higher muscle mass employed during the LP exercise. By comparison, Scott (12) reported on the same exercises and showed greater EE in the LP exercise. But, it is important to mention that their subjects performed 10 repetitions of the LP exercise and 8 repetitions of the BP exercise at 80% 1RM and sets to failure during both exercises at 60% 1RM. Although the exercises were not described, Ratamess et al. (11) reported an EE of 11.5 kcal·min<sup>-1</sup> for a large muscle mass and 6.8 kcal·min<sup>-1</sup> with small muscle mass. On the other hand, Farinatti et al. (3) found no significant differences in EE (quantified only by oxygen uptake) between the bench press, shoulder press, and triceps extension exercises.

A factor that may explain the difference is RT economy. For example, Kalb and Hunter (5) showed that economy was different between the squat exercise and the shoulder press exercise. Although their study employed other exercises, the difference between BP and LP in the present study is clear (i.e., LP efficiency was four times greater the BP efficiency). Is this sense, for each kilo lifted during the BP exercise, four times more energy was needed when compared to the LP exercise. This finding is probably due to the mechanics of each exercise. Therefore, it is reasonable to conclude that EE in RT may not be proportional only to the muscle mass employed, but also and perhaps more so influenced by RT economy. Further studies are required to investigate this hypothesis as well as to compare other exercises and elucidate the mechanisms that affect EE during RT.

The EE values corrected per repetition encountered in the present study are close to published values of 0.98 Kcal/rep at 70% on the BP exercise when performed to muscle failure (14) and 0.8 kcal·rep<sup>-1</sup> at 60%, 1.0 to 1.7 kcal·rep<sup>-1</sup> at 80% 1RM, and sets to failure on BP (12). Ratamess et al. (11) showed higher values during the BP exercise than reported in the present study. The authors demonstrated that the shorter the rest period between sets, then, the higher is the EE during the protocol. Their 3-min rest period led to an EE of 5.7 kcal·min<sup>-1</sup>, which is higher than that of the
present study (3.3 kcal·min\(^{-1}\) during BP). They also employed 5 sets of 10 repetitions at 75\% 1RM. However, there was a higher volume and higher intensity, and their subjects most likely came closer to failure than the subjects in the present study, which may help explain the differences.

CONCLUSIONS

When the subjects performed 4 sets of 10 repetitions at 70\% 1RM during the BP and LP exercises, there was an increase in EE in the 4th set and no significant differences on EE between exercises. Health professionals and coaches may find the use of multiples sets as a positive strategy to increase weight loss due to the increase on EE. Further studies are necessary to quantify EE during RT and to compare other exercises and training sessions with a higher number of exercises typically used during strength training programs.

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