**Effect of exercise intensity on postexercise energy expenditure in women**

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This study was designed to examine the effect of exercise intensity on the magnitude and duration of excess postexercise oxygen consumption (EPOC) in women. On separate days and in a counterbalanced order, seven moderately active young adult women performed a 850 kJ cycle ergometer exercise at an intensity of 40 or 60% of their previously determined peak oxygen uptake (VeO2). Baseline VeO2 and heart rate (HR) were recorded during the last 10 min of a 45 min seated rest. VeO2 and HR were measured continuously during recovery until VeO2 returned to baseline. There was no significant difference noted in the baseline measures between the two exercise programmes. Magnitude of EPOC was comparable (P > 0.05) being mean (s.d.) of 30(17) and 36(13) kJ after 40 and 60% exercises respectively. Although the EPOC duration was 53% longer following the 40% exercise than following 60% (27(15) min and 18(8) min, respectively) this difference was not statistically significant. These exercise conditions failed to produce a prolonged EPOC in the women of this study, and values recorded for magnitude of EPOC indicate that it was not significant with regard to the overall energy expenditure of the activity. It was concluded that both magnitude and duration of EPOC seemed to be independent of the chosen exercise intensities used by the women in this study.

**Keywords:** Recovery metabolism, women, cycle ergometer

One important factor that must be addressed when prescribing exercise is that the programme be designed to meet the specific objectives of the client. Evidence indicates, for example, that many women engage in aerobic exercise to reduce or control their body weight. In order to develop the most effective exercise for this particular group, professionals must know how to maximize energy expenditure among women, and be aware of their metabolic responses to exercise.

Energy expenditure associated with physical activity includes that expended during the exercise itself and that consumed in the postexercise or recovery period. Although results reported in the literature concerning the excess postexercise oxygen consump-

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Methods

**Subjects.** Seven moderately trained women volunteered for the study. Mean (s.d.) age, height, and weight were 25.7 (4.0) years, 165.8 (5.2) cm, and 61.3 (5.9) kg, respectively. All were physically active at the time of the study, although none was engaged in any systematic training. The procedures used in this investigation were reviewed and approved by the institutional committee for research involving human subjects. All subjects expressed their understanding of the procedures and their rights as subjects by signing a statement of informed consent.

**Protocol.** Subjects performed two submaximal cycle ergometer exercises that elicited an energy expenditure of 850 kJ. One was at an intensity of 40% and the other at 60% of each subject's previously determined peak oxygen uptake (VeO2). The exercise tests were administered in a counterbalanced order and were separated by a minimum of 2 days.

**Test for peak VeO2.** A continuous, incremental exercise test was performed using a mechanically-braked cycle ergometer to determine peak VeO2. Initial power output (PO) was 60 W at 60 r.p.m., with subsequent
increases of 30 W every 2 min until termination of the test. Criteria for termination of the test were: (1) an increase in VO\textsubscript{2} with little or no increase in VO\textsubscript{2}; (2) heart rate (HR) at or near the age-predicted maximum; or (3) failure to maintain the prescribed cranking rate due to fatigue. The highest minute value obtained for VO\textsubscript{2} was recorded as peak VO\textsubscript{2}.

**Submaximal exercise test.** Subjects reported to the laboratory at approximately 6.00 hours following an overnight fast and having refrained from any strenuous physical activity for 24–36 h. After applying surface electrodes to monitor HR, the subjects sat quietly in a chair for 45 min. Baseline VO\textsubscript{2} and HR were measured during the last 15 min of this period. The exercise was then performed at the prescribed intensity, with subjects again seated quietly in a chair immediately after termination of the exercise. VO\textsubscript{2} and HR were monitored continuously during the recovery period until VO\textsubscript{2} returned to the baseline value.

**Measurements.** VO\textsubscript{2} was measured by open circuit spirometry. Subjects inspired room air, and expired air was metered and analysed for fractional oxygen and carbon dioxide using an automated system (Quinton Q-Plex I, Seattle, WA, USA). VO\textsubscript{2} was converted to energy expenditure (kJ) using the caloric equivalent of 1 litre of oxygen based on the non-protein respiratory exchange ratio (RER).

Baseline VO\textsubscript{2} and HR were determined by averaging the minute values for these variables obtained during the last 10 min of the 15 min baseline measurement period. Duration of EPOC was determined by continuously averaging five consecutive 1 min values of VO\textsubscript{2} during the postexercise period. When this average was equal to the baseline value, duration was recorded as the elapsed time (min) from termination of the exercise to the first minute of this 5 min average. Magnitude of EPOC was obtained by summing the net energy expenditure for each minute of the EPOC period.

**Results**

Mean baseline values obtained before exercise at 40 and 60% of peak VO\textsubscript{2} are shown in **Table 1**. No significant difference was noted for any of the variables, indicating that the subjects were in a comparable resting state before both experiments.

**Table 1. Mean (s.d.) values measured during the baseline period**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Before 40% exercise</th>
<th>Before 60% exercise</th>
<th>t*</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO\textsubscript{2} (litre min\textsuperscript{-1})</td>
<td>0.22 (0.03)</td>
<td>0.23 (0.03)</td>
<td>0.21</td>
</tr>
<tr>
<td>VO\textsubscript{2} (ml kg\textsuperscript{-1} min\textsuperscript{-1})</td>
<td>3.67 (0.45)</td>
<td>3.68 (0.20)</td>
<td>0.13</td>
</tr>
<tr>
<td>Heart rate (b min\textsuperscript{-1})</td>
<td>62 (6)</td>
<td>59 (5)</td>
<td>-1.38</td>
</tr>
<tr>
<td>Energy expenditure (kJ min\textsuperscript{-1})</td>
<td>4.62 (0.59)</td>
<td>4.70 (0.59)</td>
<td>0.51</td>
</tr>
</tbody>
</table>

* P > 0.05

**Table 2. Mean (s.d.) values obtained during the two exercises**

<table>
<thead>
<tr>
<th>Variable</th>
<th>40% peak VO\textsubscript{2}</th>
<th>60% peak VO\textsubscript{2}</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Peak VO\textsubscript{2}</td>
<td>41.1 (0.89)</td>
<td>61.8 (1.83)</td>
<td>36.92*</td>
</tr>
<tr>
<td>VO\textsubscript{2} (litre min\textsuperscript{-1})</td>
<td>1.03 (0.13)</td>
<td>1.54 (0.19)</td>
<td>22.61*</td>
</tr>
<tr>
<td>Heart rate (b min\textsuperscript{-1})</td>
<td>108 (9)</td>
<td>137 (3)</td>
<td>10.16*</td>
</tr>
<tr>
<td>Energy expenditure (kJ)</td>
<td>871.1 (26.0)</td>
<td>879.5 (31.9)</td>
<td>1.70</td>
</tr>
<tr>
<td>Duration (min)</td>
<td>41.1 (5.2)</td>
<td>27.3 (3.6)</td>
<td>-21.87*</td>
</tr>
</tbody>
</table>

* P < 0.05

**Table 3. Mean (s.d.) values measured during the postexercise period for the two experiments**

<table>
<thead>
<tr>
<th>Variable</th>
<th>After 40% exercise</th>
<th>After 60% exercise</th>
<th>t*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (min)</td>
<td>27.7 (15.5)</td>
<td>18.1 (8.4)</td>
<td>-1.65</td>
</tr>
<tr>
<td>EPOC (kJ)</td>
<td>29.8 (17.2)</td>
<td>36.1 (12.6)</td>
<td>0.78</td>
</tr>
<tr>
<td>Heart rate (b min\textsuperscript{-1})†</td>
<td>62 (4)</td>
<td>67 (5)</td>
<td>2.25</td>
</tr>
</tbody>
</table>

* P > 0.05
† Heart rate recorded at the end of the period of excess postexercise oxygen consumption. Value following exercise at 60% peak VO\textsubscript{2} was significantly higher (P < 0.05) than baseline.

the EPOC duration following the 60% exercise. This lack of statistical significance was probably due to the relatively large interindividual variation recorded for both conditions. On the other hand, magnitude of EPOC was similar following the two exercises.

Although there was no significant difference in mean HR measured at the end of the EPOC period between the two conditions (P < 0.07), end-EPOC HR was significantly elevated (P < 0.05) above baseline following the 60% exercise.

**Discussion**

This investigation was designed to examine the effect of exercise intensity on postexercise energy expenditure in women when exercise energy expenditure was held constant. Only one other EPOC study was located that included women as subjects\textsuperscript{12}. However, that study compared the recovery response to exercise with and without a caffeine challenge, with the exercise performed at a constant intensity (55% VO\textsubscript{2, max}) and duration (90 min) for both experiments.
Postexercise energy expenditure: D. A. Sedlock

Moreover, $\dot{V}O_2$ was still elevated at the time the measurements were terminated. Therefore, neither magnitude nor duration of EPOC were reported. Results in this study indicate that a 850kJ exercise at 40 and 60% peak $\dot{V}O_2$ had no differential effect on either the magnitude or duration of EPOC. Further, energy expenditure measured during the postexercise period was relatively low following both exercise experiments.

It is commonly believed that the elevated metabolic rate during recovery from exercise exists for several hours. This tenet is based on several reports of this phenomenon spanning 50 years. In contrast to those studies, which included males as subjects, the results of this study using women did not show a prolonged elevated metabolic rate during recovery from exercise.

Although a prolonged EPOC has been demonstrated in the above-mentioned studies, results of other investigations have not supported this finding. Reasons for these discrepant findings are unclear, although exercise intensity and duration have been suggested as a possibility. With regard to exercise intensity, Brehm and Gutin have proposed a model for postexercise energy expenditure after exercise of moderate duration, such as that used in the present study. The authors suggest that recovery energy expenditure is only minimally affected when exercise intensity is within the low to moderate range (30–50% $\dot{V}O_2_{max}$). At higher exercise intensities, the slope of the curve may increase sharply (Reference 3, page 209). Results of the present study on women do not seem to support this model. Since little is known about the EPOC response in women, it is difficult to speculate why this had occurred. However, there are several possibilities. First, the study of Brehm and Gutin included both males and females, suggesting that perhaps differences in the sex of the subject groups between the latter study and the present study may have influenced the results. Second, the subjects of Brehm and Gutin were relatively exercise-trained whereas subjects of the present study were not engaged in any systematic training. Third, although one of the exercise intensities used in this study was above and the other below the implied threshold value of 50% $\dot{V}O_2_{max}$, it could be that they were not sufficiently different from this threshold to show the EPOC response.

Although no threshold value for duration of exercise has been identified as producing the EPOC response, evidence suggests that a minimum of 1 h of moderate intensity exercise is necessary to affect the duration of EPOC. For example, a prolonged EPOC period has been reported following exercise durations of 180 min, 150 min, and 90 min. Additionally, Sedlock et al. reported that a 60 min exercise gave a significantly longer EPOC than a 30 min exercise. In contrast, the exercise durations of the present study were less than 1 h (i.e. 27 and 41 min) and resulted in relatively short EPOC durations that were not significantly different from each other.

In summary, this study employed exercise intensities that are similar to what is often used by women for purposes of weight control, i.e. 850kJ exercise energy expenditure at 40 and 60% peak $\dot{V}O_2$. These conditions failed to elicit a prolonged elevated metabolic rate during the postexercise period, and the magnitude of EPOC suggests that the postexercise energy expenditure was not significant in relation to the total energy expenditure. Moreover, with the energy cost of the exercise held constant, both magnitude and duration of EPOC seemed to be independent of exercise intensity.

References

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