Beta-Endorphin Time Course Response to Intensity of Exercise: Effect of Training Status

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Introduction

Beta-endorphin (B-EP) has been reported to be increased in the circulation following exercise (2, 4, 7, 8, 12). Recent evidence suggests that intensity of exercise influences the extent of the increase in circulating B-EP (4, 11, 14). Studies have demonstrated that circulating B-EP will not increase if the exercise intensity is 60% of VO2max or lower (4, 9, 11, 14).

Another factor which may influence the magnitude of change in B-EP to exercise is the training status of the subject. It has been suggested that endurance training may alter the B-EP concentration both at rest (10, 15) and following exercise (1, 8, 12). There is some evidence to indicate that B-EP concentration at rest is lower following mild aerobic training (10, 15). In contrast, circulating B-EP at rest were reported to be unchanged following aerobic training (7, 8). Endurance training has reported increased (1, 3, 8, 13), no difference (3, 7, 8) or decreased (8, 12) B-EP concentration following exercise. There has been no evidence to identify the time course of B-EP in trained and untrained individuals to similar relative intensities of exercise. Measuring one time point after exercise may not be appropriate to determine if trained or untrained individuals respond to exercise in the same manner. This is especially true with B-EP, since some individuals may be fast responders while others may be slow responders to changes in B-EP concentration to exercise stress (2).

Controversy in the literature may also be related to the method in which B-EP were determined. Some of the original investigations used assays which were unable to distinguish between B-EP and beta-lipotrophin immunoactivity. Another factor which may have contributed to the disparity of the results is the workload utilized to reevaluate the subjects. Few studies to our knowledge have examined the response to training (7, 8) and adjusted the work load to the relative intensity of exercise (4, 11).

In order to further clarify whether training status influences B-EP concentration, the following study was conducted. The purposes of this study were to determine: 1) if B-EP concentration at similar relative intensities of exercise is influenced by training status, 2) if B-EP concentration at rest is influenced by training status, and 3) if training status alters the time course for B-EP increases at specific relative intensities of exercise.

Abstract


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The concentration of beta-endorphin (B-EP) was measured in 6 trained and 6 untrained cyclists during three intensities of exercise to determine the time course changes of B-EP. B-EP was determined by radioimmunnoassay with < 5% cross reactivity with beta-lipotrophin. A counter-balanced design was used to avoid an order effect from exercise intensity. Resting B-EP values were similar across visits. There were no differences in resting B-EP values comparing the trained (4.61 ± 0.25 pmol-l⁻¹) to the untrained (4.03 ± 0.23 pmol-l⁻¹) group. Cycling at 60% VO2max did not increase B-EP in either group at any time measured. Cycling at 70% VO2max increased B-EP by 10 min in both groups p < 0.05. The rate and magnitude of increase of B-EP were similar for both groups. B-EP changes at 80% VO2max were significantly greater that at 70% VO2max and were identical for the two groups. Both groups demonstrated increases by 5 min and further increases at 30 min of exercise p < 0.01. These changes occurred despite the fact that lactate levels were lower in the trained group at both 70 and 80% VO2max intensities. It is concluded that the time course change for B-EP is similar for trained and untrained individuals working at the same relative intensity of exercise and does not seem to be related to plasma lactate concentrations.

Key words

Beta-endorphin, submaximal exercise, training, lactate
**Table 1** Physiological characteristics of subjects

<table>
<thead>
<tr>
<th>Variable</th>
<th>Untrained</th>
<th>Trained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>25.0 ± 1.4</td>
<td>28.0 ± 2.2</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>77.3 ± 4.4</td>
<td>75.3 ± 1.4</td>
</tr>
<tr>
<td>HR max (bpm)</td>
<td>186 ± 3.1</td>
<td>184 ± 4.3</td>
</tr>
<tr>
<td>VO2max (ml·kg⁻¹·min⁻¹)</td>
<td>47.57 ± 1.7</td>
<td>58.57 ± 1.5*</td>
</tr>
<tr>
<td>B-EP (pmol·l⁻¹) at Max</td>
<td>4.03 ± 0.23</td>
<td>4.61 ± 0.25</td>
</tr>
<tr>
<td>Lactate (mmol·l⁻¹) resting</td>
<td>22.3 ± 1.5</td>
<td>21.5 ± 3.2</td>
</tr>
<tr>
<td>Lactate (mmol·l⁻¹) at Max</td>
<td>0.77 ± 0.06</td>
<td>0.62 ± 0.09</td>
</tr>
</tbody>
</table>

Values are means ± SE. n = 6 in both trained and untrained groups. * = significant difference between trained and untrained p < 0.05.

**Methods**

Twelve healthy college-age men (21–37 yrs), 26.5 ± 1.3 yrs, weighing 76.3 ± 2.1 kg, volunteered to participate as subjects after being advised of the procedures. All subjects signed a written consent form prior to participation. Subjects refrained from vigorous physical activity for at least 24 h prior to testing. All testing was conducted between 0800–1100 h, with the subjects in a 12-h post-absorptive state to avoid diurnal and eating effects. Subjects rested a minimum of 30 min after arriving at the laboratory. Maximum oxygen uptake (VO2max) was determined on the first visit.Expired air samples were analyzed by a Medical Graphics Corp. MGC-2001 system calibrated to known gases. Subjects cycled at 50 rpm on a Monark ergometer to increase workload until VO2max or leg fatigue. Standard criteria of either a levelling-off or decrease in VO2 or leg fatigue with an increase in workload for VO2max determination. Heart rates were noted during the test. Blood samples were obtained prior to and 5 and 20 min after the VO2max test by venipuncture.

All three submaximal tests were completed within two weeks of the VO2max test (except 1). A counterbalanced design was used to avoid an order effect and tests were separated with at least one day between tests. Subjects rested 30 min and then a catheter was placed in a forearm vein, with an initial blood sample being obtained. Another blood sample was obtained after 30 min of rest and the subject seated on the bicycle ergometer. After a 5–6-min warm-up the resistance to the ergometer was adjusted to either 60, 70 or 80% of VO2max based on the VO2max data. The resistance was adjusted during the cycling to ensure the proper VO2 based on oxygen uptake determinations during the workload. Heart rate and expired gases were continuously monitored during the 30-min exercise. Blood was obtained at 5, 10, 15 and 30 min of the exercise and 5 and 20 min of recovery.

Blood samples were immediately placed on ice and centrifuged within 10 min at 3000rpm at 4 °C. The plasma was removed and stored in a −70 °C freezer until analyzed. Plasma B-EP was determined using a radioimmunoassay (RIA) method (Incstar). B-EP was extracted from the plasma by column chromatography by using an anti-B-EP sepharose binding agent. B-EP was eluted off the column with 0.025 N HCl and the eluant neutralized. The amount of B-EP was determined in each sample using the RIA procedure and monitored the amount of [125I]B-EP in each duplicate sample using a gamma counter (5). This procedure has reported < 5% cross-reactivity with beta-lipotrophin and < 0.01% with alpha-endorphin, leucine and methionine enkephalins, and ACTH. The within assay variation to the known plasma B-EP standard in the present study was 7.5% and the inter-assay coefficient of variation was 2.9%. A preliminary report of the data has previously been published elsewhere, which did not concern itself with the effect of training status (4).

Plasma lactate and glucose concentrations were determined on a YSI model 23A automated analyzer calibrated to 2 standards. The samples were determined in duplicate.

**Statistical Analysis**

The data was statistically analyzed using a 3 x 8 repeated measures analysis of variance. When a significant F was obtained, a post hoc test (Scheffe) was used to identify where the differences occurred. The trained group was compared to the untrained group using paired t-tests. Statistical significance was accepted at the p < 0.05 level.

**Results**

The physiological characteristics for the two groups of subjects is presented in Table 1. The trained group had similar maximum heart rates and body weights to the untrained group. The VO2max of the trained group was significantly higher than the untrained group. There were no differences in exercise intensity between the two groups. The mean VO2's for the submaximal workloads were 60.8 ± 0.7, 70.1 ± 0.8, and 79.3 ± 0.9% for both groups. Resting concentrations for all variables were not significantly different across visits and were therefore combined. Additionally, the two resting samples for each visit (—30 and 0) were not different from each other and therefore combined.

Resting B-EP concentration for the untrained group was 4.03 ± 0.23 pmol·l⁻¹, which tended to be slightly lower but not significantly different than the 4.61 ± 0.25 pmol·l⁻¹ for the trained group. Plasma lactate concentration at rest was 0.80 ± 0.10 and 0.67 ± 0.09 mmol·l⁻¹ for the untrained and trained groups, respectively. The B-EP concentration following the VO2max test increased about 5-fold above resting for both groups and were not significantly different. The lactate concentration at VO2max increased significantly in both groups but was not different between groups (UT = 13.25 ± 1.64, T = 12.51 ± 0.79 mmol·l⁻¹). Blood glucose concentrations were fairly stable during the 30 min of cycling at the 60% and 70% intensities and did not differ for the two groups. Blood glucose increased 10–15% by 30 min at the 80% intensity and was independent of training status.

B-EP response to 60% VO2max in the two groups is shown in Fig. 1. There were no significant differences in the B-EP concentration of either group at any time measured compared to the resting value. The changes in B-EP to 70% VO2max in the two groups is shown in Fig. 2. Both groups demonstrated similar increases in B-EP at 30 min of ex-
Exercise. Both groups increased their B-EP concentration by 10 min. The trained group tended to have slightly greater B-EP levels compared to the untrained group from 5 to 15 min, but these values were not significant. B-EP were the same for both groups at 30 min. B-EP stayed elevated during the 20 min of recovery but started to decrease from the peak value by 20 min of recovery in both groups. B-EP changes at 80% \( \text{VO}_2\text{max} \) for the two groups is presented in Fig. 3. B-EP concentration was elevated in both groups by 5 min and was further increased at 30 min of exercise. Both groups demonstrated similar time course changes in B-EP at this intensity of exercise. Peak B-EP concentration occurred at 5 min into the recovery period for both groups. By 20 min of recovery, B-EP concentration had diminished slightly but was still significantly elevated above resting values.

A comparison of the B-EP response to different intensities of exercise at 30 min of exercise in relation to training status is presented in Fig. 4. Both groups demonstrated similar responses to all three exercise intensities. There were no significant changes in B-EP at 60% \( \text{VO}_2\text{max} \). Cycling at 70% \( \text{VO}_2\text{max} \) increased B-EP at 30 min in the trained group to 10.48±1.77 pmol·L\(^{-1}\) and the untrained group to 11.65±1.19 pmol·L\(^{-1}\). This represents an approximate 2 1/2-fold increase in B-EP concentration. Cycling at 80% \( \text{VO}_2\text{max} \) increased B-EP at 30 min to 18.08±3.21 and 20.65±3.29 pmol·L\(^{-1}\) in the trained and untrained group, respectively. Exercising at 80% \( \text{VO}_2\text{max} \) increased B-EP approximately 4 1/2-fold by 30 min. These data indicate that exercise intensity influences the extent of B-EP concentration but that training status does not alter this relationship.
This study confirms previous investigations that exercise at 60% VO\textsubscript{2max} does not increase B-EP concentration (3, 9, 11, 14). This suggests that independent of training status the intensity of exercise needed to increase B-EP is greater than 60% VO\textsubscript{2max}. The increases in B-EP concentration were similar for the untrained and trained group at both 70 and 80% VO\textsubscript{2max} despite lower lactate levels in the trained group. A relationship between lactate and B-EP has been proposed (2). Our results, which demonstrate a difference in the trained and untrained groups lactate response despite similar B-EP concentration, does not support the contention that these two factors are related. We have previously reported that during steady, state submaximal exercise B-EP and lactate are not strongly correlated (4).

The results at steady state submaximal workloads suggest that when the relative stress is equated the concentration of B-EP in the circulation is similar. Since there was a gradual increase in B-EP with time at both intensities, it suggests that there was an increase in the rate of release of B-EP into the circulation and/or a decrease in the rate of disappearance. Future research is needed to identify if the release rate or the disappearance rates are altered by exercise.

The results at 100% VO\textsubscript{2max} for B-EP were similar in the two groups in this study. These results are in agreement with the findings of others who have reported similar B-EP concentrations from trained and untrained subjects at a workload that was at VO\textsubscript{2max} (3, 8). Trained individuals have been reported to have higher B-EP concentrations at supramaximal workloads (3, 8). Perhaps there is a training-induced adaptation which is only apparent at workloads greater than VO\textsubscript{2max}. Recently it has been reported that sprint training increases the B-EP concentration after intense exercise (8). Our results immediately following exercise and up to 20 min after exercise showed no differences in B-EP concentration in the trained and untrained group. This is similar to the data reported by Kraemer et al. in their endurance-trained group (8). They reported that sprint training maintains a higher concentration of B-EP 5 min after maximal exercise. However, the B-EP concentration immediately post exercise was higher in the sprint-trained group. Additionally, by 15 min of recovery the B-EP concentration was similar comparing the trained and untrained state. Their data suggests that sprint training may actually result in an increased clearance rate. Perhaps there is an alteration in the clearance or production of B-EP in relation to the type of training. Further research is needed to clarify the turnover and clearance of B-EP during exercise and the influence of training on these parameters.

In conclusion, the present study has shown that the time course change for B-EP is similar for trained and untrained subjects when the relative intensity of exercise is matched. The B-EP changes appear to be independent of plasma lactate concentration. Training status does not appear to alter resting or VO\textsubscript{2max} B-EP concentration. It is concluded that training status does not seem to alter the B-EP concentration to exercise when the workloads are equated to relative intensities of work.
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References


