HORMONAL RESPONSES TO THE STRESS OF EXERCISE

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INTRODUCTION

Muscular activity is a component of the "fight or flight" response. Hormones which play an important role in the preservation of homeostasis are activated in response to acute exercise (1-9). Physical training appears to lead to a reduction in the "stress response" to a given workload (8,9). What role, this modulation of the "stress response" plays in the improved performance of trained athletes remains an intriguing question. We report in this brief review the response of several pituitary and adrenal hormones to various intensities of acute treadmill exercise stress. The effect of physical training on these hormonal responses was studied by comparing the responses of sedentary, untrained subjects to the responses of two groups of runners with different degrees of fitness (8).

SUBJECTS AND PROTOCOL

The first group consisted of seven untrained men. The runners were divided into two groups according to their level of weekly exercise: moderately trained runners (15-25 miles/week, n=7) and highly trained runners (>45 miles/week, n=7). Characteristics of the three groups studied are shown in Table 1. All tests were performed in the evening, the subjects fasted for six hours before the exercise and the runners refrained from running on the day of the tests. Exercise was performed at three intensities (50, 70 and 90% VO2max: maximal oxygen uptake), and the three tests were separated from each other by one week. The running was intermittent (30 seconds on and 30 seconds off), and the slope and speed of the treadmill were adjusted to attain each workload. The duration of the exercise was 20 minutes at 50 and 70% VO2max and 10 minutes at 90% VO2max. This was preceded by a 5 minute warm-up period at all intensities. A cool-down period of 5 minutes was allowed after the exercise at 50 and 70% VO2max and a 10 minute cool-down took place after the exercise at 90% VO2max.

An intravenous catheter was inserted before the test, and blood was collected before, during and after the exercise for measurement of hormones,

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TABLE 1. Characteristics of Subjects Studied (From ref. 8).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Untrained Subjects</th>
<th>Moderately Trained Runners</th>
<th>Highly Trained Runners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Status</td>
<td>Sedentary</td>
<td>15-25 mi/wk</td>
<td>45 mi/wk</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>35.7 ± 0.9</td>
<td>30.0 ± 3.4</td>
<td>31.6 ± 2.8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>177.3 ± 2.4</td>
<td>176.3 ± 3.3</td>
<td>174.9 ± 2.6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>78.0 ± 3.2</td>
<td>73.8 ± 3.1</td>
<td>68.6 ± 1.9*</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>19.4 ± 2.1</td>
<td>9.8 ± 2.3§</td>
<td>8.1 ± 1.2§</td>
</tr>
<tr>
<td>( \dot{V}O_2\max ) (ml/kg/min)</td>
<td>33.5 ± 1.5</td>
<td>47.3 ± 2.5+</td>
<td>57.4 ± 1.7+</td>
</tr>
</tbody>
</table>

* p < 0.05 as compared with untrained subjects
§ p < 0.01 as compared with untrained subjects
+ p < 0.001 as compared with untrained subjects

lactate and potassium. Hormones were measured by radioimmunoassay, lactate by an enzymatic method, and potassium by flame photometry.

All data are expressed as mean ± SE. Differences among groups were evaluated by multivariate analysis of variance with repeated measures. If significant effects were detected, differences among groups were evaluated by t-tests with use of the Bonferroni correction. Correlations were calculated by the least-squares linear regression analysis.

HYPOTHALAMIC-PITUITARY-ADRENAL AXIS

Whereas treadmill exercise at 50% \( \dot{V}O_2\max \) had no effect on ACTH and cortisol secretion, and 70% \( \dot{V}O_2\max \) induced a moderate hormonal response, exercise at 90% \( \dot{V}O_2\max \) was accompanied by a steep increase of plasma ACTH and cortisol (Fig. 1). The peak levels were in the range seen with the insulin tolerance test and were comparable to those observed in response to surgery (10,11). The response of the hypothalamic-pituitary-adrenal axis was similar in the three groups of different training status at identical relative exercise intensities. When the hormonal responses were plotted against the absolute workload however, it became evident that highly trained runners required higher levels of oxygen consumption for the activation of the axis (Fig. 2).

An interesting finding with the evening exercise tests was the elevated basal plasma concentrations of ACTH and cortisol in the highly trained runners (Fig. 1). When the overall basal hormone values were compared, a significant difference emerged. This led us to investigate the hypothalamic-pituitary-adrenal axis in more detail using a CRH-stimulation test (Fig. 3). Ovine corticotropin releasing hormone (oCRH) at the dose of 1 \( \mu g/kg \) was administered as an i.v. bolus at 8 pm. Untrained and moderately trained subjects had similar responses to exogenous oCRH, the highly trained runners had a blunted response of plasma ACTH and cortisol. These findings are in