Diminished Insulin Response in Highly Trained Athletes

D. Lohmann, F. Liebold, W. Heilmann, H. Senger, and A. Pohl

Insulin secretion and glucose tolerance were examined in 6 highly conditioned athletes in comparison with a control group of 115 normal healthy persons. During glucose infusion the athletes showed low insulin secretion although there was no difference in the levels of blood glucose compared to the control group. It is concluded that under physiologic conditions the extent of insulin secretion is not dependent only upon the blood glucose levels. The results show that a lack of insulin response can occur as a consequence of adaption to physical training. A reduced insulin response, therefore, does not necessarily indicate a diabetic or prediabetic state.

Pancreatic insulin secretion under physiologic conditions is in general regulated by the level of blood glucose. Diminished reactivity of pancreatic beta cells has been commonly observed in diabetes mellitus and a reduced insulin response is usually regarded as a diabetic or prediabetic state. Several investigators have shown, however, that there are exceptions to these rules. For instance, increased insulin secretion can be seen in obese patients with and without diabetic glucose tolerance. It is also known that a reduction in body weight results in a reduced insulin response. A diminished glucose tolerance, despite high insulin concentrations, has also been ascribed to the state of physical inactivity. On the other hand, physical training seems to lower the insulin response. Björntorp et al. have observed that in obese persons physical training lowered plasma insulin levels without a decrease in body fat, and the glucose tolerance remained unchanged. Björntorp et al. have also shown reduced insulin secretion in 10 trained middle-aged men during a 100-g glucose tolerance test.

The present paper describes investigations on a group of highly trained athletes (long-distance runners) whose blood glucose and insulin values were determined following glucose infusion. In this fashion the influence of resorption, liver extraction, and gastrointestinal hormones on insulin secretion could be avoided.

Materials and Methods

The glucose test was carried out according to the method of Cerasi and Luft as modified by Schulz et al. An initial injection of 0.33 g glucose/kg body weight was followed by a 2-hr infusion of 12 mg/kg/min. Six highly trained long-distance runners were examined and compared to 115 control subjects without metabolic or other diseases. The athletes were in an optimal state of physical training. Their physical characteristics are compared to the corresponding mean values of the control group in Table 1. The tests were started in the morning before

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Table 1. Physical Characteristics of Athletes and Controls

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Age (yr)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>10,000 m Result* (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22</td>
<td>169</td>
<td>58</td>
<td>28.53</td>
</tr>
<tr>
<td>2</td>
<td>23</td>
<td>181</td>
<td>65.5</td>
<td>31.22</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
<td>171</td>
<td>56</td>
<td>30.30</td>
</tr>
<tr>
<td>4</td>
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<tr>
<td>5</td>
<td>18</td>
<td>175</td>
<td>60</td>
<td>30.28</td>
</tr>
<tr>
<td>6</td>
<td>19</td>
<td>172</td>
<td>60</td>
<td>31.30</td>
</tr>
<tr>
<td>Controls (N = 113)</td>
<td></td>
<td>26 ± 0.8</td>
<td>172 ± 0.8</td>
<td>65 ± 0.9</td>
</tr>
</tbody>
</table>


physical activity. Blood glucose was determined by the o-toluidine method (Dab 7) and serum insulin by radioimmunoassay (Isocommerz). Insulin values are expressed as μU/ml.

RESULTS

As shown in Fig. 1, the kinetics of the appearance and disappearance of glucose in the blood following glucose infusion are identical for both athletes and normal people. In spite of these similarities, marked differences in the kinetics of insulin release are seen between the two groups (Fig. 2).

The mean basal insulin levels of the athletes (15 μU/ml) were approximately 50% lower when compared to those of the control group (30 μU/ml). Within a few minutes after the injection of glucose, the insulin level of the athletes increased by about 100% (30 μU/ml) and then remained constant over the whole period of observation (3 hr) (Fig. 2).

In the control group, the insulin values also increased immediately after glucose injection by about 100% (60-75 μU/ml), but after a lag period of about 30 min the values increased continuously for the next 60 min up to values of 90-110 μU/ml. They decreased only when the infusion was discontinued (Fig. 2).

DISCUSSION

Insulin secretion of the pancreas is generally stimulated when blood glucose levels increase. However, physiologic or pathologic factors can influence the
reaction of the pancreatic beta cells. The present paper shows that highly trained athletes exhibited a significantly lower basal insulin concentration as compared to the control group. Furthermore, during glucose infusion their insulin response was considerably lower than that in the control group. The fact that this is so although the blood glucose levels in both groups were identical indicates that the extent of the glucose stimulus was the same for both groups. These results are in accordance with those of Björntorp et al., who used the oral administration of glucose. Under these conditions, however, the blood glucose levels remained low, which could account for the lack of insulin increase.

In our study blood glucose concentrations during glucose infusions were similar in both the athletes and the control group. This finding suggests that insulin-mediated glucose disposal is more efficient in athletes and is in agreement with the results of Björntorp et al. in trained obese subjects. It is therefore possible that the low insulin response in trained athletes is a consequence of muscle conditioning. Björntorp et al., for instance, have found changes in muscle enzyme activity after physical training, which could explain a more efficient utilization of glucose. Thus, in summary, a reduced insulin response cannot generally be regarded as being due to a diabetic or prediabetic state, but may be an expression of metabolic adaption to physical training.

REFERENCES


