EFFECT OF ADAPTATION TO COLD ON THE OUABAIN-SENSITIVE COMPONENT OF RESPIRATION IN THE RAT KIDNEY

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The power of the sodium pump in the kidneys is relatively high, and for that reason direct correlation is found between its work and the respiration of the kidney [7]. It was shown previously that Na,K-ATPase activity in the kidneys increases during adaptation to cold [2]. It can be postulated that the increased oxygen demand of the kidneys and of animals adapted to cold [4] is due to an increase in power of the sodium pump.

EXPERIMENTAL METHOD

Male noninbred albino rats adapted to cold at about 0°C for 6 h a day, 6 times per week, for 16 weeks were used. Control animals were kept continuously at 22°C. Respiration of the kidney was measured in a suspension of fragments obtained in the cold by extrusion with a press through holes 1 mm in diameter [3] into isolation medium in the ratio of 1:3 (g/ml). The composition of the isolation medium was as follows: NaCl 140 mM, KCl 6.2 mM, $MgSO_4$ 1.5 mM, Na_2HPO_4 12 mM, dextran 6% (pH 7.5, 37°C). Before measurement the preparations were kept at 0-4°C. The respiration rate was determined polarographically, using a closed platinum electrode in an insulated cell (volume 1 ml) in isolation medium without dextran, the ratio of suspension of fragments to medium being 1:7 (ml/ml). The ouabain-sensitive component was calculated from the difference between endogenous respiration and respiration in the presence of 0.5 mM ouabain.

EXPERIMENTAL RESULTS

The animals of the experimental group at the end of adaptation did not differ from the controls in weight (344 ± 25 and 356 ± 20 g, respectively). The degree of adaptation was judged from the increase in oxygen consumption in response to injection of isoproterenol at 22°C and the weight of the interscapular brown adipose tissue (BAT). The maximal oxygen consumption following subcutaneous injection of isoproterenol in a dose of 0.8 mg/kg was observed in both groups at the 40th minute and was 2.1 ± 0.3 ml O_2/g tissue/h in the control rats and 3.8 ± 0.3 ml O_2/g tissue/h ($P < 0.01$) in the adapted rats. The weight of the BAT increased from 0.27 ± 0.03 to 0.70 ± 0.05 g ($P < 0.002$).

During adaptation to cold the relative weight of the kidneys increased by 25% ($P < 0.05$). The rate of endogenous respiration and the ouabain-sensitive component increased. The effect was clearly exhibited in recently isolated preparations. For instance, 23 min after isolation of the preparation respiration was increased by 21% ($P < 0.05$), after 57 min it was increased by 15% ($P < 0.05$), but after 77 min it was increased by only 12% ($P < 0.1$). The increase in the ouabain-sensitive component in the adapted animals after 23 and 57 min was about 30% ($P < 0.01$), but after 77 min the increases could no longer be detected (Fig. 1). Lowering the temperature caused a decrease in endogenous respiration and the ouabain-sensitive component. The difference between the indices for the control and adapted animals was greatest at 33°C (Fig. 2). Considering that the most important fact was not the size of the effect but maximal approximation to conditions *in vivo*, the main experiments to study respiration were conducted at 37°C. An important condition for a high respiration rate in the kidney is known to be the optimal Na^+ concentration in the medium, for a decrease in this parameter leads to a decrease in oxygen consumption [5, 9]. In the present experiments lowering the Na^+ concentration from 140 to 70 mM led to a decrease in endogenous respiration and the ouabain-sensitive component in the control and experimental preparations. Under these circumstances respiration and the ouabain-sensitive component of the latter fell by a greater degree, so that in medium with 70 mM Na^+ there was no difference between the control and adapted animals (Fig. 3).

Calculation shows that in recently isolated preparations in medium with a physiological Na^+ concentration, the increase in oxygen consumption by the kidney of the adapted rats was reduced by 60% by ouabain. In conjunction with data on activation of Na,K-ATPase [2] this fact is evidence of an increase in power of the sodium pump during adaptation to cold. Since respiration of the kidney preparations took place at the expense of the reserves of endogenous substrates, its increase in this case cannot be explained by an increase in the inflow of substrate into the cells associated with the work of

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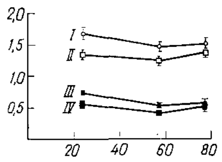

Fig. 1

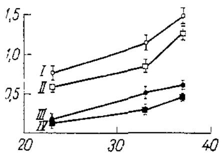

Fig. 2

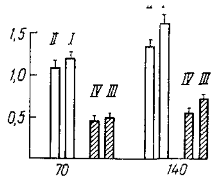

Fig. 3

Fig. 1. Dependence of endogenous respiration and ouabain-sensitive components on length of keeping of preparations. I and II) Endogenous respiration, III and IV) ouabain-sensitive component, II and IV) control group (n = 8), III and I) adapted group (n = 8). Abscissa, time of keeping kidney preparations (in min); ordinate, respiration (in μmoles O_2/g tissue/min).

Fig. 2. Dependence of endogenous respiration and ouabain-sensitive component on incubation temperature (control, n = 4; experiment, n = 5). Abscissa, temperature (in °C). Length of keeping of preparations before measurement 40 min. Remainder of legend as in Fig. 1.

Fig. 3. Effect of NaCl on endogenous respiration and ouabain-sensitive component (control, n = 5; experiment, n = 5). Length of keeping preparations before measurement 25 min. Remainder of legend as in Fig. 1.

the sodium pump. This effect was evidently due to stimulation of oxidative phosphorylation on account of acceleration of the ATP ⇌ ADP cycle. It can be tentatively suggested that activation of the sodium pump was due to an increase in tri-iodothyronine metabolism as a result of hyperfunction of the thyroid gland in the cold [6]. Evidence in support of this suggestion is given by the hypertrophy of the kidneys observed in the present experiments and also in experiments with administration of exogenous tri-iodothyronine [1], and also by activation of Na,K-ATPase synthesis in the kidneys brought about by this hormone [8].

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