THERMOREGULATION IN ALBINO MICE IN A HELIUM-OXYGEN MEDIUM AT LOW POSITIVE ENVIRONMENTAL TEMPERATURES

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Albino mice kept in a helium-oxygen atmosphere at a temperature of 10-13° fall into a state of deep hypothermia characterized by loss of motor activity, a sharp decrease in gas exchange, and lowering of the body temperature to 14-20°. In animals unable to move actively because of the restricted size of the chamber, and in animals deprived of food or bedding, the state of deep hypothermia arises much more rapidly. Mice adapted to low temperatures do not fall into a state of deep hypothermia under the same conditions.

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Comparative investigations of thermoregulation in animals in a helium-oxygen atmosphere and in an atmosphere of air, with an environmental temperature ranging from 10-40°, demonstrated the cooling effect of helium on the body in connection with the high thermal conductivity of this gas [1-2, 5-7].

In a study of the effect of a helium-oxygen atmosphere (helium 79%, oxygen 21%) on oxygen consumption and nitrogen metabolism, a state of deep hypothermia was observed in albino rats at an environmental temperature of 10-13°. The results of these experiments are described below.

EXPERIMENTAL METHOD

Two series of experiments were carried out. Series I consisted of 23 experiments at a temperature of 11-13°: 11 experiments in a helium-oxygen medium and 12 in an atmosphere of air (control). The experiments were carried out by Kalabukhov's method [4] in a respiration chamber 400 cm^3 in volume. The experimental conditions were identical with those described by Konza [5].

The experiments of series II were carried out by a method similar to that used by Shaternikov, using flasks with a capacity of 2-3 liters as respiration chambers. The mice were able to move about freely, and they received food, water, and bedding; the animals took part in the experiment for up to 7 days. Altogether 18 experiments were carried out with a helium-oxygen atmosphere and 26 with an atmosphere of air (control).

In all cases the oxygen concentration throughout the experiment, both in helium-oxygen (21.9 ± 0.6%) and in nitrogen-oxygen mixtures (21.4 ± 0.4%) was close to atmospheric. Analyses were performed on the GKhP-3 apparatus.

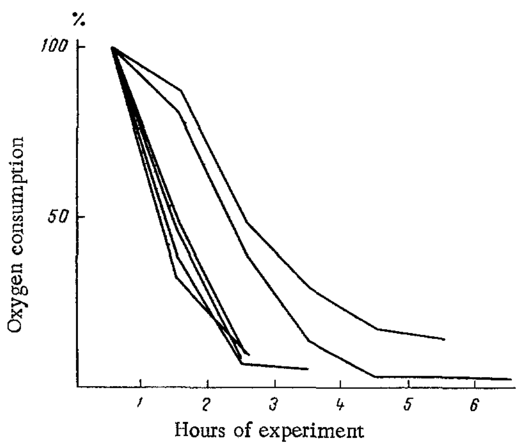

Fig. 1. Oxygen consumption of albino mice in initial period of deep hypothermia in a helium-oxygen atmosphere (individual results for 6 animals). Oxygen consumption calculated in $cm^3/h/g$ body weight and index for first hour of experiment taken as 100%.

EXPERIMENTAL RESULTS

The graph illustrated in Fig. 1 shows that the oxygen consumption of animals kept in a helium-oxygen atmosphere (experiments of series I) was sharply reduced to reach 4-7% of its initial value 3 h after the

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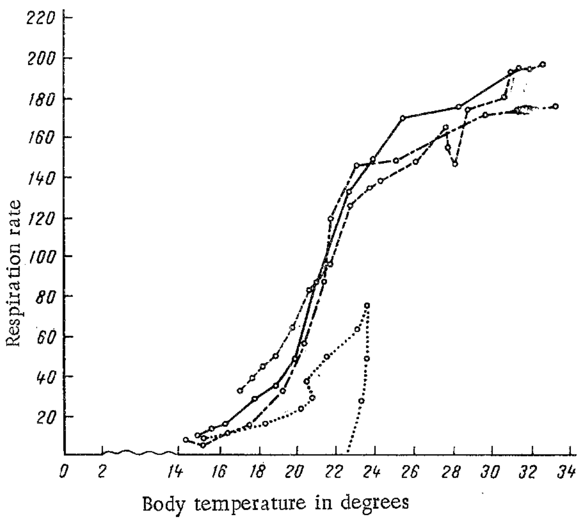

Fig. 2. Recovery period after helium-oxygen hypothermia.

beginning of the experiment. By this time the mice lay on their side, their respiration rate had fallen to 2-5/ min and their body temperature to below 20°, and a state of deep (lethargic) hypothermia had developed. If the animals remained longer under these conditions (more than 5 h), they died. Deep hypothermia was detected in all 11 experiments with the helium-oxygen mixture but in none of the 12 control experiments ($P < 0.01$).

In the experiments of series II the mice received food and bedding and were able to move about freely in the cage, so that they developed a state of hypothermia after a longer stay in the helium-oxygen atmosphere, usually on the 2nd day. At first the experimental animals used more oxygen than the controls (by 60-70%). The oxygen consumption then began to fluctuate sharply and fell to 15-25% of the initial value, while the respiration rate was 30-40/ min. If the animals stayed longer under these conditions the gas exchange continued to diminish, the body temperature fell to 14-20°, the respiration rate fell to 3-8/ min, and the mice died.

With an increase in the environmental temperature to more than 17°, the animals were observed to recover from their state of deep hypothermia. The respiration rate is shown in Fig. 2 in relation to body temperature during emergence from the hypothermic state (recovery period). As the graph shows, the body temperature at which the animals start to move again (20-22°) is the zone of rapid activation of respiration, corresponding to the hypermetabolic zone described by other workers [3]. An animal which cannot activate its respiration rapidly as it passes through this zone (Fig. 2) dies without recovering from the hypothermic state.

In the experiments of series II a state of deep hypothermia was not observed in all the mice kept in a helium-oxygen atmosphere. In 8 of the 10 experiments, deep hypothermia was discovered in the animals placed for the first time in a helium-oxygen medium at a temperature of 10-13°. Two animals kept under the same conditions did not develop deep hypothermia. A state of deep hypothermia likewise was not observed in 8 mice previously kept for several days in a cold room (0, +5°) or used in experiments at low temperatures. The oxygen consumption of these animals changed steadily with time (as also in the animals in experiments with an atmosphere of air), usually falling a little on the 5th-7th day, but it remained much as in an atmosphere of air.

At the same environmental temperatures mice kept in an atmosphere of air did not fall into a state of deep hypothermia, and only in two experiments did this state develop as a result of anoxia with increase in the oxygen concentration in the chamber to 8-10%.

The cooling action of a helium-oxygen atmosphere at a temperature of 10-13° thus produces a state of deep hypothermia in albino mice not previously adapted to the action of cold. Deep hypothermia does not arise at the same temperatures in an atmosphere of air.

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