TISSUE RESPIRATION OF THE INTERNAL ORGANS AND SKIN OF RATS DURING PROLONGED EXPOSURE TO A HIGH AMBIENT TEMPERATURE

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The oxygen consumption of tissues of various organs was determined in a Warburg apparatus at 37°C in acute experiments on albino rats. A high ambient temperature was found to reduce the respiratory gas exchange. The contribution of the tissues of different organs to this decrease in the general level of metabolism varied depending on the number of exposures to a high temperature. The more active involvement of the tissues of most organs in the adaptive responses of the animal to a high temperature was observed during the third week.

KEY WORDS: metabolism; tissue respiration.

Investigations into the mechanisms of adaptation of the body to cold are described in the literature. Considerable changes in metabolism at the level of the whole organism and also at the tissue and cellular levels have been demonstrated [6, 8, 9]. However, little attention has so far been paid to the study of changes in metabolism at the tissue and cellular levels during adaptation of animals to a high ambient temperature [3, 4, 5, 7].

The effect of prolonged exposure to heat on the tissue respiration of various internal organs and the skin was investigated in rats.

EXPERIMENTAL METHOD

Experiments were carried out on 60 albino rats of both sexes weighing 120-170 g, kept on a mixed diet. From the first to the 30th days inclusive for 4 h daily the animals were kept in an electrically heated thermostat with water jacket at an air temperature of 36-37°C and relative humidity of 56-59%; control rats were kept at a temperature of 18-23°C. The oxygen consumption was determined in homogenates (10%) of the kidneys, heart, liver, brain, lungs, and skin in a Warburg apparatus at 37°C [8]. The incubation medium suggested by Isaakyan et al. [5] was used. Before the animals were killed the total level of gas exchange and the body temperature were determined.

EXPERIMENTAL RESULTS

The control tests showed that the different organs differed substantially in their oxygen consumption. The highest oxygen consumption was found for the kidney, heart muscle, and liver tissues (14.6, 11.2, and 9.9 μl O_2/mg dry weight of tissue/h, respectively). The level of the oxygen consumption of the lungs and skin was low (2 and 0.9 μl O_2/mg/h) and the brain occupied an intermediate position (7.2 μl O_2/mg/h). The tissues of organs such as the kidney, heart, and liver utilized 4.9-16.2 times more oxygen than the lungs and skin, in agreement with data in the literature [1-4]. These differences in the tissue respiration levels of the different organs are evidently caused by differences in their function and they indicate that they participate to different degrees in the maintenance of the metabolic level in the whole organism.

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TABLE 1. Total Gas Exchange (in ml/g/h), Tissue Respiration (in μl/mg dry weight/h) of Various Organs, Respiratory Quotient, and Rectal Temperature (in °C) of Rats during Repeated Exposure to a High Ambient Temperature (M ± m, n = 4-8)

Index studied	Control 18—23°, (1)	Expt. 36—37°							
		1st day (2)	P_{1-2}	10th day (3)	P_{1-3}	20th day (4)	P_{1-4}	30th day (5)	P_{1-5}
Tissue respiration:									
kidney	16,4±0,7	18,5±0,4	<0,05	17,8±0,6	>0,05	16,3±0,4	>0,05	20,1±0,5	<0,002
heart	13,4±0,4	14,6±0,3	<0,05	12,4±0,4	<0,05	11,2±0,3	<0,01	14,6±0,3	<0,05
liver	13,2±0,2	11,7±0,3	<0,002	10,2±0,9	<0,01	10,3±0,5	<0,001	11,1±0,2	<0,001
brain	8,5±0,3	7,2±0,2	<0,02	8,5±0,4	>0,05	8,5±0,8	>0,05	8,7±0,4	>0,05
lungs	2,7±0,1	1,5±0,1	<0,001	1,9±0,4	>0,05	2,1±0,1	<0,001	2,0±0,1	<0,001
skin	1,1±0,1	0,8±0,03	<0,02	0,7±0,01	<0,01	0,4±0,1	<0,001	0,6±0,1	<0,001
O_2 consumption	2,16±0,12	1,94±0,09	>0,05	1,83±0,09	>0,05	1,66±0,06	<0,01	1,64±0,06	<0,01
CO_2 excretion	1,63±0,09	1,79±0,09	>0,05	1,71±0,05	>0,05	1,51±0,06	>0,05	1,51±0,09	>0,05
Respiratory Quotient	0,75±0,03	0,92±0,03	<0,01	0,93±0,03	<0,01	0,90±0,02	<0,01	0,92±0,02	<0,01
Rectal temperature	35,9±0,03	39,0±0,10	<0,001	38,9±0,09	<0,001	38,6±0,09	<0,001	38,0±0,0	<0,001

After repeated exposure of the rats to a high ambient temperature the total oxygen consumption fell considerably, mainly on the 20th day of exposure (23.3%), and it remained at this level under these conditions until the 30th day (Table 1). Meanwhile the CO_2 excretion was not appreciably altered, but the respiratory quotient rose by 22.7% on the first day and remained at the level until the end of the experiments. The rectal temperature in particular was high on the first day of exposure to a high temperature, but later it fell to reach a minimum by the 30th day.

The metabolic activity of the liver, brain, lung, and skin tissues during the first day of exposure of the rats to a high temperature was significantly reduced (by 11.4-44.5%), whereas in the kidneys and heart it was increased (by 12.8 and 8.9%). On the 10th day the tissue respiration of the kidneys, liver, heart, and skin was not appreciably changed from that on the first day, and only in the skin was it reduced ($P < 0.01$). Meanwhile the respiration of the brain and lungs, on the other hand, increased (by 18 and 26.6% , respectively). On the 20th day of exposure to heat the respiration was reduced only in the kidney, heart, and skin tissues (8.5-42.9%), but on the 30th day the respiratory activity of these same tissues increased, in some cases to a level higher than that observed on the first day.

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