CHANGES IN THE RATE OF GLYCOLYSIS AND GLYCOGENOLYSIS IN THE MYOCARDIUM OF RATS DURING ACCLIMATIZATION TO HIGH ALTITUDES

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The rates of glycolysis and glycogenolysis were investigated separately in the left and right ventricles in experiments on 24 male Wistar rats on the 3rd, 10th, 20th, 30th, and 40th days of their stay under natural conditions at high altitudes in the mountains (Tuya-Ashu Pass, Tyan'-Shan Mountains, Altitude 3200 m above sea level). The increase observed in the rates of these processes is considered to be a manifestation of adaptation of the myocardium to the hypoxic conditions.

It was shown previously that the resistance of the myocardium is increased in rats after training for one month in a pressure chamber (equivalent to an altitude of 7000 m), and that this increase correlates with an increase in the myoglobin concentration and in the cytochrome oxidase activity [1, 6]. Khavkina [3] found an increase in the rate of glycolysis in the myocardium of rats adapted to hypoxia under the same conditions. The increase in the rate of glycolysis during exposure to hypoxia plays both an energetic and a plastic role.

It was accordingly decided to investigate the intensity of carbohydrate metabolism in the myocardium of rats kept under natural conditions at high altitudes in the mountains.

EXPERIMENTAL METHOD

Male Wistar albino rats weighing 170-200 g were divided into two groups: group 1 consisted of control animals tested in the city of Frunze (altitude 760 m above sea level), while the animals of group 2 were trained for hypoxic conditions high in the Tyan'-Shan Mountains (at the Tuya-Ashu Pass, altitude 3200 m above sea level). The animals of group 2 were tested on the 3rd, 10th, 20th, 30th, and 40th days of their stay in the mountains. The rats were killed by decapitation, the heart was quickly removed, and the left and right ventricles were separated. A weighed sample of tissue was chopped with scissors and ground in porcelain mortars in 0.25 M mannitol solution. All procedures were carried out in the cold. The hyaloplasm was obtained in the usual way. The rates of glycolysis and glycogenolysis were measured by accumulation of lactate in a reconstituted system (pH 7.4) containing (in moles/liter): K-phosphate buffer $5 \cdot 10^{-2}$, $MgCl_2$ $7 \cdot 10^{-3}$, ATP $1 \cdot 10^{-3}$, nicotinamide $5 \cdot 10^{-3}$, NAD $2 \cdot 10^{-4}$, fructose-1, 6-diphosphate $1.7 \cdot 10^{-6}$, glucose $5 \cdot 10^{-2}$. Glycogen was used in the same concentration as glucose. The total volume of the sample was 2 ml and its protein content 0.5-0.7 mg. The samples were incubated for 30 min at 37°. Lactate was determined by the method of Barker and Summerson [4], and protein by the method of Lowry et al. [5]. Accumulation of lactic acid was expressed in μg/mg protein/h.

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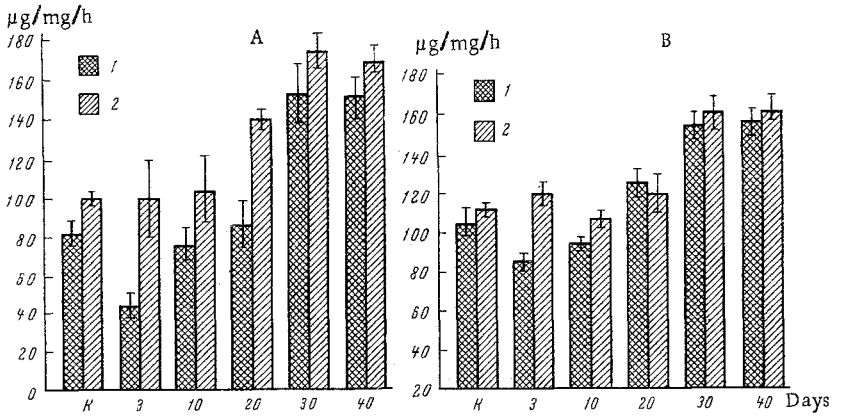

Fig. 1. Changes in rate of glycolysis and glycogenolysis in left (A) and right (B) ventricles of rats during acclimatization to high altitudes: 1) accumulation of lactate from glucose; 2) accumulation of lactate from glycogen. Abscissa, days of stay in mountains; ordinate, lactate formation (in μg/mg/h).

EXPERIMENTAL RESULTS

The mean results showing the rate of accumulation of lactate in the left and right ventricles of the rats at various times of their stay in the mountains are shown in Fig. 1. The rate of glycolysis in both ventricles was reduced on the 3rd day, but was back to normal again on the 10th day. The rate of glycolysis was significantly increased in both ventricles on the 30th and 40th days.

The rate of glycogenolysis increased in the left ventricle after the 20th day, while in the right it increased after the 30th day of the animals' stay in the mountains. A considerable increase in the degree of dispersion after the 3rd day of the rats' stay in the high mountains will be noted. This applies in particular to the accumulation of lactate formed from glycogen in the left ventricle. An increase in the degree of dispersion was previously observed by Khavkina [3] during an investigation of the rate of glycolysis in the myocardium in the early stages of adaptation of rats to hypoxia under pressure chamber conditions, and it was interpreted as the beginning of a reorganization of glycolytic metabolism.

The adaptive changes in the glycolytic metabolism of the myocardium, expressed as the stimulation of glycolysis and glycogenolysis during the rats' stay in the high mountains at an altitude of 3200 m above sea level were in operation by the 20th day and were particularly evident on the 30th-40th days. These findings agree well with statements in the literature indicating that the optimal period of adaptation to hypoxia is 3-6 weeks.

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