ENERGY UTILIZATION DURING EXERCISE OF ALBINO RATS

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Since the publication of the A.V. Hill's work, many studies have been reported on energy metabolism during exercise. These investigations were focused on the amount of oxygen transported from the circulation and many investigators have dealt with the total energy utilization in the body by determining O2 intake and CO2 output in external respiration. It is, however, difficult to pursue the intermediary metabolism by biochemical techniques in such a rapid phenomenon as exercise or muscular contraction.

Since 1968, it has been investigated, mainly with rats, the effect of exercise on the intermediary metabolism from the viewpoint of energy utilization. Thus, we have experiments on 1) difference by nutritional conditions, 2) difference by exertion in prolonged exercise and intense work, and 3) effect of training, with regard to carbohydrate and lipid metabolism in the skeletal muscle, liver, heart and adipose tissue.

This report deals with changes in carbohydrate and lipid metabolism in the skeletal

Fig. 1 Relationship between running speed and exhaustion time. The exhaustion time is represented as logarithmic scale. There was a straight line relationship at the running speed from 15m/min to 35m/min.
muscle, liver and ventricular muscle, and changes in various substances in blood, which supply the energy sources to the organs. Recently, Rosell & Saltin (1973) suggested that the availability of essential substrates for the energy release in the prolonged exercise or in very intense work has been overlooked.

The exercise made by rats was running by means of the motor driven rodent treadmill at an 2° incline. Wistar albino rats, weighing 200~300g fed on the standard diet were used. Running was carried out after fasting for 18–24hr. Fig. 1 represents relation between running speed and running time up to exhaustion. When the running speed was above 35m/min, the running time was extremely shortened. This phenomenon can be attributed solely to the exhaustion of the respiratory-circulatory system.

![Graph](image1.png)

**Fig. 2** Change of carbohydrate metabolism of rats during exercise at 25m/min on the treadmill running. Glycogen, blood sugar and blood lactate were determined by Good-Kramer & Somogyi (1933), Somogyi & Nelson (1952) and Barker & Summerson's methods (1941), respectively. After exercise, the experimental animals were anesthetized with pentobarbital sodium (4mg/100g body weight), and within 6min each organs were dissected.

![Graph](image2.png)

**Fig. 2** represents changes in blood sugar and blood lactate as well as glycogen amount in gastrocnemius muscle, ventricular muscle and liver at various running times by the running speed of 25m/min. Changes in free fatty acid and triglyceride level in serum, gastrocnemius muscle, ventricular muscle and liver were observed under the same condition with the above. Liver glycogen, blood sugar and muscle glycogen all increased when running time was short. And blood lactate increased with prolongation of running time. No change of muscle glycogen was observed in less than 30min after beginning of the exercise, but after this period a remarkable depletion was induced. In particular, the muscle glycogen was significantly depleted after 30min period of exercise. In case of complete exhaustion, all of the above mentioned values decreased.

When, however, running time was short, no change in free fatty acid level was observed in any of the organs, while triglyceride in serum and ventricular muscle decreased. These results suggest the proceeding of energy utilization in organs, because 1) ventricle glycogen underwent little change regardless of running time, 2) with prolongation of running time, carbohydrate (glycogen, blood sugar, blood lactate) decreased, while serum
FFA increased.

In changes of carbohydrate and lipid metabolism at the exhaustion owing to running speed of 25m/min, glycogen content was depleted in all the organs and increased blood lactate reduced with decrease in blood sugar. Also, triglyceride contents in all organs tended to decrease, thus lipid metabolism having produced along with carbohydrate metabolism. Therefore, similar observations as mentioned above were carried out in rats which were exhausted in running exercise at different speeds. In a tentative conclusion, the rate of glycogen and triglyceride depletion in cardiac muscles was related to the exhaustion caused by the running work.

When, however, rats were trained preliminarily, glycogen in gastrocnemius muscle was increased and blood lactate was decreased. On the other hand, a much amount of blood lactate was produced on exhaustion by the running speed of 30m/min. These facts indicate that the training may have influenced anaerobic capacity in rats.

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References