

STATE OF THE ENERGY METABOLISM IN
MUSCLES OF ADRENALECTOMIZED
RABBITS DURING CONTRACTION

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The content of free nucleotides, creatine phosphate, and inorganic phosphorus in the gastrocnemius muscles of adrenalectomized rabbits in a resting state shows no change from the control. The glycogen concentration is increased. During contraction, in the muscles of the adrenalectomized rabbit there is a greater decrease in the concentrations of creatine phosphate and glycogen per unit of work, and a greater rise of temperature than in the muscles of the control group.

One of the symptoms of a disturbance of adrenocortical function is muscular weakness, the development of which is linked with a disturbance of the mechanism of muscular contraction [6]. However, the data for the concentration of high-energy compounds in the muscles and other organs of adrenalectomized animals are to some extent contradictory. Some workers, for instance, describe a decrease in the concentrations of ATP, creatine phosphate, and glycogen [5, 11, 14] in the muscles and other tissues of adrenalectomized animals, while others did not observe these changes [2, 9, 12, 13, 16].

In the investigation described below the concentration of free nucleotides, creatine phosphate, and glycogen was investigated in the gastrocnemius muscles of adrenalectomized rabbits at rest and during contraction.

EXPERIMENTAL

Adrenalectomy and a mock operation were performed on male rabbits. The adrenalectomy was carried out in one stage on both sides under ether anesthesia. In the rabbits undergoing the mock operation the skin and soft tissues were incised but the adrenals were not removed. Adrenalectomy and the mock operation were performed on the same day and the animals were kept under identical conditions. They were used in the experiments on the 6th day after the operation. In the experiments of series I (mock operation, 8 experiments) and series II (adrenalectomy, 8 experiments) the rabbits were decapitated, the gastrocnemius muscle was excised and frozen in liquid oxygen, and ground into powder, and the concentrations of the following substances were determined: adenine nucleotides (ATP, ADP, AMP) by electrophoresis on paper [15], creatine phosphate by Alekseeva's method [1], inorganic phosphorus by Delory's method in Grigor'eva's modification [3], and glycogen by the anthrone method [10]. The concentration of nucleotides was determined spectrophotometrically at 260 and 290 nm.

In the experiments of series III (mock operation, 8 experiments) and IV (adrenalectomy, 8 experiments) the rabbits were fixed to a frame, and under superficial ether anesthesia the sciatic nerves were dissected and divided bilaterally. Stimulating electrodes were applied to the peripheral end of one tibial nerve. The tendo Achillis was connected to a myograph. A copper-constantan thermocouple was inserted into the muscle to record the temperature [4], which served as an index of the functional state of the muscle [7]. The muscle on the opposite side was used as the control. After establishment of the original temperature level, contractions of the muscle were induced by stimulating it through the nerve with square pulses 1.5 msec in duration and at a frequency of 2/sec. Contractions took place under isotonic conditions with a

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TABLE 1. Concentrations of Free Nucleotides (in μ moles/g tissue), Creatine Phosphate (in mg% creatine), Inorganic Phosphorus (in mg%), and Glycogen (in mg%) in Gastrocnemius Muscles of Muscles of Rabbits Undergoing Mock Operation or Adrenalectomy, at Rest and during Contraction ($M \pm m$)

Substance	Mock operation		Adrenalectomy	
	rest	activity	rest	activity
ATP	4,94 \pm 0,35	3,79 \pm 0,48	4,84 \pm 0,47	3,66 \pm 0,35
ADP	0,92 \pm 0,08	0,90 \pm 0,12	1,03 \pm 0,13	0,89 \pm 0,081
AMP	0,76 \pm 0,143	0,785 \pm 0,06	0,987 \pm 0,30	0,81 \pm 0,1
IMP	None	0,48 \pm 0,087	None	0,32 \pm 0,059
		$P < 0,01$		$P < 0,01$
Creatine phosphate	267 \pm 16,3	110 \pm 23	279 \pm 15	88,75 \pm 19,6
		$P < 0,01$		$P < 0,01$
Inorganic phosphorus	30,25 \pm 4,17	81,75 \pm 9,6	60,75 \pm 5,58	101,5 \pm 10,24
Glycogen	546 \pm 26	240,5 \pm 40,7	730 \pm 137	465,5 \pm 125
		$P < 0,01$	$P < 0,01$	$P < 0,05$

Note: In every case, $P < 0.001$.

load of 200 g. After the end of stimulation, in the phase of maximal elevation of the temperature both gastrocnemius muscles were excised simultaneously and frozen in liquid nitrogen for determination of the content of the substances mentioned above. The numerical results were subjected to statistical analysis.

EXPERIMENTAL RESULTS

The first two series of experiments showed that the ATP content and the total adenine nucleotides in the gastrocnemius muscles of the adrenalectomized rabbits were slightly increased on the 6th day after the operation. The creatine phosphate concentration was reduced, while that of inorganic phosphorus was unchanged. However, this difference from the values in the animals undergoing the mock operation was not statistically significant. The absence of changes in the concentrations of ATP, creatine phosphate, and inorganic phosphorus in the muscles of the adrenalectomized rats, even in those developing adynamia, has also been reported in the literature [3]. The glycogen concentration in the muscles of the adrenalectomized rabbits was increased by 176 ± 68.8 mg% ($P < 0.05$) compared with animals undergoing the mock operation (423 ± 21.5 mg%).

The experiments of series III and IV showed that during contraction of the muscles in the rabbits after the mock operation the temperature rose by $3.65 \pm 0.38^\circ\text{C}$ ($P < 0.01$), while the amplitude of the contractions fell by $43 \pm 3.9\%$ ($P < 0.001$). The work done by the muscle, calculated from the ergogram, was 0.1676 ± 0.0324 kg \cdot m ($P < 0.01$). The concentrations of ATP, glycogen, and creatine phosphate fell significantly, while that of inorganic phosphorus rose. Similar changes affecting these substances were also observed during contraction of the gastrocnemius muscle of the adrenalectomized rabbits (Table 1).

By contrast with the rabbits undergoing the mock operation or adrenalectomy, the temperature of the muscle during contraction rose by a greater amount ($4.4 \pm 0.49^\circ\text{C}$; $P < 0.001$) for a smaller quantity of work performed. The height of the contraction was considerably reduced — by $61.4 \pm 5.5\%$ ($P < 0.001$).

Calculation of the change in temperature and of the quantity of glycogen and creatine phosphate broken down per kg \cdot m of work performed by the muscle showed that in rabbits undergoing the mock operation, 936.7 mg% creatine phosphate and 1822.8 mg% glycogen were broken down per kg \cdot m work. In the adrenalectomized rabbits 1510 mg% creatine phosphate and 2096.9 mg% glycogen were broken down. The increase in temperature also was greater.

In a resting state, the content of adenine nucleotides, creatine phosphate, and inorganic phosphorus in the muscles of the adrenalectomized rabbits was thus unchanged.

During contraction the working capacity of the muscles of the adrenalectomized animals fell more sharply, more creatine phosphate and glycogen was broken down, and the temperature rose by a greater degree than in the control animals undergoing the mock operation.

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