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RAPID PROTEIN TRANSPORT BY SPINAL MOTONEURONAL AXONS OF RATS ADAPTED AND UNADAPTED BEFOREHAND TO PHYSICAL EXERCISE

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Nerve cells in an active state are distinguished by several features of a morphological character, by intensification of synthesis and accumulation of RNA and protein, increased oxygen uptake, activation of respiratory enzymes, and so on [1-3, 6, 9]. The writers showed previously that anterograde protein transport in nerve fibers depends on the functional state of the neurons and their processes [5]. According to data in the literature, the resistance of cells, organs, and systems to changes taking place during exercise is increased during adaptation [4].

In the investigation described below the effect of physical exercise, consisting of swimming for different periods of time and of different intensity, on the fast component of axonal transport (AT) of proteins was studied in motor fibers of the sciatic nerve of rats adapted and unadapted to physical exercise by swimming.

EXPERIMENTAL METHOD

Male albino rats weighing 280-320 g were used. The animals were compelled to swim daily in water at a temperature of 33-35°C for 3 h unloaded and 10-15 min carrying a load, equivalent to 1/11 of the animal's body

TABLE 1. Transport of Rapid Component of Labeled Protein along Motor Fibers of Rats Unadapted and Adapted to Physical Exercise

Experimental conditions	Swimming without load for 12±2 h		Swimming w. load of 1/11 of body wt. for 60 ± 10 min	
	velocity of AT (mm/day)	level of radioactivity of transp. mat. (con. units)	velocity of AT (mm/day)	level of radioactivity of transp. mat. (con. units)
Control	392,42±10,23	3,93±0,29	392,42±10,23	3,93±0,29
Swimming by unadapted rats	322,0±8,71*	1,92±0,2*	431,51±9,58*	8,08±0,41*
Training (swim. daily for 3 h without load or 10-15 min. w. load of 1/11 of body wt.)				
5 days	351,63±10,11*	2,23±0,16*	426,0±10,71*	6,79±0,49*
10 days	360,51±19,35	2,41±0,11*	432,0±12,05*	7,55±0,52*
20 days	387,62±11,05	3,16±0,21	391,62±19,72	3,69±0,22

Legend. $^*p < 0.05$: differences significant compared with group of control rats; each value obtained by investigation of 10-12 animals.

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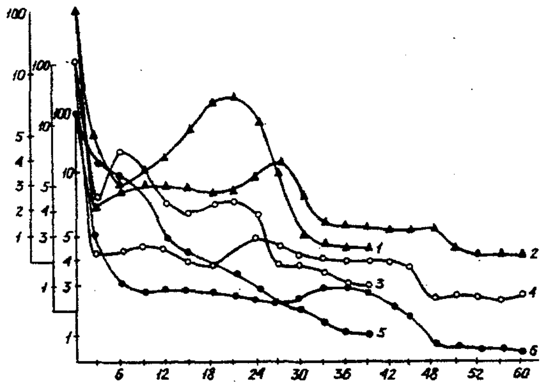

Fig. 1

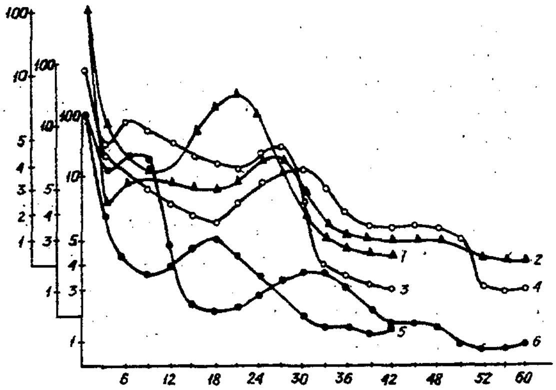

Fig. 2

Fig. 1. Transport of fast component of labeled proteins along axons of motoneurons of rats unadapted and adapted to physical exercise (swimming without a load). Abscissa, distance (in mm) from anterior horns of spinal cord; ordinate, radioactivity (conventional units). Control: 1, 2) sacrifice after 2 and 3 h. Training (swimming for 3 h without a load) for 5 days: 3, 4) sacrifice after 2 and 3 h. Training for 20 days: 5, 6) sacrifice after 2 and 3 h.

Fig. 2. Transport of fast component of labeled proteins along axons of motoneurons of rats unadapted and adapted to physical exercise (swimming with a load). Abscissa, distance (in mm) from anterior horns of spinal cord; ordinate, radioactivity (conventional units). Control: 1, 2) sacrifice after 2 and 3 h. Training (swimming for 10-15 min with load of 1/11 of body weight) for 5 days: 3, 4) sacrifice after 2 and 3 h. Training for 20 days: 5, 6) sacrifice after 2 and 3 h.

weight. After preliminary adaptation of the animals for 5, 10, and 20 days they were compelled to exercise by swimming for 12 ± 2 h without a load or for 60 ± 10 min with a load. Swimming ceased when replaced by diving, i.e., when the animals periodically rose to the water surface in order to breathe [2]. The velocity of the fast component of AT and the level of radioactivity of the transported material in motor fibers of the sciatic nerve were then determined [5]. The same parameters of AT were studied during swimming in rats not previously adapted to exercise and in control animals (Table 1).

EXPERIMENTAL RESULTS

The data in Fig. 1 and Table 1 show that the velocity of the fast component of AT along motor fibers of the sciatic nerve of rats after swimming for 12 ± 2 h fell by 18% relative to the control, and the quantity of protein transported by the axons was reduced by more than half. Similar changes in parameters of AT were found in animals after 5 and 10 days during which the animals swam for 3 h daily. However, after muscular training for 20 days, adaptive changes were observed in the metabolic response of the motoneurons to prolonged exercise by swimming, namely a statistically significant increase in the velocity and the level of radioactivity of AT to values close to those in intact animals.

Similar results (Fig. 2) were obtained by investigating the effect of much more strenuous but short-term exercise (swimming for 60 ± 10 min with a load of 1/11 of body weight) on AT: the velocity of transport was increased by 10%, but the level of radioactivity of the transported material was more than doubled. A single daily session of exercise for 10-15 min for 5 and 10 days did not significantly change the effect of neuronal hyperfunction on the parameters of AT under conditions of intensive stimulation by swimming. The training effect on the animals could be observed after 20 days of single sessions of exercise: the velocity of the fast component of AT was 391.62 ± 19.72, and the level of radioactivity of the transported material 3.69 ± 0.22 conventional units, not statistically significantly different from the control values.

The results are in agreement with those obtained by other workers, who found that the fast component of AT depends on the functional state of the nerve cells [7, 8, 10, 11].

The adaptive responses of the neurons to muscular exercise in the initial stages of adaptation depend on the intensity of stimulation and the duration of its action [5].

Adaptive reorganization of neuronal metabolism in trained animals is accompanied by activation of compensatory processes which abolish changes in the parameters of the flows of material transported within the neuroplasm, and induced by severe physical exercise. Thus the dependence of AT on the degree of functional loading and of training relative to it indicates that transport of materials from the bodies into the axons of neurons is an essential condition for the existence of nerve cells, and it may also play an important role in the replacement of substances utilized in the processes. Compensatory and adaptive changes in the fast component of anterograde transport are evidence of its possible involvement in trophic relations between the neuron and target cell.

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