MORPHOLOGICAL CHANGES IN THE CORTICAL NEURONS DURING PHYSICAL EXERTION AND PRELIMINARY TRAINING

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Physical exertion is accompanied by changes not only in the myocardium and skeletal muscles, but also in certain other organs and systems, notably the central nervous system. The state of the latter, in its turn, has a significant effect on the working capacity of the muscle apparatus and on its endurance. This accounts for the interest of the study of the structural changes arising in the various parts of the central nervous system during physical fatigue. Information on this problem is incompletele.

The content of chromatophilic material in the nerve cells of dogs has been found to decrease after physical exertion and to increase during rest [8]. The motor cells of the spinal cord of fatigued animals contained about one-fifth as much protein and RNA after intensive muscular exertion than at rest [3]. During prolonged, continuous movement or in the absence of sleep for 48-72 h, the content of Nissl's substance in the nerve cells of animals fell sharply. Investigations have shown that after a reduction in the content of Nissl's substance as a result of an increased load, restoration of its normal level occurs in 2-3 days, or sometimes in a few hours [3-5].

After swimming for periods of between 30 min and 3 h, the number of satellites in the motor neurons in the ventral horn of the lumbar enlargement of the spinal cord of mice was found to be increased. With an increase in the duration of swimming, the difference between the mean area of the satellites and their "free glia" also increased correspondingly [7]. After swimming for 40 min, the mean number of satellites in the motor neurons of the ventro-lateral nucleus of the lumbar enlargement of the spinal cord of rats increased by a statistically significant degree [1].

The object of the present investigation was to study the structural changes arising in the central nervous system during physical exertion undertaken with or without preceding training.

EXPERIMENTAL METHOD AND RESULTS

Twice a week the animals (8 rats) were made to swim for 2 h in water at a temperature of 32-35°. After 6 months of this training, the next time they had to swim for 4 h together with 8 untrained rats, swimming for the first time. The last group consisted of 8 rats which did not swim (controls). At the end of the experiment the animals were killed by decapitation. The brain was fixed in Carnoy's fluid and embedded in paraffin wax. Sections were stained with hematoxylin-eosin and by Nissl's method. The neurons of the sensorimotor area of the cortex (Area PA^m), layer V, were studied. By means of a screw ocular

TABLE 1. Mean Area of Cross Section of the Nucleus of a Cortical Neuron (in μ^2)

Control	Experiment	
	untrained rats	trained rats
45±2,5	59±2,3	44±2,3
P	0,00001	0,5

TABLE 2. Mean Area of Cross Section of a Cortical Neuron (in μ^2)

Control	Experiment	
	untrained rats	trained rats
107±4,2	118±6,8	99±6,4
P	0,005	0,05

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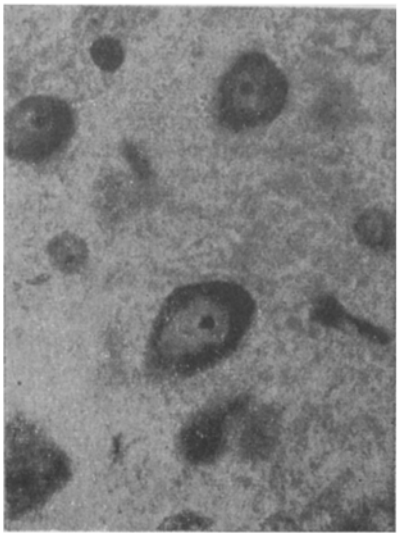

Fig. 1. Neuron of layer V of the cortex, Area PA^m, of a control animal. Nissl. 900 ×.

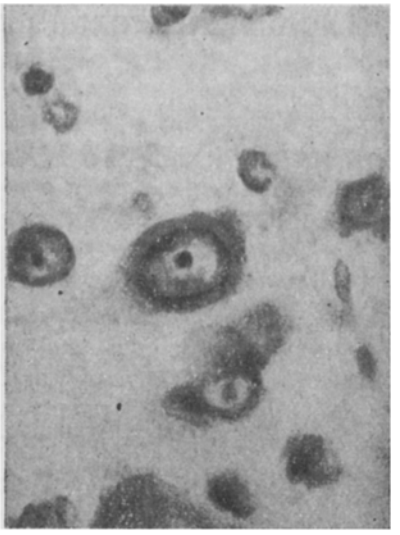

Fig. 2. Neuron of layer V of the cortex, Area PA^m, of an animal after physical exertion (swimming for 4 h). Nissl. 900 ×.

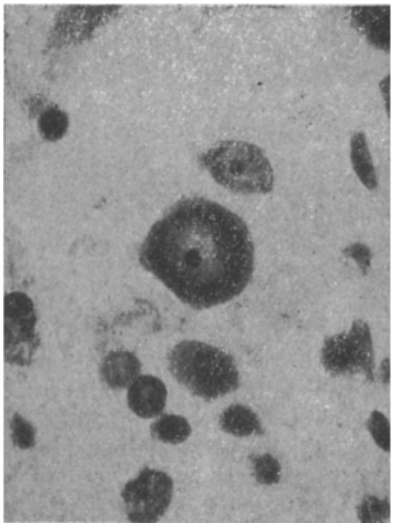

Fig. 3. Neuron layer V of the cortex, Area PA^m, of an animal performing physical work (swimming) for 4 h) after preliminary training for 6 months. Nissl. 900 ×.

micrometer the dimensions of the cross section of the neurons and of their nuclei were measured in this area. The cross section was determined as the product of two mutually perpendicular diameters (the larger and smaller) of the neuron and of its nucleus. The results were analyzed by the Student–Fisher method.

The results of the measurements are given in Tables 1 and 2.

The predominant neurons in layer V of Area PA^m of the cortex of the control group of animals were normochromic in type, with hypochromic neurons among them showing signs of peripheral chromatolysis. The cell nuclei, like the cells themselves, were of medium size (cross section of neuron 107 μ^2) and rich in chromatin. The nucleoli were large, regularly circular in shape, and situated in the center of the nucleus (Fig. 1).

The sensorimotor cortex of the experimental untrained animals contained pale, hypochromic cells. The Nissl's substance of these cells was in a state of peripheral chromatolysis, their nucleus was large, pale, and occupied two-thirds of the cell, and the nucleoli were in various states (ectopia, hypertrophy, disintegration, atrophy). The cross section of the neuron and its nucleus was larger than in the control animals (Table 1; Fig. 2).

Histological examination of the cerebral cortex of the trained animals showed that the cytoarchitectonic picture was clearly preserved. Layer V of the cortex contained normochromic neurons. The nucleus was regularly round in shape, with a central nucleolus and well-defined intranuclear granules, rich in Nissl's substance, and sometimes showing peripheral chromatolysis. The cross section of the nerve cell and of its nucleus was indistinguishable from that of the neuron and its nucleus in the control animals (Table 2 Fig. 3).

The statistical analysis of the measurements of the neurons and their nuclei in the sensorimotor area of the cerebral cortex thus showed that they were increased in the animals performing physical work. Meanwhile the amount of Nissl's substance in the cytoplasm was reduced. In animals trained to perform physical work for a long time, these changes were much less marked, and the neurons of these animals were practically indistinguishable from the corresponding cells of the control animals.

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