DYNAMICS OF BODY WEIGHT OF ANIMALS AND THEIR SKELETAL MUSCLE DURING EXPOSURE TO HYPOKINESIA

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UDC 613.766.2-06:[612.74+612.66

KEY WORDS: hypokinesia; growth of animals; skeletal muscle.

The effect of motor activity on the physiological functions of animals and man is widely familiar and continues to attract the attention of research workers. Movement takes place by means of skeletal muscle tissue which, in man, accounts for 41-43% of the body weight. The high plastic properties of muscle tissue have been demonstrated in Studitskii's laboratory. Skeletal muscles of various animals have shown to be capable of regeneration and transplantation [3, 7, 11]. According to data in the literature, restriction of movement has an adverse effect on the adult animal: the body weight falls [2, 9] and disturbances arise in the circulation [5, 6], and in activity of the nervous [12, 13] and endocrine [1, 15] systems. Hypokinesia has been shown [2, 8, 14] to affect the skeletal muscles of rats weighing 140-200 g. The absolute and relative weight of the skeletal muscles has been shown to decrease statistically significantly. No published data could be found on the response of younger animals, during the period of most active growth, to hypodynamia.

The object of the present investigation was to examine the growth of young animals kept under different conditions of hypokinesia and to investigate the response of skeletal muscles to reduced motor activity.

EXPERIMENTAL METHOD

Three series of experiments were carried out on 72 young noninbred male albino rats weighing 110-130 g (24 animals in each series). The rats in series I were kept in cages (4 × 19 × 4 cm) in which they could not turn round. In the experiments of series II the rats were kept in slightly larger cages (5 × 19 × 5 cm), in which they could turn through 180°. In series III (control) the animals were kept in ordinary animal house cages (16 × 35 × 31 cm). The experiment lasted 2 months. Every day the animals were weighed in the morning before feeding. The numerical results were subjected to statistical analysis by Student's test and used to plot curves showing the change in the animals' body weight. At the end of the experimental period the animals were killed, the gastrocnemius muscles dissected on both sides, and their weight determined. The ratio of the weight of all the muscles to the body weight (in %, the muscle index) was determined in some of the animals. Material was fixed in Zenker's fluid and then processed for histological examination. In particular, the diameter of the muscle fiber was determined by the method suggested by Zhenevskaya [4].

EXPERIMENTAL RESULTS

In the experiments of series I in which the animals were kept in very constraining cages a strong stress reaction was observed, including a response of alarm, a stage of resistance, and a stage of exhaustion [10]. During the first week after the beginning of the experiment the rats were restless and lost their appetite, but on the following days they became increasingly aggressive and lost a considerable amount of weight: After 2 weeks their mean body weight was 125 g and after 3 weeks 119 g. Accordingly no further observations were made in this series of experiments.

Laboratory of Evolutionary Histology, A. N. Severtsov Institute of Evolutionary Morphology and Ecology of Animals, Academy of Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR A. P. Avtsyn.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 93, No. 3, pp. 118-119, March, 1982. Original article submitted June 19, 1981.

0007-4888/82/9303-0371$07.50

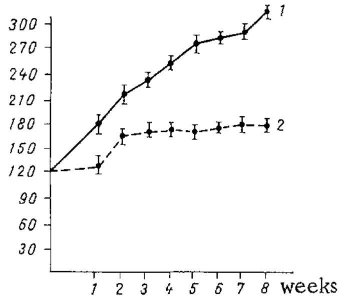

Fig. 1

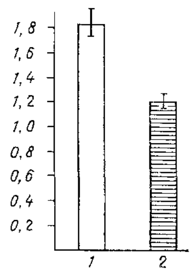

Fig. 2

Fig. 1. Body weight of rats (in g) kept in ordinary cages (1) and in constraining cages (2).

Fig. 2. Weight of gastrocnemius muscles of rats kept for 2 months in ordinary (1) and constraining (2) cages.

In the experiments of series II in which the rats were kept under conditions of restricted movement, the stage of restlessness was exhibited for several days, after which the animals became adapted and showed no outward stress reaction. Their body weight gradually increased from 125 to 180 g 2 months after the beginning of the experiment.

In the experiments of series III, in which the rats were kept in ordinary cages, the animals' body weight increased steadily to reach 330 g after 2 months. Differences between the increase in body weight of the rats with age in series II and III are clearly illustrated by the graph in Fig. 1. These differences were significant ($P < 0.001$).

Calculation of the muscle index showed that if the animals were kept in ordinary cages it was 34% after the end of the experiment, a little higher than the index obtained when rats were kept in constraining cages (32%). However, the significance of these findings could not be estimated because of the small number of animals used to determine the index. Differences in the weight of the gastrocnemius muscles in animals of series II and III are shown diagramatically in Fig. 2. These differences likewise were significant ($P < 0.001$).

The results thus indicate that the increase in body weight of young rats when kept under conditions of hypodynamia is appreciably delayed compared with that in rats kept under ordinary conditions. It can be postulated from the results of determination of the muscle index that prolonged hypokinesia is reflected in particular in growth of muscles. The results of determination of the weight of the gastrocnemius muscles, used as an example of an actively working muscle, confirm this conclusion.

The study of the histological structure of these muscles was interesting. Determination of the diameter of the muscle fibers showed that the smaller weight of the muscles in animals kept in constraining cages was due to a decrease in diameter of the muscle fibers: The mean diameter of the muscle fibers of the gastrocnemius muscles in the animals of series II was 41.6 μ, and of series III 46.2 μ($P < 0.05$). These results suggest that prolonged hypodynamia has a considerable adverse effect not only on the increase in body weight of the animal as a whole, but also on its muscle tissue. This investigation also demonstrates the plastic properties of muscle tissue exhibited under the influence of external factors.

LITERATURE CITED

1. B. B. Egorov and R. I. Gritsyuk, Kosmich. Biol., No. 5, 80 (1976).
2. R. P. Zhenevskaya, Neurotrophic Regulation of Plastic Activity of Muscle Tissue [in Russian], Moscow (1974).
3. R. P. Zhenevskaya, Izv. Otd. Estestv. Nauk Akad. Nauk Tadzh. SSR, No. 13, 109 (1956).
4. V. V. Kupriyanov, V. G. Petrukhin, et al., Arkh. Anat., No. 11, 39 (1975).
5. T. S. Mgeladze, in: Proceedings of the 1st Transcaucasian Conference of Morphologists [in Russian], Tbilisi (1975), p. 159.
6. M. F. Popova, Dokl. Akad. Nauk SSSR, 148, No. 1, 223 (1963).
7. A. N. Potapov, Kosmich. Biol., No. 2, 16 (1972).
8. N. A. Rokotova, I. D. Bogina, O. P. Bolotina, et al., in: Problems in Space Biology [in Russian], Vol. 2, 417 (1962).

9. H. Selye, The Story of the Adaptation Syndrome [Russian translation], Moscow (1960).
10. A. N. Studitskii, Experimental Surgery of Muscles [in Russian], Moscow (1959).
11. L. I. Falin, Arkh. Biol. Nauk, 49, No. 2 (1938).
12. L. I. Falin, Arkh. Biol. Nauk, 49, No. 3, 134 (1938).
13. I. V. Fedorov, Yu. I. Milov, et al., Kosm. Biol., No. 1, 22 (1968).
14. I. L. Yurgens and O. I. Kirillov, Kosm. Biol., No. 4, 3 (1972).

STATE OF THE JUXTAGLOMERULAR APPARATUS AND INTERSTITIAL CELLS OF THE RENAL MEDULLA AFTER ADMINISTRATION OF CERTAIN DRUGS AND HYPERBARIC OXYGENATION

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UDC 615.254.015.2:615.835.12].015.4:[616.611+616.61-018.1

KEY WORDS: juxtaglomerular apparatus; interstitial cells; indomethacin; frusemide; hyperbaric oxygenation.

The arsenal of drugs available for treatment of diseases of the kidneys is growing continually. However, many mechanisms of the action of these drugs on renal function still remain unexplained. Recent investigations have shown that the action of most of them is aimed at redistribution of the blood in the kidneys. In this connection data have been published on the action of drugs on the juxtaglomerular apparatus (JGA) and insterstitial cells (IC). In particular, an increase in renin activity (RA) in the blood plasma has been demonstrated after administration of frusemide [2]. This effect is explained by the direct action of frusemide on the dense spot of the JGA [10]. Meanwhile the excretion of prostaglandin (PG) E with the urine is increased [8]. Indomethacin, an inhibitor of prostaglandin synthetase, reduces the synthesis of PG A and E and also reduces RA in the blood plasma [9]. Under these circumstances the blood flow in the kidneys is redistributed from the inner zone of the cortex to the outer zone [5]. During hyperbaric oxygenation (HBO) sodium reabsorption and oxygen consumption are reduced. Urine containing a high concentration of sodium acts on the dense spot, increasing activity of the JGA and RA [7]. Venoruton, which belongs to the flavnoid group, reduces capillary permeability and improves the venous drainage. The action of trental is connected with inhibition of cyclic AMP phosphodiesterases [4]. The action of these last two drugs on the renin—angiotensin and prostaglandin systems of the kidneys is unknown. Changes in JGA and IC under the influence of all the drugs mentioned above have virtually not yet been investigated. Only the effect of indomethacin on the JGA and IC is well known [3, 6].

The object of the present investigation was to study the state of the JGA and IC after administration of a series of drugs widely used in the treatment of kidney diseases, and also after exposure to HBO.

EXPERIMENTAL METHOD

Experiments were carried out on 42 rabbits, divided into 11 experimental groups with three to six animals in each group. The control group contained six animals. Frusemide in a dose of 20 mg/kg, indomethacin 10 mg/kg, venoruton 500 mg/kg, and trental 100 mg/kg were injected intravenously into rabbits of the appropriate groups. Other rabbits were exposed to HBO (1, 6, and 12 sessions) on alternate days under a pressure of 0.5 atm. The rabbits were killed either 3 h (the time for the drug to accumulate in the organ) or 24 h (the time of its excretion from the body) after injection of the drugs. Pieces from the outer zone of the cortex and inner zone of the medulla (papilla) of the kidneys were fixed in 1% OsO_4 solu-

Department of Pathological Anatomy, First Therapeutic Faculty, Faculty of Preventive Medicine, and Department of Urology, I. M. Sechenov First Moscow Medical Institute. (Presented by Academician of the Academy of Medical Sciences of the USSR A. F. Bilibin.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 93, No. 3, pp. 119-122, March, 1982. Original article submitted September 4, 1981.

