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# EFFECT OF HYPOKINESIA AND MUSCULAR TRAINING ON STROKE VOLUME CONTROL PATTERNS IN RATS

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KEY WORDS: stroke volume of the heart; hypokinesia. muscular training.

Data in the literature on the effect of muscular training on the cardiac output of the developing organism and contradictory [5, 7, 11] and do not reveal their controlling mechanisms. The character of control of the cardiac output in the growing organism during hypokinesia likewise has not been studied.

It was accordingly decided to investigate the formation and modification of the tonic influence of the sympathetic and parasympathetic divisions of the autonomic nervous system on the stroke volume (SV) of the heart in young rats kept for a long time under conditions of hypokinesia or subjected to muscular training.

## EXPERIMENTAL METHOD

Noninbred rats aged 21 days were divided into several groups. The rats of group 2 were kept for 49 days under constrained conditions of hypokinesia [2]. Animals of group 3 were kept in ordinary training cages, with 6 to 8 rats in each cage (control). Animals of group 4 were adapted for 49 days to gradually increasing muscular exercise by swimming (trained rats) [1]. Acute experiments were carried out under urethane anesthesia (600 mg/kg). SV was determined by tetrapolar rheography [10] with the RPG-204 apparatus, made by the No. 1 Experimental Production Workshops, Academy of Medical Sciences of the USSR. Specific resistance for animals of each group was determined beforehand (data not given). Tone of the sympathetic and parasympathetic nerves was judged from changes in SV after pharmacologic blockade of the corresponding receptors. To block sympathetic nerves the animals were given a subcutaneous injection of a 0.1% solution of propranolol hydrochloride (Isis-Chemie, East Germany) in a dose of 0.8 mg/100 g body weight. Acetylcholine receptors of the heart were blocked by fractional injection of atropine (0.1%) in an average dose of 0.3 mg/100 g, divided into several portions.

## EXPERIMENTAL RESULTS

The experimental results are given in Table 1. The value of SV in rats of the control group aged 10 weeks was 6.5 times higher than at the age of 3 weeks, i.e., the cardiac output increased with growth of the animal, in agreement with data in the literature [6, 7, 9]. In rats kept under conditions of hypokinesia, SV was

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TABLE 1. Changes in SV (in ml) of Young Rats after Injection of Atropine and Propranolol

| Group of animals | No. of animals | Injection of propranolol | | | No. of animals | Injection of atropine | | |
|---|---|---|---|---|---|---|---|---|
| | | initial value | after injection | difference | | initial value | after injection | difference |
| 1 | 17 | 0,041±0,005 | 0,0205±0,002 | 0,020±0,005 | 10 | 0,038±0,006 | 0,0505±0,007 | 0,012±0,002 |
| 2 | 17 | 0,168±0,008 | 0,114±0,013 | 0,054 | 18 | 0,175±0,009 | 0,241±0,408 | 0,066±0,006 |
| 3 | 17 | 0,268±0,025 | 0,188±0,028 | 0,080±0,004 | 12 | 0,261±0,012 | 0,331±0,032 | 0,070±0,008 |
| 4 | 19 | 0,326±0,026 | 0,233±0,027 | 0,093±0,023 | 19 | 0,334±0,008 | 0,394±0,031 | 0,066±0,002 |

0.1004 ml less than in the control animals of the same age ($P < 0.05$). Meanwhile SV in rats trained by muscular exercise for 49 days was 0.057 ml greater than in the control ($P < 0.05$). The difference between values of SV in trained rats and rats kept under conditions of hypokinesia – the exercise effect – was 0.158 M ($P < 0.01$). Hypokinesia in the growing animal thus inhibits, whereas training by swimming stimulates, the increase in SV. This result is known to be associated with a significant change in the chronotropic function of the heart; trained rats developed bradycardia, whereas rats kept under conditions of hypokinesia developed tachycardia [3]. Improvement of activity of the developing heart during exposure to systematic muscular training exercises takes place through the development of more complete emptying of the chambers of the heart, i.e., through an increase in the systolic blood volume. Functions of the heart are performed more economically [4]. The heart developing under conditions of hypokinesia, on the other hand, showed evidence of uneconomic functioning: The small stroke ejection was accompanied by a higher heart rate.

The smallest changes in the values of SV after blockade of the sympathetic nerves by propranolol were observed in rats of groups 1 aged 3 weeks. At the age of 10 weeks, SV of the rats after injection of propranolol was 0.06 ml higher than the initial values for the animals of group 1. Consequently, during growth and development of the rats the influence of sympathetic nerves on values of SV increased.

In rats exposed to hypokinesia the response of SV to injection of propranolol was much less than in the control ($P < 0.05$). In turn, the response of SV of trained rats aged 10 weeks was 0.012 ml greater than the change observed in animals of the control group. The influence of sympathetic nerves on the value of SV in the developing animals thus increased, due to activation by muscular exercise.

After blockade of the acetylcholine receptors of the heart by atropine values of SV in rats aged 3 weeks were increased on average by 0.012 ml, and in control animals aged 10 weeks by 0.07 ml. On the basis of these data it can be concluded that the influence of the vagus nerves on the value of SV in rats increases with age. Consequently, the view that blocking activity of the parasympathetic nerve does not affect the systolic volume [8] was not confirmed by these experiments.

In rats kept under conditions of hypokinesia and also in rats of the control group SV increased about equally after injection of atropine. The change in SV in the trained rats was 0.01 ml greater than in the control animals aged 10 weeks. With an increase in the degree of motor activity from hypokinesia to muscular training, dependence of the value of SV on tonic activity of the vagus nerve became somewhat weaker.

To sum up, it can be concluded that the effect of both sympathetic and parasympathetic nerves on systolic ejection at the age of 3 weeks is comparatively weak, but with growth and development of the animal it becomes stronger.

The level of motor activity has a significant influence on tonic activity of the sympathetic and parasympathetic nerves, on which the value of SV of the developing animals depends. Limitation of motor activity of the animal during growth weakens the effect of the sympathetic nerves on parameters of the cardiodynamics. Meanwhile systematic muscular training strengthens the influence of the sympathetic nerves and weakens that of the vagus nerve, and thus has a significant effect on the systolic blood volume.

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# TRANSMEMBRANE POTENTIAL AND ELECTROGENICITY OF PLATELET Na, K-ATPase IN RATS WITH VARIOUS FORMS OF HYPERTENSION

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In spontaneously hypertensive rats [1, 5], just as in patients with essential hypertension, the ability of the blood platelets to aggregate is increased. Changes in aggregation in these forms of pathology are associated with disturbance of $Ca^{++}$ transport in the platelets [1, 11], and in turn, this is regarded as the result of partial depolarization of the platelet plasma membrane in primary hypertension [1]. However, it is not yet clear how specific is this lowering of the platelet membrane potential for primary hypertension, nor has the concrete mechanism of this disturbance been explained.

The aim of this investigation was to study these problems.

## EXPERIMENTAL METHOD

The platelet membrane potential in rats with spontaneous, renal, and DOCA-salt hypertension was studied with the aid of the fluorescent dye 3,3'-dipropylthiadicarbocyanine iodide [diS-$C_3$-(5)]. Since Na, K-ATPase may be involved in the mechanism of the membrane potential change, the electrogenic component of the potential, creased by Na, K-ATPase, was investigated.

Experiments were carried out on rats aged 12-18 weeks, weighing 220-250 g, with the following types of hypertension: 1) spontaneous genetic hypertension. Male spontaneously hypertensive rats (SHR strain) with a blood pressure (BP) of 190±5 mm Hg were used. The control consisted of inbred male normotensive Kyoto-Wistar rats (strain WKY) with BP of 120±7 mm Hg; 2) DOCA-salt hypertension. Hypertension was produced in inbred male WKY rats by unilateral nephrectomy, after which 50 mg DOCA in powder form (two injections of 25 mg, with an interval of 10 days) was injected subcutaneously. The duration of hypertension from the time of its onset was 8 weeks; 3) renal hypertension. Hypertension was produced in male WKY rats by constricting the left renal artery with a nichrome wire coil (internal diameter of the coil 0.32 mm). The right kidney was left intact. The duration of hypertension from the time of its onset was 8 weeks; 4) rats of the Milan hypertensive MHB strain. The control for these animals consisted of rats of the Milan normotensive strain (MNR). Systolic pressure was measured in the caudal artery once every 10 days by plethysmography, using the MPP-3 plethysmographic attachment (Hitachi, Japan); the plethysmograms and pressure in the cuff were recorded on a polygraph.

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