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V. P. Krotov

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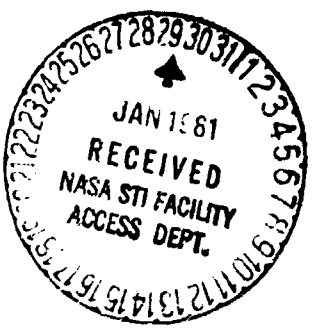

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16. Abstract
The range of daily fluctuations of the proportion of the amount of consumed water and its content in the body was evaluated by means of "water metabolism regulation factor" suggested by the author. This index constitutes a relative measure of fluctuations of the constant of tritium water elimination from the body per 24 hours. It is established that under conditions of long-term hypokinesia regulation of water metabolism is disturbed both in humans and in animals (dogs). Still more marked changes are observed 2-3 weeks after restoration of motor activity. The shifts noted are evidence of general biological regularity of disturbance of regulation systems in long-term restriction of motor activity and in the early restoration period.

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WATER METABOLISM REGULATING MECHANISMS IN HYPOKINESIA

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Until recently water metabolism has been evaluated principally /15* on the basis of data of water consumption and diuresis, and the ratio of these values even received the name "hydration coefficient of the organism." However, in fact this index gives an extremely rough indication of hydration, if only because about 50% of the total moisture losses by the organism takes place by an extrarenal route. /16 Only now is the extremely important integral index--the total fluid content in the organism--beginning to be systematically studied in clinics [1, 9] although it was determined in man as early as 1934 [13].

Data not only of the hydration status of the organism but also of the degree of the expression of its periodic fluctuations are extremely significant for the evaluation of water metabolism. In normal living conditions the quantity of water in the organism, being an integral index that depends on the interaction of the nerve centers which regulate it, fluctuates daily within a definite range. The qualitative evaluation of this range in the norm and also in hypokinesia was the object of this investigation. For this purpose we daily examined the dynamics of the alteration of the tritium water concentration in the fluids of the organism, which is determined by the ratio of the quantity of consumed water to its content in the organism and depends on the nature of neuroendocrine regulation.

Procedure

The investigation was conducted on 6 healthy men and on 4 dogs in conditions of free motor activity and in hypokinesia. During the time of bedrest (49 days) the subjects were not al-

*Numbers in the margin indicate pagination in the foreign text.

lowed to sit even to use the bedpan. Water consumption was not limited. The motor activity of the dogs was limited by a special fixing device that permitted the adoption of a "lying," "sitting," or "standing" position. After clinical examination and selection the animals were trained to stay in the fixing devices. Water was given to them together with food (1 feeding per day) at a rate of 95 ml per 1 kg of body weight.

The range of fluctuations of the hydration status of the organism, which reflects the condition of the mechanisms that participate in the maintenance of an adequate level of water metabolism, was evaluated on the basis of the water metabolism regulation coefficient proposed by us. This index is a relative measure of the fluctuation of the constant of tritium water elimination from the organism every 24 hours:

RC (arbitrary units)

where RC is the regulation coefficient, $\sigma\lambda$ is the average standard deviation and λ is the average arithmetic constant of tritium water elimination for every 24 hours.

The constant of the isotope elimination was determined by the formula:

where A_{t-1}, A_t is the activity of the isotope in the fluid phase of the organism (samples of blood, exhalation or urine) during the next 24 hours and e is the base of natural logarithms.

For the execution of the indicated investigations tritium water was injected intramuscularly or intravenously at the following rates: for humans--about 100 mcCi [5], for dogs--10 mcCi per 1 kg of body weight. The resultant data were subjected to variation statistical analysis on an M-220 computer.

Results and Discussion

In the process of the subjects' stay on bedrest (Fig. 1) the value of the water metabolism regulation coefficient changed in a wavelike manner: after a significant increase in the first week of hypokinesia (185% against the background, $P < 0.01$) it did not differ reliably from the background value during the second and third weeks of the experiment. Then (43rd-49th days) its value again grew (208% against the background, $P < 0.05$). On restoration of motor activity the value of this coefficient was increased to an even greater degree and by the end of the observation period (15th and 23rd days) it exceeded the background level by 134% ($P < 0.01$).

In animals, unlike humans, the dynamics of the coefficient was studied in conditions of strictly dosed and constant water consumption. Its value increased by 3.5-5.5 times as a result of limiting the motor activity of dogs for 30 days (Fig. 2). During the 2 weeks of the restorative period the value of the water metabolism regulation coefficient continued to exceed the background value by 3.8 to 4.2 times.

It is known that marked shifts in water metabolism, caused by its transition to a lower equilibrium level, arise as a result of hypokinesia [4, 8, 12]. We have already shown that on the resumption of /17
activity the total content of water in the organism reaches the background value by the 4th-8th day of the free regimen [3, 6]. But does normalization of water metabolism as a whole occur with this?

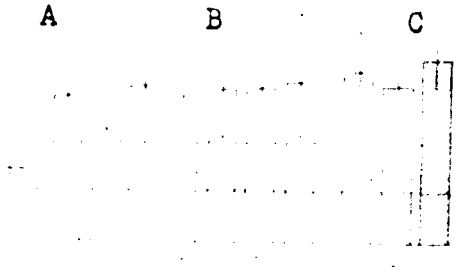

Fig. 1. Alteration of the water metabolism regulation coefficient in a person in hypokinesia.

Here and in Fig. 2: A - background; B - hypokinesia; C - restorative period; broken horizontal lines - confidence interval of the control. Abscissa - time of the investigation (weeks); ordinate - coefficient (units).

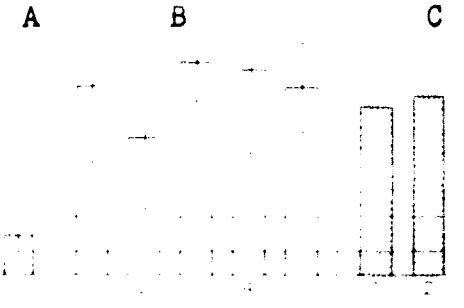

Fig. 2. Alteration of the water metabolism regulation coefficient in hypokinesia in dogs.

The regulation of water metabolism occurs as a result of the interaction of two systems--ensuring water consumption and regulating its retention in the organism. Usually an organism's consumption of water is a preliminary act that is related to future requirements. A feeling of thirst almost never arises with normal intake of food and water, in stable climatic conditions, with uniform activity of the organism [11]. The subcortical center that regulates the retention of water in the organism, as is known, is the supraoptic and paraventricular nuclei of the hypothalamus. In the organism's normal living conditions there is a close functional dependence between the tissue structures of these nerve centers. Most commonly they function as synergists--on dehydration of the organism a feeling of thirst arises and the secretion of antidiuretic hormone increases.

In pathologic conditions disturbances of the functions of one or simultaneously of both nerve centers are possible. In an experiment, for example, it was shown that with failure of the supraoptic and paraventricular nuclei, the effect of satiation with water disappears, and the animal dies of hyperhydration. And, conversely, in the case of impairment of the lateral hypothalamus and the nuclei of the white substance of the brain the condition of thirst disappears even in marked exsiccation [10].

In our investigations the water metabolism regulation was evaluated with the help of the water metabolism regulation coefficient, which was specially proposed by us for this purpose. The stay of healthy persons on bedrest led to an increase in the value of this coefficient by 2 times. On restoration of motor activity its value differed from the background value to an even greater extent (2.5 times).

In the case in which in the process of hypokinesia constant water consumption was effected, thereby artificially disrupting the functional interrelation between the centers of water metabolism regulation (the drinking center already could not realize its usual effects on the supraeptic and paraventricular nuclei of the hypothalamus),

the coefficient of its regulation exceeded the background value by 3.5-5.5 times. Apparently this is related to the fact that increase of the thresholds of neuron excitability of the anterior hypothalamus during limited mobility [2] leads to the formation of a more marked /18 range between accumulation of water in the organism and its elimination.

Noted in hypokinesia are a deterioration of the functional condition of the central nervous system and the formation of two syndromes: vegetovascular dysfunction and marked neuropsychic asthenization of the organism [7]. These syndromes are the cause of the reduction of the resources of adaptative mechanisms that control the interaction of the organism with the environment. Therefore it is completely natural that the disturbance in the nature of the interaction of the systems that regulate water metabolism was manifested particularly graphically on the restoration of motor activity, when increased demands again began to be made on all the to some extent weakened systems of the organism.

Thus, with relatively rapid adjustment of a number of parameters of water metabolism which are necessary for activity of the organism in new conditions of its existence (normalization of the total fluid content in the organism already during the 1st week of restoration of motor activity), its delicate regulation, which requires a certain lability of intersystem interrelations (for which the considered coefficient can serve as an index), remains disturbed longer and is not normalized during the entire 3-week observation period. In our opinion it is possible to obtain useful information on the peculiarities of the alteration of water metabolism regulation in conditions of sepcific effects with the help of the coefficient proposed by us.

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