

EFFECT OF STRICT BED REST FOR 30 DAYS ON HUMAN WATER METABOLISM

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The effect of strict bed rest for 30 days on the state of the water metabolism, the kinetics of water excretion, and the mean daily water loss was studied in man. Hypokinesia was found to reduce the rate of water renewal and to decrease the total water loss of the body. The relative water content as a percentage of body weight on the 25th day of hypokinesia was identical with the control.

KEY WORDS: hypokinesia, water metabolism.

Limitation of movements of the organism is a problem at present engaging the increasing attention of pathophysiologists and clinicians. Restriction of motor activity (hypokinesia) both in man and in animals disturbs the activity of the cardiovascular and neuroendocrine systems and induces changes in protein, lipid, and mineral metabolism [1, 3, 9, 12]. Changes in water metabolism during hypokinesia have been shown to be phasic in character [2, 6].

However, no investigations have been carried out to study the effect of prolonged hypokinesia on the character of elimination of water from the organism or on the mean daily water loss; the present investigation was accordingly carried out for this purpose.

EXPERIMENTAL METHOD

Tests were carried out on nine healthy men divided into two groups: 1) control (3 subjects) whose movements were unrestricted; 2) experimental (6 subjects), confined strictly to bed for 30 days. The subjects were not permitted to sit up even to use the bedpan. The foot of the bed was slightly raised so that the plane of the bed made an angle of 2° with the floor. However, since the subjects were provided with a pillow, their head remained horizontal.

The total body water was determined with the aid of tritium oxide, injected intramuscularly in a volume of about 1 ml (specific activity $100 \mu\text{Ci/ml}$). In view of data in the literature [7, 13] to show that the equilibrium distribution of tritiated water in the healthy human subject is attained 1-2 h after its injection, the concentration of tritium oxide was determined principally 60, 90, and 120 min after injection of the isotope (in some investigations, 90 and 120 min thereafter only). The material studied consisted of vapor of the expired air, which required no further treatment and was collected either in a glass trap, immersed in a mixture of ice and common salt, or in cold water. To plot the isotope excretion curve from the body, the vapor (in the morning) and the 24-h urine were collected daily; the urine was later lyophilized.

The total body water was determined in the introductory period, on the 25th day of bed rest, and on the 8th day of the recovery period.

The activity of the samples was measured on a Mark 1 Nuclear Chicago (USA) liquid scintillation counter. The efficiency of the counter for tritium is 40%. More than 3000 pulses were recorded during counting for 10 min. The volume of water in the body was calculated from the dilution formula in two ways: a) from the data of equilibrium distribution of tritium oxide 2 h after its injection, b) by extrapolating the isotope elimination curve to the zero point. The error of the method was 4%. The total water loss of the body was determined by the equation:

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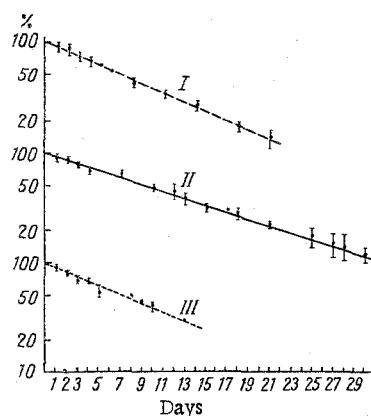


Fig. 1. Curves showing excretion of tritium oxide from the body: I) group 2, strict bed rest; II) group 2, recovery period; III) group 1 (control).

$$W_{\text{loss}} = \frac{0.693 \times BWV}{T},$$

where W_{loss} is the total water loss (in ml/24 h), BWV the quantity of water in the body (ml), and T the half-elimination period of the isotope (in days).

The experimental results were subjected to statistical analysis by Student's method. The method of determining the significance of the difference in the results obtained over a period of time in the same group was used [11].

EXPERIMENTAL RESULTS

The water content in the body of the control subjects was 49.9 ± 0.3 liters ($60.7 \pm 1.5\%$ of the body weight). Repeated determination of the water content on the 25th day of the stay in hospital revealed a decrease by 1-3 liters in all subjects. Meanwhile the body weight of all the control subjects increased on the average by 1 kg. This led to a more marked decrease in the percentage content of water, which for the group as a whole fell by 3.1% ($P < 0.05$).

The original water content in the subjects of group 2 was 44.4 ± 2.0 liters ($60.0 \pm 1.6\%$ of the body weight). Divergent changes in the volume of fluid in the body were observed on the 25th day of hypokinesia: in two subjects it was increased but in four it was lower than initially. For the group as a whole there was a tendency for the total body water content to be reduced by 2.0 ± 1.6 liters. Since a decrease in the body weight of the subjects by 2 kg was observed in the course of hypokinesia, the body water content expressed as a percentage of body weight remained virtually unchanged in these subjects.

Tests carried out in the recovery period showed that on the average for the group the body liquid volume of the subjects corresponded to its initial value of 45.1 ± 2.0 liters ($61.0 \pm 1.5\%$ of the body weight). Only in one subject was the resumption of motor activity followed by an increase in the body water content by 5.2 liters compared with the preliminary period (the percentage of water increased by 7.0%) and by 5.9 liters compared with the 25th day of hypokinesia (although in this case the percentage of water in the body increased by only 6.0%).

Consequently, for the group of healthy subjects as a whole, on the 25th day of restriction of their motor activity the relative content of body water was indistinguishable from its initial values. The results of these investigations do not agree with those published by Zhdanova [4, 5], who studied changes in human specific gravity by hydrostatic weighing and concluded that the ratio between the lipid and nonlipid components of the body changes significantly during hypokinesia in the direction of an increase in fat and that these changes lead to a decrease in the muscle and water masses in the body. Admittedly, Zhdanova's experiments lasted only 10 days. However, she considers that the changes observed in lipid metabolism must progress with an increase in the duration of the experiments. Unfortunately, her papers give no information on the nature of the diet received by the subjects during the experiments. Since the basal metabolism falls in man during restricted motor activity [8, 10], the absence of a balanced diet could easily lead to excessive deposition of fat in the body.

The changes in the water content in the control subjects obtained during the present series of experiments confirm the need for a balanced diet when such experiments are conducted. Despite a relatively mobile mode of life, a 3500 kcal diet led to a decrease in the water content and an increase in the body weight of these healthy men on the 25th day of their stay in the hospital.

The experimental results showed that the rate of water renewal in the body, determined from the half-elimination period of tritiumoxide, was 7.3 ± 0.5 days in the subjects of the control group (Fig. 1). Restriction of motor activity lengthened the half-elimination period of the isotope to 9.6 ± 0.2 days ($P < 0.01$), i.e., the rate of renewal of water during strict bed rest was significantly slowed in all the subjects. In the recovery period the rate of renewal of water increased and the half-elimination period corresponded to that in the control group (7.6 ± 0.4 days).

In the control group of subjects the total water loss was considerable (4409 ± 196 ml/day). This was evidently explained by the timetable of the members of this group, the duties of whom included weighing the subjects of group 2. This procedure was carried out daily and involved carrying the subjects with restricted mobility on stretchers. During strict bed rest the quantity of water lost by the body fell by 30% compared with the control, to reach 3092 ± 146 ml/day ($P < 0.05$). Resumption of motor activity led to an increase in the water loss of the body to 4027 ± 249 ml/day.

However, during prolonged experiments in which marked fluctuations take place in the state of hydration of the body, as determined by calculation in the usual way, the total water losses, in the writers' opinion, do not always correspond strictly to the mean daily values. They reflect rather the state of the water metabolism on the day of determination of the body water.

Knowing the daily excretion of urine of subjects of the control and experimental groups* (1309 ± 65 and 1514 ± 64 ml/day, respectively), the total quantity of water lost by the body as imperceptible losses could also be calculated. During strict bed rest the imperceptible losses were found to amount to about half of the total water lost by the body. In the subjects of the control group the relative deficit of motor activity was made good by a program of physical exercises, which led to an increase in their imperceptible water loss to 70% of the total water lost by the body.

The water metabolism in a healthy person is thus closely connected with his motor activity. These investigations show that on the 25th day of hypokinesia the relative water content of the body is indistinguishable from that before the hypokinesia began. During prolonged and strict bed rest the rate of renewal of water in the body and the total water lost are reduced.

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*The data for the diuresis and dynamics of the body weight were obtained by G. I. Kozyrevskaya and A. I. Grigor'ev.