

CHANGES IN SOME PHYSIOLOGICAL INDICES OF SALT AND WATER METABOLISM IN PERSONS CONTINUOUSLY DRINKING WATER WITH A HIGH MINERAL CONTENT

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A number of experimental observations on animals and man have been carried out in recent years to evaluate the mineral salt content of drinking water [1,4,6]. In evaluating the methods used in these studies as well as the results obtained it is necessary to add observations on several physiological reactions and morbidity among a population which is constantly drinking water with a high mineral content.

We studied several parameters of salt and water metabolism in people who have spent varying periods of time in the vicinity of Baku where the water contains high quantities of chlorides (from 232 to 740 mg/liter) and sulphates (from 96 to 1200 mg/liter) with a solid residue of 2396 to 3314 mg/liter).

The MacClure-Aldrich and Folgarde tests were used to assess salt and water metabolism. Inasmuch as diet, temperature and other factors affect the outcome of these tests particular attention was paid to a standardization of conditions under which the observations were made.

Observations were carried out on organized collectives of adolescents (in boarding homes and pioneer camps), a portion of which consumed sweet water and another portion of which drank water containing a high mineral content.

METHOD

Inasmuch as the subjects of the study were 15 and 16 year olds we cut down the water load to 1000 ml of fresh sweet water (solid residue 520 mg/liter) in carrying out Folgarde's test. Urine was collected for four hours with measurement of the amount voided every 30 minutes. The water was given in the morning while the subjects were in a fasting state. An hour after the water loading, by which time the stomach was completely evacuated of water, the subjects ate a normal breakfast, and the solid and liquid intake was recorded.

During the observations the subjects were kept in an environment where the temperature was constant at 22 to 25° C, so that sweating was eliminated as an extenuating factor.

RESULTS

In all, 40 tests were carried out of which 20 were performed on subjects drinking fresh sweet water (control groups A and B) and 20 on institutionalized children (groups C and D) who drank water containing 2.5 to 3.5 grams of salt per liter (chlorides 232 to 740 mg/liter and sulphates 96 to 1200 mg/liter). It should be noted that group C consisted of children who had arrived from Baku one month before the experiment.

From the data in Figure 1 it is evident that the character of the urine was the same in both control groups (A and B). The largest amount of urine was voided in the second, third and fourth half-hours following the load. The amount of water voided in the four hour period was only slightly less than the volume of the load. In the control groups 79 to 81% of the water load was voided in the course of four hours (variation 55 to 109%), while in the group of children (C) who had been drinking the water high in mineral content for one month the voided volume in four hours was 63.6% (variation 48 to 99%) and in the group of children (D) who had always been drinking the water high in mineral content, only 41.8% of the load was voided (variation 25 to 63%).

In evaluating the data it should be kept in mind that the water load is initially retained in the tissues and only in the second phase is mobilized and transported by the circulation to the kidney [7]. Thus the course of the voiding is dependent to an unknown degree on the state of hydration of the tissues. The data from our observations

support the view that people who have been drinking water which is of high mineral content retain a fresh water load for a longer period and void it more slowly. Consequently their tissues are more hydrophilic. This supposition was confirmed by the MacClure-Aldrich test which gives direct evidence of the hydrophilia of the skin. As is well known, the skin is an important depot for water and water is readily mobilized from the skin in pathological states (diarrhea and vomiting) as well as in certain physiological conditions (excess sweating).

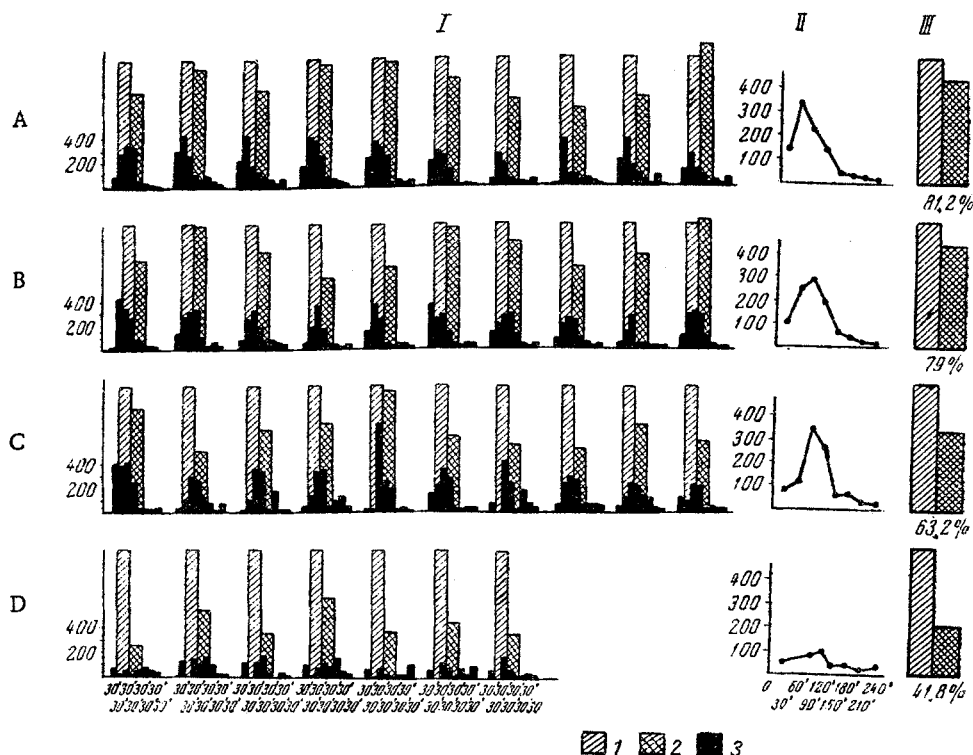


Fig. 1. Diuresis after a water load according to the method of Folgarde in different groups of adolescents. I - diuresis in individuals; 1 - amount of water load taken as 100%; 2 - amount of urine voided in 4 hours (as a percentage of water load); 3 - the amount of urine voided in 30 minutes; II - rate of diuresis (as a mean for a given group) in four hours; III - ratio of water load (1) and urine voided (2) in four hours as a mean for a given group; A and B - drank fresh sweet water; C - drank water of high mineral content for one month; D - drank water of high mineral content for more than a year.

The test on the hydrophilia of the tissues was carried out in the following manner. 0.2 ml of saline was given intradermally with a small needle on the inner third of the forearm. Immediately a characteristic papule was formed which was easily measured visually and tactilely. The time for the disappearance of the papule was measured. Observations were made on 260 children between the ages of 11 and 17. As is well known it takes 40 to 150 minutes for the papule to disappear in normal individuals [2, 6, etc.].

The results of the MacClure-Aldrich test are given in Figure 2. Despite the individual variation a significant increase in the disappearance time of the papule was noted in the individuals drinking high mineral content water. The mean rate of disappearance in those drinking fresh sweet water (in complete agreement with the aforementioned authors) was 44.8 minutes \pm 1.2 (sigma \pm 13), and 33 minutes \pm 0.9 (sigma \pm 11) in those drinking water with a high mineral content. The statistical differences were significant.

An analysis of the data indicated that the differences could not be attributed to differences in age or sex of the subjects.

The distribution of the time of disappearance for the different groups is given in Figure 3.

From figure 3 it is evident that the peak of the curve in the group drinking water of high mineral content is significantly displaced to the left, indicating an increased reaction in comparison to the fresh water group as well as an increase in the disappearance time in the group which drank water of high mineral content for only one month.

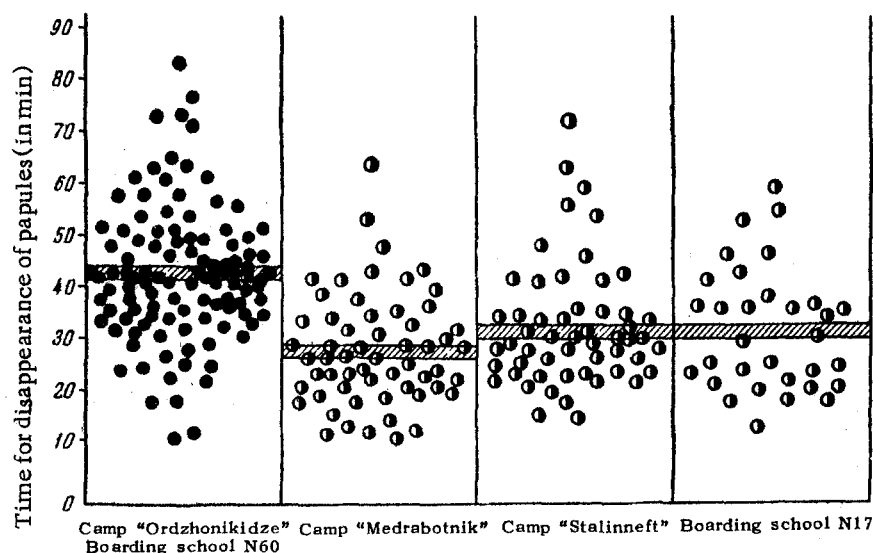


Fig. 2. MacClure-Aldrich test according to the mineral content of the drinking water. Black circles - data on individual observation in the fresh water group; half-shaded circles - the high mineral content water group. The figures underneath - the total content of solid residue in the water (in mg/liter).

The mechanism of the MacClure-Aldrich test is not entirely clear. According to a number of workers [5,8] a number of factors play a role in the hydrophilia of the tissues: changes in elastic properties, intercellular space, capillary permeability and other processes controlled by the autonomic nervous system. Several investigators [2,3] showed that in the final analysis the degree of hydrophilia of the tissues is determined by the osmotic and oncotic state of the cells.

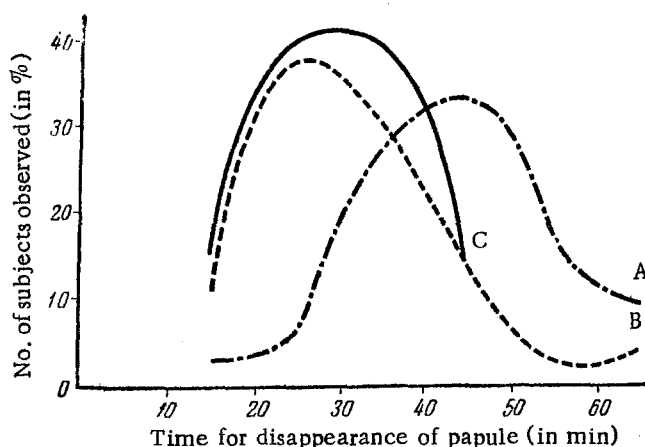


Fig. 3. Distribution of disappearance rate of saline (MacClure-Aldrich test). A) Fresh water group; B) group drinking high mineral content water for one month; C) group drinking high mineral content water for more than a year.

The deviations from the norm which we observed in those drinking water of a high mineral content were of the same order as is seen in individuals with cardiac and renal disorders. Therefore it can be presumed that deviations from the norm in salt and water metabolism among those drinking water of high mineral content may have an

unfavorable effect in patients with cardiac and renal disease, dietary edema, dysentery and other illnesses concerned with water metabolism.

SUMMARY

The MacClure-Aldrich tissue hydrophilia test and Folgarde's water tolerance test were conducted in persons living in regions distinguished by high mineral content in their water (dry residue 3314-2396 mg/liter). A decreased rate of water excretion and acceleration of absorption of physiological saline, injected subcutaneously, were found in these persons, as compared to those drinking water with low mineral content.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
