WATER ECONOMY OF THE BODY UNDER DRY DESERT CONDITIONS

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A trial was conducted in summer under field conditions to investigate the effect of ingestion of extra salt on the water economy of the body. The consumption of 10 grams of extra salt per day had no effect on the voluntary intake of water, but it caused a slight increase in urine excretion and a decrease in sweat output, the net result being an increase in the retention of water in the body. It was also noted that there was undue overdrinking of water for the first few days of exposure, probably due to psychological reasons.

In human beings skin is one of the most important tissues which controls and maintains the temperature equilibrium through the processes of sweat formation. It has been observed that a sweating man loses most of the water from the plasma[1]. A field trial was therefore undertaken to find out if the maintenance of a high level of extra cellular fluid would help man to sweat more effectively.

It is reported that ingestion of water in the form of normal saline cuts down the rate of urine flow[2]. Nishibori[3] has observed that intravenous injection of hypotonic saline caused an immediate and large increase in sweat output. It has also been noticed that a drink of normal saline reduces urine and sweat output for a specific period[4]. That sodium chloride activates antidiuretic osmoreceptors has been suggested by many workers[5,6]. Contradictory views are also found in literature. Arden conducted an experiment where 20 gm of sodium chloride in 200 cc of water were administered. A drink of plain water had become essential after 20 minutes only [6,7]. That ingestion of 9 gm of sodium chloride does not make any such disturbance is evident from earlier experiments conducted in this laboratory[4]. It was felt necessary to investigate if the presence of extra salt might effect some economy in the utilisation of water by the body under desert conditions for specific periods which might work as safe periods against dehydration during operational spells.

METHOD

The test subjects, all clinically normal, were drawn from a batch of ORs (other ranks) aged 20—30 years. Eight subjects were divided into two groups of four each, one group was maintained on a ration having normal salt content and the other group was given an extra packet of salt of 10 gm per day. A measured amount of table salt equal to the normal salt intake of each individual was supplied with the food which itself was cooked salt-free. The normal salt intake for each individual was determined in a preliminary study of two days. The extra packet of 10 gm of salt was administered to the respective groups in portions of 2 gm, dissolved in as much water as the individual liked to take at convenient intervals during the period of heavy exercise. Five different sets of activities comprising a number of typical military tasks were prescribed for each day. The subjects in both

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TABLE 1

AMBIENT DATA

Date	Dry bulb Temperature °F		Relative humidity %		Black Globe temperature °F
	Max	Min	Max	Min	1600 hours
10-6-63	103·0	88·0	62·0	35·0	118·5
11-6-63	102·0	92·0	65·0	39·0	116·0
12-6-63	100·0	86·0	61·0	40·5	116·0
13-6-63	88·0	84·0	63·0	38·0	114·0
14-6-63	98·0	83·0	67·0	39·5	113·0
17-6-63	98·0	84·0	69·0	36·0	114·5
18 6-63	98·0	84·0	66·0	30·0	115·5
19-6-63	98·0	82·0	69·0	26·0	117·0
20-6-63	102·0	80·0	62·0	37·0	114·5
21-6-63	96·0	84·0	66·0	..	112·5

groups carried out the same set of activities and the routine was followed for five consecutive days. After five working days, a two-day period of rest was interpolated before the two groups were interchanged for the salt intake. During that rest period subjects were kept on normal salt intake and thus the high salt group was allowed time to bring about a homeostasis in their electrolyte balance. Cool drinking water was made available and the subjects were permitted to drink *ad libitum.* The amount consumed in each draft was recorded. The water content of cooked food, tea and cool drinks were taken into account for calculating water intake. The amount of food ingested by each being nearly equal, metabolic water was not calculated and taken into account.

Water loss as urine and sweat in 24 hours was determined by collecting and measuring the urine output of the day together with the recording of body weight at six suitably spaced intervals. Water lost through respiration and faecal matters was not taken into account.

Air temperature, relative humidity, and black globe temperature were recorded (Table 1), as also average intake and excretion of salt (Table 2).

TABLE 2

AVERAGE INTAKE AND URINARY EXCRETION OF SALT

Salt intake (gm/day)		Urinary excretion of salt (gm/day)	
Normal group	Salt group	Normal group	Salt group
11·1	21·1	6·8	14·3

TABLE 3

WATER INGESTION (ml/kg body wt) ON DIFFERENT DAYS

Periods of the day Subject	I 1	2	II 1	2	III 1	2	IV 1	2	V 1	2
BB	105	(91)	119	(78)	86	(92)	89	(80)	81	(82)
CS	112	(78)	116	(106)	104	(91)	108	(87)	83	(79)
GB	118	(99)	130	(121)	99	(101)	98	(98)	123	(104)
KB	103	(87)	101	(86)	88	(88)	84	(71)	76	(71)
KS	(110)	107	(110)	132	(108)	121	(93)	118	(136)	102
NR	(124)	95	(134)	114	(130)	103	(106)	98	(138)	101
PB	(98)	86	(118)	100	(119)	102	(91)	79	(108)	74
SK	(147)	102	(134)	126	(130)	102	(108)	112	(115)	115

NOTE—Figures in brackets relate to the extra salt group.

RESULTS & DISCUSSION

The results are presented in Tables 3 to 4. The results for each day are tabulated into three periods—early morning to lunch, lunch to dinner and dinner to next morning. The first period of the day was relatively less hot and the activities were also not severe. The next period was hot and the subjects had to undergo severe exhaustion under direct exposure to sun. During the last period of the day, the subjects were all relaxing and were exposed to turbulent wind but it was the coolest part of the 24 hour period.

On examination of the records of water intake (Table 4) it was found that there was no appreciable difference in the voluntary water intake of the two groups. However, when the same subjects were taken as their own control and were compared, conflicting results were observed (Table 3). The individuals of the first period who started with normal salt intake consumed significantly less water in their next period when they were served with extra salt quota. Similarly the other group of subjects who in the second period of their activities were kept on normal salt intake, consumed significantly less water in the second

TABLE 4

INTAKE OF DRINKING WATER, SWEAT OUTPUT, URINE OUTPUT AND WATER BALANCE (ml/subject/day)

Sessions	Drinking water 1	2	Sweat output 1	2	Urine Output 1	2	Water Balance 1	2
Morning to Lunch	1230	1220	694	698	154	172	+382	+350
Lunch to Dinner	2227	2265	1816	1603	206	256	+205	+406
Dinner to Morning	608	610	468	496	158	214	—18	—100
24 hours	4065	4095	2978	2797	518	642	+569	+656

1. for normal group.
2. for salt supplemented group.

period than in the first period. The range of variation in the ambient conditions does not seem to be responsible for such divergences. With the first group of individuals it seems that extra salt ingestion helps in the economy of water consumption but with the other group this does not hold true. As the total water consumption for the extra salt group and the normal salt group are very nearly the same, it may be presumed that no significant difference in electrolyte imbalance sufficient to activate a positive water balance, is caused by an ingestion of 10 gm of sodium chloride. The data in Table 3 suggest that during the first spell of working in heat, one may require more water than what he would need during later days. This may be due to psychological reasons rather than to accommodative adjustments.

Data on sweat output (Table 4) show that the salt supplemented group produced less sweat than the normal group. The results are in concurrence with a previous finding[4], when 9 gm of sodium chloride dissolved in one litre of water was drunk in a single draft. In the present series of experiments, it is noticed that administration of about the same quantity of salt in divided doses does not lower the urine flow (Table 4) even for a limited period as observed previously. This may be explained in the following way. When the tissues are called upon to cede water to the blood to preserve its osmotic pressure, there start two simultaneous functions. On the one hand, tissue dehydration gains ground and on the other, osmoreceptors in the bed of carotid artery respond by swelling, which as a reflex cause the neuro-hypophysis to reduce its rate of secretion of antidiuretic hormone. Thereby the kidney not only regulates the volume of body fluids but also keeps the bulk of fluid compartments—extra-cellular and cellular fluids—normal and in normal relation to each other. The latent time taken by the kidney to adjust these relations depends on the concentration of the infusion liquid. This appears to be the reason for the retardation of urine flow when a litre of isotonic saline was drunk and a suitable explanation for the non-repeatability of identical conditions, though the same amount of salt was administered but in small doses.

The ingestion of water remained sufficiently high for all subjects and it can be safely claimed that no voluntary dehydration took place during the period of the trial. Total excretion of water in the form of urine and sweat in 24 hours was less than the total intake in both groups (Table 4). The net balance of water in the body was more in the salt group at noon hours, when the stress was maximum, than in the other group. It is not known how far this condition is beneficial to the body as a precaution against dehydration.

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REFERENCES

1. ADOLPH, E. F. & ASSOCIATES, "Physiology of man in desert" (Interscience, New York) 1947.
2. BELL, G. A., DAVIDSON, J. N. & SCARBOROUGH, N., "Text Book of Physiology and Biochemistry" (E. & S. Livingstone Ltd., London) 1959.
3. KUNDU, Y., "Human Perspiration" (Charles C. Thomas U. S. A.) 1956.
4. MANI, K. V., KUNDU, S. & JANWEJA, R. B., *Def. Sci. J.*, 13 (1963), 225.
5. WOLF, A. V., "Physiology of the urge to drink and problems of water lack" (Charles C. Thomas, Illinois, U.S.A.) 1958.
6. ZUIDEMA, G. D., CLARKE, N. P. & MINTON, M. F., *Amer. J. physiol.*, 187 (1956), 85.
7. WOLF, A. V., "The urinary function of the kidney" (Grune and Stratton, New York) 1950.