Physiology and Behavior. Vol 1, pp. 75–77. Pergamon Press Ltd., 1966 Printed in Great Britain

Serial Sodium Depletion and NaCl Solution Intake[1]

JOHN L. FALK

Department of Pathology, The University of Michigan, Ann Arbor, Mich. 48104

(Received 29 June 1965)

FALK, J. L. *Serial sodium depletion and NaCl solution intake.* PHYSIOL. BEHAV. 1 (1) 75–77, 1966.—Rapid sodium depletion was produced by intraperitoneal dialysis (IPD) in rats. This produced an increased intake of 3% NaCl solution during the following overnight fluid test period. Although more sodium was ingested than had been removed by IPD, a second dialysis (IPD_2) produced a much larger increase in NaCl solution ingestion. If the greater intake response to IPD_2 were a function of an intake adjustment learned after IPD_1, then stomach loading the NaCl solution after IPD_1, rather than making it available for ingestion, should eliminate the larger ingestion effect found after IPD_2. This did not occur. IPD_2 produced the larger ingestion effect whether or not the opportunity for post-IPD_1 ingestion was given.

Hyponatremia Salt appetite Learning

IN EXPERIMENTS previously reported [4, 5], rats depleted of sodium by the method of transperitoneal dialysis increased their consumption of a 3% NaCl solution. Also, a second dialysis (IPD_2) performed three days after the first one, during which time there was opportunity for sodium repletion to occur, produced an even greater consumption of 3% NaCl. In order to determine if this greater post-IPD_2 intake could be attributed to a learning effect based on the animals' compensatory intake response to IPD_1, the present experiment was performed.

METHODS

Subjects

Fourteen male, albino rats (Charles River Breeding Laboratories) weighing 296–363 g were used. They were caged individually in a temperature-controlled room which was constantly illuminated. Animals were divided into two groups of seven animals with equal mean weights, designated Groups I and II.

Procedure

Fluid intake schedule. The animals were adapted to laboratory conditions for four days and were allowed free access to Purina Laboratory Chow and water. Then, the following feeding and drinking schedule was put into effect. The animals were deprived of food and water at 12 noon, but were allowed water from 8 p.m. to 9 a.m. (fluid test period). From 9 a.m. to 12 noon they were given food and water in their cages (feeding-drinking period). They were then weighed and returned to their cages from which food and water had been removed. They were adapted to this regime for three days. On Day 4 of this schedule, 3% NaCl solution was given during the fluid test period in place of the usual tap water; on Day 5 distilled water was given. On Days 4 and 5 they were lightly anesthetized with ether at noon and again at 4 p.m. in order to adapt the animals to the anesthetic procedure and obtain baseline fluid test period values for 3% NaCl solution intake under post-anesthetic conditions similar to dialysis days.

On Day 6, the animals were weighed as usual at noon but were injected intraperitoneally with a load of dialyzing fluid which was withdrawn at 4 p.m. That night, Group I was offered 3% NaCl solution during the fluid test period. On Days 7 and 8, the animals were maintained on the same schedule and received water during the fluid test period. On Day 9, the dialysis procedure was repeated and again 3% NaCl was offered during the fluid test period. The schedulinn of Group II lagged Group I by two days. They were giveg identical treatment except that on Day 6 when the dialysate was removed at 4 p.m. they were given a stomach load of 3% NaCl solution and distilled water during the fluid test period. The load was administered by a No. 8 French rubber catheter attached to a burette, and the amount given to each rat was the mean 3% NaCl intake of Group I during the post-IPD_1 fluid test period. On Day 6, Group I was given a mock stomach load which consisted of passing a catheter into the stomach, leaving it in place for 15 sec, and removing it. On Day 9, Group II was dialyzed and given 3% NaCl solution to drink during the ensuing fluid test period.

Both groups of animals, then, were dialyzed twice and an attempt was made to maintain them in similar states with respect to body sodium at the time of IPD_2. Group I, however, would have had an opportunity to learn compensatory NaCl intake following IPD_1, but Group II, given the stomach load, would have no such opportunity.

[1]This research was supported by United States Public Health Service Grant B3861, Atomic Energy Commission Contract AT(11-1)1201, and United Cerebral Palsy.

Intraperitoneal dialysis. IPD was used to produce depletion of body sodium. The procedure has been described previously [4, 5], but briefly, the animals were lightly anesthetized with ether and injected intraperitoneally with a 10% body-weight load of isotonic glucose warmed to body temperature. After 4 hr, the ascitic fluid, containing approximately 104 m equiv./l.Na, was removed by paracentesis.

RESULTS

The results are shown in Fig. 1. Group I drank a mean of 14.1 ml 3% NaCl during the fluid test period following IPD_1. This was a considerable increase over baseline (Day 4). Following IPD_2, the 3% NaCl intake increased significantly above the post-IPD_1 level to 21.8 ml ($t = 2.895$, $df = 6$, $p < 0.05$). Group II, the members of which received 14.1 ml stomach loads of 3% NaCl following IPD_1, drank 20.9 ml of 3% NaCl in the fluid test period after IPD_2. This value was not significantly different from the post-IPD_2 performance of Group I ($t = 0.205$, $df = 6$).

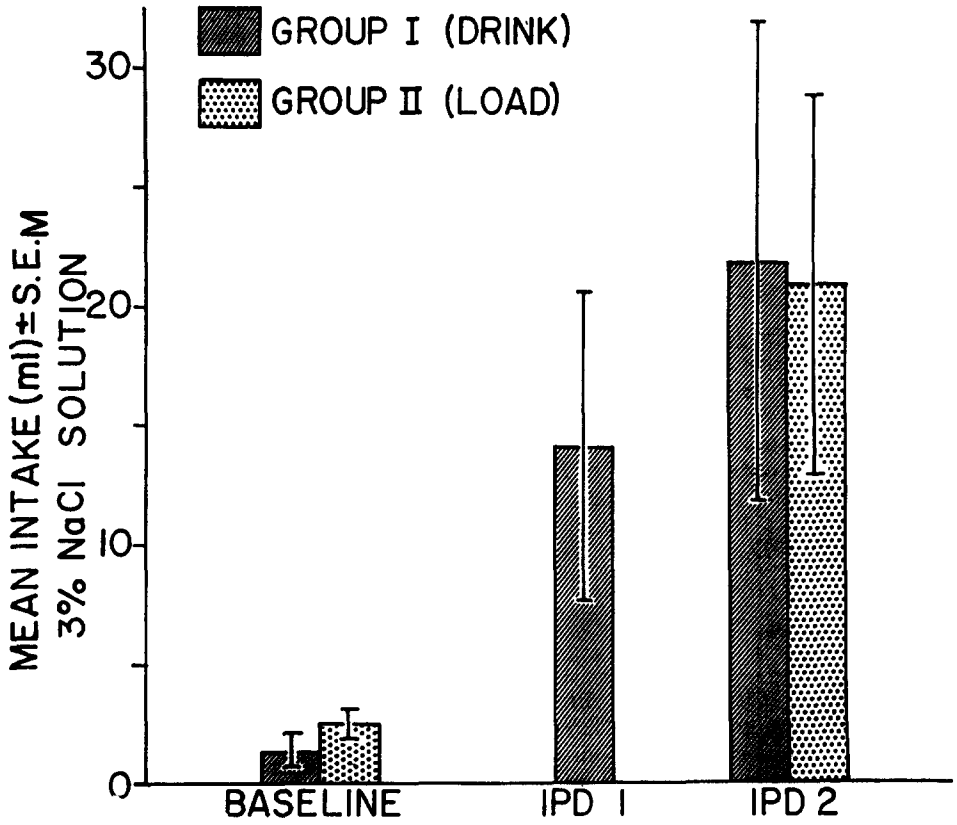

FIG. 1. Mean intake (ml) ± standard error of the mean of 3% NaCl solution during fluid test period (13 hr) before (baseline) and after intraperitoneal dialysis (IPD). Group I drank NaCl solution after IPD_1 and IPD_2. Group II was stomach loaded with NaCl solution after IPD_1 and drank NaCl solution after IPD_2.

DISCUSSION

Since Group II was loaded with the mean amount of NaCl that Group I drank after IPD_1, it is assumed that the groups were in equivalent states of sodium balance at the time of IPD_2. If the greater NaCl-intake response to IPD_2 were due to an adjustment of intake learned after IPD_1, one would expect the intake of Group II to be less than that of Group I after IPD_2 since Group I was deprived of the post-IPD_1 learning opportunity. Since this was not the case, the result suggests that the increased post-IPD_2 intake is a reflection of a greater cumulative sodium deficit produced by IPD_2 despite the more than adequate repair value of the ingested (Group I) or loaded (Group II) solutions obtained after IPD_1. The mean amount of sodium withdrawn from an animal by IPD_1 was 3.2 m equiv., and the mean ingested or loaded was 7.1 m equiv. This last fact, the overshoot of sodium intake compared to the deficit imposed, suggests another possibility: Perhaps the internal stimuli resulting from sodium depletion which initiate and maintain 3% NaCl intake have certain lag characteristics. Such a state of affairs could serve to explain the NaCl-intake overshoot as well as the greater effectiveness of IPD_2, if the sodium-deficit signals decrease slowly and monotonically from the time of sodium repletion.

Thus the possibilities for explaining the intake overshoot and the greater effectiveness of IPD_2 fall into three general categories. (a) The sodium consumed or loaded was ineffective in correcting the total body sodium deficit. This is not probable since orally-administered NaCl is quite effective in correcting a sodium deficit and the amounts taken in the present experiment were well in excess of the amounts

removed by dialysis. (b) The dialysis produced a local sodium deficit which was not readily amenable to correction by NaCl ingestion or loading. Bergstrom [1] found that in rats given parenteral sodium-containing fluid after IPD, or allowed five days of post-IPD recovery consuming a normal diet, the degree of bone sodium depletion remained the same as in the group of animals measured immediately post-IPD. This lack of sequestration of sodium in bone in spite of sodium loading suggests that localized sodium deficits can persist and might form the physiological basis for a continuance of NaCl solution intake long after serum sodium concentration has returned to within normal limits. Also, since the depletion of extracellular sodium by IPD_1 is corrected somewhat by the mobilization of bone sodium [1, 6], a bone sodium store would not be available to mitigate the effect of IPD_2. This state of affairs could account for the greater effectiveness of IPD_2 in producing NaCl solution intake. (c) The lag characteristics of stimuli resulting from sodium depletion when ECF sodium is restored sustain continued NaCl intake. One of the striking effects of sodium depletion is the consequent increase in aldosterone secretion [2]. However, when an infusion of 4 M NaCl was initiated to correct sodium depletion, the increased rate of aldosterone secretion fell within 30 minutes from the start of the infusion [3]. The aldosterone system apparently lacks the postulated lag characteristics. The above possibilities are by no means mutually exclusive, but whether any of them operate and their probable modes of operation remains, for the present, largely speculative.

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