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BRIEF COMMUNICATION

Increased Voluntary Ethanol Intake After Dietary Salt-Loading in Rats

GRAEME EISENHOFER[1]

Wellington Clinical School of Medicine, Wellington Hospital, Wellington 2, New Zealand

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EISENHOFER, G. *Increased voluntary ethanol intake after dietary salt-loading in rats.* PHARMACOL BIOCHEM BEHAV 24(6) 1825–1827, 1986.—The effect of dietary salt-loading on selection for 5% ethanol compared with dilute solutions of citric acid was examined in 9 male rats. Compared with 9 control rats maintained on a normal diet, salt-loaded rats exhibited significant increases in ethanol consumption and ethanol selection. Selection for ethanol remained elevated after resumption of the normal diet.

Ethanol Preference Ethanol consumption Dietary salt-loading Thirst

EXAMINATION of changes in voluntary ethanol intake in laboratory animals after experimental manipulation may help in understanding motivational processes involved in ethanol consumption in man. Differences in vasopressin secretion [5], electrolyte balance [6] and dipsogenic responses to hypertonic saline [7] between ethanol preferring and avoiding rats suggest that changes in fluid and electrolyte balance may be factors affecting voluntary ethanol consumption. Ethanol has been shown to inhibit osmotically-mediated thirst and fluid consumption in humans [1] and rats [3], and this may motivate ethanol consumption in situations associated with increased thirst. The present study was carried out to examine changes in voluntary ethanol consumption associated with increased thirst induced by dietary salt-loading in rats.

METHOD

Subjects were 18 experimentally naive male rats of Fischer strain with a mean (±SD) weight of 264±48 g at the beginning of the experiments. All animals were housed individually with a 12/12 hr light/dark cycle and the temperature maintained at 22–24°C. Each cage was fitted with two 300 ml glass bottles from which the animals drank by licking a stainless steel ball bearing at the end of a drinking spout attached to each bottle with a rubber stopper. Fluid consumption (not allowing for spillage) was assessed every 24 hr from the change in weight of bottles, the positions of which were alternated daily. Food (Wairarapa Stock Foods Diet 86) was available from wire boxes inserted into the cage top. Food intake (not allowing for spillage) was measured daily from the change in weight of the wire box. A high salt diet (5% NaCl by dry weight) was prepared by mixing sodium chloride and water with food pellets. Pellets were reformed by drying the precut mixture on trays at 60°C. The control diet was prepared similary except that sodium chloride was omitted.

Rats were given a choice of drinking a 5% solution of ethanol (v/v) in distilled water or a dilute solution of citric acid in distilled water. Solutions of citric acid, rather than water alone, were used as in low concentrations citric acid tends to be aversive. Citric acid solutions were adjusted for each rat to a concentration between 0.01 and 1.0% (w/v) that induced a preference for ethanol (>50% fluid consumed as 5% ethanol) compared with solutions of citric acid. Concentrations of citric acid were then reduced stepwise to a level at which rats showed a preference for citric acid solutions over solutions of ethanol (<20% selection for ethanol compared with citric acid solutions). Rats showing a preference for 5% ethanol compared with 0.01% solutions of citric acid or water were excluded from analysis. Once a stable preference for solutions of citric acid had been established over a baseline period of 7 days, rats were equally divided into two groups that did not differ with respect to bodyweight, concentration of citric acid solutions available or baseline selection for 5% ethanol as a percentage of total fluid consumption. One group was placed on the high salt diet for 10 days and then the normal diet for 7 days, after which a choice of distilled water and 5% ethanol was made available for a further 5 days. The other group was maintained on the normal diet for 17 days.

[1]Requests for reprints should be addressed to Dr. Graeme Eisenhofer at his present address: National Institutes of Health, National Institute of Neurological and Communicative Disorders and Stroke, Building 10, Room 5N214, Bethesda, MD 20892.

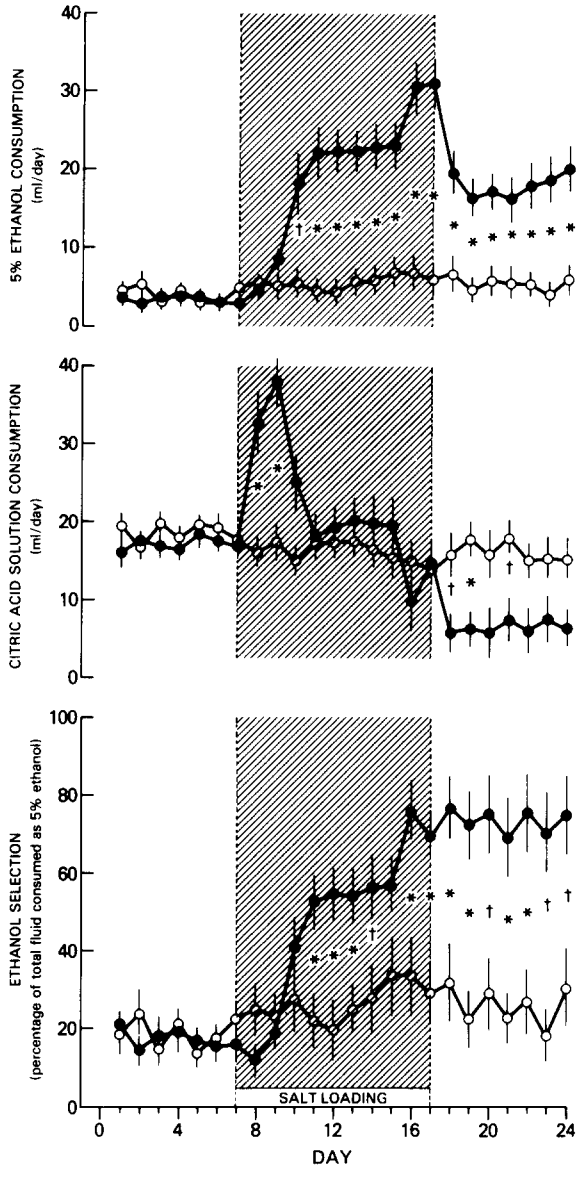

FIG. 1. Five percent ethanol consumption (upper), citric acid solution consumption (middle) and ethanol selection (lower) for rats given a salt-loaded diet from days 7 to 17 (●) and for animals maintained on a normal diet throughout the experimental period (○). Salt-loading caused significant increases in 5% ethanol consumption and ethanol selection that were maintained after resumption of the normal diet. Results are mean±SE.

The significance of changes in ethanol consumption, citric acid solution consumption and percentage of fluid consumed as 5% ethanol from the baseline phase to salt-loading and post-salt-loading phases were assessed using analysis of variance for repeated measures. Conservative or full degrees of freedom were used where appropriate according to the sample size and number of repeated observations.

RESULTS

Significant increases in 5% ethanol consumption ($F=12.5$, $p<0.005$) and citric acid solution consumption ($F=5.5$, $p<0.05$) were observed in rats during the period of salt-loading compared with rats maintained on the normal diet (Fig. 1). Whereas citric acid solution consumption was increased during days 1 and 2 of salt-loading, 5% ethanol consumption was increased on all days from day 3 to the end of salt-loading. Also, although 5% ethanol consumption remained significantly ($F=5.1$, $p<0.001$) increased after discontinuation of the salt-loaded diet, citric acid solution consumption was significantly ($F=2.4$, $p<0.05$) reduced during the post-salt loading phase in salt-loaded compared with control rats.

Compared with control animals, salt-loaded rats showed a significant ($F=6.9$, $p<0.02$) increase in selection for ethanol (percentage of total fluid consumed as 5% ethanol) during the salt-loading phase of the study (Fig. 1). At the end of the 10 day salt-loading period, animals were consuming 70–75% of their total fluid as 5% ethanol compared with 15–20% before salt-loading and 25–30% in control animals. Selection for ethanol remained significantly ($F=6.0$, $p<0.001$) elevated at 70–75% fluid consumed as 5% ethanol after resumption of the normal diet, with a fall to baseline ethanol selection in only one animal. Replacement of citric acid solutions with distilled water caused a fall in ethanol selection to baseline values in two more rats, with the remaining animals maintaining their increased selection for ethanol.

It is possible that salt-loading caused an increase in total body water. Because weights of animals were not measured each day it was not possible to express ethanol consumption in ml per kg bodyweight. Data however, was reanalyzed after assuming a possible doubling of bodyweight. The increase in 5% ethanol consumption expressed as a fraction of bodyweight remained significantly ($F=7.6$, $p<0.02$) elevated during salt-loading after assuming a doubling of bodyweight due to the possibility of fluid retention.

DISCUSSION

The present study has shown that dietary salt-loading in rats causes an increase in voluntary consumption of 5% solutions of ethanol compared with dilute solutions of citric acid. The results also show that increased selection for ethanol induced by dietary salt-loading is sustained after resumption of the normal diet and also after citric acid solutions are replaced by distilled water. These findings are consistent with those of another study showing increased voluntary consumption of ethanol during dietary salt supplementation [2]. In that study a different methodology was used with baseline ethanol selection being increased by forcing animals to consume ethanol for two days before a choice between ethanol or water was offered on every subsequent third day.

Ethanol inhibits salt-load elicited thirst and drinking by raising the osmotic threshold for thirst [1,3]. It is possible that this may act as a reinforcing factor causing increased selection for ethanol in situations associated with osmotically-mediated thirst. In the present study the increase in selection for ethanol over the ten day period of salt-loading may have occurred as the animals learned to associate the consumption of ethanol with a stronger alleviation of thirst than the consumption of citric acid solution. If so, then this effect may have relevance to 'loss of control' drinking in alcoholism [4]. Ethanol acts as a dehydrating agent, an effect that does not become apparent or uncomfortable until blood ethanol concentrations start to decline, lowering to normal the osmotic threshold at which thirst is experienced [1]. A person who exhibits 'loss of con-

trol' drinking may be compelled to drink ethanol in order to maintain an elevated osmotic threshold for thirst, thus postponing the discomfort of dehydration.

In conclusion, dietary salt-loading causes an increase in voluntary consumption of ethanol that is sustained after resumption of a normal diet. The cause of this effect is unknown, but could be secondary to suppression of osmotically-mediated thirst by ethanol.

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