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Influence of Dietary Potassium and Sodium on Cesium-137 Retention in Rats.* (28348)

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Recently, Richmond and Furchner(1) reported that high dietary levels of potassium significantly increased the excretion of a single dose of Cs^{137} in rats. In the above study, the normal diet (1% K) was supplemented with sufficient KCl to raise the potassium concentration in the diet to 5, 8 and 11% and thereby increase the corresponding salt content by 7.6%, 15.2% and 20.9%. It would seem, then, that such a high salt intake could have deleterious effects which, in turn, may account for the reported observations. Richmond and Furchner(1) gave no data on body weight changes or on feed and water intake to indicate if other physiological changes occurred. Previously, Wasserman and Comar(2) found that raising dietary K^+ from 0.2% to 1.9% decreased the retention of chronically ingested Cs^{137} by a factor of 2; others had observed little or no effect of potassium on Cs^{137} retention except when a potassium deficient diet was made adequate(3-5).

The present experiments were undertaken to determine the effect of either 5% dietary potassium or sodium on Cs^{137} retention; like Richmond and Furchner(1), potassium did enhance Cs^{137} turnover but sodium was equally effective, and both salts significantly increased water consumption.

Materials and methods. In the first experiment, female albino rats of the Carworth strain (about 6 weeks of age) were placed on either a diet consisting of ground Rockland diet (0.7% K^+ and 0.4% Na^+) or the Rockland diet containing 9.5% KCl. At one week, the rats were injected intraperitoneally with about 50 μc Cs^{137} (carrier-free) and the body retention of the radionuclide followed for 34 days. Cesium-137 retention was determined by counting the rats in a quart screw-cap jar (with air holes) at 12 inches from a 2-inch NaI scintillation probe attached to a count rate meter and a single channel analyzer. The animals were counted against a known standard placed in the same geometric situation. The retention on any given day was calculated from the equation below:

$$Cs^{137} \text{ retention } (\%) = \frac{\text{Rat count rate at time, t}}{\text{Rat count rate at t} = 0} \times \frac{\text{Std. count rate at t} = 0}{\text{Std. count rate at time, t}} \times 100$$

where time (t) is in days. The initial count was made immediately after radionuclide administration and taken as 100%.

The second experiment was identical to the first except that the basal diet was supplemented with 12.7% NaCl (5% Na^+).

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TABLE I. Influence of Dietary K^+ and Na^+ on Body Weight Changes, Feed Intake and Water Consumption in Rats.*

Exp	Group	K^+ in diet (%)	Na^+ in diet (%)	Body wt Initial (g)	Body wt Final (g)	Body wt Gain (g)	Feed intake (g/day)	H_2O intake (ml/day)
I	Control	.7	.4	261 ± 6	268 ± 7	+7	19.2 ± .6	38 ± 1
	Hi K^+	5.7	.4	255 ± 3	250 ± 6	−5	21.7 ± .9	72 ± 1
II	Control	.7	.4	268 ± 5	279 ± 7	+11	21.2 ± 1.3	41 ± 4
	Hi Na^+	.7	5.4	273 ± 4	265 ± 3	−8	25.3 ± 1.1	147 ± 7

* Values represent mean ± standard error of mean.

Each experimental group contained 5 or 6 animals.

Results and discussion. Table I summarizes the effect of diet on body weight changes, feed intake and water consumption. As may be seen, the high salt diet slightly depressed growth although the differences were not statistically significant. Feed consumption was not appreciably altered, indicating that the salt intake was proportional to the dietary concentrations of the alkali metal ions. Of considerable interest was the observation that water consumption was elevated by a factor of about 2 on the high potassium diet and by a factor of about 3.6 on the high sodium diet.

The biological retention curves of Cs^{137} for Experiment I (basal versus high KCl) are given in Fig. 1 and those for Experiment II (basal versus high NaCl) in Fig. 2. As shown by Richmond and Furchner(1) the excretion of Cs^{137} was considerably enhanced by a high level of KCl intake. Likewise, it was further noted that dietary NaCl yielded

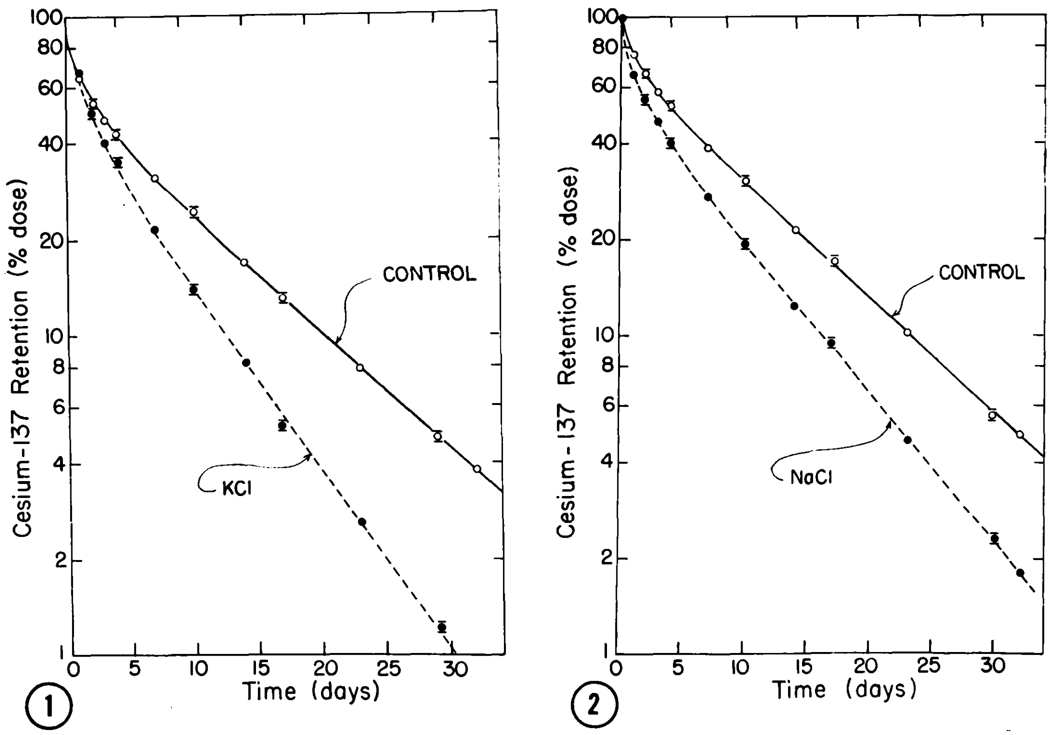

FIG. 1. Effect of increased dietary potassium levels on Cs^{137} retention. Ranges represent standard error of mean.

FIG. 2. Effect of increased dietary sodium levels on Cs^{137} retention. Ranges represent standard error of mean.

TABLE II. Parameters of Retention Equation* for Control and Salt-Supplemented Rats.

Exp	Diet	Rats/group	p_1	k_1	p_2	k_2
I	Control	6	.45 ± .03	.79 ± .04	.55 ± .03	.084 ± .002
	Hi K^+	5	.48 ± .02	.77 ± .06	.52 ± .04	.13 ± .003†
II	Control	6	.37 ± .03	.63 ± .05	.63 ± .04	.083 ± .004
	Hi Na^+	5	.43 ± .04	.69 ± .07	.57 ± .01	.11 ± .008†

* $A(t) = A_0p_1e^{-k_1t} + A_0p_2e^{-k_2t}$ where $A(t) =$ % dose retained at time, t; $A_0 = 100\%$ of dose given at $t = 0$; p_1 and $p_2 =$ fraction of A in compartments 1 and 2; k_1 and $k_2 =$ rate constants for removal from compartments 1 and 2.

† Significantly greater than respective control value at $p < .01$.

a similar response. It was thus apparent that the elevated excretion of Cs^{137} was not specific for the K^+ ion and that Na^+ was also effective. As shown above, the high salt intake caused an increased water intake which undoubtedly yielded an increase diuresis. The increased water excretion could result in a "wash-out" of retained Cs^{137}.

The parameters of the retention equations for both experiments are given in Table II and the major effect of the high salt intake was to alter the rate constant of the second component (k_2). The other parameters were not significantly influenced by treatment.

It was also of interest to estimate the integrated retention of Cs^{137} over the 34-day experimental period since the exposed dose to the animal from the radionuclide would be proportional to this value. These were calculated by integrating the kinetic equations given in Table II. In Exp. I, the integrated Cs^{137} retentions were about 670 and 460% dose-days for control and KCl-supplemented groups, respectively. For Exp. II, these values were about 780 and 570% dose-days for the control and NaCl-supplemented groups, respectively. The reasons for the differences between control groups of the 2 experiments are unknown but, in both studies, the high salt diet decreased the exposure dose from Cs^{137} by a factor of approximately 0.7.

Summary. (1) The effect of supplementation of diet with high levels of KCl and NaCl on Cs^{137} retention in rats was studied; the level of added alkali metal ion in each case was 5%. (2) Both Na^+ and K^+ increased the rate of excretion of Cs^{137} but also considerably enhanced water consumption. (3) The response was probably due to the diuretic action of the salts rather than to specific ion antagonism. (4) The exposure dose to the animal from Cs^{137} was reduced by a factor of about 0.7 by high salt (Na^+ or K^+) intake.

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