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THE EFFECT OF ENVIRONMENTAL TEMPERATURES ON THE
RETENTION OF CESIUM¹³⁷ BY MICE¹

Cs-137

MASTER

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FURCHNER, J. E., and C. R. RICHMOND. The effect of environmental temperatures on the retention of cesium¹³⁷ by mice. Am. J. Physiol. ____ (): ____, 1962.--Three groups of 12 mice each were maintained at environmental temperatures of 34°, 22°, and 5°C for a period of ~ 7 weeks after an intraperitoneal injection of Cs¹³⁷. Periodic assay of the activity in the whole body and excreta showed that as environmental temperature decreases the excretion of Cs¹³⁷ increases, probably as a result of the increased metabolic rates associated with low temperatures.

A relation between body weight and metabolic rate (1) has been used at this Laboratory in an attempt to establish a basis for the extrapolation from metabolic parameters for small mammals to metabolic parameters for man relevant to Maximum Permissible Concentration (MPC) values (2). In making such an extrapolation, it is assumed that the excretion of the element in question is related to some quantitative measure of the metabolic rate (e.g., O_2 consumption/g body wt.) of the test animal. If the assumption is valid, then a change in metabolic rate should result in a change in the excretion (and retention) of the element. Metabolic rates are a function of environmental temperatures (3,4). Changes in electrolyte levels in urine and plasma and in organ weights result from prolonged exposure to abnormal temperatures (5-7). The effects of high, normal, and low room temperatures on the retention and excretion of Cs^{137} by mice are reported here.

METHODS

To each of 36 RF female mice (age 68 days, average weight 22 g), 0.6 μc of $Cs^{137}Cl_2$ was administered intraperitoneally. The Cs^{137} activity (in c/sec) was determined at 30 min after administration in LASAC III, a 4π liquid scintillator whole-body counter (8). Immediately after assay, the mice were divided into 3 groups of 12, and a group was maintained at each of the following temperatures:

34°, 22°, and 5°C (+ 2° for each). Purina Lab Chow and water were supplied ad libitum. The animals were assayed periodically, and a Cs¹³⁷ standard was also assayed with each group. Per cent retention in each mouse was calculated from the expression,

$$R_t = (A_t/S_t) (S_o/A_o) (100)$$

where A_o and A_t are the activities (in c/sec) in the mouse at time zero and at any time t, respectively, and S_o and S_t are the activities in the standard at the same times.

The excreta of each group was collected periodically for assay. The excretion rate was calculated as per cent from the expression,

$$E_r = (E_t/A_s) (S_o/S_t) \times 100$$

where E_t is activity (in c/sec) excreted per day per group, A_s is the summed activity of that group at time zero, and S_o and S_t have the same meaning as before.

The individual values for each mouse, rather than the average values for the group, were programmed for least square analysis by an IBM 7090 computer (9). The computer was also used to test the significance of the differences of the group means on each day (10,11).

RESULTS

The mean per cent retention for each group is given in Fig. 1.

FIG. 1. Average Cs^{137} retention values (points) and ranges (bars) in mice maintained at high, normal, and low temperatures.

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The range of values is also indicated by the vertical bars at each data point from $t = 7$ until the last measurement. The curves drawn through each set of data points are plots of the best fit equations derived by computer analysis. Parameters of the equations for these curves are given in Table 1, along with their standard deviations. Plots of the first derivatives of these equations are shown as smooth curves in Fig. 2, along with the excretion rates measured by assay of the excreta. The horizontal lines through the data points indicate the duration of the collection period.

The test for significance of the difference of group means showed that each group differed significantly ($P = 0.01$) from the other two after the second day.

DISCUSSION

Three exponential components describe Cs^{137} retention in mice maintained at 34°C and at 22°C . Only two such components describe Cs^{137} retention in mice maintained at 5°C (Table 1). A three-component curve can be fit to the 5°C data, but the additional rate and intercept constants are less than their respective standard deviations and, therefore, are not significantly different from zero. After the 25th day, the activity in the mice in the cold environment

FIG. 2. Cesium¹³⁷ excretion rates modified by environmental temperatures.

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was too low to be determined accurately without prolonged counting times. The activity in the pooled excreta conformed to the derivative of the two-component retention equation (Fig. 2).

Other than the increase in intercept constant of the first component of the retention functions (a_1 in Table 1) with decreasing temperature, no obvious trend appeared among the various remaining parameters.

No measurements of metabolic rates were made. Qualitative observations indicated that the food mass passing through the animals varied inversely with temperature. Fregley (5) states that exposure at 5°C increased food intakes 70% above food intakes at 25°C, while exposure at 35°C decreased food intake approximately 50%. Differences in the amount of food consumed result in differences in potassium consumed. The concentration of potassium in food affects the rate of cesium excretion (12), and it is possible that the effect of temperature on cesium excretion may be due to this factor in some degree.

Comar et al. (13), on the basis of an experiment with iodine-deficient, thiouracil-treated rats, believe that a relation between metabolic body size and cesium retention is unwarranted. Their evidence is not conclusive, nor is the contradictory evidence presented here conclusive, because temperature stresses alter physiology in a complex way, and the alterations in Cs^{137} retention may

parallel, rather than be a result of, altered O_2 consumption.

Differences in environmental temperatures may also affect retention under conditions of chronic exposure. Table 1 gives estimated equilibrium levels for chronic exposures. The difference between the effect of low and high environmental temperatures shows up as a factor less than 2 in the estimated equilibrium levels.

Woodward et al. (13) reported a half-time for cesium in the Bikini natives of 110 days, while Liden (14) reported one of 74 days for a native of Sweden. The difference is undoubtedly due to a complex of factors such as biological variation, differences in measurement techniques, dietary intake, and activity of the subjects. If temperature plays a part, it is probably minor. Richmond et al. (15), in New Mexico, measured half-times of cesium in man and found a range of 110-147 days among 4 individuals with a mean value of 135 days.

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TABLE 1. Cesium¹³⁷ retention in mice exposed to high, normal, and low environmental temperatures

Parameter	Temperature (°C)		
	34	22	5
a_1^*	35.3 $\pm$ 4.3	40.1 $\pm$ 4.2	57.1 $\pm$ 1.8
k_1	1.06 $\pm$ 0.18	1.27 $\pm$ 0.56	0.774 $\pm$ 0.034
a_2	54.1 $\pm$ 6.1	34.4 $\pm$ 6.0	---
k_2	0.173 $\pm$ 0.0028	0.254 $\pm$ 0.056	---
a_3	10.5 $\pm$ 8.7	25.4 $\pm$ 8.6	43.5 $\pm$ 1.8
k_3	0.064 $\pm$ 0.0215	0.115 $\pm$ 0.011	0.191 $\pm$ 0.003
Equilibrium Level**	510	388	304

* From the equation, Retention = $\sum_{i=1}^n a_i e^{-k_i t}$.

** Integral of the retention equation from zero to infinite time, in units of % daily dose.

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