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VARIATIONS IN THE RETENTION AND EXCRETION OF ^{137}Cs WITH AGE AND SEX

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Variations in the Retention and Excretion of ^{137}Cs with Age and Sex

Abstract. The effects of age and sex on the retention and excretion of ^{137}Cs in the body were studied in a cross section of the general population over a four-year period. A family of linear curves relates average ^{137}Cs/g K concentrations in urine to average ^{137}Cs body burdens for various male and female age groups. An average biological half-life of 20 days is identical for males and females between the ages of 5 and 14 years. The half-life for males increases abruptly to 67 days at age 15, increases further to 93 days between 30 and 50, and decreases to 70 days after age 55. After age 15, the biological half-life for females remains relatively constant at 47 days through age 50.

The biological behavior of ^{137}Cs is important in measuring the dose received by the general population from fallout as well as that received by an individual from an uptake. Published biological half-lives(1-4) differ because only small population groups were studied. Correlation between ^{137}Cs/K concentrations in milk and in the body indicates that children between ages 5 and 11 have a much shorter biological half-life.(5) This paper reports a four-year study to determine the biological behavior of ^{137}Cs in 110 people representing a cross-section of the general population.

The study population was grouped as follows:

Age	Male	Female
5-11	12	18
12-19	20	15
21-50	23	17
55-75	5	0

9/23/68

Body burdens of ^{137}Cs were measured in the whole body counter at the Savannah River Laboratory. Adults were counted monthly; adolescents and children were counted every other month.

A urine sample was collected from each subject within several days following their whole body count and analyzed for ^{137}Cs and ^{40}K. The combined body count and urinalysis provided a material balance between assimilation, retention and excretion of ^{137}Cs. To provide a common denominator and eliminate the inconvenience of obtaining 24-hour urine samples, ^{137}Cs content is expressed as ^{137}Cs concentration per gram of potassium, a chemically similar element.

The monthly average ^{137}Cs body burden was related to the monthly average concentration of $^{137}Cs/g$ K excreted in urine. The study population was redivided into specific male and female age groups defined by good correlations. The correlation curves for three major age groups (Fig. 1) are statistically significantly different. Correlation coefficients were greater than 0.8 for all age groups. The correlation curve for 20 adult males from Richland, Washington(6) is also shown for comparison; the slope for that age group is also high. The $^{137}Cs/K$ urine concentration and ^{137}Cs body burden correlation curve for adolescent males lies between the adult male and female curves. The slope of the correlation curve for adult males greater than 50 years of age appears somewhat less than that for the 30 to 50 year age group. The slopes of these correlation curves are listed in the figure. The increasing slope of the urine and body burden correlation with age is directly related to the biological half-life of ^{137}Cs.

The monthly average ^{137}Cs body burdens as measured by the whole body counter increased with age. The ^{137}Cs body burdens increase more rapidly in males than females. These differences are affected by the variations in body weight and age and sex. Normally, potassium is proportional to body weight, and is also proportional to age until adolescence. In adults, potassium becomes relatively constant,(7) although the concentration in males is 1.6 that in females. Because of this, measured body burdens were normalized to the potassium content of the body.

After normalizing the monthly ^{137}Cs body burdens of the individuals within the various age groups with their measured amount of body potassium, the age and sex relationships to the ^{137}Cs concentration in the body still persist.

The average monthly biological half-life was determined from the following equation:

$$E_i = B_{(t-1)} \left(1-e^{-\lambda \Delta t}\right) + Ci \left(\Delta t - \frac{\left(1-e^{-\lambda \Delta t}\right)}{\lambda}\right)$$

where: E_i = average monthly amount excreted (from urinalysis)

$B_{(t-1)}$ = body burden of the previous month (from whole-body count)

Ci = average monthly intake (derived from the monthly material balance between ^{137}Cs excreted and retained in the body)

$\lambda = 0.693/T_{b\ 1/2}$ = decay constant based on biological half-life

The yearly average biological half-life of each subject was then correlated with age in Fig. 2. Although the biological half-life varies widely between individuals of the same age, the range is significantly different for each age group. The average biological half-life is 20 days for both males and females between ages 5 and 14. The biological half-life for males increases abruptly at age 15 to an average value of 67 days. The half-life appears to increase further to 93 days between the ages of 30 and 50 years. Data for a small population of males over age 55 indicate a decrease to 70 days. After age 15, the biological half-life of females through age 50 remains relatively constant at 47 days.

Mathematical models were derived for the male and female biological half-life relationship with age. The data for males are best described by two distinct components: a first degree polynomial up to age 14 and a third degree polynomial of log form from age 14 through 75. The data for females are best described by a second degree polynomial of log form because the transition at age 15 is not abrupt. More data are necessary to confirm the observed decrease in biological half-life in the elder male age group. A biological half-life curve derived by McCraw(8) from various published values for both males and females generally agrees with this study, although less data were used and both sexes were averaged.

The linear correlation curves permit the use of urinalysis to estimate the average body burdens of various segments of large populations quickly, inexpensively, and accurately. The biological half-life curves will permit more accurate assessment of doses on the basis of age and sex. Continued study may reveal other variables such as diet, climate, or physical size which will further refine the population groupings.

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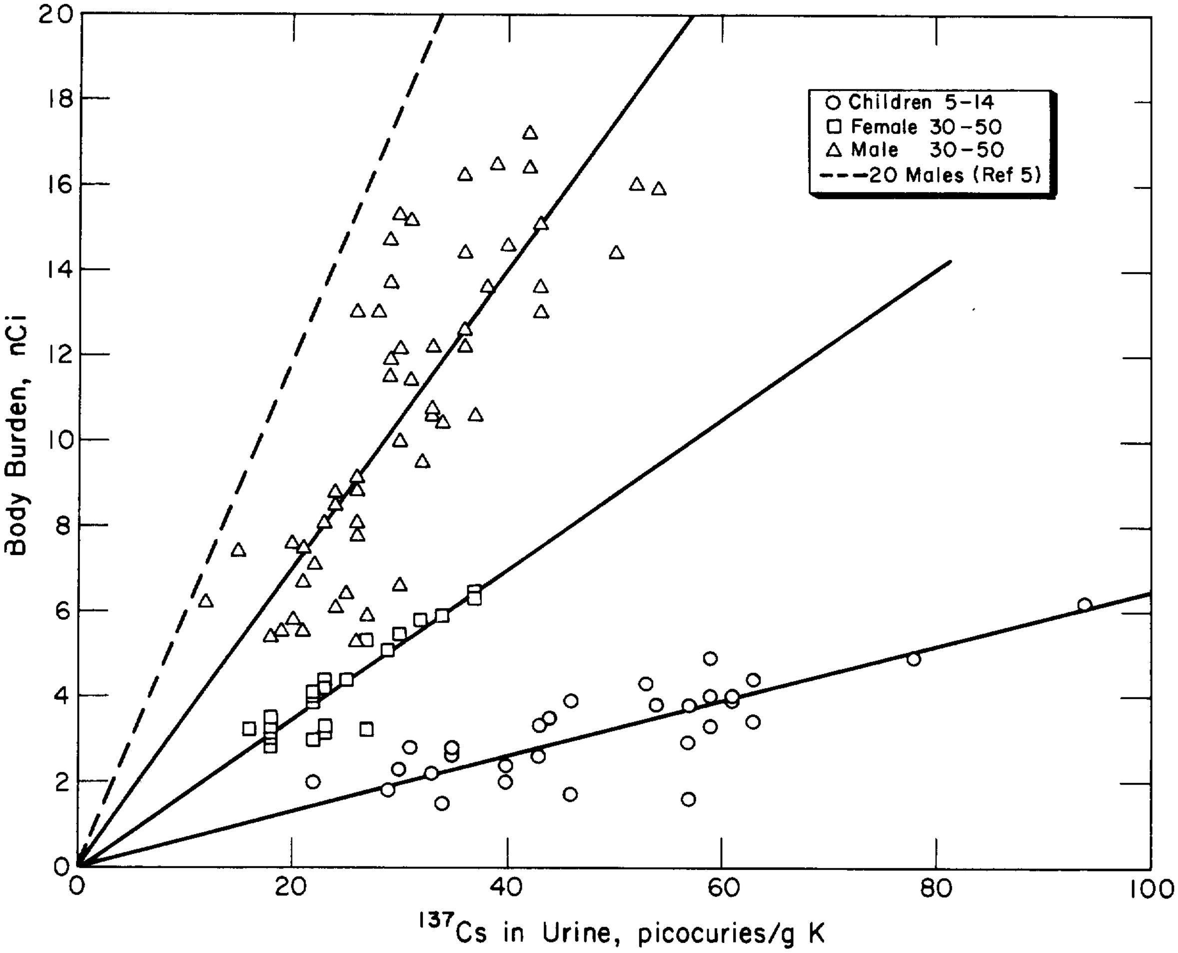

CURVE COMPARISON

AGE GROUP	SLOPE
Children 5-14 yrs	0.0644 ± 0.0025
Young females 15-29 yrs	0.1216 ± 0.0092
Adult females 30-50 yrs	0.1726 ± 0.0038
Young males 15-29 yrs	0.1940 ± 0.0198
Adult males 30-50 yrs	0.3500 ± 0.0094
Elder males 55-75 yrs	0.2415 ± 0.0148

Fig. 1. Urinary excretion relationships between specific male and female age groups.

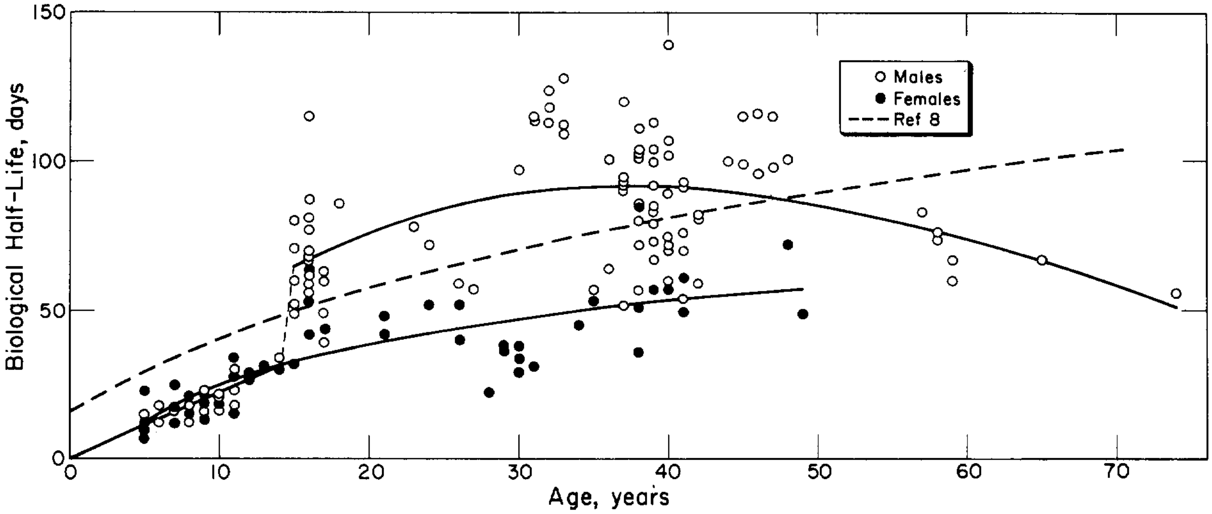

Fig. 2. Effect of age on biological half-life in males and females.

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