RADIOCESIUM BODY BURDENS IN NORTHERN CANADIANS

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ABSTRACT

Whole body measurements were carried out on 1117 Canadians living in five Arctic communities during 1989 and 1990 in order to assess the uptake of radiocesium from the lichen-caribou-human food chain. The Cs-137 body burdens increased with age, and were twice as high for men as for women. There was a discrepancy between the reported meat consumption and the measured body burdens. Average radiation doses from ingested radiocesium varied from 0.01 to 0.10 mSv/a.

INTRODUCTION

It has been known since the early 1960's, when intensive testing of nuclear weapons was carried out in the atmosphere, that the lichen-caribou-human food chain is an important pathway for the uptake of radiocesium. This is particularly true in far northern regions where fallout radionuclides accumulate on slowly growing lichens. These in turn serve as the major food source of reindeer and caribou during the long winter months. Many northern Canadians depend on caribou hunting for their main supply of meat.

After the Chernobyl accident in 1986, renewed concern was raised about possible contamination of Canadian caribou herds by fallout radiocesium. Measurements carried out on caribou meat by this laboratory between 1986 and 1988 showed that only about 25% of the radiocesium in Canada resulted from the Chernobyl accident; the remainder was residual fallout from early weapons testing. However, exposure to radiocesium depends on the diet and lifestyle of the people, as well as on the levels in caribou meat. The only way to obtain a direct measure of exposure to humans is to carry out whole-body monitoring. This paper describes such a set of measurements.

EXPERIMENTAL MEASUREMENTS

Measurements were carried out in the following communities:

Baker Lake, NWT	Feb., 1989	416 subjects
Rae-Edzo, NWT	March, 1989	378 subjects
Old Crow, Yukon	March, 1990	92 subjects
Aklavik, NWT	March, 1990	115 subjects
Ft. McPherson, NWT	April, 1990	116 subjects

Efforts were made to obtain a good representation from both sexes and all age groups.

The counting equipment was usually set up at the nursing station in each community. The subject was seated comfortably in a chair. A 5" x 4" Harshaw NaI(Tl) scintillation detector was placed close to the abdomen and thighs and a 3" x 3" detector was placed close to the chest. In the case of a small child the chest detector was omitted. Each measurement required only 5 minutes. The signals were processed by a Canberra S100 data acquisition system and the resulting gamma ray spectrum was displayed on a video screen which was visible to the subject. Cesium-137 was identified by its photopeak at 661.6 keV. At the end of the measurement the subject was given a printout of the result and an explanation of its significance. The counting system had been previously calibrated at the laboratory by using phantoms resembling an adult male, a 10-year old, and a 4-year old and filled with water containing a solution of Cs-137. The detection limit varied between 0.1 and 0.3 kBq of Cs-137, depending on the background at the nursing station. Each subject was asked to complete a dietary survey, with the assistance of a native interpreter. The subject estimated the amount of caribou eaten at each meal by pointing to models of various sized pieces of meat. Radiocesium analyses were carried out on samples of caribou meat obtained from recent kills in each community.

RESULTS AND DISCUSSION

Figure 1 shows how the radiocesium body burdens varied with age group and sex in one particular community -- Baker Lake. Results for the other communities were similar. Note that the levels were very low in children, then rose during the adolescent and early adult years to reach a peak in middle age (50 - 60). After age 60 the levels declined. Results for males were consistently about a factor of two higher than those for females.

Table 1 summarizes the results for the five communities for all adults (age >20). The predicted body burdens were calculated as follows:

$$BB(kBq) = \text{Conc. in meat}(kBq/kg) \times \text{consumption}(kg/wk)/7 \times \text{GI uptake} \times \text{biological half-time}(days)/\ln(2)$$

The average weekly consumptions of caribou meat were based on results provided in the dietary survey. GI uptake was assumed to be 100 % (1). The biological half-times for radiocesium in the body were taken to be 96 days for men and 65 days for women (2). In all cases, the observed body burdens in men were about twice as high as those in women. This is only partially explained by the differences in reported consumption. The remainder of the factor of two can be explained by the shorter biological half time for radiocesium in women (65 as opposed to 96 days). The observed body burdens are well correlated with the measured concentrations in

meat for each community (r = 0.973 for men and 0.985 for women).

The most notable feature of Table 1 is that the predicted body burdens are consistently 2 to 4 times as high as the measured values. Aklavik would appear to be an exception, but the measured values for this community are too close to the detection limit (0.2 kBq) to draw any conclusions. The discrepancy between predicted and observed values is difficult to explain. One possibility is that the GI uptake factor is considerably less than 100 % for radiocesium in meat. To test this possibility, several volunteers from this laboratory consumed known amounts of caribou meat containing Cs-137(3). Whole body, urine and fecal measurements were all consistent with a GI uptake factor >98 % The experiment also showed that the biological half times assumed here are quite reasonable. The only remaining possibility is that the people were consistently overestimating their consumption of caribou meat. It is curious that the degree of overestimation should be consistent between sexes and from one community to another. Furthermore, the degree of overestimation was found to be consistent even between different age groups in the same community. If people were, in fact, overestimating their meat consumption, then the radiocesium body burden measurements provide an independent means of estimating consumption. This could be useful for an accurate assessment of the intake of other toxic substances.
The annual dose to each sex group in each community from the observed Cs-137 body burden has been calculated from:

$$\text{Dose(mSv/a)} = 0.043 \times \text{body burden(kBq)}$$

This assumes a) body burden is maintained for one year
b) energy deposited per disintegration is 0.59 MeV
c) an adult weighs 70 kg.

The values are given at the bottom of table 1. These values represent an insignificant increase over natural background exposure of 2 to 3 mSv/a. The highest body burden observed for any individual was 9.5 kBq, which gave a dose of 0.41 mSv/a.

REFERENCES

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3. B.L. Tracy and G.H. Kramer, Verification of the ICRP retention model for the human uptake of Cs-137 from caribou meat, 37th Annual Conference on Bioassay, Analytical and Environmental Radiochemistry, Ottawa, Canada, October 7-11, 1991.

Table 1. Consumptions of caribou meat and Cs-137 body burdens

	Rae-Edzo	Baker Lake	Old Crow	Fort McPherson	Aklavik
No.of adults					
men	128	122	30	38	34
women	109	144	20	60	49
Consumption					
men (kg/wk)	1.38	2.26	1.18	0.81	0.53
women (kg/wk)	0.95	1.54	0.90	0.64	0.52
Conc. in meat					
(Bq/kg)	0.294	0.207	0.092	0.092	0.019
Predicted Cs burden					
men (kBq)	8.03	9.26	2.15	1.47	0.20
women (kBq)	3.74	2.33	1.11	0.79	0.13
Observed Cs burden					
men (kBq)	2.22	1.97	0.63	0.57	0.27
women (kBq)	1.24	0.84	0.24	0.30	0.14
Observed/predicted					
men	3.62	4.70	3.41	2.58	0.74
women	3.02	2.77	4.62	2.63	0.93
Annual dose					
men (mSv/a)	0.10	0.08	0.03	0.02	0.01
women (mSv/a)	0.05	0.04	0.01	0.01	0.01

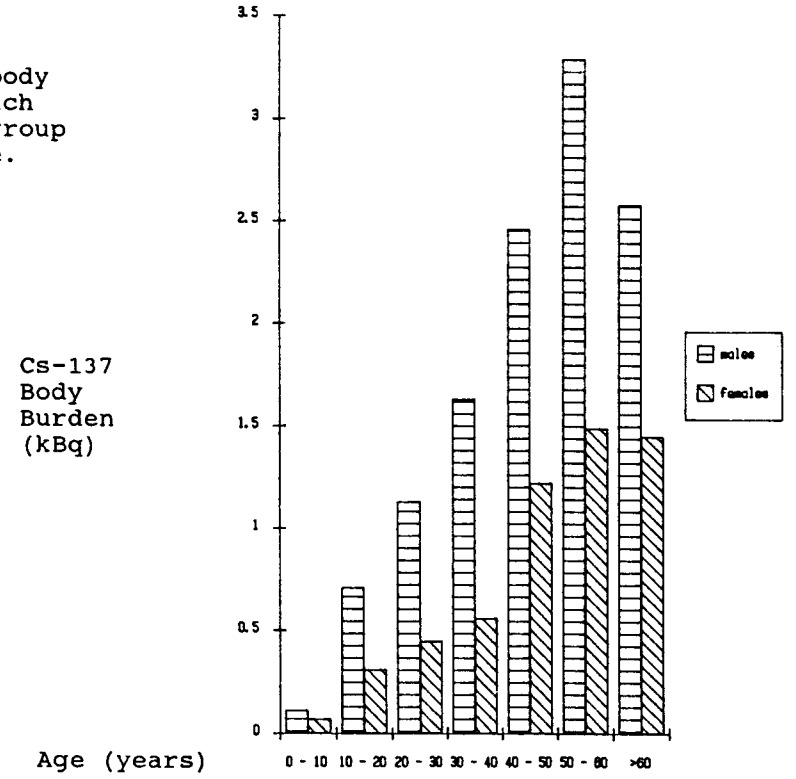

Figure 1. Radiocesium body burden for each age and sex group in Baker Lake.