NATURAL RADIATION EXPOSURE FROM ^{226}RA IN GERMANY+)

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Concentration of ^{226}Ra has been measured in more than 1ooo samples: human bone, still born infants, fetuses, blood, mixed diet, drinking water and mineral water. It could be demonstrated that there is an age-dependence of ^{226}Ra-concentration in human bone. Up to the age of 2o, two maxima of ^{226}Ra-concentration occur in bone. These maxima coincide with periods of increased velocity of skeleton growth. Normally, food is the main source of the uptake of radium by man. A transfer factor from diet to bone of about o.o98 has been noted in Germany. Compared with data (1) obtained from other countries - mainly the U.S. - the German value is higher by a factor of about 1.5. This difference may be due to the lower calcium intake in Germany, leading to increased resorption of radium.

Materials and Methods

All biological samples were dried and ashed at 65o°C. The radium content of the ash was chemically isolated from other inorganic substances. The measurement was done at a low-level Alpha- or Gamma-Spectrometer. ^{226}Ra-concentration in samples of drinking water and mineral water was determinated by collection of ^{226}Ra on selective ion-exchanger (2) and subsequent measurement in a low-level Alpha-Spectrometer.

The food examined was mixed hospital diet from Kiel University Hospital. Mineral waters from different sources were bought at random from local retailers.

Results

The average values of the measured concentration of ^{226}Ra (3) are designed in Table 1, which shows also the concentration-range (mBq ^{226}Ra/g fresh weight) in the different types of samples (Cortical bone, taken from adults; still births; neonatal deaths and placentae; blood plasma; standard diet; drinking water and mineral water).

The age-dependence of ^{226}Ra in bone is shown in Figure 1. Each point represents an average of 18 to 29 samples measured. All in all, 955 human cortical bone samples were measured.

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Sample type	^{226}Ra mBq/g	range	sample size (N)
cortical bone (adults)	o.26	o.o6 - o.52	865
still births	o.o7	o.o4 - o.11	45o
neonatal deaths 7d - 1a	o.24	o.o5 - o.38	9o
placentae	o.o3	o.o3 - o.o4	2263
blood-plasma	o.o2	o.o1 - o.o3	7 (liter)
standard-diet	o.o1	o.oo6 - o.16	235 (daily rations) equivalent: 33o kg
drinking-water	o.o1	o.ooo4- o.1o	98
mineral waters	o.o7	o.ooo4- o.6o	157

Tab. 1: Arithmetical average and range of measured radium concentration per g fresh weight

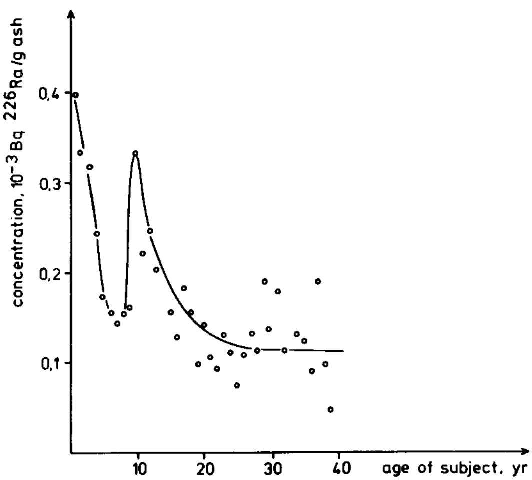

Fig. 1: Radium concentration in bone ash as a function of age

Discussion

There are two maxima to be noted in the function of age-dependence of the ^{226}Ra-concentration in bone. The first of these maxima is obtained at the age of one year, whereas the second one is reached between the age of 1o and the age of 16. These maxima coincide with the first and the second phases of rapid growth of the human skeleton. During these phases, the discrimination of Ra against Ca appears to be considerably reduced in comparison with that discrimination during the normal phases of stationary bone-growth. This is due to the rapid build-up of hydroxylapatite crystals in bone, with the result that the crystals take in as much Ra as Ca. During the phases of stationary bone-growth, diffusion and recrystalisation are the predominant processes which cause Ra to be substituted by Ca, i.e. the elimination of Ra to be accelerated.

Age-dependence of ^{226}Ra in the skeleton has already been observed with chickens.

A continual intake of ^{226}Ra with daily diet can be supposed to occur in both cases. The results can only be explained if the correlation, that exists between Ra and Ca with regard to their equivalent chemical and biochemical behaviour, is taken into consideration.

The transfer factors, which are defined as the ratios of ^{226}Ra-concentration in the target substances to those in the starting substances, were also determinated for some combinations of interest.

The transfer factors measured for these transitions are listed in Table 2.

	^{226}Ra
TF $\frac{\text{blood plasma}}{\text{food}}$	15.5
TF $\frac{\text{placentae}}{\text{food}}$	7.1
TF $\frac{\text{still-births}}{\text{food}}$	o.o31
TF $\frac{\text{bone}}{\text{food}}$	o.o98
TF $\frac{\text{still-birth}}{\text{placentae}}$	o.oo44

Tab. 2: Transfer factor (TF) for ^{226}Ra per gram

If considering the radiation exposure caused by intake of ^{226}Ra in the human body, potable waters represent only a minor part of the total intake. If presupposing a average concentration of 4 mBq ^{226}Ra/l in German drinking water, and, realistically, the consumption of o.5 liters per day of drinking water, the total intake resulting from water is of 2 mBq ^{226}Ra/d. Compared to the 15 mBq ^{226}Ra/d resulting from the intake of normal diet, potable water appears to be of minor importance. Some persons, however, consume up to 2 litres of mineral water a day, which, with a maximum concentration of o.6 Bq ^{226}Ra/l, results in a daily intake of 1.2 Bq ^{226}Ra, i.e. an annual intake of about 438 Bq ^{226}Ra. Presupposing a transfer factor water/bone of o.o98, the amount of ^{226}Ra collected during on year is of 43 Bq ^{226}Ra. Calculated on the basis of the "Strahlenschutzverordnung" (4) (Official German radiation protection regulations), this corresponds to an annual dose of $D_q{}^{226}Ra$,bone = 3.4 mSv. This value is ten times superior to the limit of o.3 mSv/a laid down in the "Strahlenschutzverordnung".

Literature

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