

## Physical Characteristics of the Japanese in Relation to Reference Man

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### Introduction

Quantitative description of physical and other characteristics of the human body is one of the basic data for estimating dose equivalent and calculating annual limit on intake of radionuclides in line with the ICRP Recommendations(1,2). ICRP Reference Man is practically based on the data reported for populations the habitat of which is Western European and North American areas although it is stated that "it is neither feasible nor necessary to specify Reference Man as representative of a well-defined population group"(3). In order to be more realistic and quantitative in the dose equivalent estimation and ALI calculation in Japan populations of which are different from those of European and North American countries in physical dimensions and other aspects, standard or reference values for the Japanese, i.e. mass and dimensions of body and organs, and the daily intake, distribution, and metabolism of elements have been being studied particularly on the basis of more recently obtained data(4). These values that has been obtained are compared with those of authorized ICRP Reference Man(3) with the intention of establishing "reference Japanese man" and contributing to improvement of models of man used in radiation protection. A calculation of dose equivalent commitment and annual limit on intake of radioiodine using the obtained data for the Japanese adult is referred. The present approach may be of importance regarding the demographic contribution of Asian populations to the world population.

### Methods

The weight and size of the body and organs were measured in autopsy for subjects who died of sudden death, mostly from traffic accidents. Autopsy was carried out 12-24 hr after death at the Tokyo Medical Examiners Office, Otsuka, Bunkyo-ku, Tokyo. From protocols of 10,598 cases recorded during the period 1971-1976, 2,880 cases were selected, using as a criterion those individuals who had been physiologically normal. Data for subjects having pathological changes in any single organ which tend to cause a change in the normal weight of organs were rejected in the statistical study carried out at the National Institute of Radiological Sciences. The obtained results, therefore, are considered to represent the normal Japanese in the strict sense.

Separate from this, bone and other autopsy tissue samples were collected from a few districts including Tokyo during the period 1961-1976. Chemical analysis are being carried out using techniques

of trace analysis developed for the present purpose, including vacuum drying and plasma-dry ashing of autopsy tissues, atomic absorption and emission spectroscopy and also partly employing rooms specifically designed for use in trace analysis, and, in some part, being assisted with simultaneous multielement analysis techniques.

A low dose of 74 nCi of I-131 were orally administered as sodium iodide to two voluntary, normal adult male subjects and the uptake and retention of ingested radioiodine in the thyroid gland was measured using the N. I. R. S. 8 in.-dia. NaI(Tl) Human Counter in a collimation mode.

Results and Discussion

The total body weight and length as presently studied was in good agreement with the published data for the Japanese of different ages reported by the Ministry of Health and Welfare and the Ministry of Education for essentially the same period. The data(5,6) is plotted as a function of age and compared with the data used for ICRP Reference Man in Fig. 1. Average total body weight of the Japanese adult male and female was approximately 59 and 51 kg, respectively being compared with approx. 75 and 58 kg for the European and American counterparts, respectively. Average length of the total body was approx. 165 and 155 cm for the male and female, respectively which are compared with approx. 175 and 164 cm for the Caucasian counterparts, respectively.

The mean weight of twelve organs for males and of eleven organs for females were obtained as a function of postnatal age as well as the relative weight of organs with respect to total body weight. Mean organ weight of the normal Japanese adult is shown in Table 1 along with the literature data for the Europeans and Americans being referred to in the ICRP Publication(3) for comparison. Remarkably lower weight of the spleen was noticed in the Japanese male, and, however, comparable values were seen in children between the data. Apparently higher values were found for the thymus and pancreas in the Japanese adult as compared to those referred to by ICRP(3). The

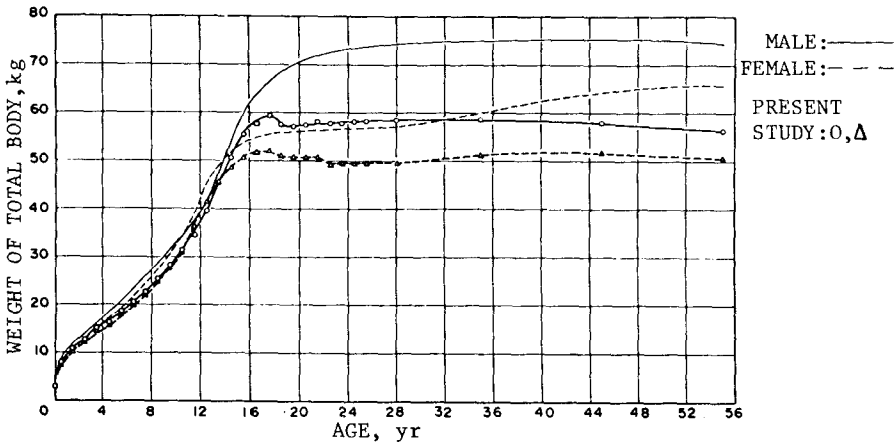


Fig. 1. Total body weight of Japanese as compared to that of Europeans and Americans.

weight of the spleen in the Japanese adult male was 127 g which is compared with the literature value of 192 g(3). The mean weight of the thymus and pancreas was 31.7 and 135 g in the Japanese adult male which are compared with those referred to by ICRP, 19.7 and 96.1 g for the European and American counterpart, respectively. Comparative weights were observed for other organs, e.g. adrenals, hypophysis or pituitary gland, testes, thyroid gland, heart, kidneys, brain and lungs. The mean liver weight in the Japanese was smaller than that referred to in Reference Man(3). These may be explained by a possible correlation between the weight of some organs and the total body weight. Similar results were seen for the Japanese adult female as also shown in Table 1. Relative weight of a given organ to the total body weight found in the present study was apparently larger than that given in Reference Man for most of organs studied except spleen. This should be stressed because it suggests that estimating weights of organs of a certain population using relative weights reported for different populations is not necessarily valid.

Table 1. Weight of organs and total body weight proposed for reference Japanese adult as compared with ICRP Reference Man values.

Organ	Japanese adult		ICRP Reference adult	
	Male (g) (%)	Female (g) (%)	Male (g) (%)	Female (g) (%)
Adrenal glands	13(0.026)	13(0.028)	14(0.020)	14(0.024)
Brain	1400(2.6)	1300(2.8)	1400(2.0)	1200(2.1)
Heart	350(0.66)	280(0.61)	330(0.47)	240(0.41)
Kidneys	330(0.59)	280(0.60)	310(0.44)	275(0.47)
Liver	1600(2.9)	1400(2.9)	1800(2.6)	1400(2.4)
Lungs	1100(2.1)	900(1.9)	1000(1.4)	800(1.4)
Pancreas	135(0.24)	100(0.24)	100(0.14)	85(0.15)
Pituitary gland	0.6(0.0010)	0.6(0.0013)	0.6(0.00086)	0.7(0.0012)
Spleen	130(0.23)	120(0.26)	180(0.26)	150(0.26)
Testes	33(0.058)	—	35(0.050)	—
Thymus	30(0.054)	25(0.053)	20(0.029)	20(0.034)
Thyroid gland	19(0.034)	17(0.035)	20(0.029)	17(0.029)
Total body weight	60000	51000	70000	58000

The present data for most of organs studied exceeds that reported for the normal Japanese in 1952(7). Improvement in the general nutritional condition may have had possible influences. Differences between the reported data for pathological cases and normal cases are also pointed out.

A comparison of per capita daily consumption of principal nutrients and categorized foodstuffs between Japan, and European countries and the United States. Calcium as well as fat is factor of two less consumed in Japan than in the latter countries, even on the unit body weight basis. Forty-eight per cent of the total fat comes from vegetables and other plants. Consumption of dairy products, meat and milk is factor of two to four lower in Japan and, however, fish meat is consumed at a rate approx. four times larger than in European and American countries. Consumption of many kinds of sea algae and their products is regarded also characteristic to the Japanese population.

For the elemental composition of the human body and daily intake, data is being accumulated and, in the present paper, strontium is referred in relation to calcium. Strontium in bone has been extensively

Table 2. Skeletal content and daily intake of Ca and Sr in adult.

	Present work	ICRP(3)
Skeletal content:		
Calcium	840 g	1000 g
Strontium	430 mg	320 mg
Daily intake:		
Calcium	0.54 g	1.1 g
Strontium	2.3 mg	1.9 mg

studied using samples of various ages including gestational stage and the mean strontium to calcium concentration ratio in the adult(20-49 yr) bone was found 0.51 mg Sr per g of Ca. Skeletal mass was estimated tentatively using the ICRP assumption, 0.14 of the total body weight until a valid data for the Japa-

nese will be available. Apparently larger skeletal strontium content in the Japanese adult male than the ICRP estimate for European and American counterpart. This may be due to the dietary Sr/Ca ratio which was found factor of two higher in Japan and this may be related to the characteristically low consumption of milk and dairy products.

Regarding the remarkably high level of natural iodine intake in the Japanese up to between 500 and 1000  $\mu\text{g}$  per day per person which has been reported, an isotope dilution effect is expected. Fraction of I-131 incorporated in the thyroid gland,  $K_2$ (8) was found 0.11 in one subject taking normal meals containing a kind of kelp and other marine algae and their products throughout the experiment. In the other subject for whom the intake of these kinds of foodstuffs had been restricted as far as possible for two weeks until the oral administration of I-131,  $K_2$  was found 0.33. Biological half-life was estimated to be 29.9 and 40.4 days for the former and the latter subject, respectively. It is suggested that the thyroidal uptake rate can be estimated as 0.15 to 0.20 and that the biological half-life is probably estimated as 35 days in the Japanese adult. The data is considerably smaller than that adopted by ICRP(8).

Establishment of reference Japanese man data will be useful for one to calculate more realistic dose-equivalent commitment and also annual limit on intake for radioactive isotopes. A result of such calculation employing a unique transformation method developed to apply the MIRD absorbed dose fraction data to an individual of an arbitrary physique and the weight of organs and other data obtained in the present study(9) shows a lower annual limit on intake for I-131 in the Japanese adult as compared with that calculated for the MIRD phantom.

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REFERENCES

1) ICRP Publication 26(1977). 2) ICRP Publication 30(1979). 3) ICRP Publication 23(1975). 4) G. Tanaka et al., Health Phys. 36,333(1979). 5) Ministry of Health and Welfare, National Nutrition Survey of Japan 1974(1977). 6)Ministry of Education, School Health Statistics Survey Report, MEJ 6908(1977). 7) Aimi et al., Acta. path. jap. 2, 173(1952). 8) ICRP Publication 10(1968). 9) H. Yamaguchi, Acta Radiologica Oncology 17, 429(1977).