XA9846841

PHYSICAL AND ANATOMICAL DATA, AND PART OF PHYSIOLOGICAL AND METABOLIC DATA FOR NORMAL JAPANESE WITH SPECIAL REFERENCE TO ESTABLISHING REFERENCE ASIAN MAN MODEL FOR THE ANATOMICAL CHARACTERISTICS

G. TANAKA, H. KAWAMURA
Division of Radioecology,
National Institute of Radiological Sciences,
Japan

Abstract

Studies on the physical, anatomical, and partial metabolic as well as physiological characteristics on Reference Japanese Man were undertaken to establish reference values for use in internal dose assessment and to assign annual limits on intakes of radionuclides for Japanese workers and members of the general public. Secular trends in, and/or probable influences of nutritional conditions on the organ mass were examined by comparing the present results with the other normal Japanese data.

The average height of male and female adults (20-50 y) were 168 and 155 cm, respectively. The body weights for males and females, 20-50 y, were - 64 and 52 kg. The data on the weight and size of twelve organs in normal males and eleven in normal females were obtained from autopsy, 12 to 24 h after sudden death.

The per caput intake of foodstuffs and principal nutrients were taken from the annual report of the National nutrition Survey for households in the urban and rural areas in all districts of Japan. Determination of elemental intake was made by collecting one full day of meals for adult males from 31 prefectures in practically all districts of Japan.

Pulmonary function parameters studied include total lung capacity, vital capacity, minute volume and 8h working volume at various levels of exertion - resting, light and heavy activity. The subjects were healthy, normal Japanese males and females.

Water balance data were obtained for 9 males and 6 females in Tokyo, under conditions of controlled energy and salt intake. The lengths of the study period were 6 and 10 days, respectively. Daily intakes of energy and salt were determined for the male student athletes for whom an indoor physical training was assigned.

INTRODUCTION

Studies on the physical, anatomical and part of metabolic as well as physiological characteristics on Reference Japanese Man were conceived in 1960s and initiated in early 1970s [1-5]. These were undertaken to establish reference values of the human body for use in internal dose assessment and to assign annual limits on intakes of radionuclides (i.e. the secondary limits set by the ICRP) for Japanese workers and members of the general public. Additional anatomical and physical data, as well as elemental intake information were added as the revision of Reference Man by ICRP Committee 2 began in 1986, and for the current IAEA-RCA Co-ordinated Research Programme which started in 1989 [6-11].

During the past five years, the studies were updated with an emphasis on developing a systematic model of the human body, based on the system used for ICRP Reference Man [1]. These studies were designed to establish Reference Japanese parameters for children and adults, and to contribute to a Reference Asian Man for internal dose assessment [8, 13]. Data on consumption of categorized foods, on the other hand, is needed to control radiation risks from contaminated foods and, more importantly, to predict pathways of radionuclides from foods to man. Analytical data on the intake of elements is significant in simulating the transfer of radionuclides through the ingestion, as well as in evaluating nutritional background of the population studied [2, 6, 7, 11]. The pulmonary function and water balance data will be also important to assess inhalation and ingestion exposures.

PHYSICAL MEASUREMENTS

Data on the measurements of Japanese physique were available in the School Health Survey that covers the entire country including children in the age range 5 to 17. This survey has been conducted since 1900 except for the period of World War 2 [14]. Approximately 72,000 subjects in kindergartens, 270,000 in primary schools, 220,000 in middle schools and 120,000 in high schools are sampled every year. Measurements are made in May for all students. The samples are few per cent of the population of these ages, and the total number of samples taken was approximately 7.78 millions during the period 1976 - 1988. Additional data were obtained for other ages from the National Nutrition Survey that includes measurement of physique, skinfold thickness and some health data. The survey is conducted in early November. Until recently, data were collected every five years. Now they are collected yearly [15]. Approximately 20,000 subjects from about 7,000 households in 300 locations were studied for each year. Data on physical measurements for the newborn to 6.5 years are available in the report on the Growth of Infants and Preschool Children that is published every five years [16]. Body surfaces were estimated as described elsewhere [12].

MEASUREMENTS OF ORGAN MASS AND BODY COMPOSITION

The data on the weight and size of twelve organs in males and eleven in females were obtained from autopsy, 12 to 24 h after sudden death from traffic accidents, shocks, poisoning and heart attack. The subjects were believed to be otherwise normal and healthy at time of death. The autopsies were conducted in Tokyo Medical Examiners Office during the period 1971-1976 [2, 4]. From 10,598 cases, 2,880 were selected which showed no pathological changes in any organs [4]. In the period 1970-1980, a total number of 5,370 cases (including the previously studied 2,880 cases) with little or no pathological changes were selected from approximately 18,000 protocols in all [9, 13]. The data were statistically analyzed by using a CDC 6600 computer [2, 4]. These data were considered to represent normal individuals, appropriate for estimating organ mass in Reference Japanese Man.

Secular trend in, and/or probable influences of nutritional conditions on the organ mass were examined by comparing the present results with the other normal Japanese data reported by Aimi et al. [17]. These were obtained by methods identical to those used in the present work, in the same institute and for the similar purpose.

Mass of the mineralized bone were measured on 17 complete sets of bone samples [18]. Because the weight of red marrow reported for Japanese was considered to be relatively small, the mass of the red marrow was estimated using literature values for the distribution of marrow in an adult skeleton reported for a Caucasoid [19, 20].

The lipid content of the body was obtained from measurements of the skinfold thickness using Nagamine's equations for Japanese of different ages [12], then the lean body mass (LBM), contents of blood, water and muscle as well as protein. The "gross content" of ICRP Reference Man [1] were taken into consideration [13].

FOOD CONSUMPTION

The per caput intake of categorized foodstuffs and principal nutrients were taken from the annual report of the National nutrition Survey briefly mentioned above. In this survey, a stratified sampling is made for households of different occupation in the urban and rural areas in all districts of Japan [15].

Determination of elemental intake was made by obtaining the aliquots of ash samples from composite full one day meals collected from five households representing 5 adult males in every 31 locations throughout the country. In general, sampling was done in both summer

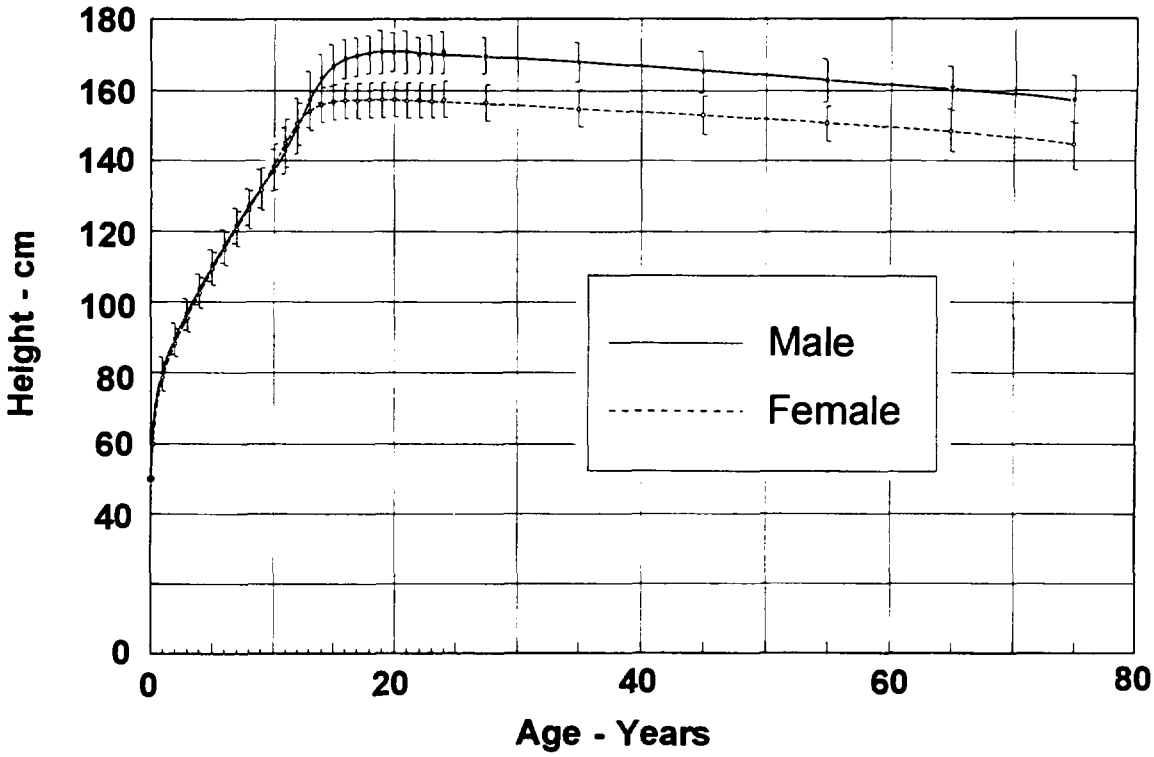


Fig 1 - Height as a function of age

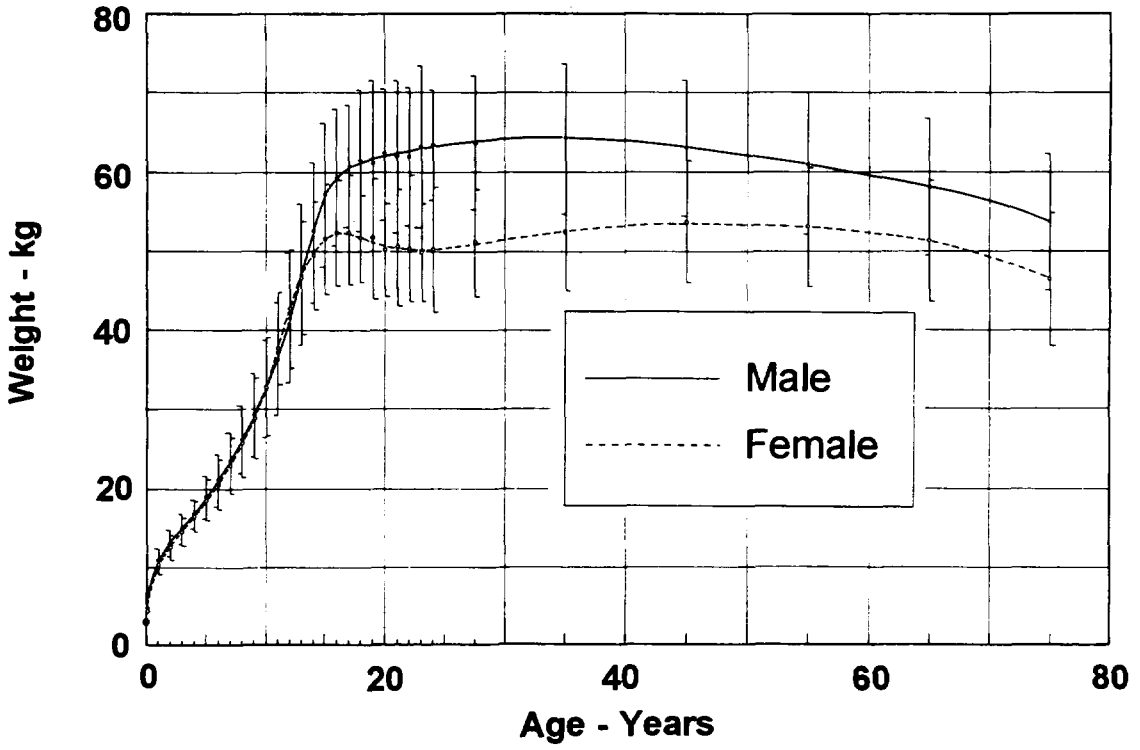


Fig 2 - Weight as a function of age

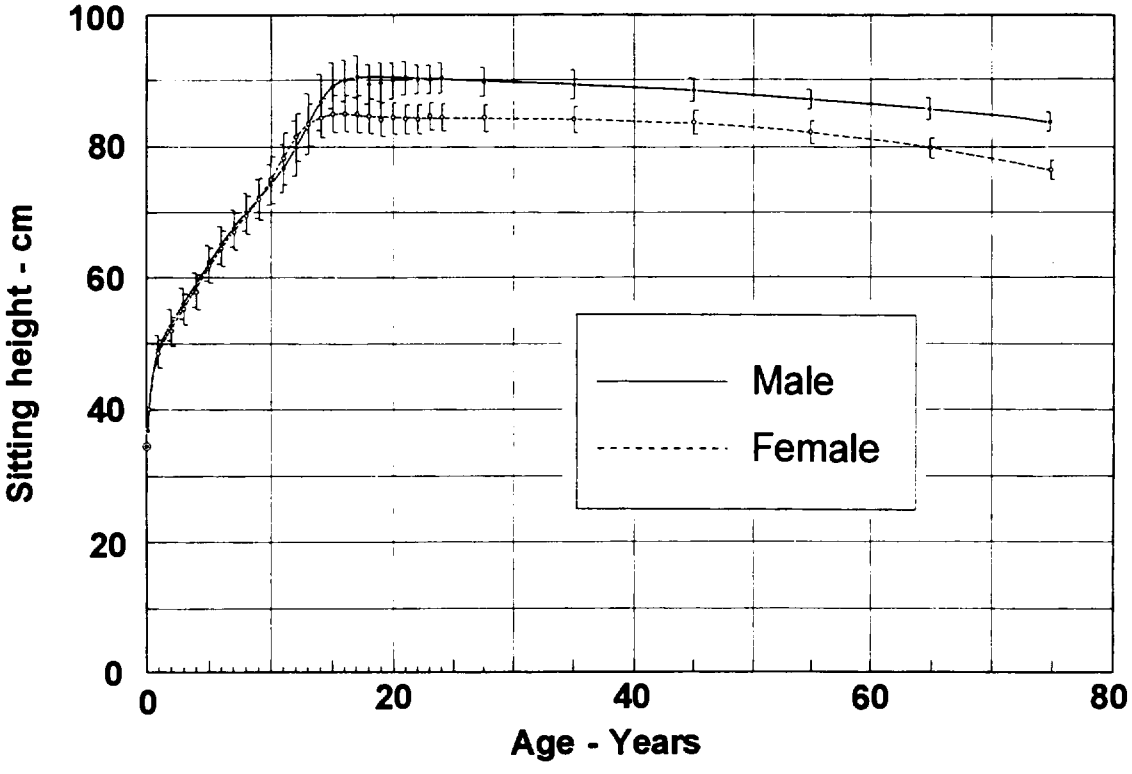


Fig 3 - Sitting height as a function of age

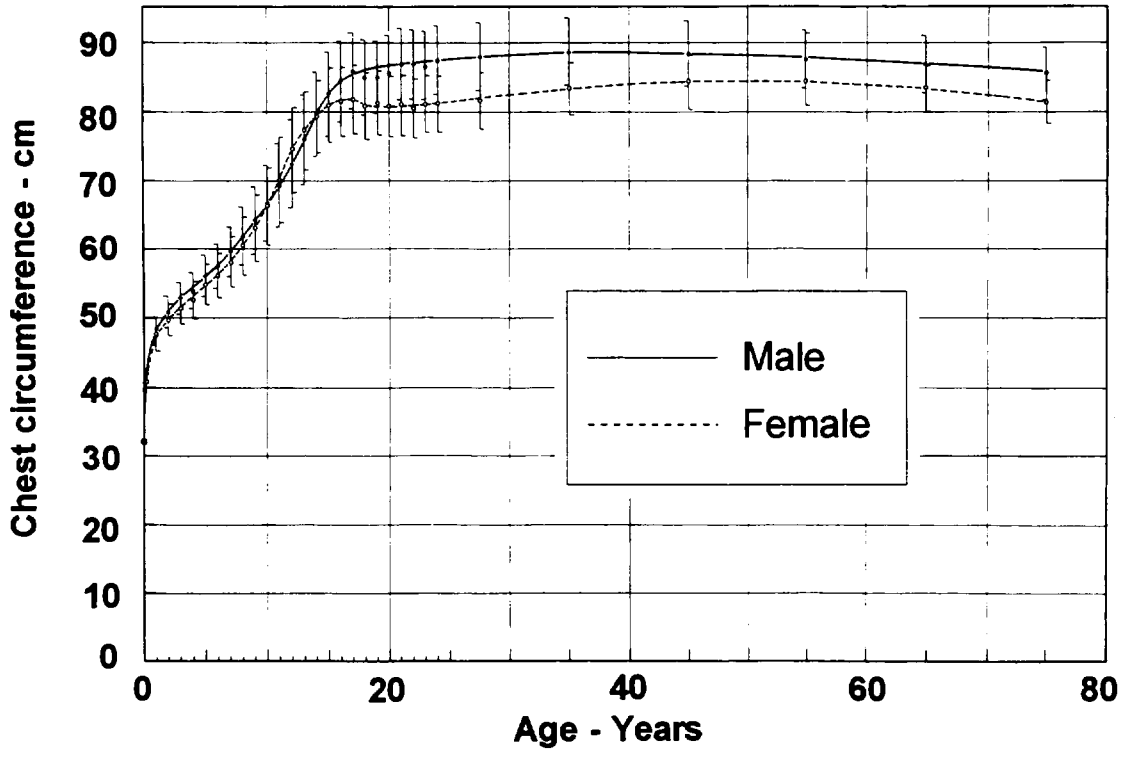


Fig 4 - Chest circumference as a function of age

TABLE I. INDIVIDUAL VALUES OF BODY HEIGHT, WEIGHT, SITTING HEIGHT AND CHEST CIRCUMFERENCE OF JAPANESE AS FUNCTIONS OF AGE

Sex	Age	Body height (cm)	Body weight (kg)	Sitting height (cm)	Chest circumference (cm)
Male	0-1 m	49.7	3.23	34.4	32.5
	2-3 m			36.8	
	1 y	75.3	9.64	(49.1)	46.9
	5 y	110.5	19.0	62.3	56.2
	10 y	137.4	32.5	74.3	66.8
	15 y	167.2	57.2	89.2	82.7
	20-29 y	170.2	63.3	90.1	87.4
	30-39 y	168.0	64.4	89.5	88.6
	40-49 y	165.2	63.2	88.7	88.3
	20-50 y	167.8	63.6	89.4	88.1
Female	0-1 m	49.3	3.16	34.4	32.4
	2-3 m			40.0	
	1 y	74.0	9.09	(48.4)	45.7
	5 y	109.6	18.6	61.9	54.9
	10 y	138.4	32.8	75.0	66.3
	15 y	156.7	51.6	85.0	81.0
	20-29 y	157.0	50.7	84.4	81.3
	30-39 y	155.0	52.5	84.2	83.3
	40-49 y	153.0	53.8	83.8	84.2
	20-50 y	155.0	52.3	84.1	82.9

and winter. The duplicate portion sampling method was used. Samples were dry ashed and stored until analysis. A clean-air chemical hood installed in a semi-clean laboratory was used. Analyses were made with extra grade purity mineral acids for further wet ashing to obtain clear sample solutions. These were analyzed for major, minor and trace elements by using ICP emission spectrometry (ICP-ES) as well as AAS [11]. For Th and U, ultrahigh purity acids were used and ^{232}Th and ^{238}U concentrations were determined using ICP mass spectrometry (ICP-MS) [21].

PULMONARY FUNCTION

Total lung capacity and vital capacity measurements were made with subjects selected from university personnel and students, and healthy local inhabitants of the Hiroshima Prefecture in the western part of main island of Honshu [22]. According to the co-ordinating respiratory physiologist, "no appropriate data are available for the newborn and (young) children because subjective strong effort is needed to obtain vital capacity and total lung capacity" [23]. The age groups presented here are partly different from those specified in the CRP protocol.

The subjects for the study of minute volume and 8h working volume were healthy, normal Japanese. Again, no appropriate data could be obtained for the newborn and 1-y old infants for the heavy activity level [24]. For the resting and light activity levels, ventilations

were calculated from age-specific basal metabolic rates of Japanese (Workshop Committee for the Ministry of Health and Welfare 1984), assuming one liter of oxygen consumption per 4.80 kcal and using appropriate ventilatory equivalents (V. E.) for oxygen in different age groups and activity levels. Energy consumption of the light activity level is defined as twice that of the resting level. Therefore, no specific number of subjects was presented. Ventilations for the heavy activity level, on the other hand, were taken from the actual experiments [25, 26].

WATER BALANCE

Data on the daily intake of water and its elimination were obtained for 9 males (18-21 y) and 6 females (18-22 y) in Tokyo, under conditions of controlled energy and salt intake [27]. The lengths of the study period were 6 and 10 days, respectively. Daily intakes of energy and salt were 3000 kcal and 18 g per person for the male student athletes for whom an indoor physical training was assigned. Daily intakes of energy and salt for the females were 1900 kcal and 6 g, respectively. They had a 1-h exercise regime using a bicycle ergometer to simulate commuting activities.

RESULTS AND DISCUSSION

Physical parameters

The body height, weight, sitting height and chest circumference of Japanese as functions of age are shown in Fig. 1-4 [12]. The individual values for the newborn to 40-49 y are shown in Table I. Secular trends, though less than a few decades ago, are still found. However, these measurements were averaged over for more than ten years. The secular trend in the sitting height was seen relatively small. As to the spurt in growth for boy and girls, reversals were seen in height (10-12 y), weight (11-12 y), sitting height (10-12 y) and chest circumference (10-13 y).

The distributions of these measurements were studied for 5 to 17 years during the period from 1980 to 1992. The frequency distribution for the body height, weight, sitting height and chest circumference for age 17 years are shown in Fig. 5 and 6. In Fig. 5, frequencies were plotted against logarithms of the body weight (kg). Sitting height and body height showed a normal distribution, while body weight and chest circumference have distributions that are skewed to higher values. However, the convention of using the population means was adopted for ease of comparison with other, published data. The average height of young male and female adults (20-29 y) was 170 and 157 cm, respectively while those of older adults (20-50 y) were 168 and 155 cm for males and females, respectively. The body weights for males and females of 20-29 y were 63.3 and 50.7 kg, respectively, similar to those of 20-50 y males and females - 63.6 and 52.3 kg, respectively. Reference values for the body height and weight were set as shown in Table II. The previous value of male height 165 cm [4] was increased to 170 cm because of the secular trend. In addition, a "two digit rule" was employed [1] considering the uncertainty due to biological variation. The height is close to that of ICRP Reference Man which is currently being reconsidered by the Task Group on Reference Man Revision.

Organ masses

The number of organ measurements for younger ages groups, i.e. newborn, 1, 5, 10 and 15 y were small: e.g. 70 male and 43 female subjects for a single age. The sampling among adults 20 to 50 y, however was sufficiently large: up to 2300 in males and about 550 in females. The individual variation was found to be particularly large for the thymus. To

eliminate fluctuations, the observed values of organ masses at various ages were processed by a computer to obtain cubic spline approximation functions. Thus "smoothed" curves were obtained for each organ. However, from a cross sectional study, these will provide quantitative information on the growth of individual organs [12]. Masses of organs as functions of postnatal age are graphically presented elsewhere [12]. The "representative values" for 1, 5, 10, 15 y and the adult are listed in Table III.

The measured weights of bone at various sites, practically all bones of Japanese, are shown in Table IV, along with the mass of the wet mineralized bone and the estimated red marrow mass. The contents of the lipid, LBM, mineral, protein and water for various ages are presented in Table V.

Dietary measurements

The national averages and associated standard deviations are listed in Table VI for the food groups identified in the CRP format. A gradual decrease in consumption of rice was seen in the past 20 years. A slight but steady increase in the consumption of meat and dairy products have been observed. However, the typical pattern of food consumption as an Asian country seems to have been maintained. This was seen partly by elemental determinations of the duplicate meals as described later in this section.

The results of chemical analyses of dietary elemental composition are shown in Table VII. In spite of a large number of publications on elemental concentrations in foods, and several reported data on the intake of elements through the total diet, only a few like the present study cover practically the whole country. However, due to a short period of collecting samples, day-to-day variation plus the local and seasonal variation may be reflected in the reported ranges.

For natural iodine, an ordinary range of intake - 0.5-1.0, up to 2.0 mg/p/d - has been assumed according to the literature. It comes mainly from sea foods, especially algae in a raw and dried form, traditionally eaten as a component of the Japanese diet. These algae are mainly "konbu", tangle or kelp in Japanese (Laminaria) and "wakame" (Undaria). Due to considerable difficulties in determining iodine in whole one-day meals, representative daily intakes should be estimated from determination of natural iodine-rich marine algae and the data on their consumption.

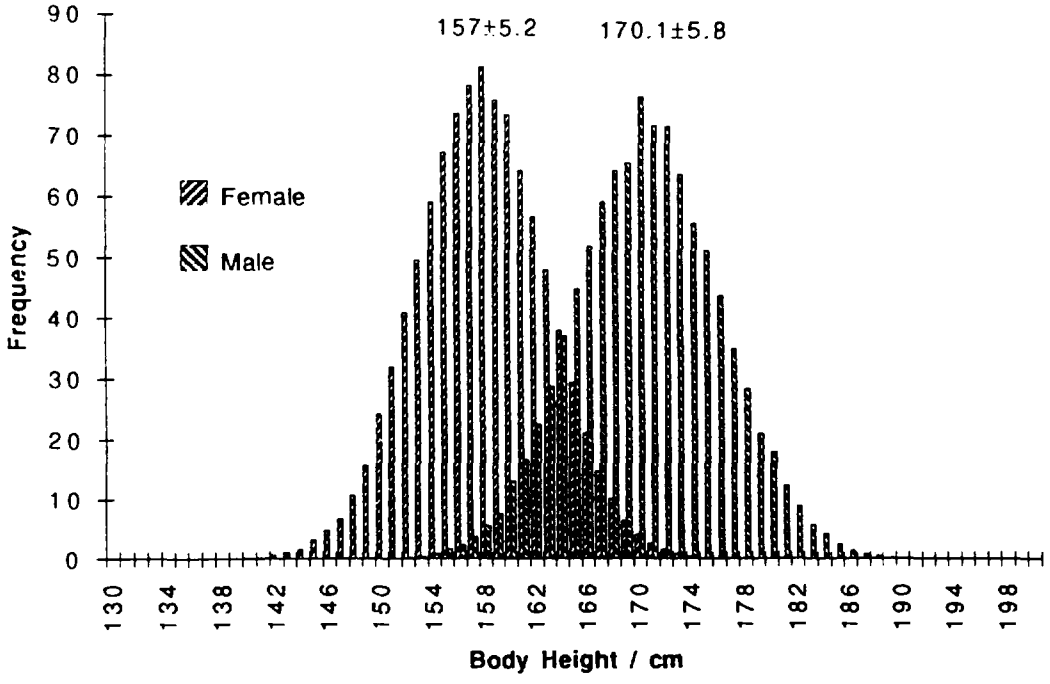
Similar stable intakes for various elements were observed in late 1960s and early 1980s, both by the duplicate portion study. The Sr-to-Ca ratio, which may reflect the pattern of food consumption or contribution of milk and dairy products in the intake of Sr and Ca, was seen essentially unchanged (Sr/Ca mass ratio found: 4.2×10^{-3} in 1967-69, 4.0×10^{-3} in 1981-82). Taking other data into consideration, tentative estimates of the elemental intake for Japanese studied by the duplicate portion method are presented in Table VIII.

Pulmonary function

As shown in Table IX, the total lung capacity was 5.24 and 5.58 l for the male of 16-19 and 20-29 y, respectively. That for the age range 20-49 y, the value was 5.59 l. The average total lung capacity was 4.05 l for the female adult, 20-49 y.

The vital capacity for the male and female, 16-79 y, was 3.89 ± 0.66 and 2.75 ± 0.46 l, respectively as shown in Table IX. It was 4.20 and 2.92 l for the 20-49 y male and female as calculated in the same table.

As shown in Table X, the minute volume for the newborn male and female was 1.6 and 3.2 l/min for the resting and light activity stage, respectively. Maximum values were seen for the age 15. In the male, it was 6.4, 12.6 and 102.9 l/min for the resting, light activity and



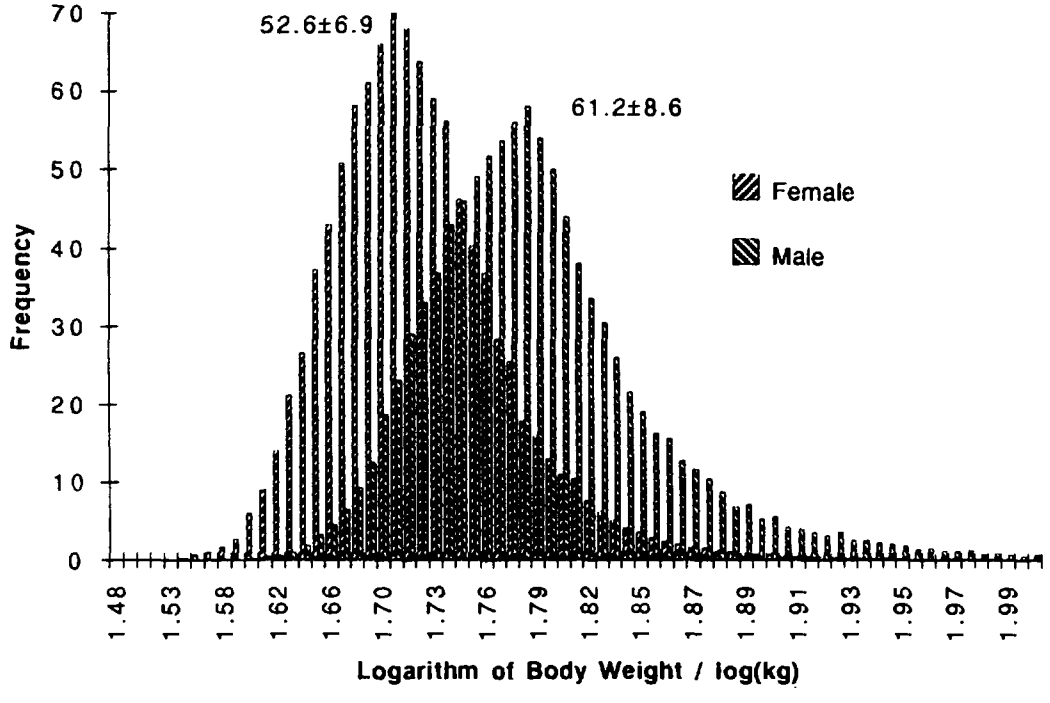
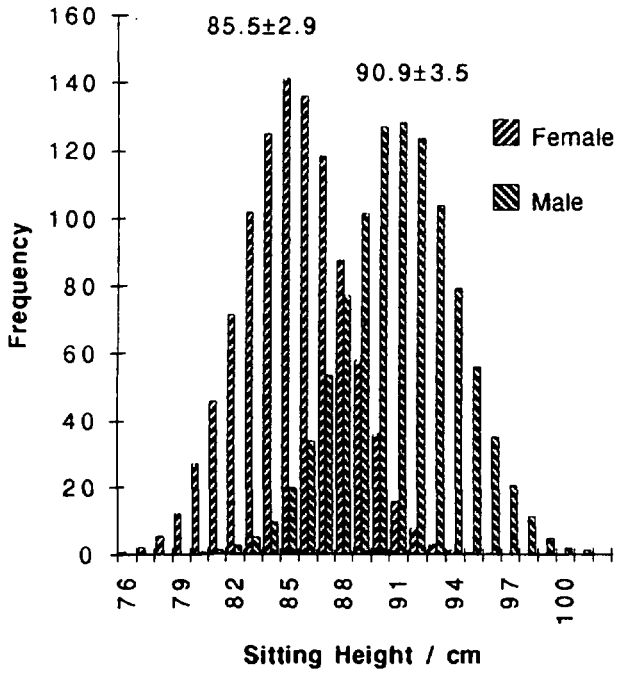


Fig. 5. Distribution of body height (upper) and weight (lower) for 17 year boys and girls found during 1980-92.



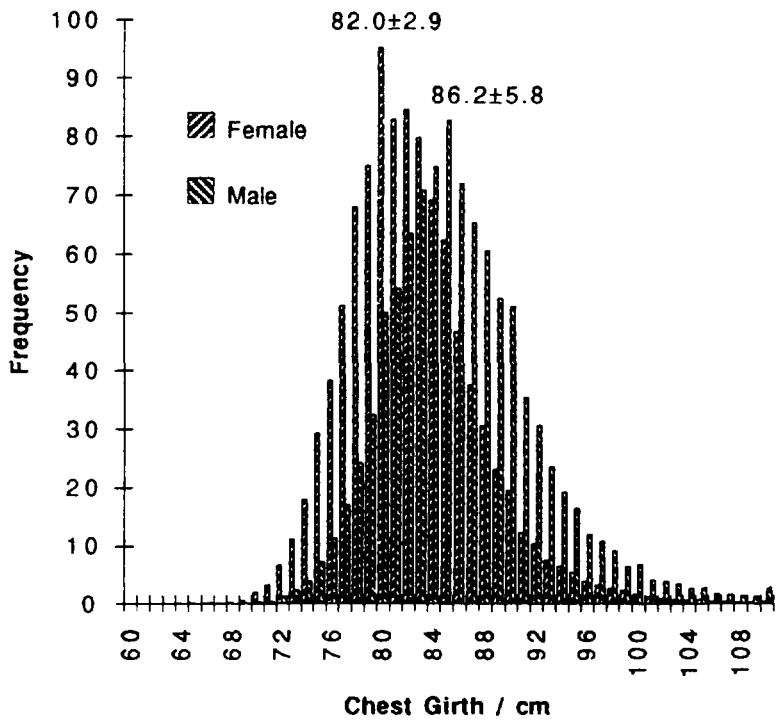


Fig. 6. Distribution of sitting height (upper) and chest circumference (lower) for 17 year boys and girls found during 1980-92.

heavy activity stage, respectively. In the 15-y female, the minute volume was 5.3, 10.6 and 57.4 l/min for the resting, light and heavy activity level, respectively. In the male adult, 20-50 y, it was 5.1, 10.2 and 87.0 l/min for the three stages, respectively in the increasing order. The minute volume for the female adult was 4.2, 8.4 and 52.5 l/min for the resting, and light and heavy activity level, respectively [25, 26].

The male and female newborn 8h working volume, in the resting stage was 768 l and under light activity was found to be 1536 l as shown in Table X. For the 15-y old boys, it was 6048 and 49392 l for the light and heavy activity level, respectively. The 8h working volume for the 15-y old girls was 5088 and 27552 l, respectively for the light and heavy activity stages. The adult male 8h volumes were 2448, 4896 and 41760 l for the resting, and light and heavy activity stage, respectively. In the female counterpart, the equivalent values were 2016, 4032 and 25200 l for each level [23].

Water balance

As presented in Table XI, the average total daily intake of water in 18 to 21-y males was 3312 g under the experimental conditions, in spring 1990. The elimination through urine, feces, and breath and sweat pooled were 1218, 182 and 1908 g in average, respectively with the total elimination 3308 g [27]. For 18 to 22-y females, the average total water intake was 2738 g under the conditions used, in summer 1990. The elimination via urine, feces, and breath and sweat pooled were 1008, 67 and 1666 g, with a total elimination 2741 g. The daily elimination of water normalized to the body weight was 31.9 $\pm$ 4.1 and 31.9 $\pm$ 4.4 g/kg for males and females, respectively [27]. Exact values of water intake were not obtained in this study.

TABLE II. BODY HEIGHT AND WEIGHT FOR REFERENCE JAPANESE MALE AND FEMALE (20-50 y)

Sex	Total body	Present work (1988)	ICRP Ref. Man (1975)
Male	Height (cm)	170	170
	Weight (kg)	60	70
Female	Height (cm)	160	160
	Weight (kg)	52	58

TABLE III. MASS OF ORGANS OF NORMAL JAPANESE OF DIFFERENT AGE GROUPS (g)

Organ	1 y		5 y		10 y		15 y		Adult	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Brain	1094	1025	1367	1302	1450	1325	1468	1331	1469	1331
Pituitary gland	0.22	0.25	0.29	0.30	0.40	0.45	0.53	0.61	0.57	0.64
Thyroid gland	2.3	2.4	4.5	4.6	8.4	8.6	15.5	15.0	19.0	16.9
Thymus	27.1	27.5	34.7	31.0	41.5	32.4	36.7	31.8	31.0	29.6
Heart	50	52	102	103	176	180	290	239	362	306
Lungs	189	176	322	286	542	472	930	678	1151	860
Left	84	81	151	131	257	219	456	310	534	388
Right	105	95	171	155	285	253	474	368	617	475
Liver	380	370	626	601	1005	974	1374	1243	1585	1358
Spleen	36	33	59	58	88	87	118	112	141	128
Pancreas	23	20	44	39	71	65	100	89	129	109
Kidneys	66	64	118	104	185	169	254	229	318	278
Left	33	33	60	53	95	86	131	116	164	143
Right	33	31	58	51	90	83	123	113	154	135
Adrenal glands	4.46	4.15	5.57	5.60	8.14	8.14	11.31	10.62	14.02	12.54
Left	2.28	2.14	2.81	2.86	4.13	4.17	5.76	5.45	7.25	6.47
Right	2.18	2.01	2.76	2.74	4.01	3.97	5.55	5.17	6.77	6.07
Testes	2.64	-	3.11	-	4.71	-	33.39	-	37.05	-
Left	1.31	-	1.50	-	2.19	-	16.47	-	18.15	-
Right	1.33	-	1.61	-	2.52	-	16.92	-	18.90	-

TABLE IV. MASSES OF THE MINERAL BONE AND ESTIMATED MASS OF THE ACTIVE RED MARROW IN THE JAPANESE ADULT MALE (g)

Bone	Mineralized bone		Wet bone	Red marrow
	Mean*	S.D.	(estimated)	(estimated)
Head	694.9	51.7	730	135.0
Cranium	602.3	50.8		
Mandible	92.6	11.7		
Clavicles	48.1	2.9	52	14.4
Scapulae	130.3	9.3	140	45.0
Ribs (12)	283.5	23.4	307	92.4
Sternum	20.8	3.5	23	20.8
Vertebrae	372.1	31.7	406	264.9
Cervical (7)	61.7	3.8		
Thoracic (12)	166.8	14.6		
Lumbar (5)	144.8	16.2		
Sacrum	94.6	10.5	102	129.5
Coxa	376.1	24.2	402	207.3
Upper limbs	576.9	30.9	631	17.7
Humerus (2)	284.4	16.0		
Radius (2)	85.6	6.0		
Ulna (2)	107.1	7.9		
Hand (2)	99.8	11.0		
Lower limbs	1569.8	75.7	1706	35.4
Femur (2)	745.1	38.2		
Patella (2)	29.4	2.3		
Tibia (2)	436.8	34.9		
Whole skeleton	4167.2	122.9	4500	962.4

* Mean and S.D. for the number of subjects 17.

TABLE V. CONTENT OF LIPID, LEAN BODY MASS (LBM), PROTEIN, MINERAL AND BODY WATER OF JAPANESE OF VARIOUS AGES

Sex	Age	B.W. (kg)	Lipid		LBM (kg)	Mineral (kg)	Protein (kg)	Water	
			(% B.W.)	(kg)				(% B.W.)	(kg)
Male	Newborn	3.22	11.6	0.37	2.85	0.07	0.20	80.0	2.58
	0-1 m	4.42	12.0	0.53	3.89	0.10	0.28	79.41	3.51
	2-3 m	5.78	12.0	0.69	5.09	0.12	0.45	78.20	4.52
	1 y	10.66	12.3	1.31	9.35	0.60	1.72	65.94	7.03
	5 y	18.46	14.3	2.64	15.82	1.32	3.78	58.07	10.72
	10 y	30.33	18.1	5.49	24.84	2.16	6.21	54.30	16.47
	15 y	53.70	16.6	8.91	44.79	3.13	9.09	60.64	32.57
	20 y	59.40	15.9	9.44	49.95	3.21	9.21	63.19	37.53
	20-25 y	59.67	16.8	10.03	49.64	3.22	9.20	62.38	37.22
Female	Newborn	3.19	11.5	0.37	2.82	0.07	0.20	80.00	2.55
	0-1 m	4.22	12.0	0.51	3.71	0.34	0.34	79.71	3.36
	2-3 m	5.74	12.1	0.69	5.05	0.61	0.61	74.66	4.29
	1 y	10.36	12.3	1.27	9.09	1.56	1.56	67.43	6.99
	5 y	18.00	14.6	2.63	15.38	3.71	3.71	57.63	10.38
	10 y	30.54	20.2	6.17	24.37	6.03	6.03	53.17	16.24
	15 y	49.46	25.0	12.37	37.10	8.18	8.18	52.64	26.04
	20 y	50.92	23.6	12.02	38.90	8.20	8.20	54.76	27.88
	20-50 y	50.96	25.7	13.11	37.85	8.23	8.23	52.46	26.73

TABLE VI. PER CAPUT DAILY CONSUMPTION OF CATEGORIZED FOODS AND ENERGY (g)

Food or energy	Mean	S.D.
Energy (kcal)	2153.7	
Cereals	322.1	86.6
Nuts and seeds	1.5	5.2
Pulses	67.7	47.1
Nuts, seeds & pulses	69.2	
Potatoes and starches	62.1	46.1
Sugars	13.0	10.4
Confectionaries	25.6	48.6
Sugars and Confectionaries	38.6	
Fats and oils	17.7	11.7
Fruits	164.9	118.5
Green and yellow vegetables	59.1	44.0
Other vegetables (including fungi)	200.4	90.0
Total vegetables	259.5	
Algae (mostly marine, dried)	5.2	7.3
Fish and shellfish	91.3	52.9
Meats	69.3	41.8
Eggs	40.3	23.0
Milk and milk products	114.5	90.7
Seasonings and beverages	114.9	160.5
Others	12.8	11.3
Total seasonings	127.7	

TABLE VII. DAILY DIETARY INTAKE OF ELEMENTS BY ADULT JAPANESE MALE

Element	Unit	Mean	Min.	Max.
Aluminum	mg	3.95	1.07	10.3
Barium	μg	358	156	645
Calcium	mg	563	238	1890
Cerium	μg			
Chlorine	mg			
Copper	mg	1.28	0.426	2.58
Iodine	mg	(0.5-1)		
Iron	mg	11.4	6.9	16.4
Lanthanum	μg			
Magnesium	mg	196	89	303
Manganese	mg	3.35	1.83	4.60
Phosphorus	mg	922	552	1270
Potassium	mg	1880	910	4350
Sodium	mg	4460	2340	6470
Strontium	mg	2.26	0.93	3.30
Sulfur	mg			
Thorium	μg	0.412	0.109	1.17
Uranium	μg	0.712	0.243	1.50
Zinc	mg	7.10	4.16	11.4

TABLE VIII. DAILY INTAKE OF ELEMENTS BY JAPANESE ADULT STUDIED BY THE DUPLICATE PORTION METHOD

Element	Sapporo 1967	Kyoto 1967-68	31 locations 1981-82	Mito 1983-84	Takamatsu 1986	All Japan estimate	Per cent ICRP Ref. Man
Na (g)	5.05	4.42	4.5	4.76	4.73	5.2	118
K (g)	1.92	1.53	1.9	2.41	2.79	2.0	61
Ca (g)	0.486	0.542	0.56	0.718	0.63	0.55	50
P (g)	1.07	0.899	0.92	1.20	1.20	1.0	71
Mg (g)	0.210	0.178	0.20	0.245	0.28	0.21	62
Fe (mg)	13.2	9.84	-	11.5	7.8	11	69
Zn (mg)	7.58	6.53	7.1	8.87	7.9	7.6	58
Al (mg)	5.14	4.57	4.0	4.23	2.3	4.5	10
Mn (mg)	3.77	3.95	3.4	4.29	4.1	3.8	103
Sr (mg)	2.04	1.94	2.3	2.84	-	2.3	121
Rb (mg)	2.10	1.64	-	-	-	2.2	100
Cu (mg)	1.40	1.14	1.3	1.25	1.4	1.3	37
Ba (mg)	0.453	0.410	0.36	0.482	0.42	0.43	57
Mo (mg)	1.037	0.195	-	0.215	0.29	0.18	60
Y (ug)	3.1	2.8	-	4.8	-	4	-
Th (ug)	-	-	0.412	-	-	0.41	14
U (ug)	-	-	0.712	-	-	0.71	37

TABLE IX. TOTAL LUNG CAPACITY AND VITAL CAPACITY OF NORMAL JAPANESE (LITER)

Sex	Age (y)	No. of people	Total lung capacity		Vital capacity	
			Mean	S.D.	Mean	S.D.
Male	16-19	10	5.24	0.68	4.10	0.44
	20-29	37	5.58	0.69	4.37	0.49
	30-39	76	5.67	1.00	4.23	0.65
	40-49	79	5.53	0.83	4.00	0.55
	16-79	342	5.51	0.88	3.89	0.66
Female	16-19	11	3.75	0.39	2.98	0.25
	20-29	24	3.91	0.49	3.00	0.39
	30-39	23	4.14	0.65	3.03	0.47
	40-49	23	4.09	0.84	2.74	0.46
	16-79	131	3.98	0.65	2.75	0.46

TABLE X. MINUTE VOLUME AND 8h WORKING VOLUME OF NORMAL JAPANESE

Sex	Age (y)	Minute volume (l/min)			8h working volume (l)		
		Resting	Light	Heavy	Resting	Light	Heavy
Male	Newborn	1.6	3.2		768	1536	
	1 y	2.9	5.8		1392	2784	
	5 y	4.2	8.4	40.1 (n = 46)	2016	4032	19248 (n = 46)
	10 y	5.3	10.6	50.4 (n = 16)	2544	5088	24192 (n = 16)
	15 y	6.3	12.6	102.9 (n = 17)	3024	6048	49392 (n = 17)
	20-50 y	5.1	10.2	87.0 (n = 123)	2448	4896	41760 (n = 123)
Female	Newborn	1.6	3.2		768	1536	
	1 y	2.8	5.6		1344	2698	
	5 y	3.9	7.8	36.0 (n = 39)	1872	3744	17280 (n = 39)
	10 y	5.1	10.2	40.0 (n = 16)	2448	4896	19200 (n = 16)
	15 y	5.3	10.6	57.4 (n = 15)	2544	5088	27552 (n = 15)
	20-50 y	4.2	8.4	52.5 (n = 9)	2016	4032	25200 (n = 9)

TABLE XI. WATER BALANCE IN YOUNG, NORMAL JAPANESE MALES AND FEMALES UNDER SOME CONTROLLED CONDITIONS

Sex	Age (y)	No. of people	Daily intake (g) (Water, milk, other liquid food)	Daily elimination (g)		
				Urine	Faeces	Sweat & breath
Male	18-21	9	3312.2 ± 139.5	1218.3 ± 69.3	181.5 ± 55.4	1908.4 ± 169.5
					Total = 3308.2	
Female	19-22	6	2737.8 ± 179.7	1007.7 ± 105.0	67.2 ± 13.6	1665.8 ± 230.4
					Total = 2740.7	

CONCLUSIONS

The physical and anatomical data for normal Japanese have been updated to provide representative and reference values which will establish a firm basis for modelling Reference Japanese Man, as well as Reference Asian Man for radiation protection dosimetry.

The dietary data represent the whole country. The elemental intake is considered to well represent the all districts of Japan. However, some elements including iodine need a little further study to specify representative values of daily intake and its variation.

Data on pulmonary function and water balance were obtained from a relatively small number of subjects. However, they still provide useful quantitative information for internal dose assessment.

REFERENCES

[1] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Report of the Task Group on Reference Man. ICRP Publication 23, Pergamon Press, Oxford (1975).

[2] TANAKA, G., KAWAMURA, H. AND NAKAHARA, Y., "Establishment of Reference Japanese". J. At. En. Soc. Japan, 19, 674-679 (in Japanese) (1977).

[3] YAMAGUCHI, H. ET AL., "The transformation method for the MIRD absorbed fraction as applied to various physiques". Phy. Med. Biol., 20, 593-601 (1975).

[4] TANAKA, G., KAWAMURA, H. AND NAKAHARA, Y., "Reference Japanese Man-I. Mass of organs and other characteristics of normal Japanese". Health Phys. 36, 333-346 (1979).

[5] TANAKA, G., KAWAMURA, H. AND NOMURA, E., "Reference Japanese Man-II. Distribution of strontium in skeleton and the mass of mineralized bone". Health Phys., 40, 601-614 (1981).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Report of the Project Formulation Meeting: Co-ordinated Research Project on Compilation of Anatomical, Physiological and Metabolic Characteristics for a Reference Asian Man, Mito, 17-21 October 1988, IAEA, Vienna (1988).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Working Material for Compilation on Anatomical, Physiological and Metabolic Characteristics for a Reference Asian Man, 2nd Research Co-ordination Meeting, Bombay, 8-12 April 1991. IAEA-J3-RC-451(1991).

[8] TANAKA, G., "Japanese Reference Man 1988-III. Masses of organs and other physical properties". Nippon Acta Radiologica, 48, 509 (1988).

[9] TANAKA, G., NAJAHARA, Y. AND NAKAJIMA, Y., "Japanese Reference Man 1988-IV. Studies on the weight and size of internal organs of normal Japanese". Nippon Acta Radiologica, 49, 344-364 (in Japanese with tables and figures in English) (1989).

[10] TANAKA, G. (1990). "Reference Japanese Man". Hoken Butsuri 25, 49-60 (in Japanese) (1990).

[11] SHIRAISHI, K., YOSHIMIZU, K., TANAKA, G. AND KAWAMURA, H., "Daily intake of 11 elements in relation to Reference Japanese Man". Health Phys. 57, 551-557 (1990).

[12] TANAKA, G., Reference Japanese Vol. 1, NIRS-M-85, National Institute of Radiological Sciences, Nakaminato, Japan (1992).

[13] TANAKA, G., Anatomical and physical characteristics for Asian Reference Man-a Proposal. NIRS-M-95, National Institute of Radiological Sciences, Chiba, Japan (1993).

[14] MINISTRY OF EDUCATION, SCIENCE AND CULTURE (1977-89). Report of the School Health Survey, MEJ 6908, MEJ 3-7816 and succeeding annual report to MEJ 3-8903, Ministry of Finance Printing Bureau, Tokyo (in Japanese) (1989).

[15] MINISTRY OF HEALTH AND WELFARE (1978-88). Kokumin Eiyo-no Genjo (Report of the National Nutrition Survey for the year of 1975), and succeeding annual report to the year of 1986, Dai-ichi Shuppan, Tokyo (in Japanese) (1988).

[16] MOTHERS' AND CHILDREN'S HEALTH AND WELFARE ASSOCIATION, Report on the Growth of Infants and Preschool Children, 1990 and preceding reports, Boshi Eisei Kenkyu-kai, Tokyo (in Japanese) (1991).

[17] AIMI, S., YASOSHIMA, S., SUGAI, M., SATO, B., SAKAI, T. AND NAKAJIMA, Y., "Studies on the weight and size of the internal organs of normal Japanese". Acta Path. Jap., 2, 173 (1952).

[18] TANAKA, G. AND HOSHI, H., Unpublished data.

[19] ELLIS, R. E., "The distribution of active bone marrow in the adult". Phys. Med. Biol., 5, 255-258 (1961).

[20] HASHIMOTO, M. (1960). "The distribution of active marrow dose in the bones of normal adult". Kyushu J. Med. Sci., 1, 103-111.

[21] SHIRAISHI, K., IGARASHI, Y., YOSHIMIZU, K., TAKAKU, Y. AND MASUDA, K., "Daily intake of ^{232}Th and ^{238}U in Japanese males". Health Phys. 63, 187-191 (1992).

[22] NISHIDA, O. ET AL. Jpn. J. Clin. Pathol., 24, 837-841 (1976).

[23] HONDA, Y., Chiba University, Chiba, Japan. Personal communication. (1993).

[24] HONDA, Y.. "On Respirative Physiology", in Characteristics of the Human Body and Other Relevant Factors in Dose Assessment, Proc. 16th NIRS Seminar on Environmental Research (ed. H. Kawamura and Y. Ohmomo), National Institute of Radiological Sciences, Chiba, Japan, 189-196 (1989).

[25] YOSHIZAWA, S., ISHIZAKI, T. AND HONDA, H. (1975).

[26] MIYAMURA, M. AND HONDA, Y., "Maximum cardiac output related to sex and age". Jpn. J. Physiol., 23, 645-565 (1973).

[27] NISHIMUTA, M., National Institute of Health and Nutrition, Tokyo, Japan. Personal communication. (1993).