STUDY ON THE SETTING OF REFERENCE CHINESE MAN

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Abstract

The procedures for internal and external dose estimation, the calculation of authorized limits and derived reference levels, and the development of phantoms in the field of radiation protection are based on values for the ICRP Reference Man. Many differences exist between Asians, Europeans and North Americans with respect to race, customs and the pattern of food consumption. The neglect of these differences in the parameters used may lead to errors in dose assessment and health effect prognosis. The research described in this paper was conducted to obtain reference values for the Chinese population or other Asian countries which might have major demographic contribution of Chinese. Based on the agreements reached in the Project Formulation Meeting "Compilation of Anatomical, Physiological and Metabolic Characteristics for a Reference Asian Man", the measurement of physique, organ mass and the food consumption were given the first priority for the first phase of the project.

I. MEASUREMENT OF PHYSIQUE

Materials and Methods

Data from nine nationwide surveys on measurement of physique (height and weight of total body, sitting height, chest girth and head circumference, etc.) were collected and evaluated for this study. The methods used in sampling, measurement and statistic analysis were reviewed. The following four reports were chosen to provide the basic material for setting the reference values of height and weight of total body:

1) Survey of development of physique of children in nine cities of China (1985) [3];

2) Survey of development of physique of children under seven of age in countryside of 10 provinces of China (1985) [4];

3) Research of the constitution and health of Chinese students (1985) [5];

4) Human dimensions of Chinese adults (1985) [6].

Altogether about 920,000 persons covering 28 provinces of China were included in the analysis.

The average and standard deviation of height and weight of total body for both sexes of each age group were calculated (Figs 1,2). The 1985 data were compared with those from 1975 to obtain a 10 year secular trend of growth of height and weight of total body. The difference of the average for each age group between male and female, city dwellers and countryside dwellers and southerners and northerners were also analyzed.

Setting the reference values of height and weight of total body

In order to evaluate the public risk from environmental radiation contamination, the dose evaluation for general public is required. Reference Man parameter should be established for the general public as well as for occupational protection. Human anatomical, physiological and metabolic characteristics depend on age and sex, especially for those under 20 years old [11]. Therefore, a series of reference values for height and weight of total body should be set for both male and female at a range of ages, ie. 0, 3 months, 1, 5, 10, 15 and 20-50 years old.

The principles for setting the reference values of height and weight of total body are as follows:

1) The reference value should be close to the population average.

2) The average should be adjusted by the difference of demographic contribution between urban population and rural population, and by the secular trend of growth in height and weight of total body.

3) Because of the spread of value in any population, establishing reference values is not a precise process. Therefore, it is preferable to set these values to the nearest integer. Table 1 shows the reference values selected for height and weight of the Chinese population. The weighted averages were adjusted to account for the differences between the urban and rural demographic contributions [12]. The difference in column 6 reflect the secular growth trend from 1975 to 1985. The reference values were then based on the sum of the 1985 means and the 10 year secular trend in column 6. The last column shows the reference values selected for each age group. The reference values of height and weight for Chinese adult [20-30] are compared with those of Japanese [13] and ICRP Reference Man in Table 2.

II. MEASUREMENT OF ORGAN MASS

Materials and Methods

Data on the mass of internal organs were obtained from the results of autopsies performed by various medical facilities on sudden death victims. The data included 19,976 autopsies performed by 15 medical colleges in China 1950-1990 [14]. These data were combined with organ mass data for 4,070 adults collected by China Institute for Radiation Protection [15,16] and 1,000 autopsies of children by Capital Institute of Children [17]. The average of weight of 12 internal organs (adrenal glands, brain, heart, kidney, liver, lung, pancreas, pituitary, spleen, testes, thymus, thyroid) were calculated for both sexes and various age groups (Tables 3-12).

Setting the organ weight reference values

The reference value of organs were proposed according to the same principles as for setting the reference values of height and weight of total body (Table 1). The reference values of Chinese adult organ mass were compared with those of Japanese and ICRP Reference Man as shown in Table 13.

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TABLE I. REFERENCE VALUES FOR HEIGHT AND WEIGHT OF NORMAL CHINESE

	Sex	Age	City dwellers 1985 X	City dwellers 1985 SD	City dwellers 1975 X	City dwellers 1975 SD	Countryside dwellers 1985 X	Countryside dwellers 1985 SD	Countryside dwellers 1975 X	Countryside dwellers 1975 SD	Weighted average 1985 X	Weighted average 1975 X	Difference	Reference value
Height (cm)	Male	Newborn	50.3	1.6	50.6	1.9	50.2	1.8	50.2	1.7	50.2	50.3	-0.1	50.0
		3 month	62.3	2.4	62.3	2.5	61.3	2.5	61.5	2.7	61.7	61.6	0.1	62.0
		1 year	76.3	2.8	75.6	3.1	74.4	3.1	73.7	3.1	75.0	74.0	1.0	76.0
		5 years	108.2	4.4	107.2	4.6	104.1	4.5	103.9	4.7	105.6	104.4	1.2	107.0
		10 years	135.5	5.9	134.4	5.9	131.5	5.9	129.7	5.6	133.0	130.5	2.5	136.0
		15 years	164.8	6.8	162.0	7.4	159.8	7.3	156.5	7.6	161.6	157.5	4.1	166.0
		20-30 yrs	169.3	5.9	169.3	5.7	167.1	5.5	165.8	6.0	167.9	166.5	1.4	170.0
		20-50 yrs	168.9	5.9	168.7	6.0	166.6	5.5	165.4	5.2	167.4	166.0	1.4	169.0
	Female	Newborn	49.7	1.6	50.0	1.8	49.5	1.7	49.7	1.2	49.6	49.8	-0.2	50.0
		3 months	60.9	2.2	60.9	2.4	59.9	2.4	60.1	2.6	60.3	60.2	0.1	60.0
		1 year	74.9	2.8	74.1	3.0	72.9	3.8	72.3	3.2	73.6	72.6	1.0	75.0
		5 years	107.3	4.3	106.5	4.4	103.2	4.6	102.0	4.5	104.7	102.8	1.9	107.0
		10 years	136.3	6.5	134.8	6.4	131.3	6.6	129.2	6.0	133.1	130.2	2.9	136.0
		15 years	156.8	5.3	155.5	5.6	154.1	5.2	153.0	5.6	155.1	153.4	1.7	157.0
		20-30 yrs	158.2	5.3	157.8	5.2	156.3	5.0	155.9	5.5	157.6	156.2	1.4	160.0
		20-50 yrs	157.8	5.3	156.9	5.4	155.8	5.8	155.5	5.5	156.6	155.7	0.9	158.0
Weight (Kg)	Male	Newborn	3.2	0.4	3.3	0.4	3.2	0.4	3.2	0.4	3.2	3.2	0.0	3.0
		3 months	6.7	0.8	6.7	0.8	6.5	0.8	6.5	0.9	6.6	6.5	0.1	7.0
		1 year	9.7	1.0	9.7	1.1	9.1	1.0	9.0	1.2	9.4	9.1	0.3	10.0
		5 years	17.2	2.0	16.9	1.8	16.2	1.7	16.1	1.6	16.6	16.2	0.4	17.0
		10 years	28.2	4.2	27.2	3.5	26.6	3.4	26.0	3.0	27.2	26.2	1.0	28.0
		15 years	50.0	6.9	46.9	6.5	47.3	6.8	43.6	5.5	48.3	44.2	4.1	52.0
		20-30 yrs	58.7	7.0	59.8	6.1	58.2	5.2	57.9	6.0	58.4	58.2	0.2	60.0
		20-50 yrs	59.0	7.3	60.0	7.0	58.5	5.3	58.2	6.1	58.7	58.5	0.2	60.0
	Female	Newborn	3.1	0.3	3.2	0.4	3.1	0.4	3.2	0.4	3.1	3.2	-0.1	3.0
		3 months	6.2	0.7	6.2	0.8	6.8	0.7	6.0	0.8	6.1	6.0	0.1	6.0
		1 year	9.1	1.0	9.0	1.0	8.5	1.0	8.4	1.0	8.7	8.5	0.2	9.0
		5 years	16.6	1.8	16.5	1.7	15.7	1.7	15.6	1.6	16.0	15.8	0.2	16.0
		10 years	28.1	4.4	27.1	3.6	26.2	3.8	25.4	3.2	26.9	25.7	1.2	28.0
		15 years	46.5	5.6	45.4	5.6	46.2	5.4	43.8	5.5	46.3	44.1	2.2	48.0
		20-30 yrs	50.5	6.2	52.8	5.8	51.4	5.3	52.6	5.5	51.1	52.6	-1.5	52.0
		20-50 yrs	51.4	6.9	54.0	4.1	52.5	5.4	52.7	6.0	52.1	52.9	-0.8	52.0

TABLE II. REFERENCE VALUES OF HEIGHT AND WEIGHT OF CHINESE COMPARED WITH THOSE OF JAPANESE AND ICRP

	Height (cm)		Weight (Kg)	
	Male	Female	Male	Female
The present paper	170	160	60	52
ICRP	170	160	70	60
Japanese	170	160	60	52
Zingshan Zhang et al	169	158	60	54

TABLE III. AVERAGE WEIGHT OF NORMAL CHINESE HEART BY SEX AND AGE - (g)

Age	Male			Fraction of Body Weight	Female			Fraction of Body Weight
	n	X	SD	(%)	n	X	SD	(%)
< 1 month	489	22.1	8.4	0.7	263	21.5	7.0	0.7
1 month	47	28.3	10.7	0.7	21	30.4	12.0	0.8
3 months	88	36.1	9.9	0.7	49	32.7	9.0	0.6
7 months	70	44.6	14.9	0.6	54	40.5	12.4	0.6
1 year	341	59.5	48.0	0.7	304	49.7	11.1	0.6
3 years	158	73.8	25.5	0.6	134	67.9	16.1	0.6
5 years	200	99.6	24.0	0.6	164	97.0	55.3	0.6
10 years	105	152.5	48.6	0.5	55	141.9	38.6	0.6
15 years	206	258.7	55.0	0.5	100	231.0	48.3	0.5
20 years	924	291.1	51.3	0.4	461	249.1	43.1	0.5
30 years	705	302.5	55.2	0.5	279	268.0	51.0	0.5
40 years	484	308.7	58.2	0.5	144	283.7	62.3	0.5
50 years	217	315.9	66.4	0.5	85	287.7	69.3	0.5
60 years	88	361.8	79.3	0.6	52	306.4	61.2	0.6

TABLE IV. AVERAGE WEIGHT OF NORMAL CHINESE LUNGS BY SEX AND AGE - (g)

Age	Male			Fraction of Body Weight	Female			Fraction of Body Weight
	n	X	SD	(%)	n	X	SD	(%)
< 1 month	146	61.4	22.0	2.1	68	56.5	17.8	2.0
1 month	18	86.2	42.8	2.0	5	80.6	27.0	1.8
3 months	23	115.4	39.5	1.9	17	121.1	48.8	2.2
7 months	20	140.2	43.6	1.8	13	141.2	43.7	1.9
1 year	108	207.7	167.3	2.1	116	187.1	63.9	2.2
3 years	64	295.7	329.6	2.4	54	241.8	76.5	1.9
5 years	107	362.0	120.4	2.2	86	354.3	124.6	2.1
10 years	64	564.2	228.7	2.1	35	472.6	189.7	1.8
15 years	78	941.6	435.3	1.6	39	769.3	232.5	1.8
20 years	336	998.3	295.9	1.6	204	829.5	229.3	1.5
30 years	271	1084.2	326.2	1.6	130	861.5	234.6	1.7
40 years	194	1112.9	366.1	1.9	62	835.7	234.9	1.6
50 years	117	1138.4	330.2	1.9	44	872.3	314.3	1.7
60 years	68	1242.1	268.7	2.1	42	924.4	223.6	1.8

TABLE V. AVERAGE WEIGHT OF NORMAL CHINESE SPLEEN BY SEX AND AGE - (g)

Age	Male			Fraction of Body Weight	Female			Fraction of Body Weight
	n	X	SD	(%)	n	X	SD	(%)
< 1 month	546	11.9	8.1	0.40	277	11.3	5.7	0.40
1 month	54	20.7	11.1	0.50	23	18.1	7.5	0.50
3 months	93	25.6	9.6	0.50	53	20.5	6.4	0.40
7 months	69	30.0	11.2	0.40	53	30.0	12.7	0.40
1 year	328	45.1	22.9	0.50	308	39.7	17.2	0.50
3 years	154	56.4	23.8	0.40	137	48.9	24.6	0.40
5 years	214	78.9	75.4	0.40	168	65.3	28.4	0.40
10 years	111	106.7	49.0	0.40	61	94.4	44.0	0.40
15 years	153	161.7	73.3	0.30	91	150.6	67.5	0.40
20 years	734	175.0	73.5	0.30	384	149.7	68.6	0.30
30 years	669	168.6	84.5	0.30	246	156.8	67.3	0.30
40 years	564	157.7	83.0	0.30	164	133.0	48.5	0.30
50 years	295	144.8	60.9	0.30	103	119.4	61.3	0.20
60 years	162	153.9	80.4	0.30	93	113.8	75.1	0.20

TABLE VI. AVERAGE WEIGHT OF NORMAL CHINESE LIVER BY SEX AND AGE - (g)

Age	Male			Fraction of Body Weight	Female			Fraction of Body Weight
	n	X	SD	(%)	n	X	SD	(%)
< 1 month	547	114.8	61.9	3.8	283	115.3	37.9	3.9
1 month	53	164.7	67.0	3.9	23	146.3	30.9	4.0
3 months	92	198.6	46.0	3.5	53	194.5	64.1	3.5
7 months	69	266.5	64.0	3.4	55	256.5	70.9	3.5
1 year	323	370.9	127.6	4.1	302	341.6	89.3	4.0
3 years	158	497.0	123.6	3.9	138	468.8	129.5	4.0
5 years	220	635.6	159.7	3.7	166	624.4	315.7	4.0
10 years	108	885.9	234.5	3.4	66	943.2	955.2	3.8
15 years	179	1249.4	255.0	2.5	92	1233.0	273.1	2.8
20 years	972	1359.7	232.8	2.3	439	1271.6	248.2	2.4
30 years	819	1359.4	234.1	2.3	295	1296.1	250.9	2.5
40 years	669	1350.9	234.7	2.3	180	1249.4	247.3	2.4
50 years	330	1316.8	255.8	2.3	115	1230.7	243.1	2.4
60 years	168	1225.8	270.3	2.1	94	1076.9	290.4	2.1

TABLE VII. AVERAGE WEIGHT OF NORMAL CHINESE KIDNEYS BY SEX AND AGE - (g)

Age	Male			Fraction of Body Weight	Female			Fraction of Body Weight
	n	X	SD	(%)	n	X	SD	(%)
< 1 month	539	28.1	10.8	0.9	282	27.7	11.3	0.9
1 month	51	47.3	39.0	1.2	22	35.8	11.6	0.9
3 months	93	50.3	16.9	1.0	57	45.6	18.6	0.8
7 months	71	61.3	15.9	0.8	58	57.1	20.8	0.8
1 year	371	76.0	23.5	0.9	324	70.8	18.9	0.8
3 years	162	93.0	32.6	0.8	146	89.4	24.8	0.8
5 years	215	122.9	30.8	0.7	172	120.2	36.3	0.7
10 years	107	172.0	45.6	0.7	70	168.6	48.4	0.6
15 years	217	253.0	53.9	0.5	105	242.1	46.7	0.6
20 years	1026	276.7	56.7	0.5	452	257.3	51.2	0.5
30 years	795	281.9	57.8	0.5	300	266.3	52.0	0.5
40 years	619	279.3	57.9	0.5	180	256.8	50.9	0.5
50 years	314	275.8	59.8	0.5	108	250.4	52.9	0.5
60 years	163	269.9	62.5	0.5	93	232.6	56.1	0.4

TABLE VIII. AVERAGE WEIGHT OF NORMAL CHINESE BRAIN BY SEX AND AGE - (g)

Age	Male			Fraction of Body Weight	Female			Fraction of Body Weight
	n	X	SD	(%)	n	X	SD	(%)
< 1 month	288	398.0	408.0	13.1	151	415.6	554.2	13.8
1 month	31	545.7	563.9	13.4	11	505.3	534.1	14.0
3 months	54	706.5	725.4	13.3	26	611.9	634.0	11.6
7 months	48	812.9	853.2	10.5	41	791.5	810.2	10.7
1 year	241	1024.6	1035.9	11.4	232	950.7	964.0	11.2
3 years	77	1219.8	1232.5	9.0	72	1126.7	1139.1	9.1
5 years	97	1293.8	1312.5	7.8	82	1182.5	1194.2	7.4
10 years	51	1388.0	1392.0	5.3	25	1300.6	1298.2	5.5
15 years	96	1446.6	144.1	3.0	50	1306.6	111.9	3.6
20 years	582	1439.8	135.4	3.0	267	1296.8	150.0	2.5
30 years	555	1434.1	144.3	2.5	193	1314.7	121.3	2.5
40 years	399	1424.7	149.3	2.5	97	1340.8	307.0	2.6
50 years	79	1400.2	120.5	2.4	66	1272.4	163.8	2.5
60 years	79	1355.0	188.6	2.3	38	1228.7	219.3	2.4

TABLE IX. AVERAGE WEIGHT OF NORMAL CHINESE PANCREAS BY SEX AND AGE - (g)

Age	Male			Fraction of Body Weight	Female			Fraction of Body Weight
	n	X	SD	(%)	n	X	SD	(%)
< 1 month	382	4.4	3.2	0.2	205	4.3	2.3	0.2
1 month	33	6.9	3.4	0.2	14	6.6	2.1	0.2
3 months	59	10.1	11.8	0.2	41	9.2	3.8	0.2
7 months	49	11.6	4.5	0.1	39	11.2	5.5	0.2
1 year	288	21.0	30.1	0.2	252	17.7	7.0	0.2
3 years	124	31.0	31.0	0.2	100	27.4	13.9	0.2
5 years	171	39.5	14.3	0.2	130	41.8	55.1	0.3
10 years	87	56.2	20.6	0.3	52	49.4	15.3	0.2
15 years	146	88.4	25.2	0.2	58	84.8	31.2	0.2
20 years	741	104.8	28.2	0.2	319	98.9	26.2	0.2
30 years	573	110.0	30.0	0.2	218	99.8	28.9	0.2
40 years	462	110.7	30.1	0.2	136	95.5	29.0	0.2
50 years	226	107.8	30.9	0.2	94	92.8	24.2	0.2
60 years	119	109.8	63.7	0.2	69	100.2	82.1	0.2

TABLE X. AVERAGE WEIGHT OF NORMAL CHINESE ADRENALS BY SEX AND AGE - (g)

Age	Male			Fraction of Body Weight	Female			Fraction of Body Weight
	n	X	SD	(%)	n	X	SD	(%)
< 1 month	739	7.3	3.3	0.2	457	7.2	3.2	0.2
1 month	269	5.7	2.7	0.2	152	5.2	2.3	0.2
3 months	221	4.9	2.0	0.7	166	4.8	2.2	0.8
7 months	397	5.0	2.1	0.6	305	5.0	1.9	0.6
1 year	713	5.2	2.2	0.6	591	5.4	2.8	0.6
3 years	350	6.4	3.9	0.5	304	6.1	3.3	0.5
5 years	398	7.5	4.1	0.4	298	7.3	3.9	0.4
10 years	210	9.8	4.8	0.3	121	10.0	4.7	0.4
15 years	81	12.6	4.5	0.2	65	14.2	5.3	0.3
Adult	2722	14.7	5.7	0.2	1303	14.3	6.2	0.3

TABLE XI. AVERAGE WEIGHT OF NORMAL CHINESE THYROID BY SEX AND AGE - (g)

Age	Male			Fraction of Body Weight	Female			Fraction of Body Weight
	n	X	80% normal range	(%)	n	X	80% normal range	(%)
< 1 month	362	2.3	1.1-3.9	0.08	205	2.3	1.1-4.3	0.08
1 month	157	1.9	1.1-3.1	0.06	87	2.1	1.1-3.4	0.07
3 months	177	2.6	1.2-4.4	0.04	145	2.3	1.6-3.7	0.04
7 months	218	2.6	1.5-4.0	0.04	207	2.5	1.3-4.1	0.03
1 year	544	3.3	1.7-5.3	0.03	486	3.1	1.6-5.1	0.03
3 years	265	4.3	2.3-6.4	0.03	190	4.4	2.5-6.9	0.03
5 years	347	6.4	3.1-10.2	0.04	247	5.7	3.4-8.7	0.04
10 years	157	9.7	4.9-16.2	0.05	104	9.9	5.0-16.5	0.05
15 years	69	12.3	7.0-19.9	0.02	45	13.1	7.6-19.5	0.03
Adult	913	27.4	10.7-55.8	0.05	401	26.6	10.1-33.5	0.04

TABLE XII. SECULAR TREND IN ORGAN WEIGHT OF ADULT CHINESE - (g)

Organs	Before 1970		After 1970		Difference	
	Male	Female	Male	Female	Male	Female
Heart	286.6	248.2	309.1	254.2	22.5	6.0
Lungs	956.1	806.1	1140.1	939.3	184.0	133.2
Spleen	164.1	145.6	199.0	170.0	35.0	24.4
Liver	1349.8	1270.3	1411.1	1279.4	61.3	9.1
Kidneys	275.8	258.8	280.4	249.5	4.6	9.3
Brain	1435.3	1294.5	1459.3	1309.3	24.0	14.8
Pancreas	103.7	98.7	112.6	100.4	8.9	1.7

The weights of liver and kidneys of the Chinese adult were less than those of Japanese and ICRP Reference Man. The weight of Chinese heart is less than that of Japanese Reference Man, but is the same as that of ICRP. The weight of pancreas of Chinese is less than that of Japanese, but greater than that of ICRP Reference value. The weight of brain and adrenals of Chinese adult are similar with those of both Japanese and ICRP Reference Man. The weight of lungs, spleen, thyroid, thymus, pituitary and testes are all greater than the Japanese and ICRP reference values. The weight differences of brain, heart and lungs between male and female are smaller for Chinese compared with those of Japanese and ICRP Reference Man. The relative weight of brain, lungs, spleen, thyroid and testes for Chinese adult are all greater than those for Japanese and ICRP Reference Man (Table 13).

TABLE XIII. TOTAL AND FRACTIONAL ORGAN WEIGHT PROPOSED FOR REFERENCE CHINESE MAN COMPARED WITH JAPANESE AND ICRP REFERENCE MAN

Organs	Reference Chinese Man				Japanese Reference Man				ICRP Reference Man			
	Male		Female		Male		Female		Male		Female	
	(g)	%	(g)	%	(g)	%	(g)	%	(g)	%	(g)	%
Brain	1480	2.5	1320	2.5	1500	2.5	1300	2.5	1400	2.0	1200	2.0
Heart	330	0.55	260	0.50	400	0.67	280	0.54	330	0.47	240	0.40
Kidneys	290	0.48	250	0.48	320	0.53	280	0.54	310	0.44	275	0.46
Liver	1470	2.5	1300	2.5	1600	2.7	1400	2.7	1800	2.6	1400	2.3
Lungs	1320	2.2	1070	2.1	1100	1.8	900	1.7	1000	1.4	800	1.3
Pancreas	120	0.20	102	0.20	130	0.22	110	0.21	100	0.14	85	0.14
Spleen	220	0.37	190	0.32	140	0.23	120	0.23	180	0.26	150	0.25
Adrenals	14	0.023	14	0.027	14	0.023	13	0.025	14	0.020	14	0.023
Thyroid	27	0.045	27	0.052	19	0.032	17	0.033	20	0.029	17	0.028
Thymus	36	0.060	28	0.054	33	0.055	25	0.048	20	0.029	20	0.033
Pituitary	0.8	0.0013	0.8	0.0015	0.6	0.0010	0.6	0.0012	0.6	0.00086	0.7	0.0012
Testes	56	0.093	-		37	0.062	-		35	0.050	-	
Total body	60000		52000		60000		52000		70000		60000	

TABLE XIV. THE DIFFERENCE BETWEEN MALE AND FEMALE DRY BONE WEIGHTS IN CHINESE ADULTS

Bone	Male (237)		Female (43)	
	Mean ± S.D.	% S.W.*	Mean ± S.D.	% S.W.*
Skull	576.0 ± 100.1	16.75	522.6 ± 122.0	21.05
Mandible	72.4 ± 16.0	2.11	55.2 ± 12.2	2.22
Clavicle (2)	38.3 ± 10.6	1.11	26.3 ± 7.1	1.06
Scapula (2)	101.2 ± 23.0	2.94	65.9 ± 13.4	2.65
Rib (2)	235.1 ± 59.8	6.84	163.7 ± 40.9	6.59
Sternum	16.4 ± 4.7	0.48	10.7 ± 2.5	0.43
Vertebral column	291.0 ± 64.3	8.46	228.0 ± 48.6	9.18
Humerus (2)	223.9 ± 51.4	6.51	138.4 ± 33.0	5.57
Ulna (2)	91.1 ± 20.0	2.65	59.1 ± 14.0	2.38
Radius (2)	74.1 ± 17.8	2.15	47.8 ± 12.5	1.93
Hands (2)	96.7 ± 22.2	2.81	70.3 ± 15.9	2.83
Innominates (2)	282.5 ± 71.1	8.21	201.2 ± 53.9	8.10
Sacrum	65.5 ± 15.6	1.90	49.4 ± 12.2	1.99
Femur (2)	615.7 ± 131.2	17.90	402.5 ± 95.0	16.21
Patella (2)	20.7 ± 4.7	0.60	13.5 ± 3.6	0.54
Tibia (2)	353.6 ± 82.3	10.28	255.7 ± 57.4	9.09
Fibula (2)	84.8 ± 20.4	2.47	57.9 ± 15.9	2.33
Feet (2)	204.3 ± 49.1	5.94	128.6 ± 32.6	5.18
Total	3438.0 ± 633.4	100.00	2482.6 ± 488.6	100.00

* Percentage of the total skeleton weight

TABLE XV. THE DIFFERENCES BETWEEN SOUTHERN AND NORTHERN REGIONS FOR DRY BONE WEIGHTS IN CHINESE ADULTS

Bone	Male (237)			Female (43)		
	South±SD	North±SD	S/N	South±SD	North±SD	S/N
Skull	548.6±101.9	595.0±91.9	0.92	509.9±138.0	544.1±54.1	0.94
Mandible	67.0±15.8	76.0±15.1	0.88	53.0±8.6	60.7±8.6	0.88
Clavicle (2)	33.0±9.4	41.6±10.3	0.79	25.6±7.3	30.2±6.5	0.85
Scapula (2)	88.5±23.5	109.6±18.2	0.81	63.4±14.5	71.7±8.3	0.88
Rib (2)	191.2±48.2	264.3±46.3	0.72	150.8±33.5	195.3±39.7	0.77
Sternum	15.2±5.4	17.1±4.0	0.89	10.3±1.9	11.3±3.0	0.91
Vertebral column	269.8±65.0	304.6±59.7	0.89	222.0±73.5	250.0±42.8	0.89
Humerus (2)	191.1±51.5	245.5±38.4	0.78	131.5±32.0	156.3±29.8	0.84
Ulna (2)	77.6±20.9	99.5±14.7	0.78	54.6±13.2	70.8±7.9	0.77
Radius (2)	61.9±16.7	81.9±13.8	0.76	44.3±12.7	57.1±6.2	0.78
Hands (2)	80.0±19.4	107.6±14.6	0.74	65.9±14.4	81.6±14.1	0.81
Innominates (2)	247.4±71.0	307.3±64.9	0.81	196.4±49.5	222.5±42.5	0.88
Sacrum	57.3±14.9	71.1±12.7	0.81	45.7±10.5	58.8±11.7	0.78
Femur (2)	527.7±13.0	670.6±100.9	0.79	384.5±93.4	451.7±79.1	0.85
Patella (2)	18.7±4.9	22.1±4.0	0.85	13.2±3.9	14.3±2.9	0.92
Tibia (2)	300.7±86.9	387.5±61.5	0.78	214.9±60.5	252.9±43.5	0.85
Fibula (2)	77.5±39.0	93.2±15.1	0.83	52.4±16.6	70.4±9.9	0.74
Feet (2)	165.9±41.0	229.2±36.4	0.72	119.8±25.3	149.6±30.8	0.80
Total	3011.3±600.1	3735.2±465.1	0.81	2379.4±503.1	2749.1±337.5	0.87

TABLE XVI. RELATIVE WEIGHTS OF DRY BONES AS PERCENTAGES OF THE TOTAL SKELETON OF CHINESE ADULTS

Bone	China (% S.W.*)		ICRP-23 (% S.W.*)	
	Male	Female	[Spiers, 1968]	[Ingalls, 1931]
Skull	16.75	21.05	16.60	-
Mandible	2.16	2.22	1.77	1.65
Clavicle (2)	1.11	1.06	1.00	1.08
Scapula (2)	2.94	2.65	3.02	3.12
Rib (2)	6.84	6.59	4.41	6.64
Sternum	0.48	0.43	0.30	0.65
Vertebral column	8.46	9.18	8.33	-
Humerus (2)	6.51	5.57	6.66	7.24
Ulna (2)	2.65	2.38	2.94	2.70
Radius (2)	2.15	1.93	2.42	2.18
Hands (2)	2.81	2.83	3.04	2.76
Innominates (2)	8.21	8.10	7.47	-
Sacrum	1.90	1.99	-	2.24
Femur (2)	17.90	16.21	17.76	18.44
Patella (2)	0.60	0.54	-	-
Tibia (2)	10.28	9.09	10.16	10.78
Fibula (2)	2.47	2.33	2.50	2.32
Feet (2)	5.94	5.18	11.64	6.18

* Percentage of the total skeleton weight.

TABLE XVII. THE WEIGHT OF SKELETON FOR CHINESE ADULTS AS COMPARED WITH THOSE OF JAPANESE AND ICRP

Sex	China		Japan		ICRP-23	
	S.M. (Kg)	% B.W.	S.M. (Kg)	% B.W.	S.M. (Kg)	% B.W.
Male	8.0* (North 8.5 South 6.9)	13.3	8.3	13.8	10.0	14.3
Female	5.5* (North 5.9 South 5.1)	10.6	5.8	11.3	6.8	11.3

* Incl. Os hyoideum, Os coccygis and teeth
S.M. = skeleton weight
B.W. = body weight

III. MEASUREMENT OF SKELETON MASS

Materials and Methods

The skeleton of 237 male and 43 female of Chinese adults from north and south of China were collected. The dry weights of various bones were measured. The skeletal wet weights were then calculated by multiplying dry weight with the ratio of wet vs dry weight of skeleton from ICRP-23. These are 2.17 for male and 2.13 for female. There are significant differences in weight of various bones and the total skeleton weight between male and female, as well as between northerner and southerner (Tables 14,15). The relative dry weight of individual bones as percentage of the total Chinese skeleton are shown in Table 16.

Setting the reference value

Based on these data, the reference values proposed for total skeleton of Chinese adult are 8.0 Kg for male and 5.5 Kg for female. These are lower than those for ICRP Reference Man but close to those of Japanese. The relative weight of skeleton as percentage of total body weight are 13.3 for male and 10.6 for female (Table 17).

IV. FOOD CONSUMPTION AND NUTRIENT, ELEMENTS AND RADIONUCLIDES INTAKES OF CHINESE

Materials and Methods

The references used for this purpose are as follows:

1) The second of nationwide survey of nutrition of Chinese in 1982 [18];

2) Table of component of food (1989) [19];

3) Investigation of food radioactivity and estimation of internal dose by ingestion in China (1987) [20].

In the second nationwide survey of nutrition of Chinese in 1982, 172 sampling points were chosen for study (50 for city and 116 for countryside), covering 27 provinces of China. Thirty to fifty families were sampled for each point. The study was done by interviewing families and obtaining data on the consumption of various foods (weight of raw material, edible part only). A total of about 48,000 persons were surveyed. From the survey we obtained information on national average daily per capita food consumption patterns for 25 kinds of food. The national average daily intake per capita of 11 kinds of nutrient, 17 minor and trace elements, 17 radionuclides were also calculated based on the table of food components and the results of investigation of food radioactivity according to the following formula:

$$I_i = \sum_j C_{ij} D_j$$

I_i: daily intake of i element or radionuclide
C_{ij}: average concentration of i element or radionuclide in food j
D_j: daily consumption of food j

TABLE XVIII. FOOD CONSUMPTION PER CAPITA IN DIFFERENT COUNTRIES (Kg Wet/a)

Country	Grains	Potato & starch	Sugar & its crop	Beans & nuts	Veg.	Fruit	Meat & poultry	Eggs	Aquatic product	Milk & product	Oil & fat
France	76.1	90.8	35.6	4.3	112.0	74.2	99.1	12.9	18.7	320.6	19.1
UK	74.6	90.4	48.6	4.9	60.5	47.1	73.5	13.8	7.9	363.6	15.1
USA	61.8	47.9	50.1	8.1	94.7	72.3	110.1	16.0	6.9	246.1	22.5
New Zealand	76.2	51.8	36.0	3.2	128.0	73.3	113.5	17.1	4.7	396.9	6.7
Japan	117.9	28.5	26.2	10.4	131.9	57.3	28.6	16.2	34.1	57.0	11.9
Brazil	90.8	69.0	43.5	26.8	22.0	131.9	30.9	4.0	4.8	49.7	8.2
India	136.0	10.6	24.5	19.5	46.7	23.3	1.5	0.1	2.3	33.8	4.5
China*	186.8	60.9		5.3	117.5	10.0	14.1	3.2	4.1	3.1	6.1

* Quoted from reference (2) data.

TABLE XIX. NATIONAL AVERAGE DAILY FOOD CONSUMPTION PER CAPITA, 1982 (g/day/person)

Food	Kindergarten (2-6 years)	Primary school (7-12 years)	Middle school (13-18 years)	Adult
Rice	107.8	120.4	204.5	208.0
Flour	99.0	254.3	288.9	198.0
Other cereals	4.3	8.6	71.6	92.0
Potatoes	15.3	34.8	70.1	163.0
Beans	7.2	15.4	3.7	9.6
Bean products	8.8	6.8	9.1	5.9
Green vegetables	89.3	122.9	237.4	232.0
Yellow vegetables	27.4	49.6	47.0	73.0
Dry vegetables	0	0	0	0.1
Salted vegetables	6.0	4.2	26.7	13.7
Fungi	0.7	0.4	0.9	1.0
Fruits	65.3	12.6	4.1	28.0
Nuts and seeds	1.9	0.3	1.3	2.0
Milk, milk products	35.4	14.0	3.3	9.0
Eggs	14.1	26.0	4.0	9.7
Meats	44.1	60.3	48.1	42.3
Fish, shellfish	9.8	22.2	3.4	11.8
Starches and sugar	16.9	4.3	5.0	8.6
Animal fats	2.3	15.6	10.8	6.0
Vegetable oils	3.7	0.6	4.4	3.7
Other oils	7.5	10.1	7.0	7.5
Soy sauces	8.3	15.5	14.0	12.8
Salt	4.0	5.7	9.0	11.2
Drinks	0.1	0.9	0	3.1
Other	13.4	5.2	5.6	9.4

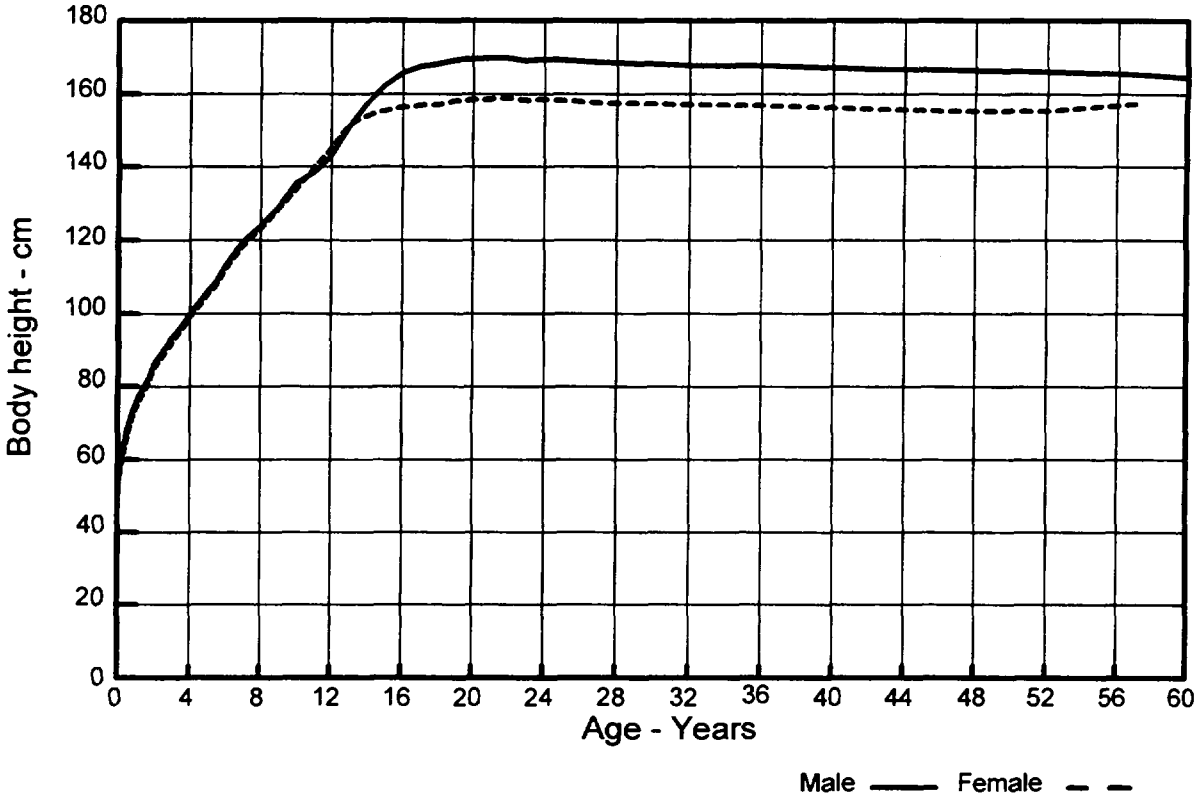

Fig. 1 - Total body height of Chinese

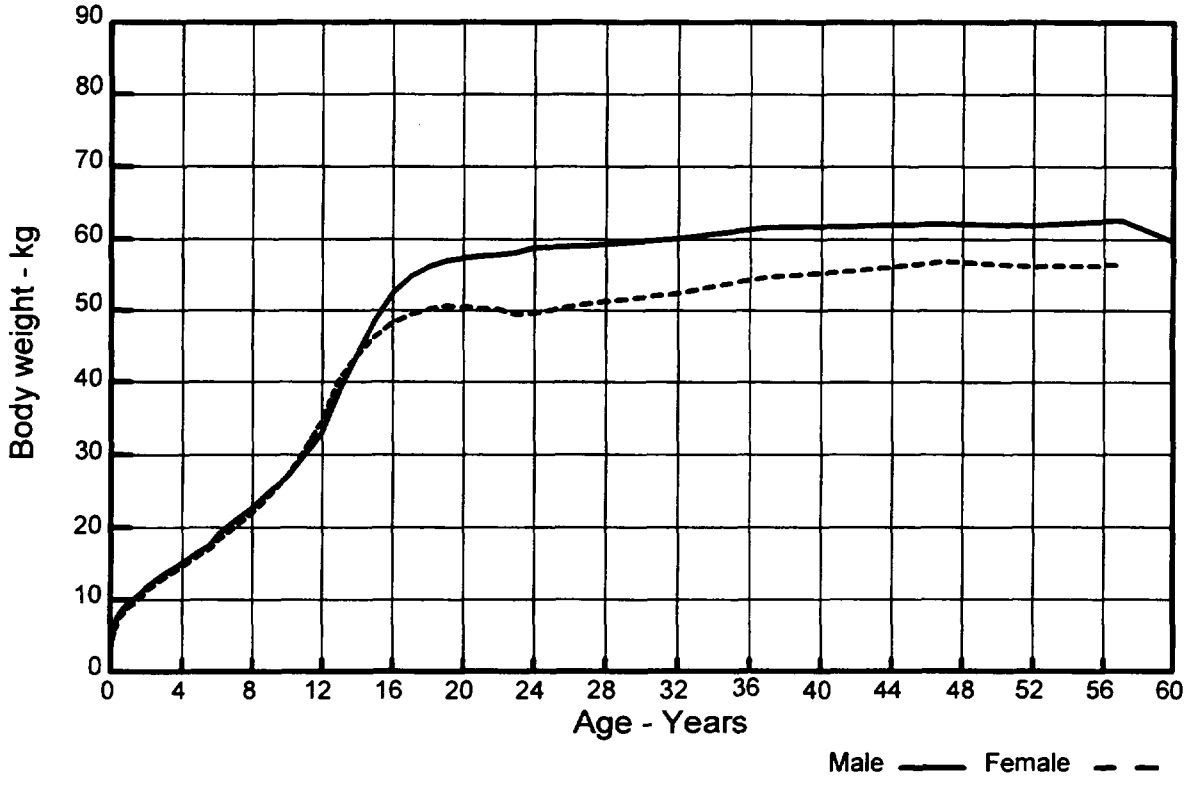

Fig. 2 - Total body weight of Chinese

Results

As shown in Table 18, the consumption of cereals was greater and the consumption of meats, eggs and milk was less for Chinese than those for Japanese, European and American. Average daily consumption per capita of 25 kinds of food and average daily intake per capita of 11 nutrients for various age group of Chinese were shown in Tables 19,20. Only 5.4% of the caloric intake and 8.1% of the protein are obtained from animal food products for Chinese in 1982, compared with 30% and 50% respectively for developed countries. The intake of 17 elements and 17 radionuclides were calculated and compared with the values assumed by ICRP as shown in Tables 21,22. Chinese average daily intake of C,N,S,and Ca are less than those for ICRP Reference Man, while the intake of P,Fe,Na,Cl,Rb,Th and Mg are greater. These findings are related to the pattern of food consumption. For example, the lower intake of nitrogen and sulfur is due to less consumption of protein. Consumption of less milk and more salt leads to diminished intake of Ca and greater intake of Na,Cl and Mg. For the radionuclide intakes the comparison indicated that the Chinese and ICRP values are similar.

TABLE XX. NATIONAL AVERAGE DAILY NUTRIENT INTAKE PER CAPITA, 1982

Nutrient	Kindergarten (2-6 years)	Primary school (7-12 years)	Middle school (13-18 years)	Adult
Protein (g)	38.1	57.6	67.2	66.0
Fat (g)	48.8	52.0	57.1	49.1
Carbohydrate (g)	203.7	308.0	439.5	432.7
Energy (calorie)	1404.0	1928.0	2534.0	2465.0
Cellulose (g)	3.3	4.6	6.9	7.7
Vitamin A (IU)	428.0	760.0	414.0	273.0
Carotene (mg)	0.9	1.3	1.6	3.5
Vitamin B1 (mg)	1.2	1.7	2.4	2.4
Vitamin B2 (mg)	0.5	0.7	0.7	0.9
Vitamin C (mg)	88.0	89.0	94.0	120.0
Nicotinic acid (mg)	9.0	14.0	20.0	17.0

TABLE XXI. NATIONAL AVERAGE DAILY INTAKE OF ELEMENTS PER CAPITA, 1982

Elements	Chinese	ICRP
C (g)	260.8	310.3
N (g)	11.1	16.0
S (g)	0.8	1.1
Ca (g)	0.7	1.1
P (g)	1.6	1.4
Fe (mg)	35.8	16.0
Sr (mg)	1.5	1.9
Zn (mg)	12.2	13.0
La (g)	7×10^{-10}	-
Ce (g)	5×10^{-10}	-
Na (g)	5.7	4.4
Mg (g)	0.4	0.3
Cl (g)	10.1	5.2
U (g)	1.2×10^{-6}	1.9×10^{-6}
Th (g)	4.0×10^{-6}	3.0×10^{-6}
K (g)	2.6	3.3
Rb (mg)	4.2	2.2

TABLE XXII. NATIONAL AVERAGE DAILY INTAKE OF RADIONUCLIDES PER CAPITA, 1982 (Bq/day/person)

Radionuclides	Chinese	ICRP
238-U	1.5×10^{-2}	2.4×10^{-2}
234-U	1.6×10^{-2}	2.4×10^{-2}
235-U	7.0×10^{-4}	1.1×10^{-3}
232-Th	1.6×10^{-2}	1.2×10^{-2}
226-Ra	6.8×10^{-2}	8.5×10^{-2}
228-Ra	8.7×10^{-2}	-
210-Pb	2.0×10^{-1}	-
210-Po	1.8×10^{-1}	1.2×10^{-1}
227-Ac	8.9×10^{-4}	-
40-K	7.2×10	9.1×10
87-Rb	3.8	2.0
14-C	4.8×10	-
3-H	6.2	-
90-Sr	1.7×10^{-1}	-
137-Cs	1.1×10^{-1}	-
144-Ce	1.9×10^{-2}	-
106-Ru	2.0×10^{-2}	-

TABLE XXIII. NATIONAL AVERAGE FOOD CONSUMPTION (g/person/day) IN 1990 AS COMPARED WITH THAT IN 1982

Food	1990	1982
Cereals	461.4	498.0
Pulses	39.5	17.5
Potatoes	101.0	163.0
Meats	48.9	27.1
Eggs	17.1	9.7
Milk & Milk products	11.0	2.5
Fish & Shellfish	22.9	11.8
Vegetables	323.8	342.7
Fruits	101.1	29.3
Sugar & confectionery	3.3	4.4
Vegetable oils	22.5	11.5
Animal fats	5.8	4.4
Beverages & water	512.1	
Drink	14.0	3.8

Recent Chinese food consumption data

In the last ten years, the living standard of Chinese is much improved with the development of economy. A new Chinese Total Diet survey was carried out in 1990. The preliminary results are shown in Table 23, and compared with the corresponding figures for the 1982 survey. After eight years, the consumption of cereals, vegetables and salt were decreased, but the consumption of animal food (such as meat, eggs and milk products, aquatic products), pulses, oils, drink and fruits were much increased for Chinese. The intakes of energy, protein and fat come from animal food have been increased by 159.3%, 169.1% and 46.0% respectively. It is evident that the diet quality of Chinese is much improved and the composition of diet of Chinese is more balanced even though the plant foods are still the main sources of nutritional intake. The consumption of animal foods remain less than that for the western population (Table 24). Various nutritional intakes are close to the goal of WHO on nutrition (Table 25).

TABLE XXIV. NATIONAL AVERAGE NUTRITIONAL INTAKE IN 1990 AS COMPARED WITH THAT IN 1982

Nutrition	Mean	
	1990	1982
Energy (Kcal)	2203.3	2498.0
% from animal food	14.0	5.4
% from plant food	84.9	93.9
Protein (g)	64.0	66.0
% from animal food	21.8	8.1
% from beans	8.3	9.0
% from plant food	69.9	82.9
% of energy	11.6	10.5
Fats (g)	51.2	44.1
% from animal food	53.0	36.3
% from plant food	47.0	63.7
% of energy	21.2	16.0
Carbohydrate (g)	365.6	433.2
% of energy	66.1	70.8

TABLE XXV. NATIONAL AVERAGE NUTRITIONAL INTAKE OF CHINESE COMPARED WITH GOAL OF NUTRITION OF WHO

	Goal of nutrition of WHO		Average intake in Chinese (1990)
	Low limit	High limit	
Energy (Kcal)			2203.3
Fats (% of energy)	15.0	30.0	21.2
Saturate fatty acid	0.0	10.0	6.1
No saturate fatty acid	3.0	7.0	5.7
Cholesterol (mg/day)	0.0	300.0	178.6
Carbohydrate (% of energy)	55.0	75.0	66.1
Compound carbohydrate	50.0	70.0	
Cellulose (g/day)			
No-starch-polysaccharide	16.0	24.0	
Cellulose	27.0	40.0	26.6
Sugar (% of energy)	0.0	10.0	0.6
Protein (% of energy)	10.0	15.0	11.6
Salt (g/day)	-	6.0	13.9

TABLE XXVI-I. THE ELEMENTAL CONTENT OF ORGANS AND TISSUES IN NORMAL CHINESE (μg/g wet sample)

Organ and tissue	Element														
	Zn			Cu			Mn			Fe			Cr		
	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD
Stomach	45	18.67	4.50	47	1.363	0.481	46	0.675	0.306	46	40.21	20.58	41	0.223	0.175
Large	45	17.52	5.41	44	1.296	0.580	42	1.085	0.528	44	36.25	18.17	42	0.418	0.546
intestine	46	16.71	5.17	47	1.374	0.534	47	0.943	0.521	48	47.06	34.93	43	0.310	0.351
Small	47	22.24	3.84	49	2.833	0.813	49	0.508	0.208	49	67.98	25.95	49	0.547	0.639
intestine	51	43.53	11.13	49	8.268	5.643	52	1.520	0.589	51	218.4	136.8	43	0.239	0.220
Heart	53	16.61	3.00	50	0.955	0.317	53	0.357	0.181	51	211.6	112.0	44	0.238	0.202
Liver	51	13.35	6.27	52	1.031	0.499	52	0.597	0.416	51	193.7	122.4	51	0.569	0.455
Spleen	52	27.11	6.24	52	1.976	0.703	53	1.055	0.345	51	89.08	52.86	46	0.214	0.204
Lung	50	61.63	17.95	51	1.975	0.689	47	2.467	0.790	50	90.65	49.08	40	0.635	0.485
Kidneys	49	13.07	2.91	48	4.263	1.762	49	0.460	0.183	48	65.15	25.66	41	0.441	0.452
Skeleton*	8	12.85	7.58	8	0.620	0.340	8	0.570	0.490	8	48.59	44.77	5	0.214	0.200
Cerebrum	50	28.63	6.40	49	1.158	0.389	50	1.299	0.503	49	56.50	37.44	41	0.250	0.212
Thymus	48	16.43	4.81	49	1.482	0.562	47	0.754	0.397	45	83.16	40.67	37	0.298	0.202
Pancreas	48	20.96	5.04	51	0.799	0.262	47	0.467	0.217	50	50.83	27.46	41	0.193	0.113
Adrenal	44	18.91	8.47	44	2.259	1.027	40	0.978	0.443	40	96.05	48.59	40	1.206	0.985
gland	33	10.04	2.33	34	0.657	0.183	32	0.251	0.103	32	26.48	14.89	29	0.142	0.096
Thyroid	14	9.91	2.96	14	0.841	0.329	14	0.441	0.266	14	55.95	32.00	13	0.526	0.620
Pituitary															
Testes															
Ovary															

* Rib

Table XXVI-II. THE ELEMENTAL CONTENT OF ORGANS AND TISSUES IN NORMAL CHINESE (μg/g wet sample)

Organ and tissue	Element														
	Ni			Co			Mo			Sr			K		
	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD
Stomach	43	0.167	0.163	45	0.009	0.006	47	0.049	0.023	44	0.222	0.108	46	1529.1	404.7
Large intestine	42	0.280	0.380	43	0.019	0.008	45	0.039	0.021	45	0.621	0.492	45	1334.3	478.4
Small intestine	42	0.208	0.198	45	0.012	0.009	46	0.046	0.017	46	0.342	0.235	46	1352.6	350.6
Heart	44	0.151	0.188	47	0.019	0.010	49	0.059	0.026	44	0.098	0.054	50	2157.0	469.0
Liver	43	0.101	0.119	51	0.036	0.016	51	0.951	0.359	48	0.100	0.053	50	2199.2	523.1
Spleen	45	0.117	0.110	52	0.010	0.008	49	0.022	0.017	47	0.111	0.056	53	2559.0	464.0
Lung	51	0.277	0.276	46	0.022	0.014	50	0.032	0.022	52	0.265	0.162	52	1879.6	402.4
Kidneys	50	0.163	0.184	53	0.013	0.107	52	0.221	0.075	51	0.140	0.082	51	1997.0	374.0
Skeleton*	47	1.822	1.121	48	0.043	0.032	46	0.284	0.260	52	56.92	22.69	49	1392.0	411.0
Cerebrum	43	0.314	0.367	49	0.011	0.012	48	0.040	0.020	49	0.105	0.086	49	2370.5	555.1
Thymus	5	0.155	0.118	5	0.037	0.027	8	0.049	0.042	8	0.455	0.369	8	1579.3	804.6
Pancreas	45	0.169	0.221	48	0.016	0.023	47	0.084	0.049	47	0.147	0.080	48	2398.5	446.2
Adrenal gland	43	0.360	0.400	47	0.015	0.012	48	0.138	0.053	46	0.171	0.116	49	1819.3	487.6
Thyroid	41	0.113	0.094	49	0.012	0.008	51	0.043	0.030	46	0.227	0.084	50	1689.1	391.0
Pituitary	38	0.427	0.450	39	0.056	0.056	44	0.082	0.222	44	0.484	0.222	44	1547.4	680.8
Testes	34	0.203	0.373	27	0.007	0.006	34	0.035	0.014	33	0.092	0.041	34	1867.2	366.2
Ovary	13	0.392	0.521	12	0.008	0.007	14	0.032	0.015	12	0.190	0.101	14	1499.0	299.2

* Rib

TABLE XXVI-III. THE ELEMENTAL CONTENT OF ORGANS AND TISSUES IN NORMAL CHINESE (μg/g wet sample)

Organ and tissue	Element														
	Na			Ca			Mg			Cd			Pb		
	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD
Stomach	47	1392.6	435.4	47	25.87	14.05	47	147.13	50.78	46	0.185	0.083	45	0.064	0.058
Large intestine	46	1512.0	673.2	44	27.01	14.99	44	195.50	104.02	43	0.168	0.110	42	0.059	0.036
Small intestine	48	1788.2	556.8	45	23.92	11.65	46	153.91	63.13	44	0.249	0.149	44	0.050	0.064
Heart	50	1233.0	432.0	50	18.14	12.00	50	184.50	63.20	49	0.547	0.693	43	0.050	0.040
Liver	52	1189.6	355.7	51	21.02	12.78	51	178.48	51.52	43	0.239	0.220	44	0.164	0.091
Spleen	53	1032.0	334.0	52	22.69	13.01	52	155.20	46.20	50	0.207	0.104	49	0.097	0.060
Lung	53	1415.9	539.2	53	24.61	15.24	53	118.85	52.05	50	0.257	0.202	50	0.098	0.075
Kidneys	51	1419.0	380.0	52	20.93	9.92	52	140.30	40.30	46	5.300	2.724	45	0.092	0.050
Skeleton*	51	3135.0	866.0	47	71128	26516	51	1657.0	802.0	52	2.204	0.600	48	0.353	0.361
Cerebrum	48	1275.6	357.3	49	19.24	10.24	48	137.14	45.10	45	0.106	0.041	46	0.051	0.031
Thymus	8	1242.2	637.2	8	285.9	41.25	8	131.02	69.47	7	0.092	0.042	7	0.047	0.026
Pancreas	50	1271.4	336.6	49	25.00	12.81	50	181.49	73.47	46	0.399	0.221	46	0.109	0.079
Adrenal gland	48	1344.8	519.3	48	34.89	22.00	48	125.20	34.44	46	0.247	0.185	46	0.111	0.081
Thyroid	50	1706.0	503.2	49	64.26	31.09	51	97.64	38.22	48	0.303	0.163	46	0.022	0.029
Pituitary	41	1843.9	563.4	43	106.0	66.99	45	143.67	67.75	39	0.828	0.199	45	0.409	0.331
Testes	36	1134.7	471.1	34	17.85	9.73	35	104.60	25.25	24	0.142	0.096	31	0.037	0.029
Ovary	14	1367.0	52.57	14	21.47	12.00	14	114.22	39.15	12	0.117	0.058	11	0.031	0.018

* Rib

TABLE XXVII. SUMMARY OF ELEMENTAL CONCENTRATIONS FOR VARIOUS ORGANS AND TISSUES IN NORMAL CHINESE COMPARED WITH THOSE OF INDIA, JAPAN AND REPORTED BY THE ICRP

Element	Organ or Tissue	Comparative Results A:B	Relative concentrations - A/B
1. Zn	Thyroid		1.5
Pb	Bone, Liver	China < ICRP	31.0, 10.5
Cd	Kidney		6.0
Fe	Lung		1.9
2. Ni	Heart		3.2
Zn	Adrenal, Thymus	China > ICRP	2.1, 2.0
Mn, Mo	Bone		4.7, 6.0
Cr	All Tissues		1.3 - 147
3. Cu	Adrenal	India > China	3.0
Pb	Kidney		174.
4. Ca	Multiple Tissues*	Japan > China	2.0 - 8.0
Sr	Multiple Tissues*	Japan < China	1.5 - 5.0
Cd	Kidney, Liver and Pancreas	Japan > China	3.5, 40.5, 13.5

* Heart, Liver, Spleen, Kidney, Cerebrum and Pancreas

TABLE XXVIII. THE VALUES OF PULMONARY FUNCTION TEST IN HEALTHY ADULTS (M ± SD)

Items	Male	Female
VC	4.087 ± 0.678	2.956 ± 0.508
IC	2.578 ± 0.491	1.895 ± 0.375
ERV	1.511 ± 0.437	1.072 ± 0.356
FRC	3.112 ± 0.611	2.348 ± 0.479
RV	1.615 ± 0.397	1.245 ± 0.336
TLC	5.766 ± 0.782	4.353 ± 0.644
RV/TLC**	28.011 ± 5.619	28.792 ± 6.773
FVC	3.977 ± 0.692	2.886 ± 0.547
FEV_1	3.285 ± 0.652	2.486 ± 0.531
$FEV_1\%$	82.673 ± 6.505	85.917 ± 6.418
MMEF	3.452 ± 1.160	2.836 ± 0.945
$\dot{V}_E$	6.628 ± 1.688	5.648 ± 1.466
MBC	116.423 ± 27.313	83.307 ± 20.149
BR	94.058 ± 2.122	92.963 ± 2.501
PEF	7.126 ± 1.364	5.428 ± 1.151
$\dot{V}_{75}$	5.860 ± 1.290	4.750 ± 0.983
$\dot{V}_{50}$	3.424 ± 1.053	2.950 ± 0.887
$\dot{V}_{25}$*	1.325 ± 0.658	1.152 ± 0.689
$\dot{V}_{50}/\dot{V}_{25}$**	2.937 ± 1.072	3.149 ± 1.374
D_LCO_{SB}	25.204 ± 5.887	17.815 ± 3.691

** P>0.05
* P<0.05
Rest P<0.01

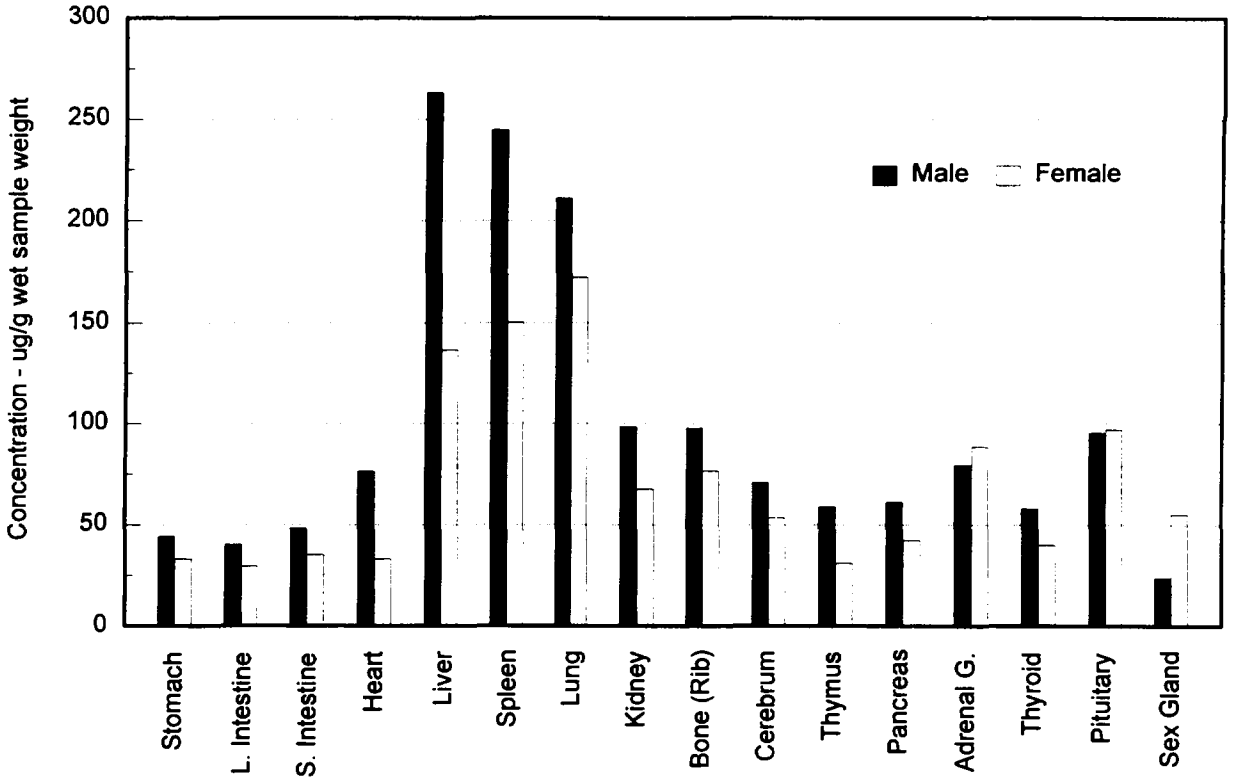

Fig. 3 - Fe concentration in various organs

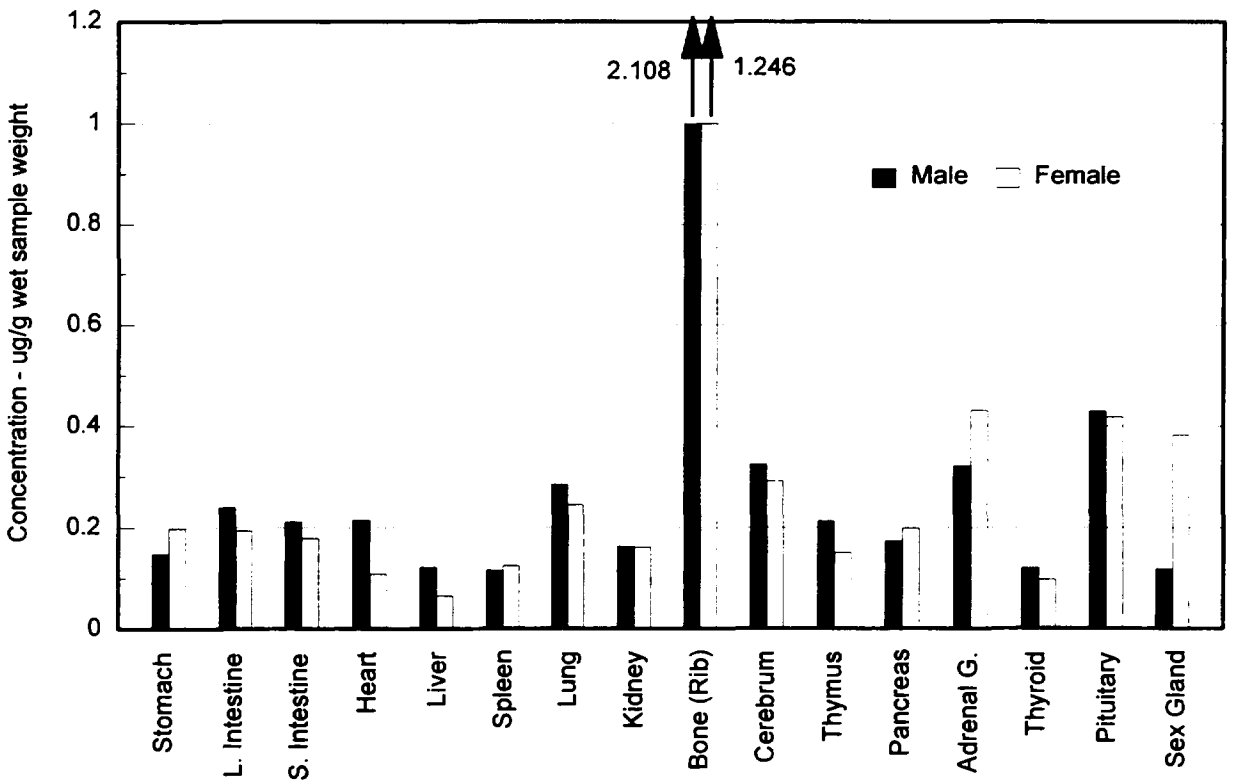

Fig. 4 - Ni concentration in various organs

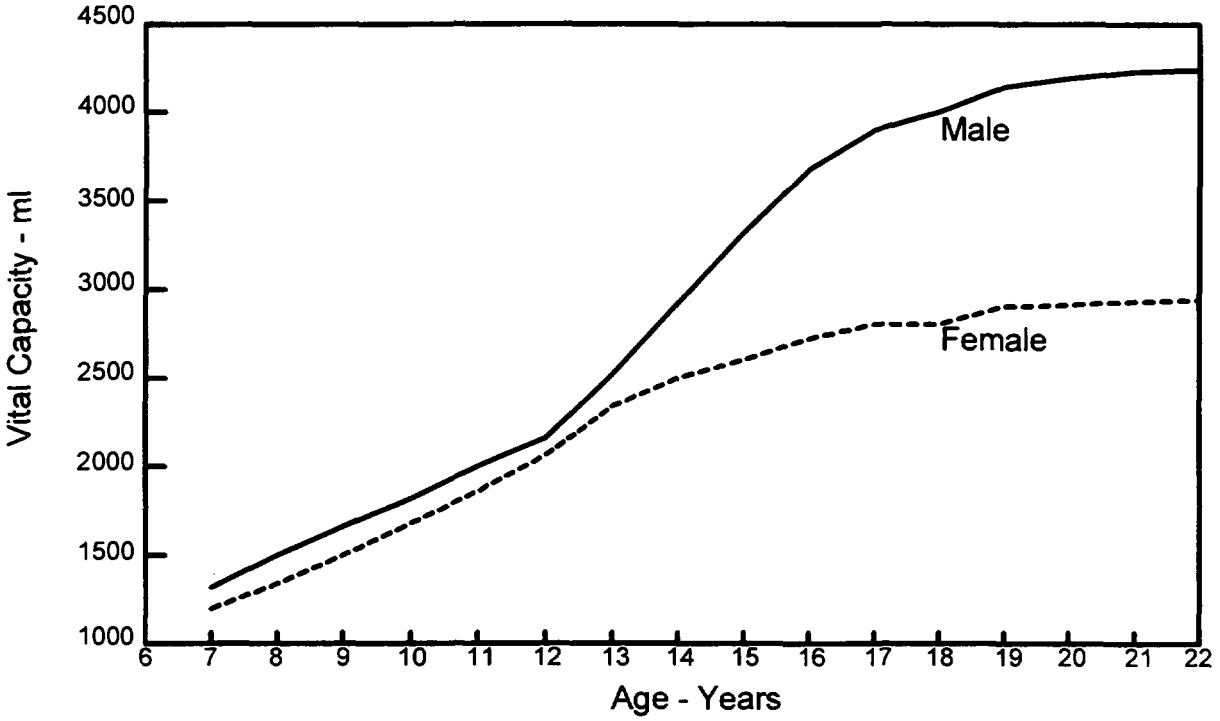

Fig. 5 - Vital capacity as a function of age

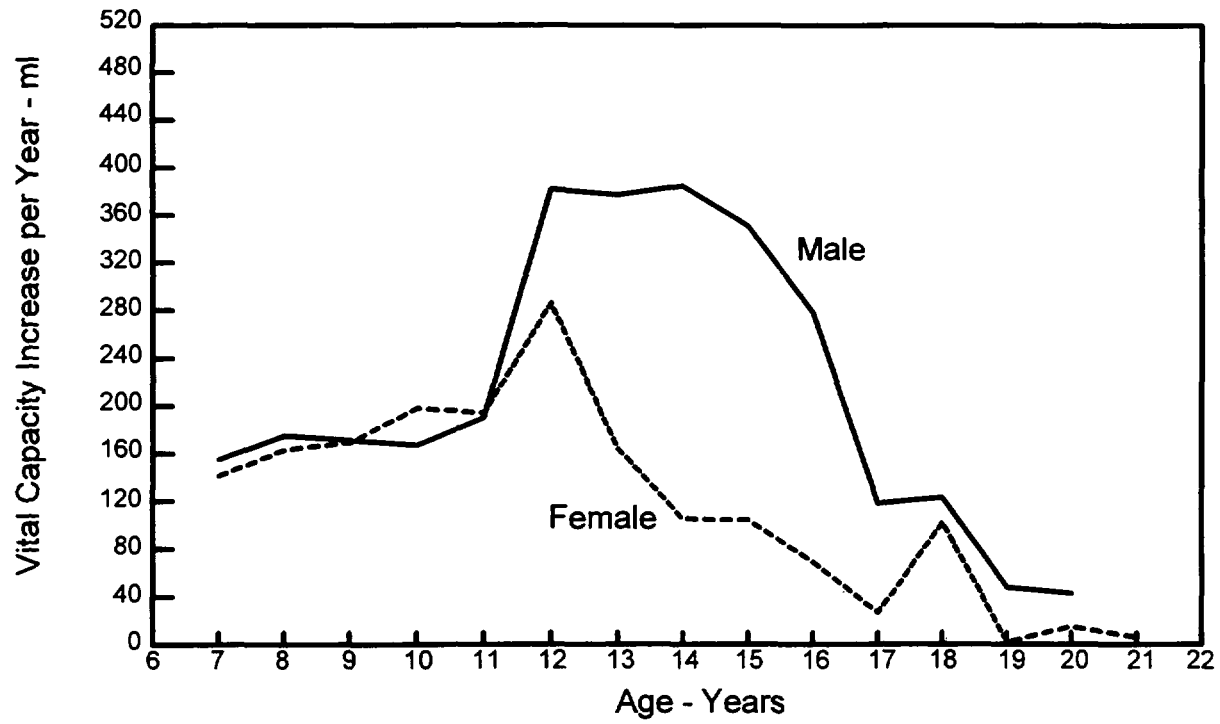

Fig. 6 - Increase in vital capacity as a function of age

TABLE XXIX. THE VALUES OF PULMONARY FUNCTION TEST OF DIFFERENT AGE AND SEX IN HEALTHY ADULTS

	15 - 19 (yrs)		20 - 29 (yrs)		30 - 39 (yrs)		40 - 49 (yrs)		50 - 59 (yrs)		> 60 (yrs)	
	M	F	M	F	M	F	M	F	M	F	M	F
VC	4.317 ± 0.539	3.018 ± 0.353	4.618 ± 0.640	3.252 ± 0.433	4.411 ± 0.519	3.311 ± 0.403	4.030 ± 0.603	3.002 ± 0.405	3.769 ± 0.508	2.689 ± 0.373	3.385 ± 0.487	2.399 ± 0.356
IC	2.648 ± 0.377	1.873 ± 0.262	2.774 ± 0.692	1.977 ± 0.333	2.767 ± 0.492	2.015 ± 0.418	3.593 ± 0.475	2.029 ± 0.540	2.424 ± 0.379	1.776 ± 0.218	2.292 ± 0.457	1.670 ± 0.241
ERV	1.669 ±0.300	1.183 ± 0.212	1.841 ± 0.340	1.275 ± 0.320	1.673 ± 0.327	1.313 ± 0.248	1.438 ± 0.885	1.024 ± 0.344	1.347 ± 0.446	0.908 ± 0.286	1.093 ± 0.385	0.709 ± 0.312
FRC	3.118 ± 0.497	2.348 ± 0.421	3.318 ± 0.562	2.358 ± 0.529	3.117 ± 0.491	2.501 ± 0.339	3.096 ± 0.814	2.217 ± 0.548	3.019 ± 0.610	0.294 ± 0.457	2.980 ± 0.644	2.329 ± 0.581
RV	1.411 ± 0.400	1.035 ± 0.325	1.581 ± 0.354	1.032 ± 0.379	1.559 ± 0.424	1.188 ± 0.301	1.641 ± 0.363	1.215 ± 0.240	1.725 ± 0.410	1.360 ± 0.294	1.770 ± 0.368	1.508 ± 0.331
TLC	5.796 ± 0.729	4.425 ± 0.608	6.096 ± 0.739	4.487 ± 0.637	5.993 ± 0.763	4.651 ± 0.623	5.662 ± 0.837	4.336 ± 0.628	5.583 ± 0.769	4.192 ± 0.562	5.465 ± 0.752	4.078 ± 0.726
RV/TLC	24.165 ± 4.714	23.615 ± 6.015	23.980 ± 5.336	25.230 ± 4.599	25.840 ± 5.584	24.520 ± 8.017	28.980 ± 4.459	28.670 ± 3.903	30.765 ± 4.988	32.350 ± 4.902	32.315 ± 4.481	37.010 ± 4.405
FVC	4.289 ± 0.508	3.116 ± 0.365	1.571 ±0.587	3.169 ± 0.409	4.319 ± 0.495	3.288 ± 0.548	3.868 ± 0.610	2.908 ± 0.444	3.600 ± 0.519	2.561 ± 0.373	3.219 ± 0.377	2.279 ± 0.355
FEV_1	3.752 ± 0.452	2.868 ± 0.372	3.824 ± 0.607	2.843 ± 0.418	3.577 ± 0.358	2.822 ± 0.458	3.157 ± 0.505	2.417 ± 0.330	2.855 ± 0.414	2.118 ± 0.261	3.559 ± 0.377	1.850 ± 0.292
FEV_1%	87.670 ± 6.153	91.965 ± 4.651	83.670 ± 8.639	89.710 ± 5.811	83.670 ± 6.036	86.185 ± 4.683	81.770 ± 3.740	83.700 ± 4.880	79.490 ± 6.177	43.110 ± 5.580	79.790 ± 3.971	80.840 ± 5.533

VC	Vital Capacity	TLC	Total Lung Capacity	$\dot{V}_E$	Ventilation Rest	$\dot{V}_{50}$	Expiratory Flow in 50% VC
IC	Inspiratory Capacity	FVC	Forced Vital Capacity	MBC	Maximum Breathing Capacity	$\dot{V}_{25}$	Expiratory Flow in 25% VC
ERV	Expiratory Reserve Volume	FEV_1	Forced Expiratory Volume in the First Second	BR	Breath Rate	D_LCO_{SB}	Single breath Diffusing Capacity of the Lung for Carbon Monoxide
FRC	Functional Residual Capacity	FEV_1%	$\frac{FEV_{1X100\%}}{FVC}$	PEF	Peak Expiratory Flow		
RV	Residual Volume	MMEF	Maximum Mid-expiratory Flow	$\dot{V}_{75}$	Expiratory Flow in 75% VC		

TABLE XXIX. THE VALUES OF PULMONARY FUNCTION TEST OF DIFFERENT AGE AND SEX IN HEALTHY ADULTS (CONTINUED)

	15 - 19 (yrs)		20 - 29 (yrs)		30 - 39 (yrs)		40 - 49 (yrs)		50 - 59 (yrs)		> 60 (yrs)	
	M	F	M	F	M	F	M	F	M	F	M	F
MMEF	4.556 ± 0.928	3.588 ± 0.675	4.387 ± 1.102	3.320 ± 0.910	3.546 ± 0.903	3.200 ± 0.730	3.170 ± 0.509	2.850 ± 0.820	2.867 ± 0.632	2.300 ± 0.850	2.358 ± 0.700	1.774 ± 0.638
V_E	6.185 ± 1.469	5.435 ± 1.152	6.854 ± 1.850	5.375 ± 1.479	6.845 ± 1.886	5.425 ± 1.514	6.285 ± 1.772	5.605 ± 1.110	6.625 ± 1.618	6.100 ± 2.005	6.980 ± 1.617	5.585 ± 1.437
MBC	135.180 ± 21.012	92.380 ± 12.469	134.700 ± 22.395	89.950 ± 12.882	131.765 ± 19.505	101.055 ± 21.557	112.670 ± 16.319	85.100 ± 16.358	103.425 ± 18.022	74.970 ± 9.360	87.525 ± 16.165	62.225 ± 10.946
BR	95.335 ± 1.826	94.060 ± 1.276	94.841 ± 1.405	93.580 ± 1.822	94.660 ± 1.839	94.500 ± 1.585	94.325 ± 1.777	93.155 ± 2.013	93.360 ± 2.249	91.840 ± 3.183	91.835 ± 2.217	90.840 ± 2.598
PEF	7.429 ± 0.967	5.398 ± 0.913	7.351 ± 1.404	5.573 ± 0.996	7.715 ± 1.429	9.190 ± 1.110	6.909 ± 1.166	5.797 ± 1.328	6.903 ± 1.297	4.938 ± 0.756	6.360 ± 1.577	4.682 ± 1.105
$\dot{V}_{75}$	6.234 ± 0.649	4.892 ± 0.717	5.975 ± 1.311	4.879 ± 0.893	6.156 ± 1.274	5.363 ± 0.984	5.823 ± 1.208	4.937 ± 1.945	5.539 ± 1.366	4.406 ± 0.869	5.414 ± 1.690	4.053 ± 0.891
$\dot{V}_{50}$	4.201 ± 0.953	3.510 ± 0.642	6.862 ± 1.103	3.216 ± 0.706	3.590 ± 0.946	2.211 ± 0.815	3.360 ± 0.784	2.989 ± 0.901	2.936 ± 0.985	2.653 ± 0.957	2.623 ± 0.772	2.146 ± 0.626
$\dot{V}_{25}$	1.950 ± 0.478	1.911 ± 0.841	1.982 ± 0.699	1.585 ± 0.425	1.419 ± 0.481	1.154 ± 0.525	1.038 ± 0.308	0.943 ± 0.360	0.915 ± 0.414	0.752 ± 0.358	0.697 ± 0.293	0.467 ± 0.159
$\dot{V}_{50}/\dot{V}_{25}$	2.131 ± 0.300	2.084 ± 0.506	8.091 ± 0.439	2.081 ± 0.350	2.618 ± 0.611	3.817 ± 0.587	3.436 ± 1.311	3.252 ± 0.674	3.364 ± 0.857	3.556 ± 1.1110	3.913 ± 1.054	4.954 ± 1.840
D_LCO_{SB}	30.350 ± 5.150	10.890 ± 2.536	29.810 ± 3.244	20.000 ± 3.167	27.870 ± 3.934	20.060 ± 2.140	23.735 ± 4.317	18.163 ± 3.976	21.525 ± 3.598	15.600 ± 2.590	17.925 ± 3.410	13.120 ± 1.897

V. ANALYSIS ELEMENTAL CONTENT IN ORGANS OF NORMAL CHINESE

Fifty-three adult accidental death victims were examined within 24 hours after death from 1989 to 1991. Seventeen organs (stomach, large intestine, small intestine, heart, liver, spleen, lung, kidney, skeleton, cerebrum, thymus, pancreas, adrenal gland, thyroid, pituitary, testes and ovaries) of each victim were weighted and sampled for analysis of content of 15 elements (Zn, Cu, Mn, Fe, Cd, K, Na, Ca, Mg, Cr, Ni, Co, Mo, Sr, and Pb). The chemical analysis to determine the concentration of elements in the organs were carried out using an atomic absorption spectrophotometer. The results of analysis are presented in Table 26 (1-3) and compared with the corresponding values for ICRP Reference Man (Table 27).

For most of elements, the values are close to those reported for ICRP Reference Man. For a few elements such as Zn in thyroid, Pb in bone, and Cd in kidney, the contents are lower than those for ICRP. However, the concentration of Ni in heart, Zn in adrenal and thymus, Mn and Mo in rib and Cr in all tissues are all higher than those for ICRP Reference Man, as shown in Table 2.

In general, the elemental concentration in various organs and tissues of normal Chinese are roughly the same as those for Japanese or Indian. However, there are individual differences in the concentration of specific elements. For example, the average Cu concentration in adrenal gland and Pb in kidney for Chinese are markedly lower than those for Indian. The concentrations of Ca in heart, liver, spleen, kidney, cerebrum and pancreas of Chinese are several times lower than those for Japanese. The average Sr concentration in these tissues are higher than those for Japanese. The average Cd concentration in liver and kidney are also lower than those for Japanese.

TABLE XXX. THE CORRELATION COEFFICIENT OF AGE, HEIGHT AND WEIGHT WITH PULMONARY FUNCTION IN HEALTHY ADULTS

Items	Age (yrs)		Height (cm)		Weight (kg)	
	M	F	M	F	M	F
VC	- 0.579	- 0.576	0.670	0.570	0.304	0.239
IC	- 0.327	- 0.243	0.539	0.318	0.566	0.375
ERV	- 0.534	- 0.562	0.372	0.521	- 0.202	- 0.094*
FRC	- 0.118*	- 0.099*	0.461	0.346	- 0.158	- 0.108*
RV	0.295	0.456	0.308	0.037*	- 0.072*	0.021*
TLC	- 0.236	- 0.253	0.683	0.394	0.170	0.117*
RV/TLC	0.526	0.695	- 0.099*	- 0.232	- 0.199	- 0.029*
FVC	- 0.653	- 0.625	0.655	0.524	0.240	0.216
FEV_1	- 0.729	- 0.752	0.576	0.522	0.135*	0.091*
$FEV_1\%$	- 0.415	- 0.595	0.029*	0.152*	- 0.159	- 0.226
MMEF	- 0.714	- 0.669	0.210	0.323	- 0.211	- 0.004*
$\dot{V}_E$	0.061*	0.060*	0.147*	0.017*	0.227	0.205
MBC	- 0.650	- 0.505	0.377	0.326	0.041*	0.179
BR	- 0.528	- 0.493	0.147*	0.316	-0.087	-0.0413
PEF	- 0.295	- 0.323	0.226	0.333	0.263	0.236
$\dot{V}_{75}$	- 0.249	- 0.355	0.210	0.354	0.172	0.193
$\dot{V}_{50}$	- 0.522	- 0.500	0.215	0.208	-0.123	- 0.002*
$\dot{V}_{25}$	- 0.733	- 0.712	0.272	0.322	-0.233	- 0.082*
$\dot{V}_{50}/\dot{V}_{25}$	0.638	0.745	- 0.211	-0.367	0.246	0.070*
D_LCO_{SB}	- 0.771	- 0.687	0.425	0.466	0.008*	0.197

* $P > 0.051$, Rest $P < 0.05$

TABLE XXXI. THE NORMAL PREDICTIVE EQUATION OF 9 INDEXES IN PULMONARY FUNCTION

Items	Sex	Normal predictive equation	r
VC	M	- 5.425 - 0.020 x A + 0.058 x H + 0.012 x W	0.8118
	F	- 2.827 - 0.012 x A + 0.04 x H	0.7359
FRC	M	- 7.812 + 0.005 x A + 0.079 x H - 0.042 x W	0.6473
	F	- 4.955 + 0.005 x A + 0.055 x H - 0.030 x W	0.5564
RV/TLC	M	- 2.31 + 0.218 x A + 0.232 x H - 0.295 x W	0.6289
	F	22.091 + 0.284 x A - 0.091 x W	0.7014
MMEF	M	1.50 - 0.046 x A + 0.032 x H - 0.028 x W	0.7342
	F	4.339 - 0.038 x A	0.6689
MBC	M	- 38.20 - 0.987 x A + 1.162 x H	0.6986
	F	76.193 - 0.633 x A + 0.636 x W	0.5548
$\dot{V}_{75}$	M	4.69 - 0.022 x A + 0.035 x W	0.3271
	F	- 2.889 - 0.016 x A + 0.053 x H	0.4891
$\dot{V}_{50}$	M	4.75 - 0.033 x A	0.5222
	F	4.003 - 0.026 x A	0.4996
$\dot{V}_{25}$	M	- 1.35 - 0.025 x A + 0.030 x H - 0.022 x W	0.7743
	F	2.318 - 0.029 x A	0.7120
D_LCO_{SB}	M	- 10.30 - 0.254 x A + 0.273 x H	0.8146
	F	- 4.303 - 0.136 x A + 0.151 x H + 0.079 x W	0.7788

A = Age (yrs), H = Height (cm), W = Weight (kg), M = Male, F = Female

On the other hand, the differences by sex for concentration of some elements in organs are found. For example, in male adult, the concentration of Fe in liver, spleen and lung, Ni in thymus are all higher than those for female in normal Chinese (as shown in Figs 3 and 4).

VI. PULMONARY FUNCTION OF NORMAL CHINESE

There are a few data on complete indexes of pulmonary function, but a lot of data are available on vital capacity measurements for Chinese students from 7 to 22 years old [6.8]. Figs 5 and 6 show the increasing vital capacity of students with age. The vital capacity of both male and female students increased with age from 7 - 22. The average increase per year was 194.2 ml for male and 116.4 ml for female. The period of maximum increase in vital capacity for male was 12-15 years old and 10-12 for female. After 21 years old for male and 19 for female the vital capacity becomes stable. The mean vital capacity of female was 70% of that of male.

Systematic tests of pulmonary function (including 20 indexes) were conducted in healthy adults in 1986 to establish reference values based on the reference value of height and weight of total body for various age and sex groups. The results are presented in Tables 28 and 29. Taking the age, height and weight of total body as the independent variables, the best regression equations and the multiple correlation regression coefficients for each index were

TABLE XXXII. CALCULATED REFERENCE VALUES OF 9 INDICES OF PULMONARY FUNCTION FOR VARIOUS AGE AND SEX GROUPS

Age	Sex	VC	FRC	RV/TLC	MMEF	MBC	$\dot{V}_{75}$	$\dot{V}_{50}$	$\dot{V}_{25}$	D_LCO_{SB}
15 - 19	M	4.527	3.193	24.132	4.666	139.887	6.180	4.255	2.111	31.208
Years	F	3.273	2.315	21.983	3.769	97.226	5.192	3.613	1.883	21.156
20 - 30	M	4.655	3.223	24.880	4.110	134.665	6.240	3.925	1.805	29.760
Years	F	3.273	2.410	24.459	3.389	93.440	5.191	3.353	1.593	20.565
20 - 50	M	4.397	3.194	26.828	3.618	123.633	6.020	3.595	1.525	26.947
Years	F	3.073	2.350	27.299	3.009	87.110	4.925	3.093	1.303	18.903

Note:

VC: Vital Capacity
FRC: Functional residual volume
RV/TLC: Residual Volume/total lung capacity
MMEF: Maximum mid-expiratory flow
MBC: Maximum breathing capacity
$\dot{V}_{75}$: Expiratory flow in 75% vital capacity
$\dot{V}_{50}$: Expiratory flow in 50% vital capacity
$\dot{V}_{25}$: Expiratory flow in 25% vital capacity
D_LCO_{SB}: Single-breath diffusing capacity of the lung for carbon monoxide

TABLE XXXIII. ELEMENTAL CONTENT OF ORGANS AND TISSUES OF REFERENCE MAN IN ICRP-23 PUBLICATION

Organ and tissue	Element (μg/g wet sample)														
	Zn	Cu	Mn	Fe	Cr	Ni	Co	Mo	Sr	K	Na	Ca	Mg	Pb	Cd
Stomach	18.67	1.67	0.306	28.67	0.014	0.041	0.016	0.031	0.080	1400	1000	66.67	106.67	0.093	0.400
Large intestine	19.46	1.30	0.594	20.00	0.027	0.110	0.008	0.027	0.197	1108	1000	113.0	148.65	0.124	0.350
Small intestine	18.75	1.56	0.546	26.56	0.020	0.055	0.017	0.050	0.144	1359	1000	84.34	120.31	0.131	0.420
Heart	25.45	3.33	0.200	45.45	0.016	0.048	0.030	0.039	0.025	2182	1212	36.36	163.64	0.055	0.480
Liver	47.22	6.67	1.388	177.8	0.009	0.067	0.061	1.800	0.018	2500	1000	50.00	172.20	1.700	2.220
Spleen	17.77	1.22	0.128	272.2	0.072	0.072	0.035	0.060	0.288	3111	1222	66.66	127.66	0.350	0.722
Lung	11.00	1.20	0.120	36.00	0.090	0.047	0.002	0.031	0.057	1900	1800	87.00	71.00	0.390	0.350
Kidneys	48.39	2.90	0.903	74.19	0.010	0.055	0.013	0.035	0.058	1903	2000	93.55	129.03	1.097	31.900
Skeleton*	48.00	0.72	0.520	81.00	0.480	0.500	0.028	0.040	32.00	1500	3200	100000	1100.0	11.00	1.20
Cerebrum	12.14	5.79	0.278	52.86	0.003	0.079	0.032	0.064	0.024	3000	1571	85.71	150.00	0.100	0.785
Thymus	6.50	0.70	0.090	11.0	0.009	0.022	0.009	0.011	0.070	600	-	85.00	30.00	0.050	0.700
Pancreas	25.00	1.50	1.100	39.00	0.018	0.060	0.024	0.048	0.035	2300	1400	91.00	160.00	0.550	0.960
Adrenal gland	7.86	1.07	0.717	37.14	0.050	0.036	0.014	0.069	0.016	1000	-	40.71	44.29	0.121	0.350
Thyroid	31.00	1.10	0.200	55.00	0.014	0.060	0.011	0.045	0.130	1200	2200	350.0	100.00	0.200	0.700
Testes	14.86	0.83	0.128	23.43	0.037	0.054	0.022	0.043	0.046	2000	1000	113.0	148.65	0.128	0.540

* Rib

derived by using the method of step wise regression. The correlation coefficients of age, height and weight with pulmonary function parameter in healthy adult are listed in Table 30 and the normal predictive equations of 9 indexes in pulmonary function test are shown in Table 31. The reference values for the 9 indices, calculated based on the normal predictive equations, are listed in Table 32.

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