13 ANTHROPOMETRY

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This chapter, which describes the anthropometric data collected in the IUNS project, will cover the following topics:

(i) the selection of variables;
(ii) measurement and standardisation procedures;
(iii) the derivation of variables;
(iv) limitations of the data; and
(v) distribution statistics for each variable.

These distribution statistics will be compared between project centres, with data reported from the SENECA study, with unpublished data from the study made available by Dr Wijn A van Staveren, with other reported data, and with some unreported data from China, Japan, New Zealand and Australia.

13.1 THE SELECTION OF VARIABLES

The biological basis for the selection of the anthropometric variables was related to their expected associations with food habits, health and well-being in the elderly. Weight was included because it reflects the recent and present balance between energy intake and energy expenditure and because weight and changes in weight in the elderly are related to mortality rates [1-4]. Stature was included because it reflects genetic potential and nutritional status during growth. In addition, stature is related to fat-free mass which is an index of protein stores [5]. Both weight and stature are related to percentage of body fat (caloric reserves) and to calcium stores as indexed by total body bone mineral [6-8].

Weight can be adjusted for stature by calculating the body mass index (BMI = weight /height^2 (kg/m^2)) which is related to percentage of body fat and to fat-free mass [9]. A major interest in BMI values for the elderly concerns their relationships with mortality rates. These relationships are close during follow-up intervals that begin in middle age but are less marked for intervals that begin in old age [10-12]. These associations with mortality rates reflect:

(i) relationships between BMI values and risk factors for cardiovascular disease independently of the distribution of adipose tissue "fat patterns" [13];
(ii) possible reductions in immunocompetence in association with low amounts of fat-free mass (FFM) [14-16]; and
(iii) an increased prevalence of falls and fractures associated with reductions in muscle strength and bone density [17-19].

Waist and hip circumferences were measured to provide the waist-hip ratio (WHR) which is a useful index of adipose tissue distribution [20]. In addition, waist circumference is related to the amount of visceral adipose tissue, but it does not provide reasonably accurate predictions of the amount of visceral adipose tissue [21].

The triceps skinfold thickness was included because it is closely related to percent body fat [9] and, in association with arm circumference, it can be used to calculate arm muscle area or arm muscle circumference. Although these indices overestimate the true values by amounts that increase with adiposity [22-24], they are guides to protein stores and are related to mortality rates in follow-up studies of the middle-aged [25,26].

13.2 MEASUREMENT AND STANDARDISATION PROCEDURES

The measurement procedures were, as far as practicable, standardised across the data collection centres. All measurements were made by trained observers who followed the instructions in a formal "Working Plan and Manual of Operations" that defined the procedures and the sequence in which the variables should be measured. The measurement procedures match those used in the SENECA Study [27] and those recommended by a North American Consensus Conference [28] except as noted below. All measurements were made in duplicate and the means of paired values were used in the analyses.

Stature was measured to be nearest 0.1 cm using a microtoise® attached to a wall. Each subject stood on a horizontal platform without shoes and with the heels together and the head in the Frankfort plane. The subject assumed his/ her full stature and inhaled deeply just before the measurement was made. Weight was measured to the nearest 500 g with the subject wearing light clothing, either fasting or after breakfast. In the SENECA Study, weight was measured after breakfast with the subjects wearing light undergarments. Lohman et al. [28] recommended that weight be measured to the nearest 100 g and adjusted for the weight of the clothing.

Triceps skinfold thickness was measured in the posterior midline of the arm, parallel to its long axis, midway between acromiale and the olecranon. The site of measurement was marked on the skin and the calliper jaws were placed on an elevated fold. After their full pressure was exerted, the thickness was read to the nearest 0.2 mm using a Holtain calliper. Harpenden callipers were used in the SENECA Study but data obtained with these two types of calliper are similar.

For the measurement of waist and hip circumferences, the subject wore light clothing and stood with their feet about 12 to 15 cm apart with the weight equally distributed between them. Waist circumference was measured at the level of the umbilicus to the nearest 0.1 cm at the end of normal expiration. Hip circumference was measured to the nearest 0.1 cm as the maximum circumference over the buttocks usually at the level of the greater trochanters but not lower than the pubic symphysis. In the SENECA Study, the waist measurements were made midway between the lower costal margin and the iliac crest at the end of gentle expiration. Lohman et al. [28] recommend that this measurement not be made over clothing, that an assistant ensure the tape is horizontal, and that the tape does not indent the skin. They further recommend that the measurement be made at the level of the natural waist or, if a waist narrowing cannot be identified, at a level midway between the lower costal margin and the iliac crest.

Arm circumference was measured on the left side with the subject standing and the arm hanging relaxed just away from the trunk. The circumference was measured at the same level as the triceps skinfold to the nearest 0.1 cm without indenting the skin.

13.3 THE DERIVATION OF VARIABLES

The following variables were derived from the recorded values:

- body mass index BMI; weight/ height^2 (kg/m^2)
- waist/ hip ratio (WHR; waist circumference/ hip circumference);
- arm muscle area (AMA; cm^2). This is calculated as AMA = $[AC - 3.14 * (TSF / 10)]^2 / 12.56$ where AC is arm circumference (cm) and TSF is triceps skinfold thickness (mm).
- fat-free mass (FFM; kg). Predicted values were obtained using an equation of Deurenberg et al [30]: FFM = 0.282*S + 0.395*W + 8.4*sex - 0.144*age - 23.6 where S = stature in cm, W = weight in kg, sex = 1 for men and 0 for women, age in years.
- total body fat (TBF; kg) body weight - FFM.
- percentage body fat (%BF) = TBF/ 100 * body weight.

13.4 LIMITATIONS OF THE DATA

The cross-sectional design limits the interpretation of changes in data with increasing age. Any differences between age groups within ethnic samples may reflect cohort effects, changes within individuals and selective mortality. The available data do not allow these effects to be evaluated separately. The sample sizes are small, especially for older men in the CTJ-R, CTJ-U and GRK-S groups and ACA>80 yrs.

The predicted values for %BF were obtained using an equation that does not appear to have been cross-validated [30], but, in the validation group the s.e.e. values were similar for each sex (4.01% males; 3.74%, females). As shown by Deurenberg et al [30], predictions of body composition in the elderly are more accurate from a combination of bioelectric impedance (resistance) and anthropometry than those from anthropometry alone but impedance measurements were not obtained in all of the study centres. The values obtained by the use of Deurenberg's equations must be evaluated with caution because there are considerable differences between the populations from which the equations were derived and the populations to which they have been applied.

13.5 WEIGHT

The sample sizes were very small for ACA and GRK-S men and women aged more than 80 years. The median weights for men aged less than 70 years in the CBJ and FIL groups were 65.0 and 55.7 kg respectively, while the medians for men aged 70-79 years ranged from 49.8 kg (FIL) to 76.0 kg (SWE) and those for men older than 80 years ranged from 46.4 kg (FIL) to 73.5 kg (GRK-M). In women aged less then 70 years, the median weights were 60.2 kg and 50.6 kg in the CBJ and FIL groups respectively. In women aged 70-79 years, the medians for weight ranged from 49.0 kg (CTJ-R) to 68.5 kg (GRK-M) and in women older than 80 years the medians ranged from 41.0 kg (CTJ-R) to 62.0 kg (GRK-S) (Table 13.1).

Median weights were markedly larger for groups of European ancestry than for Oriental groups, and they were also greater for men than women; these latter differences being large for both younger and older SWE groups (15.7 and 12.6 kg respectively) and for the younger GRK-S subjects (11.2 kg) but small for the FIL groups (<70 years, 5.1 kg; >70 years, 3.4 kg). In each ethnic sample within a gender, the medians for the younger groups exceeded those for the older groups. The differences between the medians for age groups of men in the same ethnic sample varied from 1.0 kg (CBJ) to 8.2 kg (GRK-S) while those for women varied from 0.6 kg (SWE) to 8.0 kg (CTJ-R). The standard deviations were small in CTJ-R men and women and in ACA women but relatively large in the GRK-M groups. These differences in standard deviations remained after adjusting for the mean values.

Table 13.1. Descriptive statistics for weight (kg).

Groups and Ages	Men N	Men Mean	Men SD	Men Median	Women N	Women Mean	Women SD	Women Median
ACA 70-79 yr	41	74.8	9.8	76.8	36	66.8	8.8	67.4
ACA >80 yr	5	68.2	5.5	68.5	6	61.1	8.8	64.2
GRK-M 70-79 yr	64	76.4	11.0	75.0	59	68.9	11.3	68.5
GRK-M >80 yr	28	72.3	10.9	73.5	35	61.5	13.7	62.0
GRK-S 70-79 yr	26	75.7	13.8	74.7	20	64.8	10.6	63.5
GRK-S >80 yr	15	67.9	9.7	66.5	9	61.2	8.3	60.5
SWE 70-79 yr	51	76.9	10.4	76.0	75	62.5	12.0	60.3
SWE >80 yr	19	74.3	10.6	72.3	59	59.6	10.7	59.7
FIL <70 yr	33	56.8	9.1	55.7	105	52.1	11.8	50.6
FIL >70 yr	40	51.4	11.3	49.8	94	46.6	11.3	46.4
CBJ <70 yr	79	66.7	11.2	65.0	124	61.9	12.5	60.2
CBJ >70 yr	43	63.1	9.2	64.0	53	55.1	9.0	55.5
CTJ-R 70-79 yr	73	54.7	7.1	54.0	79	48.2	8.9	49.0
CTJ-R >80 yr	10	47.1	7.6	46.5	19	42.9	8.6	41.0
CTJ-U 70-79 yr	107	65.9	10.1	65.0	102	55.3	11.4	55.0
CTJ-U >80 yr	19	61.3	9.7	61.5	32	52.1	10.4	51.0

13.5.1 Comparisons with reported data

In the SENECA Study of subjects aged 70-75 years [27], the mean weights for men range from 70.5 kg (Anogia, Archanes; Greece) to 78.2 kg (Culenborg; Netherlands) and those for women range from 56.8 kg (Chateau Renault, Amboise; France) to 71.4 kg (Culenborg, Netherlands). The SENECA means are higher than the means or medians for the IUNS Asian samples, but are similar to those for the IUNS groups of European origin despite the slightly younger ages of the SENECA subjects. In Table 13.2 and later tables of reported findings, data from groups with fewer than 20 subjects have been omitted. Some comparisons are made difficult by the wide age ranges in some earlier reports. The median weights for elderly men in groups of European ancestry in the IUNS project are similar to reported values except that they are considerably larger than values from Scotland [31] and they are smaller than the mean reported by Flynn et al [32] for a US group. The reported mean and median weights for European and US women are similar to the corresponding IUNS values for women of European ancestry except the SWE women in the IUNS study, who had somewhat lower weights. Also, the means and medians reported for women >80 years by Milne [31] for Scottish groups and by Montoye et al [33] for US groups tend to be lower than IUNS data for groups of European ancestry at similar ages. The differences between reported means for men and women range from 4.0 kg in one US group [33] to 15.0 kg in another US group [34]. This is similar to the range of gender differences for weight in the IUNS groups.

The gender difference in mean weight reported by Steen et al. [35] from a Swedish group aged 70 years (9.4 kg) is notably smaller than that for the SWE groups in the IUNS project (15.7 kg for groups 70-79 years; 12.6 kg for groups aged >80 years). The differences in weight between younger and older groups of elderly subjects vary markedly among reports. Small differences (0.4 kg) were noted for Scottish men [31],and some US women by Montoye et al. [33]. The upper limits of the differences between means or medians for younger and older age groups are similar between the IUNS data set and reported findings. The variability of these age differences may reflect vagaries of sampling.

Table 13.2. Reported data for weight (kg).

Authors	Age (yr)	Men N	Men Mean (Median)	Men SD	Women N	Women Mean (Median)	Women SD
Rissanen et al. (1988, Finland)	>70	150	71.5	11.9	226	66.7	11.9
Lowik et al. (1992, Netherlands)	70-74	-	-	-	52	67.0	9.5
(1985, Scotland)	70-79	73	66.9	12.0	101	62.3	12.3
	>80	20	66.5	13.2	34	53.8	11.4
Steen et al. (1977, Sweden)	70	402	76.2	-	466	66.8	-
Montoye et al. (1965, US)	70-74	65	(73.3)	-	74	(65.0)	-
	75-79	34	(69.4)	-	42	(65.4)	-
	>80	25	(67.0)	-	41	(54.8)	-
Damon et al. (1972, US)	65-74	53	77.0	-	-	-	-
Lee et al. (1981, US)	70-70.9	-	-	-	56	68.9	13.4
Shimokata et al. (1989, US)	70-96	201	(73.9)	-	94	(61.0)	-
Czajka-Narins et al. (1991, US)	70-74	32	75.5	12.5	68	69.0	12.5
	75-79	25	75.8	12.5	49	63.4	10.5
Flynn et al. (1992, US)	71-80	106	80.0	12.0	-	-	-
Chumlea et al. (1992, US)	67-92	41	75.0	11.7	63	60.0	10.7

Groups in which N < 20 have been omitted from this and following tables of reported data.

13.5.2 Discussion

Weight can be obtained with minimal errors of measurement and, although a non-specific measure of total body size, it is related to the prevalence of some serious diseases and to mortality rates in the elderly. These relationships are stronger if weight is adjusted for stature using body mass index.

The interpretation of these and other IUNS data must take into account the cross-sectional design of the study. Differences between age groups could be influenced by cohort effects (sampling), changes within individuals and selective mortality. Cohort effects are more likely to be important when the groups are small. A loss of weight is common in the elderly but this is not noted in some groups, particularly if they are physically active [1,32,36-40]. Selective mortality would affect the differences between age groups since weight is positively associated with survival in the elderly [31,36]. Cohort effects and selective mortality could also influence the magnitude of difference in median weights between genders.

13.6 STATURE

In the IUNS data, as shown in Table 13.3, the median statures for men <70 years in the CBJ and FIL groups were 161.3 and 160.0 cm respectively while those for men aged 70-79 years ranged from 157.7 cm (FIL) to 175.0 cm (SWE). The medians for men aged >80 years ranged from 161.0 cm (CTJ-R) to 173.0 cm (SWE). The medians for women aged <70 years in the CBJ and

FIL groups were 155.3 and 148.1 cm respectively while those for women aged 70-79 years ranged from 146.6 cm (FIL) to 161.0 cm (SWE) and those for women older than 80 years ranged from 148.0 cm (GRK-S) to 157.0 cm (SWE), after excluding the estimate for the small sample of GRK-S women in this age group.

Men were taller than women within the younger and older age groups for all IUNS samples. The medians for men exceeded the corresponding medians for women by only 6.0 cm in the CBJ groups aged <70 years. The medians for men aged 70-79 years exceeded those for women by amounts that ranged from 6.8 cm (CBJ) to 15.5 cm (GRK-M) while the corresponding differences for those aged >80 years varied from 11.0 cm (CTJ-R) to 16.0 cm (SWE). The differences between the median statures for younger (70-79 years) and older (>80 years) age groups varied markedly within each gender. For CBJ men, the median stature for those aged 70-79 years was slightly larger than that for the group aged <70 years. The remaining comparisons showed smaller medians in the older groups with differences between age groups (70-79 vs. >80 years) of 1.2 to 3.3 cm that did not vary systematically with gender. Values of the standard deviation tended to be high in the ACA and GRK-M men and in the ACA , CTJ-R and CTJ-U women, in the younger GRK-S women, and in the older FIL and GRK-M women. These differences in variability were not due to variations between the means. These comments, as for those on Table 13.6, do not relate to very small samples (ACA men and women >80 years and GRK-S women >80 years).

13.6.1 Comparisons with reported data

In the SENECA Study, the mean statures for men range from 160 cm (Sabina Hills; Italy) to 173 cm (Culenborg; Netherlands) [27]. The SENECA means for women range from 146 cm (Vila Franca de Xira; Portugal) to 160 cm (Culenborg; Netherlands). These ranges for subjects aged 70-75 years are similar to those for IUNS groups aged 70-79 years. The means for men from the SENECA Study exceed those for women by amounts that range from 9.0 cm (Burgdorf, Switzerland) to 16.0 cm (Hamme, Belgium and Yverdon, Switzerland). Many reported studies are limited by small sample sizes, particularly for men in older age groups and the descriptive statistics from some studies are for wide age ranges.

In Table 13.4, the mean and median statures in men for European and US groups are similar to corresponding values for IUNS groups of similar ancestry. The reported means for men exceed those for women by 12.2 to 15.0 cm for groups aged about 75 years and by 10.0 to 13.3 cm for groups older than 80 years [35,41-44]. These gender-biased differences are similar to those in the IUNS project. The reported means and medians for younger groups are larger than those for older groups by 0.6 to 2.0 cm. This variation among reports could reflect the small sample sizes in some studies.

Table 13.3. Descriptive statistics for stature (cm).

	Men				Women			
Groups and Ages	**N**	**Mean**	**SD**	**Median**	**N**	**Mean**	**SD**	**Median**
ACA 70-79 yr	41	169.9	7.2	170.0	36	159.1	6.3	158.0
ACA >80 yr	5	164.3	2.5	165.6	6	154.9	6.4	153.8
GRK-M 70-79 yr	64	165.2	6.4	165.5	59	149.8	5.3	150.0
GRK-M >80 yr	28	163.3	6.8	162.0	35	148.6	6.1	149.0
GRK-S 70-79 yr	26	165.9	6.2	164.5	20	151.3	5.7	151.5
GRK-S >80 yr	15	163.9	6.4	163.0	9	149.9	3.9	148.0
SWE 70-79 yr	51	174.1	5.7	175.0	75	161.2	4.8	161.0
SWE >80 yr	19	172.9	5.0	173.0	59	157.9	5.6	157.0
FIL <70 yr	33	159.7	6.1	160.0	105	148.8	5.6	148.1
FIL >70 yr	40	158.1	6.6	157.7	93	147.1	6.1	146.6
CBJ <70 yr	77	161.6	4.4	161.3	122	155.8	4.1	155.3
CBJ >70 yr	44	161.6	3.9	161.7	54	154.6	3.8	154.9
CTJ-R 70-79 yr	73	163.0	6.1	164.0	79	151.0	5.7	150.0
CTJ-R >80 yr	10	159.9	4.7	161.0	19	148.6	6.1	150.0
CTJ-U 70-79 yr	107	168.1	5.0	169.0	102	154.2	5.7	155.0
CTJ-U >80 yr	19	166.4	5.8	166.0	32	151.5	6.3	151.0

Table 13.4. Reported data for stature (cm).

Authors	Age (yr)	Men N	Men Mean (Median) (Median)	Men SD	Women N	Women Mean	Women SD
Rissanen et al. (1988, Finland)	>70	150	167.6	5.4	226	155.0	6.0
Marquer and Chamla	70-74	89	163.0	5.5	-	-	-
(1961, France)	75-79	36	162.1	5.8	-	-	-
	>80	32	160.5	5.7	-	-	-
Lowik et al. (1992, Netherlands)	74	-	-	-	52	161.0	5.0
(1981, Scotland)	70-74	37	166.6	6.6	54	152.5	5.4
	75-79	33	166.5	7.6	42	152.3	5.4
	>80	-	-	-	26	151.9	7.2
(1985, Scotland)	70-79	73	166.2	7.0	101	153.4	5.5
	>80	20	165.2	8.2	34	151.9	7.2
Karlberg & Mossberg							
(1991, Sweden)	70-79	371	171.4	6.3	406	159.2	5.5
Steen et al. (1977, Sweden)	70	402	174.0	-	466	160.0	-
Damon et al. (1972, US)	65-74	53	172.0	-	-	-	-
Lee et al. (1981, US)	70-79	-	-	-	56	158.0	7.0
Borkan et al. (1983, US)	70-79	43	171.6	6.9	-	-	-
Shimokata et al. (1989, US)	70-96	201	173.1	-	94	157.0	-
Frisancho (1990, US)	70-74.9	1257	170.6	6.8	1467	157.6	6.1
Czajka-Narins et al. (1991,US)	70-74	32	171.0	8.8	68	157.0	8.0
	75-79	25	170.0	8.6	49	155.0	5.0
	80-84	-	-	-	35	154.0	4.0
Chumlea et al. (1992, US)	67-92	41	174.7	7.5	63	156.6	7.0
Flynn et al. (1992, US)	71-80	106	174.0	6.0	-	-	-

13.6.2 Discussion

In young or middle-aged adults, stature is an important index of nutrition and health during growth. For corresponding reasons, stature is an important measure in the elderly; although stature decreases with ageing to extents that differ among individuals. The occurrence of larger median statures for groups aged 70-79 years than for groups older than 80 years in the IUNS project could reflect cohort differences. The total secular trend for young adult stature, comparing those born in 1904 with those born in 1914, which are the mid-points of the birth years for the age groups considered, was about 3 cm in the Netherlands [45].

Corresponding estimates do not appear to be available for the ethnic groups included in the IUNS project, but the secular changes were probably larger in the Netherlands than in most of the IUNS ethnic groups. The differences between cohorts could also be due to sampling variations, especially when the samples are small. Additionally, selective mortality could affect the differences in stature between younger and older age groups because all-causes mortality rates tend to be negatively related to stature [12,46]. These decreases in all-causes mortality with increasing stature occur despite an opposite association between stature and the prevalence of breast cancer [47,48]. Since tall adults tend to have small BMI values, the decrease in mortality rates with tall stature may be mediated through BMI [49].

The differences between age groups with mean ages of about 75 and 85 years may be influenced by changes in stature within individuals. The reported mean decreases per decade in the elderly range from 1.0 to 2.3 cm for men and from 1.0 to 2.9 cm for women [32,39,44,50-56]. These decreases are mainly due to decreases in trunk length [42,56]. It has been suggested that losses in stature with ageing are greater in developed countries than in developing countries [54] but this is not supported by the IUNS data.

13.7 BODY MASS INDEX

The IUNS medians for body mass index (BMI) for ages <70 years were lower in the FIL group than in the CBJ groups for each gender (Table 13.5). The median BMI values for those aged 70-79 years were smallest for the FIL subjects (20.0 kg/m^2 men, 21.1 kg/m^2 women) and largest for the GRK-M men and women (28.1 and 30.0 kg/m^2 respectively). For men older than 80 years, the median BMI values ranged from 18.8 kg/m^2 (CTJ-R) to 27.2 kg/m^2 (GRK-M) and for women the medians ranged from 18.7 kg/m^2 (CTJ-R) to 28.3 kg/m^2 (GRK-M). There were only small gender differences for most comparisons within age and ethnic groups but the differences between medians exceeded 1.0 BMI units for the younger CTJ-R (<70 yr; >70 yr) and GRK-M groups and for the FIL groups with men having the smaller medians but the medians for men exceeded those for women in the younger SWE groups by 1.8 kg/m^2.

When the medians for groups older than 80 years were compared, the medians for men were smaller than those for women by 1.0 BMI units or more in the GRK-M and GRK-S groups. With the exception of CTJ-U men and GRK-S women, in whom the values were almost the same for both age groups, the medians were consistently larger for the younger groups than for the older groups in each gender. The size of these differences between age groups did not appear to be related to urban/rural residence or the degree of development of the country. The standard deviations were small for the CTJ-R groups and relatively large for the CBJ groups and GRK-M women. These differences remained after the standard deviations were adjusted for the means. The standard deviations were generally larger for women than for men.

For some IUNS groups, BMI values were categorised and the percentage prevalence calculated for each category (Table 13.6). These percentages show clearly the marked differences in the prevalence of low values between ethnic groups - such values were common in the CTJ-R and FIL groups; high BMI values were uncommon in these groups. In all groups, low values were more common in older than younger groups and high BMI values were generally less common in older groups than in younger groups.

Table 13.5. Descriptive statistics for body mass (kg/m^2).

Groups and Ages	Men N	Men Mean	Men SD	Men Median	Women N	Women Mean	Women SD	Women Median
ACA 70-79 yr	41	26.0	3.4	25.8	36	26.4	3.1	26.5
ACA >80 yr	5	25.3	2.2	24.9	6	25.4	3.0	25.4
CBJ <70 yr	77	25.5	3.8	25.1	122	25.1	5.0	25.3
CBJ >70 yr	43	24.2	3.5	24.1	53	23.0	3.5	23.3
CTJ-R 70-79 yr	73	20.6	2.5	20.3	79	20.9	3.3	21.5
CTJ-R >80 yr	10	18.4	2.9	18.8	19	19.4	3.2	18.7
CTJ-U 70-79 yr	107	23.3	3.3	23.0	102	23.1	4.3	23.1
CTJ-U >80 yr	19	22.4	3.6	23.1	32	22.7	4.5	22.4
FIL <70 yr	33	22.4	4.1	22.3	105	23.5	4.7	23.4
FIL >70 yr	40	20.4	3.5	20.0	93	21.5	4.6	21.1
GRK-M 70-79 yr	64	28.0	3.6	28.1	59	30.7	5.1	30.0
GRK-M >80 yr	28	27.1	3.7	27.2	35	27.9	6.1	28.3
GRK-S 70-79 yr	26	27.4	4.4	27.4	20	28.3	4.5	27.7
GRK-S >80 yr	15	25.2	2.9	26.2	9	27.2	3.7	27.6
SWE 70-79 yr	51	25.4	3.2	24.9	75	24.0	4.4	23.1
SWE >80 yr	19	24.9	3.3	24.8	59	23.9	4.0	24.2

Table 13.6. Percentage prevalence of particular body mass index values.

Groups and Ages	Men N	Men Mean	Men SD	Men Median	Women N	Women Mean	Women SD	Women Median
ACA 70-79 yr	2.4	36.6	48.8	12.2	2.8	33.3	50.0	13.9
ACA >80 yr	0.0	60.0	40.0	0.0	0.0	50.0	50.0	0.0
CTJ-R 70-79 yr	41.1	54.8	4.1	0.0	35.4	51.9	10.1	2.5
CTJ-R >80 yr	70.0	30.0	0.0	0.0	63.2	31.6	5.3	0.0
FIL <70 yr	27.3	48.5	15.1	9.1	22.9	44.8	26.7	5.7
FIL >70 yr	47.5	42.5	7.5	2.5	44.1	37.6	11.8	6.4
GRK-M 70-79 yr	1.6	20.3	48.4	29.7	1.7	3.4	45.8	49.1
GRK-M >80 yr	3.6	28.6	39.3	28.6	8.6	28.6	22.9	40.0
GRK-S 70-79 yr	3.9	26.9	34.6	34.6	0.0	15.0	60.0	25.0
GRK-S >80 yr	6.7	26.7	66.7	0.0	0.0	44.4	22.2	33.3
SWE 70-79 yr	2.0	49.0	41.2	7.8	14.7	46.7	30.7	8.0
SWE >80 yr	10.5	42.1	42.1	5.3	18.6	40.7	32.2	8.5

The sample sizes are the same as in Table 13.4

13.7.1 Comparisons with reported data

In the SENECA data, the mean BMI values range from 24.4 kg/m^2 (Elverum, Norway) to 30.3 kg/m^2 (Sabina Hills, Italy) in men and from 23.9 kg/m^2 (Chateau Renault, Amboise, France) to 30.5 kg/m^2 (Sabina Hills, Italy and Marki, Poland;[27]) in women. The ranges of the IUNS medians for groups of European ancestry were similar to those from the SENECA Study but those for IUNS groups of Asian origin were smaller. In 13 of the SENECA Study centres, the means for women exceed those for men by amounts varying from 0.2 to 3.1 BMI units. In 5 groups the values for the men are larger than those for women by 0.3 to 2.2 BMI units. Similar variations were noted in the IUNS project.

The central tendencies (means, medians) that have been reported for BMI in the elderly (Table 13.7) are similar to those for the younger groups of European ancestry in the IUNS project, except that the values for SWE women are lower. The means and medians for men >80 years old reported from European and US studies are smaller than those for the IUNS groups of European ancestry at corresponding ages but larger than those for the Oriental groups in the IUNS project. The means and medians for women of European ancestry >80 years are lower than those for the GRK-M and GRK-S groups in the IUNS project but similar to those for the SWE group. The reported values for women >80 years in UK and US studies are larger than the values for the IUNS Oriental groups.

In the reported data, the means and medians for women generally exceed those for men but the values for the two genders are almost identical in the data of Shimokata et al. [57], Tayback et al. [58] and Chumlea et al. [34] from the US. In the reported data, as in the IUNS project, BMI values decrease as older groups are considered [41,59]. The standard deviations of BMI values in reported studies are similar to those in the IUNS groups and, as in the IUNS data, the standard deviations tend to be greater in women than in men [34,41,42,60,61].

Table 13.7. Reported data for body mass index (kg/m^2).

Authors	Age (yr)	Men N	Men Mean (Median)	Men SD	Women N	Women Mean (Median)	Women SD
Rissanen et al. (1988, Finland)	>70	150	25.4	3.7	226	27.7	4.5
Melchionda et al. (1986, Italy)	70-74	174	(26.0)	-	225	(24.6)	-
Deurenberg et al. (1989a, Netherlands)	70	35	25.0	2.2	37	25.9	3.2
Lowik et at (1992, Netherlands)	74	-	-	-	52	25.7	3.2
Lee et al. (1981, UK)	60-89	-	-	-	72	27.4	5.1
Burr & Phillips (1984, UK)	70-74	171	(25.1)	-	250	(26.3)	-
	75-79	188	(23.9)	-	329	(26.1)	-
	80-84	87	(23.7)	-	200	(25.5)	-
	>85	41	(23.1)	-	88	(23.6)	-
Shimakata et al. (1989, US)	76-96	201	(24.4)	-	94	(24.1)	-
Frisancho (1990, US)	70-74.9	1257	25.3	4.0	1467	26.6	5.3
Tayback et at (1990, US)	55-74	149	(25.5)	-	1661	(25.6)	-
Czajka-Narins et al. (1991, US)	70-74	32	25.9	4.1	68	28.1	5.0
	75-79	25	26.3	4.9	49	26.2	4.3
	80-84	-	-	-	35	24.3	3.8
Chumlea et al. (1992, US)	67-92	41	24.1	3.7	63	24.3	3.8

The data in Table 13.7 can be compared with the percentage prevalence of particular BMI values in the SENECA Study (Table 13.8). The prevalences of particular BMI categories in the SENECA Study have been made available by Dr W van Staveren. The prevalence of values <20 kg/m^2 for BMI in men is zero for Culenborg (Netherlands) and only 1.8% for Haguenau (France) but the prevalences are 4.9% for Hamme (Belgium) and 4.4% for Roskilde (Denmark). In women, some of the prevalences of values <20 kg/m^2 are low: 0.9% (Vila Franca de Xira (Portugal) and 1.0% (Hamme, Belgium) but they are relatively high for Romans (France, 9.6%) and Padua (Italy, 8.7%). Low BMI values may be associated with increased mortality rates [11]. BMI values ≥30 kg/m^2 are usually more common in women than men. In men, the prevalence of these large values range from 7.7% (Roskilde, Denmark) to 33.3% (Bellinzona, Switzerland). In women, there are relatively low prevalences of BMI values ≥30 kg/m^2 in the Romans (France, 12.5%) and Padua (Italy, 13.0%) groups, but there are high prevalences in the Betanzos (Spain, 40.7%), Hamme (Belgium, 36.5%) and Haguenau (France, 30.9%) groups.

These high BMI values are also associated with high mortality rates. These SENECA data, which are restricted to the larger groups in that study (N >40), show prevalences of low values that are similar to those in IUNS groups of European ancestry, except that higher prevalences were found in older SWE men and in SWE women. Markedly higher prevalences of low values were found in the CTJ-R and FIL groups. High values (≥30 kg/m^2) are, however, more common in the GRK-M groups and the younger GRK-S groups in the IUNS project than in most of the groups in the SENECA Study.

Table 13.8. Percentage prevalence of particular body mass index (kg/m^2) values for groups with N > 40 in the SENECA study.

Groups	Men <20	Men 20-25	Men 25.1-29.9	Men >30	Women <20	Women 20-25	Women 25.1-29.9	Women >30
H/B	4.9	39.3	47.5	8.2	1.0	20.2	42.3	36.5
R/DK	4.4	28.6	59.3	7.7	7.7	45.0	29.7	17.6
H/F	1.8	28.2	48.2	21.8	7.3	30.9	30.9	30.9
R/F	2.6	29.0	51.8	16.7	9.6	42.3	35.6	12.5
P/I	3.1	35.4	46.9	14.6	8.7	44.6	33.7	13.0
C/NL	0.0	40.4	50.9	8.8	1.7	22.2	47.9	28.2
V/P	2.8	26.2	50.5	20.6	0.9	27.5	45.0	26.6
B/E	2.3	19.8	53.5	24.4	2.6	19.5	37.2	40.7
Y/CH	3.5	30.6	47.1	18.8	4.6	34.1	46.6	14.8

H/B = Hamme, Belgium; R/DK = Roskilde, Germany; H/F = Hagenau, France; R/F = Romans, France; P/I = Padua, Italy; C/NL = Culenborg, Netherlands; V/P = Vila Franca de Zira, Portugal; B/E = Betanzos, Spain and Y/CH = Yuerdon, Switzerland

13.7.2 Discussion

The body mass index is not a good measure of fatness since it is influenced by fat-free mass (FFM) and stature. Nevertheless, it is closely related to percentage of body fat [9,62] and can be used to categorise individuals in regard to fatness. The BMI is an important measure because of its established relationship to mortality rates. This relationship is most marked in cohort studies that begin in middle age [11,12,36] but even for those 70 years or older at entry into such studies, mortality rates are higher if the baseline BMI is outside the range 20 to 32 kg/m^2 after existing illnesses and smoking habits are taken into account.

This range is approximate because the estimates of cut-off points, at which mortality rates increase substantially, differ among reports due partly to variations in study design including duration of follow-up, analytic approaches, and perhaps real differences in the relationship between BMI values and mortality rates between populations. Since both low and high BMI values are associated with increased mortality rates in middle and old age, the elderly, to some extent, represent a population of survivors with an over representation of those who had BMI values between 20 and 32 kg/m^2 in middle age. The percentage prevalences in the IUNS study indicate that the CTJ-R and FIL groups are at risk because of low BMI values and the GRK-M groups are at risk because of high BMI values.

Comparisons between those aged 70-79 years and those aged >80 years could be influenced also by changes within individuals. Decreases of about 0.8 BMI units/ decade in elderly men and 1.0 BMI units/ decade in elderly women have been reported [63], but others have not found significant changes in BMI with age [37,64].

13.8 WAIST CIRCUMFERENCE

The samples were small for ACA and GRK-S groups older than 80 years; there were, correspondingly, small samples for hip circumference and waist-hip ratio. Waist circumference was not measured in the CBJ and FIL groups. The IUNS median values for waist circumference in men aged 70-79 years ranged from 77.0 cm (CTJ-R) to 100.1 cm (GRK-M) and the corresponding values for men aged more than 80 years ranged from 77.7 cm (CTJ-R) to 100.5 cm (GRK-M) (Table 13.9). The medians for women aged 70-79 years ranged from 75.0 cm (CTJ-R) to 108.0 cm (GRK-M) and those for women aged more than 80 years ranged from 75.4 cm (CTJ-R) to 105.0 cm (GRK-M). The medians for men were larger than those for women in corresponding age groups by small amounts in the CTJ-R and CTJ-U groups varying from 2.0 to 5.0 cm and by large amounts in the SWE groups (14.0 cm, younger; 12.9 cm, older) and in the older GRK-S groups (14.0 cm). The differences between age groups within a gender were small for all groups and they differed in direction. The standard deviations were small for the CTJ-R groups but relatively large for the older GRK-M and the younger GRK-S groups. These differences in standard deviations were markedly reduced when the values were adjusted for the means.

Table 13.9. Descriptive statistics for waist circumference (cm).

Groups and Ages	Men N	Men Mean	Men SD	Men Median	Women N	Women Mean	Women SD	Women Median
ACA 70-79 yr	40	94.9	10.0	94.8	35	97.6	7.7	97.5
ACA >80 yr	5	89.0	8.7	91.7	6	96.3	8.3	97.5
CTJ-R 70-79 yr	73	77.7	6.8	77.0	79	75.6	7.8	75.0
CTJ-R >80 yr	10	77.1	6.7	80.0	19	75.4	10.1	75.0
CTJ-U 70-79 yr	107	88.5	9.8	89.0	102	84.6	11.5	85.0
CTJ-U >80 yr	19	87.7	8.2	89.0	32	85.9	10.0	86.0
GRK-M 70-79 yr	63	100.1	8.8	101.0	59	108.0	10.3	109.0
GRK-M >80 yr	28	100.5	10.1	103.0	35	103.6	13.2	105.0
GRK-S 70-79 yr	26	100.8	11.3	100.0	20	107.0	11.1	106.0
GRK-S >80 yr	15	96.9	8.9	96.0	9	105.7	12.0	110.0
SWE 70-79 yr	51	95.4	9.1	93.0	76	79.5	11.3	79.0
SWE >80 yr	19	94.3	10.0	94.9	59	82.6	9.8	82.0

Photo 13.1. Spata, Greece (1988): a man in his early 80s with abdominal obesity, also common amongst women.

13.8.1 Comparisons with reported data

There are few reported data for waist circumference in the elderly with which the IUNS data can be compared (Table 13.10). The mean values for French men are smaller than the corresponding values for IUNS groups of European ancestry but they are larger than the CTJ-R values and similar to the CTJ-U values. The reported central tendencies for US men are lower than those for the GRK-M groups but are otherwise similar to the IUNS means and medians [39,65]. As for the IUNS project, the reported data indicate marked variation between studies in gender differences.

Table 13.10. Reported data for waist circumference (cm).

Authors	Age (yr)	Men N	Men Mean (Median)	Men SD	Women N	Women Mean (Median)	Women SD
Marquer & Chamla	70-79	35	87.3	10.4	-	-	-
(1961, France)	80-91	33	88.3	8.5	-	-	-
Friedlaender et al. (1977, US)	>70	20	97.1	8.0	-	-	-
Shimokata et al. (1989, US)	70-96	201	(91.0)	-	94	(79.3)	-
Chumlea et al. (1992, US)	67-92	41	96.7	11.1	63	94.3	11.9

13.8.2 Discussion

The volume of visceral adipose tissue is related to the prevalence of non-insulin dependent diabetes mellitus and to risk factors for cardiovascular diseases [66-68]. Waist circumference is correlated (r = 0.3) with the amount of visceral adipose tissue [21]; although this correlation is higher than those for many other anthropometric variables, it is not high enough to allow predictions of the amount of visceral adipose tissue. In the data from the IUNS project, there were small and inconsistent differences in waist circumference between age groups. Some serial data indicate, however, that waist circumferences increase in the elderly by about 1.5 to 3.4 cm/ decade. and that these increases are independent of levels of physical activity [37,56].

13.9 HIP CIRCUMFERENCE

In the IUNS project, hip circumferences were not measured in the CBJ and FIL groups (Table 13.11). The median values for men aged 70-79 years ranged from 86.0 cm (CTJ-R) to 105.3 cm (GRK-M) while those for men older than 80 years ranged from 84.5 cm (CTJ-R) to 103.0 cm (GRK-S). The medians for women aged 70-79 years ranged from 88.0 cm (CTJ-R) to 105.5 cm (GRK-S) and those for women aged >80 years ranged from 84.0 cm (CTJ-R) to 105.0 cm (GRK-S). The differences between the medians for men and women were small within ethnic groups but there was a slight tendency for the medians to be larger in women. There was a tendency for the medians to be larger in younger groups than in older groups and this tendency was more consistent in men than women. These differences between age groups were marked for the CTJ-R and GRK-M women. The standard deviations differed by little among groups.

Table 13.11. Descriptive statistics for hip circumference (cm).

Groups and Ages	Men N	Men Mean	Men SD	Men Median	Women N	Women Mean	Women SD	Women Median
ACA 70-79 yr	40	98.9	6.7	99.0	35	100.7	6.5	100.0
ACA >80 yr	5	96.0	2.6	96.7	6	97.0	6.2	97.0
CTJ-R 70-79 yr	73	86.5	5.3	86.0	79	87.1	6.6	88.0

CTJ-R >80 yr	10	85.7	5.5	84.5	19	86.0	7.7	84.0
CTJ-U 70-79 yr	107	100.3	9.5	100.0	102	98.3	11.5	96.0
CTJ-U >80 yr	19	97.4	7.9	97.0	32	99.5	10.9	100.0
GRK-M 70-79 yr	63	103.0	6.6	103.0	59	105.6	9.1	105.0
GRK-M >80 yr	28	101.1	7.5	100.0	35	102.1	9.3	101.0
GRK-S 70-79 yr	26	105.5	9.4	105.0	20	107.3	10.4	105.5
GRK-S >80 yr	15	102.7	8.1	103.0	9	104.9	9.1	105.0
SWE 70-79 yr	51	101.9	7.0	101.0	76	99.1	9.7	98.0
SWE >80 yr	19	101.8	8.1	100.0	59	99.4	8.9	99.5

13.9.1 Comparisons with reported data and discussion

The reported data are restricted to US samples and they are limited in value because of the wide age ranges in the two reports available (Table 13.12). The reported means and medians are lower than the corresponding IUNS values for the GRK-M and GRK-S groups and for the groups of Swedish men but are similar to those for the SWE women and the ACA groups [57,34]. In the two reported studies, as in the IUNS project, the gender differences were small and inconsistent in direction. The standard deviations reported by Chumlea et al. [34] are similar to those from the IUNS project. Hip circumference is correlated with total body fat (r = 0.74; [21]) and is used in calculating the waist-hip ratio which an index of the patterning of adipose tissue.

Table 13.12. Reported data for hip circumference (cm).

Authors	Age (yr)	Men N	Men Mean (Median)	Men SD	Women N	Women Mean (Median)	Women SD
Shimokata et al. (1989, US)	70-96	99	(97.0)	-	94	(97.8)	-
Chumlea et at (1992, US)	67-92	41	99.1	6.8	63	98.6	9.6

13.10 WAIST-HIP RATIO

The IUNS age-adjusted medians for the waist-hip ratio in men aged 70-79 years ranged from 0.89 (CTJ-U) to 0.97 (GRK-M) and the medians for men aged more than 80 years ranged from 0.91 (CTJ-R and CTJ-U) to 1.00 (GRK-M) (Table 13.13). The medians for women aged 70-79 years ranged from 0.90 (SWE) to 1.03 (GRK-M) and from 0.86 (SWE) to 1.03 (GRK-M) for women aged more than 80 years. The CTJ-R and CTJ-U medians were relatively low in each gender while those for the GRK-M and GRK-S groups were relatively high. The difference between genders was inconsistent across groups but within an ethnic group they were consistent for younger and older groups. The difference between genders was large for the SWE groups. The medians did not differ systematically when the younger and older groups were compared within a gender but there was a slight tendency for the median ratios to be larger in the older groups. The standard deviations for the waist-hip ratio differed little among groups.

Table 13.13. Descriptive statistics for waist-hip ratio.

Groups and Ages	Men N	Men Mean	Men SD	Men Median	Women N	Women Mean	Women SD	Women Median	
ACA 70-79 yr	40	0.96	0.05	0.97	35	0.97	0.04	0.97	
ACA >80 yr	5	0.93	0.08	0.95	6	0.99	0.06	0.99	
CTJ-R 70-79 yr	73	0.90	0.06	0.90	79	0.87	0.08	0.87	
CTJ-R >80 yr	10	0.90	0.06	0.91	19	0.88	0.08	0.88	
CTJ-U 70-79 yr	107	0.88	0.05	0.89	102	0.86	0.07	0.86	
CTJ-U >80 yr	19	0.90	0.04	0.91	32	0.86	0.06	0.86	
GRK-M 70-79 yr	63	0.97	0.05	0.97	59	1.02	0.06	1.03	
GRK-M >80 yr	28	0.99	0.06	1.00	35	1.01	0.06	1.03	
GRK-S 70-79 yr	26	0.95	0.04	0.95	20	1.00	0.03	1.00	
GRK-S >80 yr	15	0.94	0.05	0.94	9	1.01	0.08	1.02	
SWE 70-79 yr	51	0.94	0.05	0.92	76	0.80	0.07	0.80	SWE
>80 yr	19	0.93	0.05	0.92	59	0.83	0.06	0.83	

The percentage prevalences of values for the waist-hip ratio that were greater than 0.9 for men and 0.8 for women were calculated for the CTJ-R, GRK-M, GRK-S and SWE groups (Table 13.14). A majority of each group, except the younger SWE women, exceeded the chosen cut-off points. Indeed, these values were exceeded by all GRK-M and GRK-S women and by all the older GRK-M men.

Table 13.14. Percentage prevalences of waist-hip ratios in excess of selected cut off points.

Groups and Ages	Men >0.9	Women >0.8
ACA 70-79 yr	85.0	100.0
ACA >80 yr	60.0	100.0
CTJ-R 70-79 yr	50.7	88.6
CTJ-R >80 yr	60.0	84.2
GRK-M 70-79 yr	93.6	100.0
GRK-M >80 yr	100.0	100.0
GRK-S 70-79 yr	96.1	100.0
GRK-S >80 yr	86.7	100.0
SWE 70-79 yr	76.5	48.7
SWE >80 yr	63.2	71.2

Photo 13.2. Melbourne, Australia (Greek) (1990- 1991): women in their early 80s with abdominal obesity or high waist-hip ratios.

13.10.1 Comparisons with reported data

In the SENECA Study, the means for the waist-hip ratio range from 0.91 (Anogia, Arcanes, Greece) to 1.0 (Vila Franca de Xira, Portugal) in men and from 0.83 (Roskilde, Denmark; Chateau Renault, Amboise, France; Burgdorf and Bellinzona, Switzerland) to 0.91 (Culenborg, Netherlands) in women [27]. The SENECA means are similar to the IUNS medians for men but somewhat lower than the IUNS medians for women.

The means and medians of Chumlea et al. [34] and Shimokata et al. [57] for men are similar to those for GRK-M and GRK-S men in the IUNS project but higher than those for the SWE and Asian groups of men (Table 13.15). The median for women reported by Shimokata et al. [57] is markedly lower than the corresponding value for men and it is lower than the medians for all IUNS groups except the younger SWE group.

Table 13.15. Reported data for waist-hip ratio .

Authors	Age (yr)	Men N	Men Mean (Median)	Men SD	Women N	Women Mean (Median)	Women SD
Lowik et al. (1992, Netherlands)	74	-	-	-	52	0.96	0.05
Shimokata et al. 1989, US)	70-96	201	(0.96)	-	94	(0.80)	-
Chumlea et al. (1992, US)	67-92	41	0.98	0.06	63	0.96	0.07

The percentage prevalences of values for the waist-hip ratio that exceeded the chosen cut-off points in the SENECA Study are given in Table 13.16. In men, the prevalences are particularly high for Vila Franca de Xira (Portugal, 95.3%) and Romans (France, 92.3%). Very high prevalences for women were found in the Marki (Poland, 100%) and the Culenborg (Netherlands, 93.5%) groups. These prevalences are similar to those from the IUNS project for groups of European ancestry except for the low value (48.7%) in SWE women aged 70-79 years.

Table 13.16. Percentage Prevalence of waist-hip ratios exceeding chosen cut off points in the SENECA study.

Groups	Men >0.9	Women >0.8
H/B	71.1	78.4
R/DK	68.5	77.5
CA/F	83.9	75.0
H/F	82.7	79.8
R/F	92.3	82.1
M/GR	91.7	84.0
AA/GR	57.7	86.1
M/H	85.0	96.1
P/I	85.3	81.3
FMP/I	77.8	83.3
C/NL	91.9	93.5
E/N	66.7	75.0
V/P	95.3	90.8
B/E	81.8	90.3
Y/CH	83.5	81.6
BU/CH	86.7	70.0
BE/CH	88.5	73.1
M/PL	88.2	100.0

CA/F = Chateau Renault, Amboise, France; M/GR = Markopoulo, Greece; AA/GR - Anogia, Arkanes, Greece; M/H = Monor, Hungary; FMP/I = Fara Sabina, Magliano Sabina, Roggio Mireto, Italy; E/N - Eberum, Netherlands; BU/CH = Burgdorf, Switzerland; BE/CH = Bellinzone, Switzerland; and M/PL = Marki, Poland.

13.10.2 Discussion

The waist-hip ratio is an index of the amount of adipose tissue in the abdominal area adjusted for an indirect measure of frame size. It is of biological interest because abdominal adipose tissue, especially deep or visceral adipose tissue, is associated with increased risks of cardiovascular diseases, hypertension, gall bladder diseases and diabetes mellitus [69-72]. The waist-hip ratio is not closely related to total body fat (r = 0.39; [27]) but has a close relationship (r = 0.5 to 0.8) with the amount of visceral adipose tissue in men [27,73].

13.11 ARM CIRCUMFERENCE

The medians for men aged <70 years in the CBJ and FIL groups were 27.5 and 27.1 cm respectively while those for men aged 70-79 years ranged from 24.0 cm (CTJ-R) to 30.4 cm (ACA) and those for men older than 80 years ranged from 21.5 cm (CTJ-R) to 29.0 cm (GRK-M; SWE). (Table 13.17) The medians for women <70 years old were 28.0 cm in the CBJ group and 26.9 cm in the FIL group. The medians for women aged 70-79 years ranged from 24.0 cm (CTJ-R) to 32.0 cm (GRK-M) while those for women aged more than 80 years ranged from 21.0 cm (CTJ-R) to 29.3 cm (GRK-S). The differences between the genders were small and inconsistent for those aged 70-79 years and for those older than 80 years. There were decreases in the means from younger to older groups of men; these decreases ranged from 1.0 to 2.0 cm. There was a similar pattern in women with decreases of 0.7 to 4.0 cm except in the CTJ-U sample where the median for the older group exceeded that for the younger group by 0.5 cm. The standard deviations for groups aged 70-79 years were larger for women than men but the differences in standard deviations between men and women older than 80 years were small and inconsistent. The standard deviations were small for the CBJ and CTJ-R groups and for the older GRK-S men.

Table 13.17. Descriptive statistics for arm circumference (cm).

	Men				Women			
Groups and Ages	**N**	**Mean**	**SD**	**Median**	**N**	**Mean**	**SD**	**Median**
ACA 70-79 yr	40	30.4	4.3	30.0	35	31.2	4.3	30.0
ACA >80 yr	5	28.2	1.7	28.2	6	27.2	2.5	28.0
CBJ <70 yr	79	27.7	2.5	27.5	123	28.5	3.4	28.0
CBJ >70 yr	44	26.2	2.9	26.2	55	26.6	3.1	27.0
CTJ-R 70-79 yr	73	24.0	2.2	24.0	79	23.7	2.6	24.0
CTJ-R >80 yr	10	22.3	3.0	21.5	19	21.4	2.5	21.0
CTJ-U 70-79 yr	107	27.7	4.3	27.0	101	26.1	4.5	26.0
CTJ-U >80 yr	19	25.5	4.2	26.0	32	26.6	3.4	26.5
FIL <70 yr	33	27.2	2.7	27.1	105	26.9	4.3	26.9
FIL >70 yr	40	24.9	3.4	24.7	94	24.9	4.1	25.0
GRK-M 70-79 yr	63	30.0	3.2	30.4	59	31.6	3.6	32.0
GRK-M >80 yr	28	28.7	4.4	29.0	35	28.4	5.0	28.0
GRK-S 70-79 yr	26	30.4	3.5	30.0	20	21.3	4.0	31.2
GRK-S >80 yr	15	27.7	2.6	28.0	9	29.3	2.8	29.0
SWE 70-79 yr	50	30.0	4.5	30.0	76	28.0	4.9	28.2
SWE >80 yr	19	28.9	3.1	29.0	59	27.5	4.3	27.5

13.11.1 Comparisons with reported data

There were only modest differences between the means for arm circumference in the SENECA Study for various groups. For men, the means range from 27.2 cm (Padua, Italy) to 30.8 cm (Chateau Renault, Amboise, France) and those for women range from 26.5 cm (Padua, Italy) to 32.0 cm (Marki, Poland). The ranges of these means are similar to those for medians from the IUNS project for groups of European ancestry aged 70-79 years. The means and medians from other reported studies range from 24.5 to 30.7 cm for men aged about 75 years and from 23.0 to 29.6 cm for older men (Table 13.18). The corresponding values for women aged about 75 years range from 24.9 to 30.0 cm while those for older women range from 22.1 to 28.8 cm. These values tend to be smaller than those from the IUNS project for groups of European ancestry but are generally larger than the IUNS medians for Asian groups.

In the reported data, the values for men are almost all larger than those for women but many of the differences are small. As in the IUNS data, the reported median and mean values are larger in younger than in older groups for gender- and ethnic-specific comparisons. The standard deviation values reported in the literature are similar to those for the IUNS groups.

Table 13.18. Reported data for arm circumference (cm).

Authors	Age (yr)	Men N	Men Mean (Median)	Men SD	Women N	Women Mean (Median)	Women SD
Yurkiw et al. (1983, Canada)	>65	26	31.2	2.7	24	28.9	3.8
Burr & Phillips (1984, UK)	70-74	45	(25.5)	-	47	(25.5)	-
	75-79	119	(24.5)	-	219	(24.9)	-
	80-84	56	(23.7)	-	131	(23.5)	-
	>85	31	(23.0)	-	75	(22.1)	-
McEvoy & James (1982, UK)	66-96	60	29.1	2.7	53	27.7	2.7
Nutrition & Health in Old Age	<80	-	27.2	2.9	-	26.8	3.9
(1984, UK)	>80	-	26.4	3.9	-	26.1	3.7
Falciglia et al. (1988, US)	70-79	115	30.7	3.1	239	30.0	4.1
	80-89	49	29.6	3.5	111	28.8	4.6
Shimokata et al. (1989, US)	70-96	201	(30.0)	-	94	(28.3)	-
Frisancho (1990, US)	70-74.9	1251	30.6	3.4	1465	30.5	4.3
Chumlea et al. (1992, US)	67-92	41	30.1	2.8	63	28.7	3.4

13.11.2 Discussion

Decreases in arm circumference within individuals of about 1.0 to 2.0 cm/ decade for men and 1.4 cm/ decade for women have been reported [55,56,63]. This is similar to the differences seen between younger and older IUNS groups. Therefore, the observed differences could reflect changes within individuals, but they may also be influenced by cohort differences.

13.12 TRICEPS SKINFOLD THICKNESS

Descriptive statistics for triceps skinfold thicknesses in the IUNS groups are presented in Table 13.19. The medians for men aged 70-79 years ranged from 6.0 mm (CTJ-R) to 14.0 mm (SWE) and from 3.5 mm (CTJ-R) to 14.0 mm (CTJ-U) in men aged more than 80 years. The medians for groups of women aged 70-79 years ranged from 12.0 mm (CTJ-R) to 24.5 mm (GRK-S) and those for women older than 80 years ranged from 7.0 mm (CTJ-R) to 22.0 mm (GRK-S). The medians were consistently larger for women than men when corresponding age groups were compared. These gender differences were usually larger for younger groups than for older groups and were particularly large for the younger GRK-M and the older CTJ-R and GRK-S groups. The medians for the younger groups of men and women exceeded those for the older groups by 1.0 to 5.0 mm except in the GRK-M men and SWE women where the medians for the older groups slightly exceeded those for the younger groups. The standard deviations were small for the CTJ-R and CTJ-U younger men, the older GRK-M men and the younger CTJ-R women, but were large for the SWE older men. These differences remained when the standard deviations were adjusted for the means.

Table 13.19 Descriptive statistics for triceps skinfold thickness (mm).

	Men				Women			
Groups and Ages	**N**	**Mean**	**SD**	**Median**	**N**	**Mean**	**SD**	**Median**
ACA 70-79 yr	40	12.0	4.6	11.9	35	19.5	4.9	20.2
ACA >80 yr	5	10.8	1.7	10.6	6	14.1	4.6	12.9
CBJ <70 yr	79	11.1	5.6	10.0	123	24.0	9.2	22.5
CBJ >70 yr	44	12.4	6.5	10.7	54	18.3	8.1	18.0
CTJ-R 70-79 yr	73	6.7	3.7	6.0	79	11.7	4.5	12.0
CTJ-R >80 yr	10	7.7	7.5	3.5	19	9.4	6.1	7.0
CTJ-U 70-79 yr	107	14.7	4.1	15.0	102	16.7	5.8	16.5
CTJ-U >80 yr	19	13.6	4.4	14.0	32	15.9	5.2	15.2
GRK-M 70-79 yr	63	11.5	4.5	10.0	59	21.4	5.8	21.0
GRK-M >80 yr	28	12.3	4.2	12.5	35	18.0	6.8	19.0
GRK-S 70-79 yr	26	16.0	7.2	15.0	20	25.5	7.1	24.5
GRK-S >80 yr	15	12.6	4.8	11.0	9	21.9	6.4	22.0
SWE 70-79 yr	51	16.1	10.4	14.0	76	16.9	6.2	16.0
SWE >80 yr	19	12.9	4.8	12.0	58	17.5	6.5	17.0

13.12.1 Comparisons with reported data

The means for triceps skinfold thickness in the SENECA Study range from 7.8 mm (Monor, Hungary) to 21.4 mm (Marki, Poland) for men and from 11.0 mm (Markopoulo, Greece) to 29.9 mm (Marki, Poland) for women [27]. These ranges are considerably broader than those for the younger IUNS groups of European ancestry and the values tend to be higher than those for the Asian groups in the IUNS project. Compared with data from IUNS groups aged 70-79 years of European ancestry, other reported data (Table 13.20) from studies in Scotland, Sweden and the UK are slightly lower but those reported for some US groups are larger [41,74].

Table 13.20. Reported data for triceps skinfold thickness (mm).							
Authors	Age (yr)	Men N	Men Mean (Median)	Men SD	Women N	Women Mean (Median)	Women SD
Yurkew et al. (1983, Canada)	>65	26	18.9	6.8	24	24.6	8.1
Hejda (1963, Czechoslovakia)	>80	34	9.0	-	45	16.0	-
Rissanen et al. (1988, Finland)	>70	150	9.9	4.2	226	21.7	7.8
(1979, Scotland)	70-79	73	17.9	2.3	99	22.3	1.8
	>80	20	18.4	1.8	32	20.8	2.2
Steen et al. (1977, Sweden)	>70	402	8.6	-	466	18.2	-
Burr & Phillips (1984, UK)	70-74	45	(8.0)	-	47	(15.9)	-
	75-79	119	(7.0)	-	219	(14.6)	-
	80-84	56	(6.6)	-	131	(12.7)	-
	>85	31	(6.5)	-	75	(11.5)	-
McEvoy & James (1982, UK)	66-96	60	13.4	-	53	19.8	-
Lee & Lasker (1959, US)	70-80	105	9.7	-	-	-	-
	>80	28	9.2	-	-	-	-
Montoye (1965, US)	70-74	36	14.3	-	44	22.6	-
	75-79	20	14.8	-	24	21.6	-
	>80	-	-	-	29	14.0	-
Damon et al. (1972, US)	60-89	-	-	-	72	27.0	9.0
Yearick (1978, US)	63-96	25	12.3	7.0	75	20.0	6.7
Lee et al. (1981, US)	60-89	-	-	-	72	27.0	9.0
Falciglia et al. (1988, US)	70-79	115	23.5	13.3	239	25.1	9.3
	80-89	49	21.6	11.0	111	23.3	9.7
Shimokata et al. (1989, US)	70-96	201	(9.5)	-	94	(19.0)	-
Frisancho (1990, US)	70-74.9	1251	11.0	5.8	1463	24.0	8.5
Czajka-Narine et al. (1992, US)	70-74	32	18.8	10.0	68	31.6	9.7
	75-79	25	19.3	8.3	49	28.1	8.7
	80-84	-	-	-	35	27.7	9.9
Chumlea et al. (1992, US)	67-92	41	10.9	3.3	63	18.2	5.6

The reported data show decreases in means or medians as older groups are considered, within all samples of women and most samples of men. In two reports for men, however, the values for older groups are slightly larger than those for younger groups; this may reflect sampling variations. In the studies of US men and women, the standard deviations are much larger than in the IUNS groups but they are very small for the groups of Scots reported by Milne [110].

13.12.2 Discussion

In the IUNS data, triceps skinfold thicknesses were systematically larger in the younger than in the older groups within each gender. These cross-sectional findings could reflect decreases in these thicknesses with age within elderly individuals, but reported data concerning such changes are inconclusive. Some have reported small mean increases of 0.3 to 0.5 mm in elderly men during intervals of 16 to 30 years [37,55,56] but larger decreases (3.0 mm/ decade for men, and 6.0 mm/ decade for women) have been reported by Chumlea et al. [63]. In 73 male manual workers, Patrick et al. [75], found that triceps skinfold thicknesses increased during the first year after retirement but there were few significant changes during the next four years.

The present data could be influenced also by decreases in the compressibility of skinfolds with ageing [76-80]. Additionally, the IUNS data could be affected by selective mortality since mortality rates are higher in those with low values for triceps skinfold thicknesses [78,81-83]. These factors would tend to increase skinfold thicknesses in older as compared with younger groups.

13.13 ARM MUSCLE AREA

The data in Table 13.21 show that the median arm muscle areas for men aged 70-79 years ranged from 37.6 cm^2 in the CTJ-R group to 56.6 cm^2 in the ACA group. The corresponding values for men older than 80 years ranged from 30.5 cm^2 in the CTJ-R group to 49.2 cm^2 in the GRK-M group. The medians for women aged 70-79 years ranged from 31.4 cm^2 in the CTJ-R group to 48.6 cm^2 in the ACA group. In women older than 80 years, the median values ranged from 26.2 cm^2 in the CTJ-R group to 42.2 cm^2 in the GRK-M group. The median values were consistently larger for men than for women when corresponding age and ethnic groups were compared except for the older CTJ-U groups in which the median for women was greater than that for men by 2.8 cm^2.

These gender differences were larger for the younger than for the older groups and they were particularly large for the GRK-S younger groups (men, 54.6 cm^2; women, 40.6 cm^2) and for the SWE older groups (men, 48.0 cm^2; women, 38.2 cm^2). The medians were smaller for the older than for the younger groups within each gender except for the CTJ-U women (younger, 32.6 cm^2; older, 37.4 cm^2). The differences between age groups were generally larger for men than for women. In men, the differences between age groups were small for the SWE groups; in women, they were small for the GRK-S and CBJ groups but large for the GRK-M group. The standard deviations were greater in men than in women but showed little tendency to vary with age. It is also interesting to note the prevalence of low values because, as discussed later, low values for arm muscle area are associated with increased mortality rates.

Table 13.21. Descriptive statistics for arm muscle area (cm^2).

Groups and Ages	Men N	Men Mean	Men SD	Men Median	Women N	Women Mean	Women SD	Women Median
ACA 70-79 yr	40	57.6	18.8	56.6	35	51.1	16.0	48.6
ACA >80 yr	5	49.3	7.2	49.5	6	41.9	8.4	40.7
CBJ <70 yr	79	47.0	8.6	46.7	123	35.3	8.0	35.6
CBJ >70 yr	44	40.2	9.3	38.8	54	35.2	6.4	34.4
CTJ-R 70-79 yr	73	38.3	6.0	37.6	79	32.2	5.3	31.4
CTJ-R >80 yr	10	32.0	8.1	30.5	19	27.3	5.5	26.2
CTJ-U 70-79 yr	107	43.7	15.8	39.3	102	35.6	12.7	32.6
CTJ-U >80 yr	19	37.0	13.6	34.6	32	37.9	10.4	37.4
GRK-M 70-79 yr	63	56.2	12.0	56.1	59	49.8	10.8	48.4
GRK-M >80 yr	27	52.1	8.8	49.2	35	42.1	11.8	42.2
GRK-S 70-79 yr	26	51.9	8.8	54.6	20	43.9	10.8	40.6
GRK-S >80 yr	15	45.2	6.6	47.0	9	40.3	5.6	39.6
SWE 70-79 yr	49	53.8	14.8	50.9	74	43.3	10.9	40.2
SWE >80 yr	19	49.7	11.2	48.0	57	40.2	8.6	38.2

It has been claimed that values less than 12 cm^2 for arm muscle area, excluding bone area, are not compatible with life [24]. This value is approximately equivalent to arm muscle areas that include bone of 22.0 cm^2 for men and 18.5 cm^2 for women. All the IUNS 5th percentile levels exceeded these values except those for older men in the CTJ-R and CTJ-U groups. In addition, the minimum values of arm muscle area were less than 22.0 cm^2 for the younger CTJ-U and SWE men, and for the older CBJ men and the minimum values for women were <18.5 cm^2 in the CBJ and CTJ-U younger groups and in the GRK-M older group.

13.13.1 Comparisons with reported data

The data from the SENECA Study (personal communication, van Staveren; Table 13.22) are similar to IUNS data for groups of European ancestry at ages 70-79 years. The medians for arm muscle area in men in Table 13.23 ranged from 41.2 cm^2 (Marki, Poland) to 58.1 cm^2 (Chateau Renault, Amboise, France) and in women the range was from 35.0 cm^2 (Vila Franca de Xira, Portugal) to 63.7 cm^2 (Markopoulo, Greece). In comparison with younger groups of European ancestry in the IUNS project, the range of medians in the SENECA groups extends to higher values and to lower values in both men and women. The medians for men exceeded those for women except in the data from Markopoulo (Greece) where the median value for men was 6.3 cm^2 less than that for women. In other groups, the gender differences varied markedly from a low of 4.4 cm^2 for Marki (Poland) to a high of 15.5 cm^2 for Haguenau (France). There was a similar gender based difference in the IUNS data for younger groups of European ancestry where the medians for men exceeded those for women by 7.7 to 14.0 cm^2.

The means and medians reported for UK groups by Burr and Phillips (1984) and in the Nutrition and Health in Old Age Study (1979) are considerably lower than the IUNS values for groups of

European ancestry (Table 13.23). The reported means and medians from UK and US studies are generally smaller than the corresponding values for the IUNS groups of European origin but larger than those for groups of Asian origin.

Table 13.22. Arm muscle area (cm^2) in the SENECA study.

Groups and Ages	Men N	Men Mean	Men SD	Men Median	Women N	Women Mean	Women SD	Women Median
H/B	121	50.3	11.6	50.0	101	44.3	9.9	42.7
R/DK	84	55.2	9.8	56.4	87	40.8	9.1	40.0
CA/F	31	59.1	15.5	58.1	24	46.2	13.3	45.0
H/F	110	51.2	9.2	50.6	110	35.2	8.8	35.1
R/F	104	56.4	8.7	55.5	93	44.3	10.7	43.4
M/GR	24	53.5	11.9	57.4	25	64.5	14.9	63.7
AA/GR	26	45.7	7.6	45.0	36	37.4	9.9	36.6
M/H	20	53.6	13.2	56.0	26	44.7	8.2	43.6
P/I	96	48.3	8.8	47.4	91	36.7	7.8	36.2
FMP/I	20	56.2	12.6	56.1	24	45.9	12.2	43.6
C/NL	99	52.8	9.1	51.5	106	45.0	9.4	44.0
E/N	32	46.0	11.2	44.3	28	37.5	6.7	37.8
V/P	109	47.0	7.6	47.0	110	36.1	7.8	35.0
B/E	88	54.3	9.9	54.0	116	45.8	12.4	45.4
Y/CH	85	53.2	8.7	52.7	85	41.8	9.2	40.8
BU/CH	30	51.6	8.3	52.3	30	46.0	11.3	44.2
BE/CH	26	49.8	7.9	48.9	25	45.9	11.0	44.1
M/PL	17	42.3	8.8	41.2	13	41.4	12.3	36.8

H/B = Hamme, Belgium; R/DK = Roskilde, Germany; H/F = Hagenau, France; R/F = Romans, France; P/I = Padua, Italy; C/NL = Culenborg, Netherlands; V/P = Vila Franca de Zira, Portugal; B/E = Betanzos, Spain and Y/CH = Yuerdon, Switzerland

Table 13.23 Reported data for arm muscle area (cm^2).

Authors	Age (yr)	Men N	Men Mean (Median)	Men SD	Women N	Women Mean (Median)	Women SD
Nutrition & Healthin Old Age	<80	-	46.5	10.3	-	36.7	10.3
(1979, UK)	>80	-	44.5	11.8	-	36.0	10.3
Burr & Phillips (1984, UK)	70-74	45	(41.4)	-	47	(32.7)	-
	75-79	119	(39.4)	-	219	(32.3)	-
	80-84	56	(37.1)	-	131	(29.7)	-
	>85	31	(34.7)	-	75	(26.9)	-
Falciglia et al. (1988, US)	70-79	115	44.6	14.6	239	39.8	12.7
	80-89	49	42.3	11.8	111	37.9	13.3
Frisancho (1990, US)	70-74.9	1250	47.8	11.5	1463	36.0	10.8

All reports are in agreement that mean and median values are larger for men than women and that the means and medians decrease in older age groups. These differences between age groups occur for each gender but they are larger in men than women.

13.13.2 Discussion

Anthropometric indices of the cross-sectional muscle area of the arm are made with the assumption that the muscle mass is circular in cross-section and that it is surrounded by a layer of subcutaneous adipose tissue of constant thickness. These assumptions are inaccurate and do not take bone into account. The usual equation to calculate arm muscle area overestimates the true value from computed tomography by about 20-25% but the overestimation is reduced to about 7% when gender-specific constants are included to correct for the bone area (10 cm^2 for men; 6.5 cm^2 for women) Rice et al. [22-24]. The overestimations tend to be greater in the obese [23]. Furthermore, the validity of arm muscle area may decrease with age due to increases in the fat content of muscle tissue [84].

Despite its inaccuracy, arm muscle area is useful as shown by its correlations with creatinine excretion/ stature (r = 0.95), total muscle mass in the upper limb (r = 0.82), and total muscle mass in the upper and lower limbs combined (r = 0.4); [24,25,85]. The occurrence of minimum values for arm muscle area in the IUNS project that are less than the lowest levels reported to be compatible with life casts some doubt on earlier claims. The values suggested by Heymsfield et al. [24] may require some revision.

13.14 BODY COMPOSITION

Measured or predicted body composition values for the elderly are needed to estimate stores of protein, energy and trace minerals, energy expenditure, and for the inclusion of body composition values in studies of levels of lipids and lipoproteins and immuno-competence [86]. They are also important because of their relationships with mortality and morbidity rates [11]. Because it is extremely difficult to measure body composition in general samples of the elderly, it is necessary to apply equations that predict body composition values from variables that are easily obtained. It is clear that predictive equations derived from young adults are inaccurate for the elderly Broekhoff et al. [87,88] and that equations specific for the elderly are needed. These equations are typically developed from studies in which body size, bioelectric impedance and body density measures are recorded. The inclusion of impedance values makes such equations more accurate but impedance was not measured in the IUNS project.

The literature was reviewed to identify equations that were applicable to the elderly and for which the independent variables had been recorded in the IUNS project. In some of these studies, body density was used to calculate body composition using the 2-component model of Siri [89]. With this model, it is assumed that the body consists of fat and of FFM and that the density of FFM is the same in old age as in young adulthood. This is not the case. The elderly have lower densities of FFM than young adults because of lower proportions of bone mineral and they may have higher concentrations of water [90-93]. As a result, use of the 2-component Siri model for the elderly results in erroneous body composition values from body density. Similarly, calculations of body composition in the elderly from total body potassium are suspect if the formulae applied do not take age into account [94].

Also, predictive equations that include impedance as an independent variable must be specific for the elderly because it appears that a higher proportion of body water is extracellular in the elderly than in young adults [95,96]. It is known, in addition, that the accuracy of general predictive equations is influenced by the fatness of the subjects [97,98]. To overcome these limitations, one can add group-specific adjustments to the 2-component model and, in effect, use values for the density of fat-free mass that are age-, gender-, and fatness-specific [30]. In principle, it is better to apply a multi-component model with measurements of body density, total body water and total body bone mineral for individuals [99-102], but the propagated effects of the errors associated with each measurement may outweigh the advantages. The IUNS data set allowed the prediction of fat-free mass (FFM, kg), total body fat (TBF, kg), and body fat as a percentage of body weight (% BF). These estimated values were obtained from equations developed by Deurenberg et al. [8]: % BF (males) = 0.970 BMI + 0.136 age - 4.67; and % BF (females) = 1.028 BMI + 0.283 age - 5.56. These authors reported only small differences between values predicted for % BF and those obtained from body density after applying the 2-component model [89] with corrections for age and fatness [90,91].

13.15 PERCENT BODY FAT

The IUNS medians for estimated % BF ranged from 26.2% (ACA) to 33.0% (GRK-M) and from 21.5% (CTJ-R) to 34.8% (GRK-M) in men older than 80 years (Table 13.24). In the women aged <70 years, the medians were 42.1% for the CBJ group and 43.0% for the FIL group. For women aged 70-79 years, the medians ranged from 42.3% (SWE) to 49.2% (GRK-S) while in women older than 80 years the medians ranged from 45.2% (SWE) to 50.7% (GRK-M). All the medians for men exceeded those for women in corresponding age groups.

Table 13.24. Descriptive statistics for estimated per cent body fat (% BF).

	Men				Women			
Groups and Ages	**N**	**Mean**	**SD**	**Median**	**N**	**Mean**	**SD**	**Median**
ACA 70-79 yr	41	30.4	4.1	30.7	36	44.2	2.5	44.6
ACA >80 yr	5	31.8	2.7	32.0	6	47.4	2.7	47.8
CBJ <70 yr	77	28.1	4.6	28.4	122	41.6	3.6	42.1
CBJ >70 yr	43	29.0	4.8	29.3	53	43.8	2.7	44.0
CTJ-R 70-79 yr	73	23.0	4.4	23.0	79	42.4	4.1	43.1
CTJ-R >80 yr	10	21.5	6.2	22.9	19	45.8	4.1	46.1
CTJ-U 70-79 yr	107	27.2	4.7	27.5	102	43.2	4.1	43.6
CTJ-U >80 yr	19	27.4	5.6	28.5	32	46.8	4.1	46.9
FIL <70 yr	33	23.2	7.2	23.9	105	42.5	4.0	43.0
FIL >70 yr	40	23.5	6.2	23.6	93	45.4	4.5	45.0
GRK-M 70-79 yr	64	33.0	3.6	33.3	59	48.7	2.7	49.2
GRK-M >80 yr	28	34.1	3.9	34.8	35	50.4	3.3	50.7
GRK-S 70-79 yr	26	32.0	5.0	32.4	20	47.1	2.6	47.2
GRK-S >80 yr	15	32.1	4.0	33.1	9	49.3	1.9	49.6
SWE 70-79 yr	51	29.9	3.5	29.6	75	42.2	3.7	42.3

SWE >80 yr	19	31.2	4.1	32.0	59	45.4	3.2	45.2

13.15.1 Comparisons with reported data

The reported data (Table 13.25) must be interpreted taking into account the methods by which they were obtained. The data of Svendsen et al. [103] were obtained from dual energy x-ray absorptiometry which gives results for older individuals that are similar to those from body density measured in combination with total body water and total body bone mineral [100]. Steen et al. [35] calculated body cell mass from total body potassium and total body water using assumptions derived from young adults. This may have led to an underestimation of % BF. The data of Norris et al. [102] were calculated from body density taking age and fatness into account.

These gender differences were large (12.7 to 23.2%) and they were larger for the older groups than for the younger groups. It is interesting to note that the 25th percentile levels for many groups of women exceeded 40% BF. The values for older groups were almost always larger than those for the corresponding younger groups. In men, the standard deviation values were small for the GRK-M and SWE groups and relatively large for the ACA and FIL groups. The standard deviation values were small for the CBJ, GRK-M and GRK-S women and relatively high for the ACA women.

Table 13.25. Reported data for estimated per cent body fat (% BF).

Authors	Age (yr)	Men N	Men Mean (Median)	Men SD	Women N	Women Mean (Median)	Women SD
Svendsen et al. (1991, Denmark) from dual energy x-ray absorptiometry	75	23	21.3	5.1	23	33.7	9.9
Melchionda et al. (1986, Italy) from skinfold thicknesses	70-74	174	(25.3)	-	225	(38.1)	-
Virgili et al. (1992, Italy) from skinfold thicknesses	70-79	10	27.1	4.1	8	39.4	4.7
	>79	11	25.4	4.0	12	37.8	5.9
Virgili et al. (1992, Italy) from total body water	70-79	10	30.0	8.8	8	38.4	9.1
	>79	11	32.2	9.5	12	39.4	10.3
D'Amicis and Ferro-Luzzi (1992, Italy) from skinfold thicknesses	60-97	449	16.27	-	497	39.4	-
Deurenberg et al. (1989, Netherlands) from body density with adjustments for age and fatness	70	35	31.0	4.5	37	43.9	4.3
Lowik et al. (1992, Netherlands) from skinfold thicknesses	74	-	-	-	52	42.7	5.5
Lowik et al. (1992, Netherlands) from impedance	74	-	-	-	52	46.4	6.5
Durnin & Womersley (1974, Scotland) from body density	50-72	24	28.0	8.5	-	-	-
	50-68	-	-	-	37	39.0	7.6
Steen et al. (1977, Sweden) from total body potassium	70	49	16.1	-	56	26.6	-
Norris et al. (1963, US) from body density adjusted for age and fatness	70-79	21	22.8	10.5	-	-	-
Flynn et al.(1989, US) from total body potassium	74	106	37.0	9.0	-	-	-

Others estimated % BF from skinfold thicknesses using the equations of Durnin and Womersley [106] which lead to marked underestimations. The means of Norris et al. [102] and of Svendsen et al. [103] are lower than those in the IUNS project for groups of similar age with the exception of the ACA men. It is also noteworthy that the standard deviations were high for the groups studied by Norris et al. [102], and Virgili et al. [104] and Flynn et al. [32]. The reported data are in agreement with the IUNS project data in showing larger means and medians for women than for men.

13.15.2 Discussion

There were increases in % BF as older age groups were considered despite reported decreases in % BF within individuals as they aged [55]. These increases could be cohort effects but are more likely to reflect selective mortality because, as noted earlier, low weight and low values for the body mass index are associated with increased mortality rates in the elderly.

13.16 TOTAL BODY FAT (TBF, KG)

The IUNS medians for total body fat for men aged <70 years were 13.8 kg in the FIL group and 18.3 kg in the CBJ group. For men aged 70-79 years, the medians ranged from 17.7 kg (CTJ-U), which is suspect, to 25.0 kg (GRK-M) and those for men older than 80 years ranged from 10.7 kg (CTJ-R) to 25.6 kg (GRK-M) (Table 13.26). The medians for women younger than 70 years ranged from 21.7 kg for the FIL group to 25.6 kg for the CBJ group. For women aged 70 to 79 years, the medians ranged from 24.0 (CTJ-U) to 32.6 (GRK-M) while those for women older than 80 years ranged from 18.2 kg (CTJ-R) to 31.0 kg (GRK-M). The medians for the women were consistently larger than those for the men.

These gender differences were small for the younger SWE groups (2.6 kg) but large for the younger CTJ-R groups (9.0 kg). The differences in medians between older and younger groups were inconsistent in size and direction even within ethnic groups. This difference was particularly large for CTJ-R women for whom the younger median was the larger by 3.1 kg.

The standard deviations were usually larger for women than for men. They tended to be larger for younger than for older groups of women but the gender differences for men were inconsistent. The standard deviations were particularly large for GRK-M older women and GRK-S younger men.

Table 13.26. Descriptive statistics for estimated total body fat (TBF, kg).

	Men				Women			
Groups and Ages	N	Mean	SD	Median	N	Mean	SD	Median
ACA 70-79 yr	41	23.0	5.6	23.2	36	29.6	4.7	30.4
ACA >80 yr	5	21.8	3.4	21.9	6	29.0	4.7	29.1
CBJ <70 yr	77	19.2	6.3	18.3	122	26.1	7.3	25.6
CBJ >70 yr	73	12.8	3.8	12.3	79	20.1	5.1	21.3
CTJ-R >80 yr	10	10.5	4.3	10.7	19	19.7	4.7	18.2
CTJ-U 70-79 yr	107	18.3	5.7	17.7	102	24.2	6.6	24.0
CTJ-U >80 yr	19	17.3	5.8	18.4	32	24.5	5.9	24.8
FIL <70 yr	33	13.7	5.9	13.8	105	22.4	6.5	21.7
FIL >70 yr	40	12.6	5.8	11.8	93	21.4	6.2	20.6
GRK-M 70-79 yr	64	25.5	5.9	25.0	59	33.7	6.7	32.6
GRK-M >80 yr	28	25.0	5.9	25.6	35	31.1	7.8	31.0
GRK-S 70-79 yr	26	24.8	7.8	23.6	20	30.6	6.0	29.1
GRK-S >80 yr	15	22.1	5.1	22.1	9	30.3	4.9	30.6
SWE 70-79 yr	51	23.3	5.8	23.3	75	26.7	7.0	25.9
SWE >80 yr	19	23.5	6.0	22.4	59	27.3	6.1	27.7

13.16.1 Comparisons with reported data

The IUNS medians for TBF in groups of European ancestry are considerably higher than those reported by Svendsen et al. [103] and Norris et al. [102] for groups in Denmark and the US respectively. Similarly, the IUNS medians for total body fat in women of European ancestry are higher than the median reported by Svendsen et al. [103] for Danish women (Table 13.27).

Table 13.27. Reported distribution statistics for estimated total body fat.							
Authors	**Age (yr)**	**Men N**	**Men Mean (Median)**	**Men SD**	**Women N**	**Women Mean (Median)**	**Women SD**
Svendsen et al. (1991, Denmark) from dual energy x-ray absorptiometry	75	23	14.1	7.1	23	21.7	8.8
Virgili et al.(1992, Italy) from skinfold thickness	70-79	10	18.0	-	-	-	-
	>79	11	15.2	-	12	22.6	-
Virgili et al.(1992, Italy) from total body water	70-79	10	20.0	-	-	19.2	-
	>79	11	24.0	-	12	23.7	-
Steen et al.(1977, Sweden) from total body potassium	70	49	12.5	6.5	56	18.1	7.2
Norris et al. (1963, US) from densitometry with adjustments for age and fatness	70-79	21	16.2	-	-	-	-

13.16.2 Discussion

It is not surprising that the IUNS means for TBF in the elderly were larger for women than for men; it is well-known that such differences are present from soon after birth. The inconsistent differences between the medians for younger and older groups in the IUNS project may reflect selective mortality and cohort effects. Data for changes in TBF within elderly individuals are scarce. Steen [105] did not find changes after 70 years of age in a group of Swedish men; there was a decrease of only 0.9 kg in TBF from the younger to the older medians in the IUNS data for SWE groups. Parízková and Eiselt [55] reported decreases of about 1.0 kg in TBF during 8 to 10 years in Czechoslovakian men aged 70-80 years at entry.

13.17 FAT-FREE MASS (FFM, KG)

The median values for fat-free mass (FFM) in the IUNS groups for men aged <70 years were 46.9 kg for the CBJ group and 44.2 kg for the FIL group. The lowest and highest medians for men aged 70-79 years were 41.8 kg (CTJ-R) and 52.9 kg (SWE) respectively. In men older than 80 years, the medians ranged from 36.7 kg (CTJ-R) to 50.3 kg (GRK-M and SWE) (Table 13.28). The medians for women younger than 70 years were 35.2 kg in the CBJ group and 29.2 kg in the FIL group.

Table 13.28. Descriptive statistics for estimated fat-free mass (FFM, kg).								
	Men				Women			
Groups and Ages	N	Mean	SD	Median	N	Mean	SD	Median
ACA 70-79 yr	41	51.7	5.0	52.4	36	37.2	4.7	36.9
ACA >80 yr	5	46.4	2.3	46.4	6	32.1	4.7	33.0
CBJ <70 yr	77	47.5	5.2	46.9	122	35.8	5.5	35.2
CBJ >70 yr	43	44.5	5.9	44.5	53	30.9	4.3	30.7
CTJ-R 70-79 yr	73	41.9	3.9	41.8	79	27.6	4.4	27.7
CTJ-R >80 yr	10	36.6	3.6	36.7	19	23.2	4.4	22.7
CTJ-U 70-79 yr	107	47.6	4.8	47.2	102	31.1	5.2	30.5
CTJ-U >80 yr	19	44.0	4.3	44.5	32	27.5	5.1	27.3
FIL <70 yr	33	43.1	4.0	44.2	105	29.7	5.7	29.2
FIL >70 yr	40	38.8	6.0	38.2	93	25.3	5.7	25.0
GRK-M 70-79 yr	64	50.9	5.5	50.3	59	35.2	5.0	36.0
GRK-M >80 yr	28	47.3	5.7	47.5	35	30.4	6.4	29.8
GRK-S 70-79 yr	26	50.9	6.4	49.6	20	34.1	5.1	34.2
GRK-S >80 yr	15	45.9	5.0	45.3	9	30.9	3.7	30.8
SWE 70-79 yr	51	53.6	5.0	52.9	75	35.8	5.3	35.0
SWE >80 yr	19	50.8	5.0	50.3	59	32.4	5.1	32.4

In women aged 70-79 years, the medians ranged from 25.0 kg (FIL) to 36.9 kg (ACA) while in women older than 80 years the medians ranged from 22.7 kg (CTJ-R) to 32.4 kg (SWE). All the ethnic-specific medians for men exceeded the corresponding values for women within both younger and older groups. These differences ranged from 13.8 kg (CBJ older) to 17.9 kg (SWE; younger, older). Additionally, the means of the older groups were consistently smaller than those of the younger groups within each gender. These differences were relatively small for the SWE groups (2.6 kg, men; 2.6 kg, women) but were large for GRK-M women (6.2 kg). The differences between the genders in the standard deviations were inconsistent.

13.17.1 Comparisons with reported data

There are few reports of FFM in the elderly and the results from some studies may have been influenced by systematic errors. Steen et al. [35] reported means for Swedish groups aged 70 years of 53.6 kg (men) and 40.3 kg (women). These values are similar to those for the younger IUNS groups from Sweden (52.9 kg, men; 35.0 kg, women). Any differences may reflect the older age of the IUNS groups (about 5 years) errors of the predictive equations and the method used to Steen et al. [35] to calculate FFM may have led to overestimates. Virgili et al. [104] reported data for small Italian groups that allow the calculation of fat-free mass. One set of Virgili calculations were based on total body water and could be presumed to be accurate.

The means were 46.5 kg for men aged 70-79 and were 45.8 kg for men and 36.5 kg for women older than 79 years (Table 13.29). In comparison with the IUNS data for groups of European ancestry, the Virgili means for younger men are slightly low but those for older men are similar to the IUNS values. The Virgili means for women aged more than 79 years are considerably higher than the corresponding values from the IUNS project for groups of European ancestry. Virgili et al. [104] also reported FFM calculated from skinfold thicknesses using the equations of Durnin and Womersley[106]. The means were similar to those obtained from total body water.

Table 13.29. Reported data for estimated fat free mass (FFM, kg).

Authors	Age (yr)	Men N	Men Mean (Median)	Men SD	Women N	Women Mean (Median)	Women SD
Virgili et al.(1992, Italy) from skinfold thickness	70-79	10	48.5	-	-	-	-
	>79	11	44.6	-	12	37.6	-
Virgili et al. (1992, Italy) from total body water	70-79	10	46.5	-	-	-	-
	>79	11	45.8	-	12	36.5	-
D'Amicis & Ferro-Luzzi (1992, Italy) from skinfold thicknesses	60-97	449	46.5	6.5	497	38.3	6.0
Deurenberg et al. (1990, Netherlands) from body density with adjustments for age and fatness	70	35	52.0	6.6	37	38.1	4.1
Flynn et al. (1992, US) from total body potassium	71-80	105	50.0	11.0	-	-	-

D'Amicis and Ferro-Luzzi [64] reported means and standard deviations for FFM in large samples of Italians aged 60 to 97 years. These values, which were obtained from skinfold thicknesses using the equations of Durnin and Womersley [106], are difficult to interpret because of the wide age range. The means and standard deviations are, however, similar to those for groups aged 70-79 years of European ancestry in the IUNS project. In the data of Virgili et al. [104] and D'Amicis and Ferro-Luzzi [64], the means for men exceed those for women. Additionally, in the data of Virgili et al. [104] the means for older groups are smaller than those for younger groups.

13.17.2 Discussion

The smaller values for FFM in older than in younger groups may reflect cohort differences or selective mortality but they could be influenced also by changes in individuals with ageing. In Czechoslovakian men studied for 8 to 10 years and aged 70-80 years at entry, Parízková and Eiselt [55] found small decreases (mean 0.44 kg) in those who were physically active and larger decreases (mean 1.58 kg) in those who were physically inactive. These decreases in FFM are largely due to reductions in the muscle mass of the limbs; ageing is not associated with decreases in the FFM of the trunk [85].

13.18 NORTHERN CHINA

The data from Northern China are for ages 70-82 years with a mean age of about 72 years. They can be compared with data from the older CBJ groups and the younger CTJ-R and CTJ-U groups in the IUNS project, but any conclusions must be tentative because of the wide age range and small sample sizes. The mean statures for Northern Chinese groups of men are similar to those for Chinese groups in the IUNS project, but means for the Northern Chinese women tend to be small compared with the CBJ, CTJ-R and CTJ-U groups. When urban groups are compared (BX vs CBJ and CTJ-U), the means for Northern Chinese men are intermediate between those from the IUNS project but those for women are lower than the IUNS means. The medians for weight from the North China groups are similar to those for IUNS groups of Chinese men (older CBJ, younger CTJ-R and CTJ-U) but tend to be larger than the IUNS data for Chinese women.

13.19 JAPAN (JPN)

These Japanese groups were measured in Okazaki, Hiroshima and Yokohama are referred to as JPN-O, JPN-H and JPN-Y, respectively. Only the data from the JPN-O group have been separated into age groups matching those in the IUNS project. For the JPN-O group, the mean statures are smaller than those for the IUNS Chinese and Filipino groups but similar to the medians for the FIL groups. When the data from the Japanese groups are combined for all ages, there are only small differences between the medians by group within gender. The medians for weight in the JPN-O group, in each gender, for those aged 70-79 or 80+ years were markedly smaller than those for the CBJ and CTJ-U groups but similar to those for the CTJ-R and FIL groups. When data from all ages were combined, the medians from the three Japanese groups were closely similar for women. However, in men, the JPN-H group median was considerably larger than in the other groups.

The medians for BMI in the JPN-O group are close to the centre of the range for IUNS Asian groups. When all ages were combined, the medians for the JPN-O men and women were considerably larger than those of the other Japanese groups with the exception of the median for men in the JPN-H group. When all ages were combined, the medians for waist circumference were similar for all groups within each gender except for larger values in JPN-H men and smaller values in JPN-Y women. The data for the JPN-O groups are similar to those from the CTJ-R groups but smaller than those from the CTJ-U groups.

The median hip circumferences from the JPN-O groups were smaller than those from the CTJ-U groups but larger than those from the CTJ-R groups. There were only small differences in median hip circumferences between the Japanese groups when all ages were combined. The median waist-hip ratios from the JPN-O group closely matched those from the CTJ-R and CTJ-U groups. Among the Japanese groups, the medians varied little except that the median for the JPN-Y group of women was considerably smaller than those for the other groups of women.

3.20 NEW ZEALAND (NZ-MOS)

Selected descriptive statistics for data collected in Mosgiel (New Zealand; NZ-MOS) are presented in Tables 13.30-13.35. The design of this study was described by Campbell and Borrie [107]. The NZ-MOS medians for the body mass index are similar for the two genders and they are smaller for the older groups than for the younger groups. These medians are considerably smaller than those for the GRK-M and GRK-S groups in the IUNS study but they are larger than the medians for the SWE groups. The standard deviations of BMI did not vary with age in the NZ-MOS data but they were larger in women than in men. These standard deviations are similar to those for IUNS groups of European ancestry. BMI values <19.9 kg/m^2 were more common (13.1%) in older women than in younger women (6.8%) or in either age group of men. BMI values >30.0 kg/m^2 were more common in women than men and were more common in younger women (19.3%) than in older women (13.1%).

The median values for the waist-hip ratio were higher in men than women. However, in each gender, there were only slight differences between the medians for younger and older groups. In comparison with the medians for IUNS groups of European ancestry, the NZ-MOS medians are close to those for GRK-S and SWE men but are slightly lower than those for GRK-M men. The NZ-MOS medians for women are considerably lower than those for the GRK-M and GRK-S groups in the IUNS project but similar to those for the SWE group. The standard deviations from the NZ-MOS data are similar to those for the IUNS men but larger than those for women. Waist-hip ratio values >0.9 occurred in 81.3% of the younger men and 76.3% of the older men in the NZ-MOS study and values >0.8 were present in 75.5% of the younger women and 80.6% of the older women.

The NZ-MOS medians for arm muscle area (cm^2) are considerably larger for men than women. The medians for men and women are similar to the corresponding medians for the SWE group but smaller than those for the GRK-M and GRK-S groups. The NZ-MOS medians for older groups are smaller than those for younger groups within each gender. Corresponding differences of similar magnitude were seen in the IUNS data except for a smaller difference between age groups of SWE men and a larger difference between age groups of GRK-M women.

Table 13.30. Descriptive statistics for body mass index (kg/m^2) from the Mosgiel study (New Zealand, NZ-MOS).

	Men		Women	
	70-79 yr	>80 yr	70-79 yr	>80 yr
Number	202	75	322	152
Mean	26.1	25.0	26.2	24.8
SD	7.0	3.5	4.8	4.4
5%	19.9	19.8	19.1	18.4
25%	23.7	22.7	22.6	22.1
50%	26.3	24.6	26.1	24.6
66%	27.7	26.1	28.0	26.1
95%	31.0	31.2	34.6	32.1

Table 13.31. Percentage prevalences of body mass index categories from the Mosgiel study (New Zealand, NZ- MOS).

	Men		Women	
	70-79 yr	>80 yr	70-79 yr	>80 yr
<19.9 kg/m^2	5.4	5.3	6.8	13.1
20-25 kg/m^2	32.2	49.3	34.8	41.8
25.01-29.9 kg/m^2	53.0	40.0	39.1	32.0
>30 kg/m^2	9.4	5.3	19.3	13.1

Table 13.32. Descriptive statistics for waist-hip ratio from the Mosgiel study (New Zealand, NZ-MOS).

	Men		Women	
	70-79 yr	**>80 yr**	**70-79 yr**	**>80 yr**
Number	203	76	323	164
Mean	0.96	0.94	0.86	0.88
SD	0.06	0.05	0.18	0.18
5%	0.84	0.86	0.75	0.76
25%	0.92	0.90	0.80	0.81
50%	0.96	0.95	0.84	0.86
66%	0.99	0.97	0.87	0.89
95%	1.05	1.03	0.97	1.01

Table 13.33. Percentage prevalences of waist-hip ratio categories from the Mosgiel study (New Zealand, NZ-MOS).

	Men		Women	
	70-79 yr	**>80 yr**	**70-79 yr**	**>80 yr**
<0.9	18.7	23.6	-	-
>0.9	81.3	76.3	-	-
<0.8	-	-	24.55	19.4
>0.8	-	-	75.5	80.6

Table 13.34. Descriptive statistics for arm muscle area (cm^2) from the Mosgiel study (New Zealand, NZ-MOS).

	Men		Women	
	70-79 yr	>80 yr	70-79 yr	>80 yr
Number	200	75	324	163
Mean	50.9	44.3	41.4	38.4
SD	10.1	7.8	9.8	9.7
5%	33.6	33.1	27.0	24.2
25%	44.2	38.0	34.4	31.6
50%	50.6	43.7	41.0	38.0
66%	55.0	47.6	45.0	42.3
95%	68.6	60.4	58.1	54.8

Table 13.35. Percentage prevalences of body mass index categories from the Adelaide study (Aust-A).

	Men		Women	
	70-79 yr	>80 yr	70-79 yr	>80 yr
Number	171	30	196	42
<19.9 kg/m^2	7.6	16.7	19.4	28.6
20-25 kg/m^2	56.7	53.3	49.0	42.9
25.1-29.9 kg/m^2	28.1	23.3	24.0	26.2
>30 kg/m^2	7.6	6.7	7.7	2.4

The standard deviations of the NZ-MOS values are similar to those for IUNS groups of European ancestry.

13.21 AUSTRALIANS IN ADELAIDE (AUST-A)

Stature data from the Adelaide Study are presented in Table 13.3. The means exceed those for the IUNS groups except that the SWE means for men are larger and the SWE means for women are closely similar. The means for men exceed those for women by 12.7 and 14.0 cm in the younger and older groups respectively. In each gender, the mean for the older group is smaller than that for the younger group; this difference is 1.8 cm for men and 2.6 cm for women. In the AUST-A study, small values for BMI (<19.9 kg/m^2) were more common in women than men and were more common for older than for younger groups. In the same study, large BMI values (>30 kg/m^2) were uncommon and had similar percentage prevalences in younger men and women but the prevalences were higher in older men than in older women. These data were self-reported and therefore it is expected that stature would be over-reported and weight would be underreported and thus values for BMI would be reduced [108,109].

13.22 CONCLUSIONS AND RECOMMENDATIONS

The IUNS project was a first step to determine the relationships between food habits and health in many groups of elderly people. This project has provided important cross-sectional data and it has served an important educational function in communities where public health research is uncommon. African, American and Indian groups should be included in the next phase and strenuous efforts should be made to improve the sampling strategy and to increase the sample sizes, particularly for elderly men. The subjects included in Phase 1 should be followed-up to document changes in recorded values, ages at death, and causes of death. Specific recommendations for anthropometry in any extension of the project include the establishment of formal criteria to ensure stature measurements are meaningful, e.g., exclusion of those unable to assume the standard position. Knee height should be measured because of its close relationship to stature in young adults and in the elderly. During the planning period, the best equations for the prediction of body composition should be selected and the independent variables should be included in the protocol. These will, almost certainly, include bioelectric impedance. Anthropometric training should be provided in a central location and data collection should be computer-assisted to allow continuous monitoring of observer differences and extreme values and to determine what further training is indicated. These improvements in data collection, together with better sampling, should ensure that the results can be tested meaningfully for statistical significance and that the findings are more widely comparable.

13.23 SUMMARY

- GRK-M women had the highest mean body mass index (BMI 30), followed by GRK-S women (BMI 29) and ACA women (BMI 27). The remaining Caucasian elderly of both genders had average BMIs of 25. Filipino and Chinese elderly had average BMI between 20-22, the rural Chinese having the lowest BMI of all study communities (BMI 19).

- Overall, women tended to have higher BMIs than the men, and young elderly had higher BMIs than their older counterparts.

- Waist circumference was measured at the level of the umbilicus and hip circumference as the maximum circumference over the buttocks.

- The GRK and ACA women had the highest average waist hip ratios (WHRs about 1.1) compared with the SWE (about 0.8) and CTJ women (about 0.9) and the men. The men in all study communities had average WHRs between 0.9 and 0.95.

- Percent body fat was calculated using the Deurenberg equation:
  FFM (fat free mass) = 0.282*S + 0.395*W + 8.4*sex - 0.144*age - 23.6
  S = stature (cm), W = weight (kg), sex = 1 men, 0 women, age (years).

TBF (total body fat) = weight - FFM; % body fat = TBF/ weight*100

- Average % body fat ranged between 43-50% in women and between 25-35% in men. GRK-M women had the highest mean % body fat (48%), followed by GRK-S women (47%) and ACA women (45%). SWE, CTJ and FIL women had about 43% average body fat.

- The Caucasian men all had average % body fat of about 33%. The Asian men appeared to have markedly lower average percentages of body fat (23%).

13.24 REFERENCES

1. Cornoni-Huntley JC, Harris TB, Everett DF, Albanes D, Micozzi MS, Miles TP, Feldman JJ. An overview of body weight of older persons, including the impact on mortality. J. Clin. Epidemiol, 1991; 44: 743-753.

2. Dwyer JT, Coleman KA, Krall E, Yang GA, Scanlan M, Galper L, Winthrop E, Sullivan P. Changes in relative weight among institutionalized elderly adults. J. Gerontol, 1987; 42: 246-251.

3. Harris T, Cook EF, Garrison R, Higgins M, Kannel W, Goldman L: Body mass index and mortality among non-smoking older persons. The Framingham Heart Study. JAMA, 1988; 259: 1520-1524.

4. Fischer J, Johnson MA Low body weight and weight loss in the aged. J. Am. Diet. Assoc. 1990: 1697-1706.

5. Forbes GB. Stature and lean body mass. Am. J. Clin. Nutr. 1974; 27: 595-602.

6. Rico H, Revilla M, Hernandez ER, Villa LF, Delbuergo MA, Alonso AL. Age-related and weight-related changes in total body bone mineral in men. Mineral Electrolyte Metab, 1991; 17: 321-323.

7. Katzman DK, Bachrach LK, Carter DR, Marcus R. Clinical and anthropometric correlates of bone mineral acquisition in healthy adolescent girls. J. Clin. Endocrin. Metab, 1991; 73: 1332-1339.

8. Deurenberg P, van der Kooy K, Evers P, Hulshof T. Assessment of body composition by bioelectrical impedance in a population aged > 60 y. Am. J. Clin. Nutr,1990; 51: 3-6.

9. Roche AF, Siervogel RM, Chumlea WC, Webb P. Grading body fatness from limited anthropometric data. Am. J. Clin. Nutr, 1981; 34: 2831-2838.

10. Fitzgerald AP, Jarrett RJ. Body weight and coronary heart disease mortality: an analysis in relation to age and smoking habit. 15 years follow-up data from the Whitehall Study. Int. J. Obesity 1992; 16: 119-123.

11. Roche AF. Sarcopenia: A critical review of its measurement and health-related significance in the middle-aged and elderly. Am. J. Hum. Biol.; (in press).

12. Waaler HT. Height, Weight and Mortality. The Norwegian Experience. Sweden: Acta Med. Scandinavia, 1984; 679: 56.

13. Bonithon-Kopp C, Raison J, Egloff M, Guy-Grand B, Ducimetiere P Skinfold and body circumferences as measures of body fat patterning in a French female active population: relationships with the metabolic risk profile. J. Clin. Epidemiol, 1991; 44: 475-482.

14. Jeejeebhoy K. Immunity and body composition, In. Body Composition: The Measure and Meaning of Changes with Aging, JC Watkins, R Roubenoff, IH Rosenberg (ed): Boston, MA, Foundation for Nutritional Advancement, 1992: 45-51.

15. Roubenoff R, Kehayias JJ. The meaning and measurement of lean body mass. Nutrition Rev, 1991; 49: 163-175.

16. Tellado JM, Garcia-Sabrido JL, Hanley JA, Shizgal HM, Christou NV. Predicting mortality based on body composition analysis. Ann. Surg, 1989; 209: 81-87.

17. Bevier WC, Wiswell RA, Pyka G, Kozak KC, Newhall KM, Marcus R. Relationship of body composition, muscle strength, and aerobic capacity to bone mineral density in older men and women. J. Bone Min. Res, 1989; 4: 421-432.

18. Marcus R, Drinkwater B, Dalsky G, Dufek J, Raab D, Slemenda C, Snow-Harter C. Osteoporosis and exercise in women. Med. Sci. Sports Exerc, 1992; 24: S301-S307.

19. Vellas B, Baumgartner RN, Wayne SJ, Conceicao J, Lafont C, Albarede J-L, Garry PJ. Relationship between malnutrition and falls in the elderly. Nutrition, 1992; 8: 105-108.

20. Ashwell M, Chinn S, Stalley S, Garrow JS Female fat distribution - a simple classification based on two circumference measurements. Int. J. Obesity.1982; 6: 143-152.

21. Despres J, Prud'Homme D, Pouilot MC, Tremblay A, Bouchard C Estimation of deep abdominal adipose tissue accumulation from simple anthropometric measurements in men. Am. J. Clin. Nutr, 1991; 54: 471-477.

22. Baumgartner RN, Rhyne RL, Troup C, Wayne S, Garry PJ. Appendicular skeletal muscle areas assessed by magnetic resonance imaging in older persons. J. Gerontol, 1992; 47: M67-72.

23. Forbes GB, Brown MR, Griffiths HJL. Arm muscle plus bone area: Anthropometry and CAT scan compared. Am. J. Clin. Nutr, 1988; 47: 929-931.

24. Heymsfield SB, McManus C, Smith J, Stevens V, Nixon DW. Anthropometric measurement of muscle mass: Revised equations for calculating bone-free arm muscle area. Am. J. Clin. Nutr, 1982; 36: 680-690.

25. Heymsfield SB, Smith R, Aulet M., Bensen B, Lichtman S, Wang J, Pierson RN, Jr. Appendicular skeletal muscle mass: measurement by dual-photon absorptiometry. Am. J. Clin. Nutr, 1990; 52: 214-218.

26. Menotti A, Keys A, Kromhout D, Nissinen A, Blackburn H, Fidanza F, Giampaoli D, Karvonen M, Pekkanen J, Punsar S, Seccareccia F. All cause mortality and its determinants in middle aged men in Finland, The Netherlands, and Italy in a 25 year follow up. J. Epid. Community Health, 1991; 45: 125-130.

27. de Groot CPG, Sette S, Zajkas G, Carbajal A, Amorim Cruz JA Nutritional status: anthropometry. Europ. J. Clin, Nutr, 1991; 45: 31-42.

28. Lohman TG, Roche AF, Martorell R. Anthropometric Standardization Reference Manual. Champaign, IL, USA: Human Kinetics Publishers, Inc; 1988.

29. Deurenberg P, van der Kooy K, Hautvast JGA. The assessment of the body composition in the elderly by densitometry, anthropometry and bioelectrical impedance, In: In Vivo Body Composition Studies. Recent Advances. Basic Life Sciences, Volume 55, S Yasumura, JE Harrison, KG McNeil, AD Woodhead and FA Dilmanian (eds): New York, Plenum Press, 1990b: 391-393.

30. Deurenberg P, van der Kooy K, Leenen R, Weststrate JA, Seidell JC Sex and age specific prediction formulas for estimating body composition from bioelectrical impedance: a cross-validation study. Int. J. Obesity, 1991; 15: 17-25.

31. Milne JS. Clinical Effects of Aging. A Longitudinal Study. London, Groom Helm, Ltd, 1985.

32. Flynn MA, Nolph GB, Baker AS, Krause G. Aging in humans: A continuous 20-year study of physiologic and dietary parameters. J. Am. Coll. Nutr. 1992; 11: 660-672.

33. Montoye HJ, Epstein F, Kjelsberg MO. The measurement of body fatness. A study in a total community. Am. J. Clin. Nutr, 1965; 16: 417-427.

34. Chumlea WC, Baumgartner RN, Garry PJ, Rhyne RL, Nicholson C, Wayne S. Fat distribution and blood lipids in a sample of healthy elderly people. Int. J. Obes, 1992; 16: 125-133.

35. Steen B, Bruce A, Isakkson B, Lewin T, Svanborg A. Body composition in 70-year-old males and females in Gothenburg, Sweden. A population study. Acta Med. Scand. Suppl, 1977; 611: 87-112.

36. Burr ML, Lennings CI, Milbank JE. The prognostic significance of weight and of vitamin c status in the elderly. Age & Ageing, 1982; 11: 249-255.

37. Carmelli D, McElroy MR, Rosenman RH. Longitudinal changes in fat distribution in the Western Collaborative Group Study: A 23-year follow-up. Internat. J. Obes, 1991; 15: 67-74.

38. Durnin JVG. Energy intake, energy expenditure, and body composition in the elderly, In: Nutrition, Immunity and Illness in the elderly, R. K. Chandra (ed): New York, Pergamon Press, 1985: 19-33.

39. Friedlaender JS, Costa PTJ, Bosse R, Ellis E, Rhoads JG, Stoudt HW. Longitudinal physique changes among healthy white veterans at Boston. Hum. Biol, 1977; 49: 541-558.

40. Parízková J, Eiselt E. Body composition and anthropometric indicators in old age and the influence of physical exercise. Hum. Biol, 1966; 38: 351-363.

41. Czajka-Narins DM, Tsui J, Kohrs MB, Nordstrom JA. Anthropometric indices of a non-institutionalized elderly population. Age & Nutr, 1991; 2: 95-103.

42. Frisancho AR. Anthropometric Standards for the Assessment of Growth and Nutritional Status. Ann Arbor, MI, University Michigan Press, 1990.

43. Karlberg J, Mossberg HO. Weight-for-height standards in adulthood. J. Internal Med, 1991; 229: 303-308.

44. Milne JS. A longitudinal study of height in older people. J. Clin. Experimental Gerontol, 1981; 3: 63-76.

45. Roede MJ, van Wieringen JC. Growth Diagrams 1980. Netherlands Third Nation-wide Survey. Tijdeschrift voor Sociale Gezondheidszorg, 1985; 63: 1-34.

46. Keys A, Taylor HL, Blackburn H, Brozek J, Anderson JT, Simonson E. Mortality and coronary heart disease among men studied for 23 years. Arch. Intern. Med, 1971; 128: 201-214.

47. London SJ, Colditz GA, Stampfer MJ, Willett WC, Rosner B, Speizer FE: Prospective study of relative weight, height, and risk of breast cancer. JAMA, 1989; 262: 2853-2858.

48. Tretli S. Height and weight in relation to breast cancer morbidity and mortality. A

prospective study of 570,000 women in Norway. Int. J. Cancer, 1989; 44: 23-40.

49. Albanes D, Brown C. Relative weight, height, and risk of breast cancer. JAMA, 1990; 263: 3148.

50. Chandler PJ, Bock RD. Age change in adult stature: Trend estimation from mixed longitudinal data. Ann. Hum. Biol, 1991; 18: 433-440.

51. Chumlea WF, Garry PJ, Hunt WC, Rhyne RL. Distributions of serial changes in stature and weight in a healthy elderly population. Hum. Biol, 1988; 60: 917-925.

52. Cline MG, Meredith KE, Boyer JT, Burrows B. Decline of height with age in adults in a general population sample: estimating maximum height and distinguishing birth cohort effects from actual loss of stature with aging. Hum. Biol, 1989; 61: 415-426.

53. Dequeker JV, Baeyens JP, Classens J. The significance of stature as a clinical measure of ageing. J. Am. Geriatric Soc, 1969; 17: 169-179.

54. Miall WE, Ashcroft MT, Lovell HG, Moore FA. Longitudinal study of the decline of adult height with age in two Welsh communities. Hum. Biol, 1967; 39: 445-454.

55. Parízková J, Eiselt E. A further study on changes in somatic characteristics and body composition of old men followed longitudinally for 8-10 years. Hum. Biol, 1971; 43: 318-326.

56. Parízková J, Eiselt E. Longitudinal changes in body build and skinfolds in a group of old men over a 16 year period. Hum. Biol, 1980; 52: 804-809.

57. Shimokata H, Tobin JD, Muller DC, Elahi D, Coon PJ, Andres R. Studies in the distribution of body fat: I. Effects of age, sex, and obesity. J. Gerontol, 1989; 44: M66-M73.

58. Tayback M, Kumanyika S, Chee E. Body weight as a risk factor in the elderly. Arch. Intern. Med, 1990; 150: 1065-1072.

59. Burr ML, Phillips KM. Anthropometric norms in the elderly. Brit. J. Nutr, 1984; 51: 165-169.

60. Lee CJ, Johnston GH, Lawler GS. Some clinical indices of nutrition and health status among elderly Kentucky residents volunteering to be surveyed: comparison by sociological factors, life styles and health characteristics. Nutr. Res, 1981; 1: 47-62.

61. Rissanen A, Heliövaara M, Aromaa A. Overweight and anthropometric changes in adulthood: A prospective study of 17,000 Finns. Int. J. Obesity, 1988;12:391-401.

62. Killeen J, Vanderburg D, Harland WR. Application of weight-height ratios and body indices to juvenile populations--The National Health Examination Survey Data. J. Chron. Dis, 1978; 31: 529-537.

63. Chumlea WC, Rhyne RL, Garry PJ, Hunt WC. Changes in anthropometric indices of body composition with age in a healthy elderly population. Am. J. Hum. Biol, 1989; 1: 457-462.

64. D'Amicis A, Ferro-Luzzi A. Overweight of the elderly. Age & Nutr, 1992; 3: 55-58.

65. Marquer P, Chamla MC. L'évolution des caracteres morphologiques en fonction de l'age, chez 2089 Francais, de 20 a 91 ans. Bull. et Mém. Societé Anthrop, 1961; 2: 2-69.

66. Després J, Moorjani S, Ferland M, Tremblay A, Lupien PJ, Nadeau A, Pinault S, Thériault G, Bouchard C. Adipose tissue distribution and plasma lipoprotein levels in obese women: Importance of intra-abdominal fat. Arteriosclerosis, 1989; 9: 203-210.

67. Fujioka S, Matsuzawa Y, Tokunaga K, Tarui S: Contribution of intra-abdominal fat accumulation to the impairment of glucose and lipid metabolism in human obesity. Metabolism, 1987, 36: 54-59,.

68. Peiris AN, Stagner JI, Vogel RL, Nakagawa A, Samols E. Body fat distribution and peripheral insulin sensitivity in healthy men - role of insulin pulsatility. J. Clin. Endocrin. Metab, 1992; 75: 290-294.

69. Hartz AJ, Rupley DC, Rimm AA: The association of girth measurements with disease in 32,856 women. Am. J. Epidemiol, 1984; 119: 71-80.

70. Lapidus L, Bengtsson C, Larsson B, Pennert K, Rybo E, Sjöström L. Distribution of adipose tissue and risk of cardiovascular disease and death: a 12 year follow-up of participants in the population study of women in Gothenburg, Sweden. Br. Med. J, 1984; 238: 1257-1261.

71. Seidell JC, Mensink RP, Katan MB. Measures of fat distribution as determinants of serum lipids in healthy volunteers consuming a uniform standardized diet. Eur. J. Clin. Invest, 1988; 18: 243-249.

72. Gillum RF. The association of body fat distribution with hypertension, hypertensive heart disease, coronary heart disease, diabetes, and cardiovascular risk factors in men and

women aged 18-79 years. J. Chronic Dis, 1987; 40: 421-428.

73. Ashwell M, Cole TJ, Dixon AK. Obesity: new insight into the anthropometric classification of fat distribution shown by computed tomography. Brit. Med. J, 1985; 290: 1692-1694.

74. Falciglia G, O'Connor J, Gedling E. Upper arm anthropometric norms in elderly white subjects. J. Am. Diet. Assoc, 1988; 88: 569-574.

75. Patrick JM, Baasey EJ, Fentem PH. Changes in body fat and muscle in manual workers and at retirement. Eur. J. Appl. Physiol, 1982; 49: 187-196.

76. Brozek J, Mori H. Some interrelations between somatic, roentgenographic and densitometric criteria of fatness. Hum. Biol, 1958; 30: 322-336.

77. Brozek J, Kinsey W. Age changes in skinfold compressibility. J. Gerontol, 1960; 15: 45-51.

78. Garn SM, Hawthorne VM, Pilkington JJ, Pesick SD. Fatness and mortality in the West of Scotland. Am. J. Clin. Nutr, 1983; 38: 313-319.

79. Garn SM, Gorman EL: Comparison of pinch-caliper and teleroentgenogrammetric measurements of subcutaneous fat. Hum. Biol, 1956; 28: 232-250.

80. Hammond WH: Measurement and interpretation of subcutaneous fat, with norms for children and young males. Br. J. Prev. Soc. Med, 1955; 9: 201-211.

81. Campbell AJ, Spears GFS, Brown JS, Busby WJ, Borrie MJ. Anthropometric measurements as predictors of mortality in a community population aged 70 years and over. Age & Ageing, 1990; 19: 131-135.

82. Friedman PJ. A prospective comparison of methods to identify lethal wasting malnutrition. Nutr. Res, 1986; 6: 139-146.

83. Menotti A, Keys A, Nissinen A, Kromhout D, Seccareccia F. The Seven Countries Study. 25 Year Experience in Three Countries. Epidemiology of Atherosclerosis - Satellite Meeting 8th International Symposium on Atherosclerosis, 1988: 19-25.

84. Forsberg AM, Nilsson E, Werneman J, Bergstrom J, Hultman E. Muscle composition in relation to age and sex. Clin. Sci, 1991; 81: 249-256.

85. Reid IR, Evans MC, Ames R. Relationships between upper-arm anthropometry and

soft-tissue composition in postmenopausal women. Am. J. Clin. Nutr, 1992; 56: 463-466.

86. Baumgartner RN. Body composition in elderly persons: A critical review of needs and methods. Prog. Food Nutr. Sci. 1993; 17: 223-260.

87. Deurenberg P, Weststrate JA, van der Kooy K. Is an adaptation of Siri's formula for the calculation of body fat percentage from body density in the elderly necessary? European J. Clin. Nutr, 1989a; 43: 559-568.

88. Flint MM, Drinkwater BL, Wells CL, Horvath SM. Validity of estimating body fat of females: effect of age and fitness. Hum. Biol, 1977; 49: 559-572.

89. Siri WE. Body composition from fluid spaces and density, In: Techniques for Measuring Body Composition., J. Brozek and A. Henschel (ed): Washington, DC, National Academy of Sciences, 1961: 223-244.

90. Deurenberg P, van der Kooy K, Hulshof T, Evers P. Body mass index as a measure of body fatness in the elderly. European J. Clin. Nutr, 1989b; 43: 231-236.

91. Fuller NJ, Jebb SA, Laskey MA, Coward WA, Elia M. Four-component model for the assessment of body composition in humans: Comparison with alternative methods, and evaluation of the density and hydration of the fat-free mass. Clin. Sci, 1992; 82: 687-693.

92. Fryer JH Studies of body composition in men aged 60 and over, In: Aging Around the World, N. Shock, ed. (ed),1962: 59-78.

93. Slaughter MH, Christ CB, Stillman RJ, Boileau RA: The mineral and water content of the fat-free body: Effects of gender, level of fatness and age. Obesity Res, 1993; 1: 34S.

94. Flynn MA, Nolph GB, Baker AS, Martin WM, Krause G. Total body potassium in aging humans: A longitudinal study. Am. J. Clin. Nutr, 1989; 50: 713-717.

95. Forbes GB. Human Body Composition. Growth, Aging, Nutrition, and Activity. New York, Springer-Verlag, 1987.

96. Schoeller DA. Changes in total body water with age. Am. J. Clin. Nutr, 1989; 50: 1176-1181.

97. Norgan NG, Ferro-Luzzi A. The estimation of body density in men: Are general equations general? Ann. Hum. Biol, 1985; 12: 1-15.

98. Segal KR, Van Loan M, Fitzgerald PI, Hodgdon JA, Van Itallie TB. Lean body mass

estimation by bioelectrical impedance analysis: A four-site cross-validation study. Am. J. Clin. Nutr, 1988; 47: 7-14.

99. Guo S, Roche AF, Houtkooper L: Fat-free mass in children and young adults predicted from bioelectric impedance and anthropometric variables. Am. J. Clin. Nutr. 1989; 50: 435-443.

100. Guo S, Chumlea WC, Wu X, Wellens R, Siervogel RM, Roche AF. A comparison of body composition models. In: Human Body Composition. In Vivo Methods, Models, and Assessment. KJ Ellis and JD. Eastman (eds). Plenum Press, NY, 1993: 27-30.

101. Lohman TG. Applicability of body composition techniques and constants for children and youths. Exer. Sport Sci. Rev, 1986; 14: 325-357.

102. Norris AH, Lundy T, Shock NW. Trends in selected indices of body composition in men between the ages 30 and 80 years. Ann. N. Y. Acad. Sci, 1963; 110: 623-639.

103. Svendsen OL, Haarbo J, Heitmann BL, Gotfredsen A, Christiansen C. Measurement of body fat in elderly subjects by dual-energy x-ray absorptiometry, bioelectrical impedance, and anthropometry. Am. J. Clin. Nutr, 1991; 53: 1117-1123.

104. Virgili F, D'Amicis A, Ferro-Luzzi A. Body composition and body hydration in old age estimated by means of skinfold thickness and deuterium dilution. Ann. Hum. Biol, 1992; 19: 57-66.

105. Steen B. Body composition and aging. Nutr. Rev, 1988; 46: 45-51.

106. Durnin J, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Brit. J. Nutr, 1974; 32: 77-97.

107. Campbell AJ, Borrie MJ. Reference values for upper arm anthropometric measurements for a New Zealand community sample of subjects aged 70 years and over. Hum. Biol, 1988; 60: 587-596.

108. Rowland ML. Reporting bias in height and weight data. Statistical Bull, 1989; 70: 2-11.

109. Giles E, Hutchinson DL: Stature- and age-related bias in self-reported stature. J. Forensic Sci, 1991; 36: 765-780.

110. Milne JS. Longitudinal studies of body weight and skinfold thickness in older people. J. Clin. Exper. Gerontol, 1979; 1: 101-122.

13.25 ILLUSTRATIONS

Photo 13.1. Spata, Greece (1988): a man in his early 80s with abdominal obesity, also common amongst women.

Photo 13.2. Melbourne, Australia (Greek) (1990-1991): women in their early 80s with abdominal obesity or high waist-hip ratios.

CHAPTER 13

ANTHROPOMETRIC DATA

13.1 THE SELECTION OF VARIABLES

13.2 MEASUREMENT AND STANDARDISATION PROCEDURES

13.3 THE DERIVATION OF VARIABLES

13.4 LIMITATIONS OF THE DATA

13.5 WEIGHT
13.5.1 Comparisons with reported data
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13.6 STATURE
13.6.1 Comparisons with reported data
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13.7 BODY MASS INDEX
13.7.1 Comparisons with reported data
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13.8 WAIST CIRCUMFERENCE
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13.9 HIP CIRCUMFERENCE
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13.10 WAIST-HIP RATIO
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13.11 ARM CIRCUMFERENCE
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13.14 BODY COMPOSITION

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13.16 TOTAL BODY FAT (TBF, KG)
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13.17 FAT-FREE MASS (FFM, KG)
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13.18 NORTHERN CHINA

13.19 JAPAN (JPN)

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