9. Adults 60 years of age and older

9.1 Introduction

9.1.1 *Background*

The demographic situation

For the purposes of this report, the term "elderly" is applied to those aged 60 years and over, who represent the fastest-growing segment of populations throughout the world. In developing countries, the percentage of elderly tends to be small although the absolute numbers are often large: in 1990 there were more than 280 million people aged 60 or over – 58% of the world's elderly – living in less developed regions. The proportion of elderly is rising more rapidly in developing countries than in developed ones; by the year 2020 it is expected that almost 70% of the world's elderly people will be in developing countries, with the absolute number exceeding 700 million compared with 318 million in the more developed regions (*1*). Factors responsible for this changing pattern of population aging include a rapid decline in both fertility and premature mortality (*2*). Declining fertility is particularly apparent in some developing countries such as China, Cuba, and Uruguay, although fertility levels in others such as Bangladesh, Kenya, and Zaire remain high (*3*).

A clear example of population aging is provided by China. Since the founding of the People's Republic of China in 1949, the average life span of the Chinese has increased from 35 to 70 years. A rapid decline in fertility in the past 10 to 15 years has resulted in a large reduction in the proportion of the population under 15 years in addition to the large increase in the numbers of elderly (*4*). Within the older population, the numbers over 80 years of age are increasing the most rapidly and will grow significantly faster than numbers of those between 60 and 70 years during the next few decades.

Other demographic changes that accompany population aging are sex differences in longevity, urbanization, and the composition of the labour force. In most countries, older women outnumber older men and the percentage of women in each age group is steadily increasing. The urbanization that has been an important trend in the past half-century has seen the migration of younger people from rural areas to cities, resulting not only in larger urban populations but also a disproportionately older population in rural areas, especially in developing countries. In developing countries without a compulsory retirement age, people continue to work past the age of 60 or 65 years. With increasing industrialization, however, this is likely to change as workers shift from agricultural activities to industrial production and service occupations (*3*).

The demographic characteristics of the elderly themselves are also likely to be different in the future from what they are at present. The changes that take place will have an enormous impact on health services demanded and provided in all countries, but especially in developing countries, where economic development is uneven and resources are more limited than in industrialized nations.

Anthropometry and aging

Height. Decline in height with age has been noted in studies throughout the world (*5*). The rate of decline is 1–2 cm/decade and more rapid at older ages (*6*). It is particularly apparent in sitting height and is the result of vertebral compression, change in height and shape of the vertebral discs, loss of muscle tone, and postural changes. Results of cross-sectional studies may be confounded by the secular increases in height among younger cohorts in industrialized countries and in some developing countries (*7*): older cohorts have a lower mean stature by comparison with younger cohorts, in addition to the real physical loss in stature evident in longitudinal studies. In Japan, where there has been a large increase in average stature since 1947, this effect is seen particularly clearly. Height-related differences in survival rates may also affect results of cross-sectional studies but this remains to be investigated further. A longitudinal study of 70-year-olds in Gothenburg, Sweden (*6*), studied serial changes in height, weight, and BMI for the age interval 70 to 82

Table 48

Longitudinal changes in height, body weight, and body mass index of men and women aged 70–82 years[a]

	Women (n = 172)			Men (n = 110)		
Age (years)	Height (cm)	Weight (kg)	Body mass index	Height (cm)	Weight (kg)	Body mass index
70	160.2 ± 5.7	66.9 ± 10.5	26.1 ± 3.9	174.8 ± 6.5	79.4 ± 9.6	26.0 ± 2.9
	$p < 0.001$	$p < 0.001$	$p < 0.05$	$p < 0.001$	$p < 0.001$	not significant
75	159.3 ± 5.6	65.4 ± 10.3	25.8 ± 4.0	173.4 ± 6.5	77.5 ± 10.0	25.8 ± 3.1
	$p < 0.001$	$p < 0.001$	not significant	$p < 0.001$	$p < 0.001$	$p < 0.05$
79	158.3 ± 5.7	64.0 ± 10.6	25.5 ± 4.0	172.8 ± 6.5	76.0 ± 10.3	25.5 ± 3.3
	$p < 0.01$	not significant	not significant	not significant	$p < 0.001$	$p < 0.001$
81	158.0 ± 5.9	63.7 ± 11.0	25.5 ± 4.4	172.8 ± 6.4	74.6 ± 10.3	25.0 ± 3.3
	$p < 0.001$	$p < 0.001$	$p < 0.01$	$p < 0.001$	not significant	not significant
82	157.7 ± 5.8	62.7 ± 10.7	25.2 ± 4.2	172.4 ± 6.5	74.4 ± 10.0	25.0 ± 3.2

[a] Reproduced from reference *6* with the permission of Food & Nutrition Press Inc., Trumbull, CT, USA.

years; results are given in Table 48. This type of change, however, may vary from population to population depending upon various environmental and genetic factors.

Weight. Weight also declines with age, but the pattern of change is quite different from that of height and varies by sex (*5*). In affluent countries, the average weight of both men and women increases through middle age. Weight gains in men tend to plateau at around 65 years and weight generally declines thereafter; in women, however, the weight increases are frequently greater and the plateau occurs about 10 years later than in men. In non-European indigenous populations, such as Australian Aborigines, the increase in average weight in the middle years is not evident, but the decline at older ages is. Data on underprivileged populations are limited.

Body weight varies not only among individuals but also within a given individual during aging. Reduction in body water content has been reported as an important cause of decline in weight after 65 years, and was decribed in a Swedish longitudinal study of a small number of 70-year-olds (*8*). Changes accompanying the weight loss include a decline in muscle cell mass, and in cell mass in general, which is more pronounced in men.

Body mass index. Like weight, average body mass index in industrialized populations tends to increase in middle age and stabilizes somewhat earlier in men than in women. In men, the plateau may begin at 50–60 years or even at 70 years of age; in women it starts at 70 years or later. Both sexes generally show a decrease in average BMI after 70–75 years of age (*5, 9, 10*).

These trends have been observed in Europeans and populations of European ancestry, but may vary with environmental and genetic factors among different ethnic groups. The relationship between BMI and fat and muscle mass changes with age. Data from NHANES I and II have shown that BMI is more highly correlated with subcutaneous fat (estimated by subscapular skinfold) in younger than in older men and women, and with muscle mass in older than in younger adults (*11*). Thus, a young person with a high BMI is likely to have more subcutaneous fat than a person with a relatively low BMI value. However, BMI may have different significance in elderly individuals and young adults, because of the reduction in height with age, and it is uncertain whether current height or young adult height is the better for deriving this index.

It should be emphasized that BMI may not decline with age; indeed, it may be higher at age 70 and above than at younger ages because of the age-related changes in both height and weight and morphological changes in the vertebral column that result from osteopenia and increased curvature. Morphological changes in the spine influence mobility, balance, and sometimes also respiration. With extensive vertebral changes, height measurement cannot be accurate and has little value.

Body composition. Significant changes in fat-free mass and patterns of fat distribution occur with aging. Cross-sectional studies show a slow, progressive redistribution of fat in the elderly, with subcutaneous fat on the limbs tending to decrease and intra-abdominal fat to increase. The former is reflected in a decline in calf, thigh, triceps, and biceps skinfolds (*5, 12*) and the latter by an increase in abdomen:hip circumference ratio (AHR). Women accumulate more subcutaneous fat than men and lose it at a later age (*5*). Computed tomography scans have shown that fat weight is similar in middle-aged and older men but that there is less subcutaneous fat and significantly more intra-abdominal fat in older men (*13*). The same investigators also reported more fat between and within muscles in older men.

The Baltimore Longitudinal Study of Aging in the USA measures a large sample of volunteer adults every 2 years. A number of indices have been computed, including the ratio of subscapular skinfold to triceps skinfold; this index compares subcutaneous fat at a trunk site with that at an extremity site. There are large sex differences in the ratio, which is greater for men at all ages than for women, and increases with age in men but not in women (*14*).

Using underwater weighing of 200 healthy Swedish men and women aged 45-78 years, Bjorntorp & Evans (*15*) reported changes in the percentage of weight that is represented by body fat. At 45-49 years, men averaged 25% fat; this seemed to stabilize at 38% at age 60-65 years. Women had more body fat than men at 45-49 years (30%) and stabilized at an average of 43% at 55-59 years. Between 60 and 78, neither men nor women showed much change in percentage body fat.

9.1.2 *Population variation in anthropometry*

Child growth and maturation vary significantly among populations, and these early differences are not diminished in adult populations, which may be even more heterogeneous (*7*). In any given population, individual variation is also increased because of variable rates of aging from person to person and from physiological system to physiological system within the same individual. The broad heterogeneity of the elderly must therefore be taken into consideration in any study of this segment of the population.

Data from various elderly populations throughout the world have been compared (see Table 49) to examine the distribution of anthropometric parameters (*16*).[1] The variation in sex-specific distribution by geographical region/ethnic group, age, and health status was investigated. Analysis of height-for-age in 19 studies with adequate population data revealed wide geographical and ethnic differences. Of those aged 70-79

[1] Much of the material published in reference *16* represents background work originally undertaken for the purposes of the Expert Committee meeting.

years, Guatemalans had the lowest mean height and Americans (USA), Dutch, and Swedes the highest. Height decreased with age in all populations; differences ranged from 1.9 to 6.7 cm in men and from 2.0 to 6.0 cm in women. See Table 50.

The listed populations showed a decrease in BMI with increasing age (see Table 51). In most populations, BMI is greater in women than in men, and the distribution by age groups shifts to the left, especially in

Table 49

Sample characteristics of study sites included in analysis of elderly populations[a]

Original study	Location and/or population		Age range (years)	Sample size
Brazilian National Survey of Health and Nutrition, 1989	Brazil	national sample	60–108	4419
Nutritional Assessment of Guatemalan Ambulatory Elderly	Guatemala	one rural location	60–103	202
Longitudinal Study of Health and Social Support in the Hong Kong Chinese Elderly Cohort	Hong Kong		70–100	977
Nutrition in Old Age in Italy	Italy	17 locations	60–97	921
Italian Nutrition Examination Survey of the Elderly (INESE)	Italy	five locations	65–95	1248
Survey of Health and Living Status of the Elderly in Taiwan, 1989	China (Province of Taiwan)	national sample	60–97	3818[b]
Established Populations for Epidemiologic Studies of the Elderly (EPESE)	USA		65–90+	
		East Boston		3164[b]
		Iowa		3647
NHANES I Epidemiologic Follow-up Study (NCHS-US)	USA	national sample	60–86	3695
IUNS Study of Food Habits in Later Life	Australia	Anglo-Australians	60–79	111
		Greek descent	70–104	186
	China	Beijing	60–95	264
		Tianjin	70–96	441
	Greece	Sparta	70–94	70
	Sweden	Johanneberg	69–91	204
Chinese Nationwide Nutrition Survey	China	national sample	60–94	1764
Melbourne Chinese Health Study	Australia	Chinese descent	60–80	68
Rotterdam Elderly Study	Netherlands	Rotterdam	60–103	3752
Mini-Finland Health Survey	Finland	national sample	60–90 +	2126

[a] Reproduced from reference *16* with permission.

[b] Self-reported weight and height.

Table 50
Mean and standard deviation of height (in cm) by age group and geographical location[a]

	Age group (years)		
Location	60-69	70-79	≥ 80
Men			
Australia (Anglo-Australians)	168.2 ± 10.0[b]	164.0 ± 10.0	–
Australia (Chinese descent)	162.8 ± 5.3[b]	165.0 ± 7.5[b]	–
Australia (Greek descent)	–	165.2 ± 6.4[c]	163.3 ± 6.7
Brazil	165.0 ± 11.0	163.0 ± 10.0	162.0 ± 8.2
China (Beijing)	161.8 ± 4.4	161.6 ± 3.9	–
China (nationwide)	162.1 ± 6.7	160.8 ± 7.7	155.4 ± 6.8[b]
China (Province of Taiwan)	165.6 ± 7.1	164.9 ± 8.6	165.2 ± 8.9
China (Tianjin)	–	166.0 ± 6.0	164.2 ± 6.2
Finland	169.7 ± 11.9	168.7 ± 6.2	167.4 ± 6.4
Greece (Sparta)	–	165.9 ± 6.2	165.9 ± 6.4[b]
Guatemala (rural area)	155.1 ± 5.2	156.0 ± 5.7	153.2 ± 6.8[b]
Hong Kong	–	161.9 ± 6.0	161.7 ± 8.0
Italy (5 locations)	165.5 ± 6.1[d]	164.3 ± 6.7	161.8 ± 6.3
Italy (17 locations)	164.0 ± 7.4	162.2 ± 6.7	160.1 ± 6.8
Netherlands (Rotterdam)	175.1 ± 6.4	172.6 ± 6.4	170.8 ± 7.3
Sweden	–	174.1 ± 5.7	172.9 ± 5.0[b]
USA (East Boston)	170.4 ± 7.9[d]	167.6 ± 7.3	166.9 ± 7.3
USA (Iowa)	176.0 ± 6.6	175.3 ± 6.8	175.0 ± 7.6
USA (national sample)	174.0 ± 6.7	172.0 ± 6.6	170.6 ± 6.6
Women			
Australia (Anglo-Australians)	165.3 ± 8.6	166.4 ± 8.0	–
Australia (Greek descent)	–	149.9 ± 5.3	148.6 ± 6.0
Brazil	152.0 ± 7.4	150.0 ± 7.9	149.0 ± 8.9
China (Beijing)	156.0 ± 4.4	154.6 ± 3.8	–
China (nationwide)	150.6 ± 6.1	148.3 ± 6.3	146.3 ± 7.3
China (Province of Taiwan)	154.8 ± 5.9	153.9 ± 6.1	153.1 ± 5.8
China (Tianjin)	–	152.8 ± 5.9	150.4 ± 6.3
Finland	157.0 ± 5.7	154.7 ± 5.7	153.0 ± 6.3

Table 50 (*continued*)

Location	Age group (years)		
	60–69	70–79	≥ 80
Women (*continued*)			
Guatemala (rural area)	142.9 ± 6.2	139.7 ± 6.6	139.6 ± 5.5[b]
Hong Kong	–	148.4 ± 6.4	145.6 ± 7.2
Italy (5 locations)	153.2 ± 6.3[d]	151.4 ± 6.1	150.6 ± 7.0
Italy (17 locations)	152.5 ± 6.7	150.5 ± 6.5	147.5 ± 6.9
Netherlands (Rotterdam)	163.0 ± 6.2	159.4 ± 6.6	157.2 ± 6.2
Sweden	–	161.1 ± 1.8	157.9 ± 5.6
USA (East Boston)	157.7 ± 6.6[d]	157.2 ± 6.6	156.2 ± 7.8
USA (Iowa)	161.8 ± 6.1[d]	161.3 ± 6.6	161.3 ± 6.5
USA (national sample)	160.6 ± 5.9	159.1 ± 6.0	158.4 ± 5.9

[a] Reproduced from reference *16* with permission.
[b] Sample size < 25.
[c] Age group 74–79 years.
[d] Age group 65–69 years.

Table 51
Mean and standard deviation of body mass index by age group and geographical location[a]

Location	Age group (years)		
	60–69	70–79	≥ 80
Men			
Australia (Anglo-Australians)	27.7 ± 4.3[b]	26.6 ± 3.4	–
Australia (Chinese descent)	22.5 ± 2.8	22.9 ± 2.7	–
Australia (Greek descent)	–	28.0 ± 3.6[c]	27.0 ± 3.7
Brazil	23.7 ± 5.4	22.9 ± 5.0	22.4 ± 4.1
China (Beijing)	25.5 ± 3.9	24.2 ± 3.5	–
China (nationwide)	20.8 ± 3.0	21.7 ± 3.9	20.9 ± 2.6[b]
China (Province of Taiwan)	23.0 ± 3.7	22.5 ± 3.9	22.6 ± 4.6
China (Tianjin)	–	22.2 ± 3.3	21.0 ± 3.8
Finland	26.0 ± 3.7	25.6 ± 3.7	24.3 ± 3.9
Greece (Sparta)	–	27.4 ± 4.4	25.2 ± 2.9[b]
Guatemala (rural area)	21.3 ± 2.6	20.2 ± 2.2	19.6 ± 2.3

Table 51 (*continued*)

Location	Age group (years) 60–69	70–79	≥ 80
Men (*continued*)			
Hong Kong	–	21.2 ± 3.4	20.6 ± 4.2
Italy (5 locations)	26.9 ± 3.7[d]	26.5 ± 3.8	25.1 ± 3.6
Italy (17 locations)	26.6 ± 4.6	25.5 ± 4.3	25.1 ± 3.7
Netherlands (Rotterdam)	25.9 ± 2.9	25.8 ± 3.3	24.9 ± 3.4
Sweden	–	25.3 ± 3.2	24.8 ± 3.3
USA (East Boston)	26.8 ± 4.2[d]	26.4 ± 4.2	25.0 ± 4.1
USA (Iowa)	26.2 ± 3.6[d]	25.6 ± 3.7	23.9 ± 3.3
USA (national sample)	26.4 ± 4.0	25.6 ± 3.7	24.6 ± 3.8
Women			
Australia (Anglo-Australians)	26.1 ± 5.0	25.6 ± 3.0	–
Australia (Greek descent)	–	30.7 ± 5.1	27.8 ± 6.1
Brazil	25.8 ± 6.7	25.0 ± 7.4	23.9 ± 4.9
China (Beijing)	25.5 ± 5.3	23.0 ± 3.5	–
China (nationwide)	21.7 ± 3.9	20.7 ± 3.6	19.6 ± 3.1
China (Province of Taiwan)	23.4 ± 3.8	22.9 ± 3.9	21.8 ± 4.7
China (Tianjin)	–	22.1 ± 4.1	21.5 ± 4.3
Finland	27.8 ± 4.5	26.8 ± 4.5	25.6 ± 4.0
Guatemala (rural area)	22.4 ± 3.3	21.4 ± 4.4	20.7 ± 4.1[b]
Hong Kong	–	22.4 ± 4.0	20.9 ± 3.6
Italy (5 locations)	29.0 ± 5.0[d]	28.4 ± 5.3	26.6 ± 4.7
Italy (17 locations)	28.6 ± 4.5	28.5 ± 5.4	26.9 ± 5.0
Netherlands (Rotterdam)	26.8 ± 4.1	27.1 ± 4.3	27.0 ± 4.2
Sweden	–	24.1 ± 4.4	23.9 ± 4.0
USA (East Boston)	27.7 ± 5.7[d]	27.4 ± 5.5	25.5 ± 5.4
USA (Iowa)	26.1 ± 4.5[d]	25.2 ± 4.4	22.8 ± 4.0
USA (national sample)	26.5 ± 5.3	25.7 ± 4.9	24.5 ± 5.0

[a] Reproduced from reference *16* with permission.
[b] Sample size < 25.
[c] Age group 74–79 years.
[d] Age group 65–69 years.

women (see Fig. 64). If height is unchanged, a decrease in BMI reflects mostly a decrease in body weight; however, when height also decreases, as it does in the elderly, changes in BMI are smaller than they would be in younger age groups with stable height.

Body mass index varies widely among elderly populations (Table 51). Among men there appear to be two clusters, with samples from Central and South America and of individuals of Chinese descent having considerably lower BMI than others. Women appear to fall into three clusters: the lowest BMI values were among those of Chinese origin (in most studies) and in rural Guatemala, the next highest values were in Brazil, northern Europe, and the USA, and among Anglo-Australians, and highest values occurred among Australians of Greek origin.

Among the 19 studies considered, plus some additional data from Japan and the Philippines, differences were found in the prevalence of thinness (BMI <18.5) and overweight (BMI ≥30) (see Fig. 64). Prevalence of thinness in 70–79-year-old men ranged from 0% (in Anglo-Australians, Australians of Greek descent, Greeks in Sparta, and Swedes) to 18% (Japanese). Among women of the same age group the range was 0% (Anglo-Australians, Australians of Greek descent, Greeks in Sparta) to 28% (Filipinos in Manila). A similar pattern of increase with age in the prevalence of thinness in both men and women was evident in the majority of studies.

Most studies show that the distribution of BMI among those reporting poor health extends further to the left than it does among those reporting very good/excellent health. However, some studies show considerable overlap in the left-hand side of the distributions of those reporting poor health and those reporting excellent health. In national surveys in Italy and the USA, the BMI distribution of those reporting poor health also extends further to the right than those in the other groups. In contrast, in the Hong Kong study, the distribution of those reporting excellent health extends further to the right than those in the other groups (Fig. 65).

9.1.3 *Anthropometry as an indicator of nutritional and health status*

Anthropometric characteristics of individuals and populations are simple and strong predictors of future ill health, functional impairment, and mortality; in turn, they may be modified by disease. For these reasons, anthropometric data are used in many contexts to screen for or monitor disease. In the elderly, however, anthropometry is a relatively new tool and thus difficult to evaluate. The comparative analysis of world populations discussed above suggests that the predictive power of anthropometric indicators relative to a specific outcome is likely to vary with a number of factors such as age-related biological changes, illness, secular changes, childhood diseases, lifelong practices (smoking, diet, exercise), and socioeconomic factors.

Figure 64
Distribution of body mass index

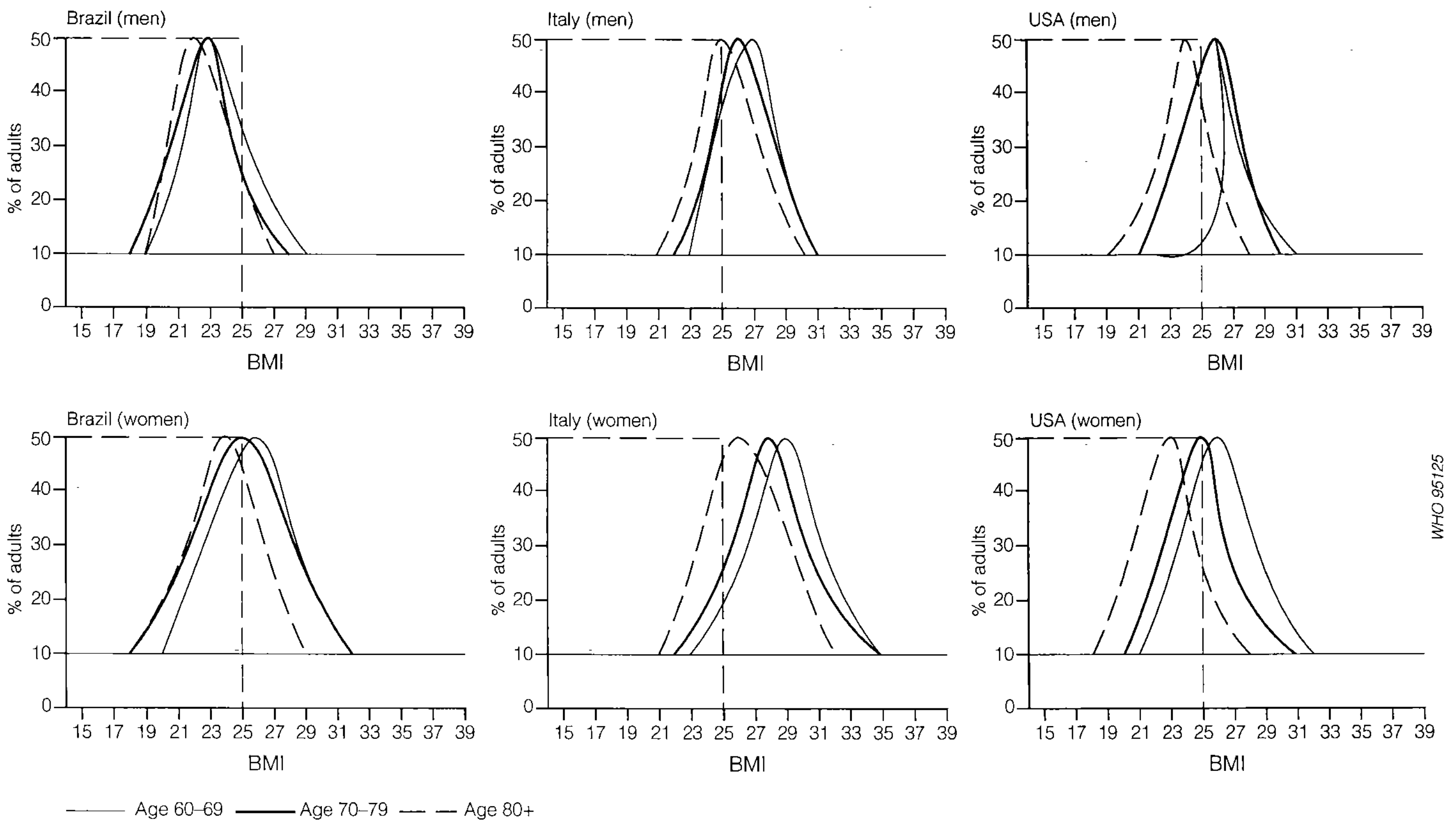
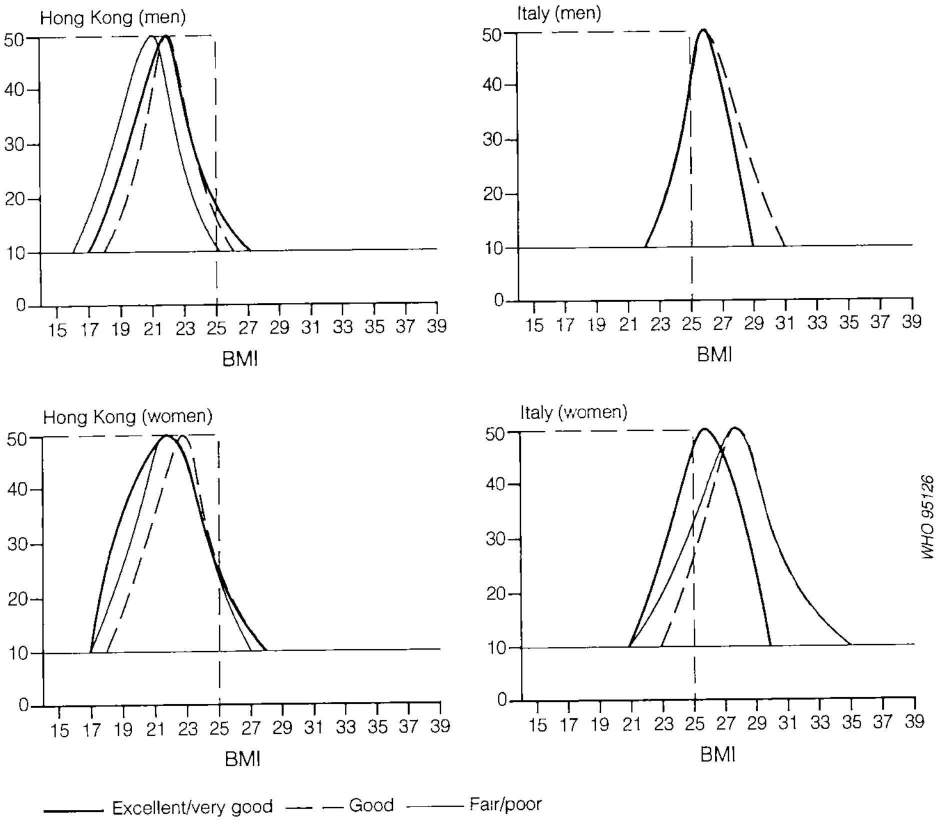


Figure 65
Distribution of body mass index by self-reported health status



Among middle-aged adults (50–65 years) overweight is an important public health problem in many countries and in some the combined prevalence of grade 2 and 3 overweight (BMI ≥30) (see section 7) is as high as 40%. For individuals over 65 years of age the health risk of overweight is unclear; in fact, population data indicate that moderate overweight at older ages is associated with lower mortality (*17*). Among those older than 80 years, thinness and loss of lean body mass may be a more significant problem than overweight. Whether a high abdomen:hip ratio is a risk factor among the elderly is unclear.

Evidence from both acute and chronic illness, as well as from starvation studies, indicates that both lean and fat body mass play a role in determining health status and outcome. Lean body mass is the single most important predictor of survival in critical illness (*18*), and is a significant predictor of outcome in malignancy, AIDS, and some acute illnesses. Data collected by physicians in the Warsaw ghetto during the Second World War have shown that, in starvation, loss of more than 40% of baseline lean body mass is fatal. This same critical figure seems to apply also to AIDS and to normal aging (*19*). The physiological basis for this limit is not clear, but presumably a substantial loss of lean mass reduces body cell mass below the minimum level necessary to maintain physiological function. Current data also indicate that nutritional therapy in illness affords important physiological benefits long before there is measurable improvement in lean body mass, but that return to normal physiological function is not achieved until body composition begins to normalize. These research findings reinforce the argument for applying anthropometry to clinical situations. It should also be noted that serum albumin level is an important predictor of survival in healthy ambulatory adults, even within the normal range of 3.5 to 5.0 g/dl (*20*).

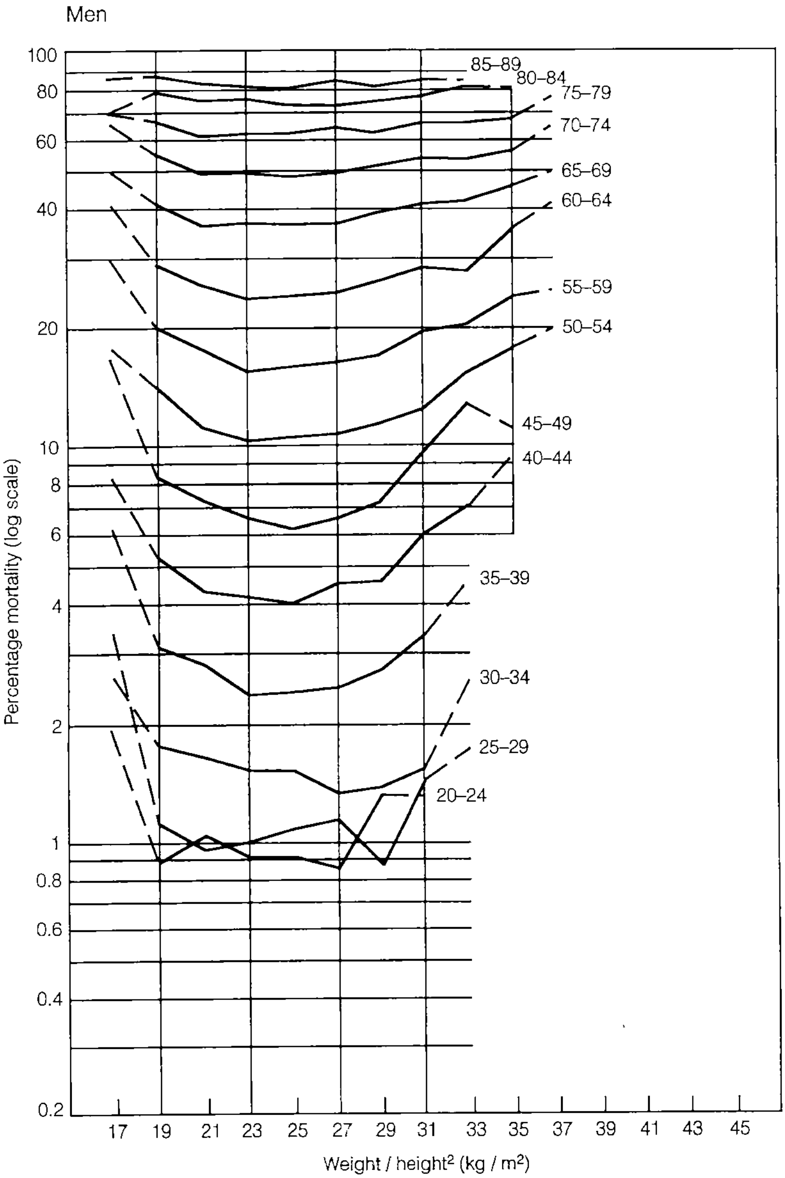
In contrast, there appears to be no benefit in maintaining fat mass except as an energy reserve during times of nutritional privation. The importance of fat mass lies in the risks it confers for the development of chronic diseases. This, too, underlines the value of estimating fat mass separately from lean mass, in order to classify individuals with respect to health risks and the need for intervention.

Height, weight, and BMI are good indicators for risk of morbidity and mortality, at least in young and middle-aged adults. In Norway, Waaler (*9, 10*) looked at the relationship between mortality and these variables in a sample of nearly 1.7 million individuals. A strong negative association was noted between height and all-cause mortality, with higher mortality in shorter individuals; this may be a reflection of socioeconomic influences earlier in life. The relationship between BMI and all-cause mortality was U-shaped (see Fig. 66). It should be noted that BMI declined after 70 years and that this cohort and older ones represent survivors. Causes of death associated with low BMI are tuberculosis, obstructive lung disease, and cancer of the lung and stomach; those associated with high BMI are cerebrovascular disease, cardiovascular disease, diabetes, and, in men, colon cancer. In the majority of the elderly, the nadir of the curve was at 21-27 and 23-27 for men and women, respectively.

A U-shaped relationship between BMI and mortality has also been reported for Finnish men (*21*). Lowest mortality occurred at a somewhat higher BMI among men over 75 years of age than among younger men, but the curve showed excess mortality at the tails of the distribution. Among thin men mortality from cardiovascular causes increased with BMI in the younger cohorts but not in those aged 55-90. A U-shaped relationship between BMI and mortality was also apparent in young women, but was more uncertain for older women, who showed little variation in mortality with BMI. Overweight did not reduce life expectancy in Finnish women aged 65-79 years (*22*); indeed, a modest degree of overweight seemed to be protective against death. The most favourable BMI was 27-31, a considerably higher figure than was found in Norway.

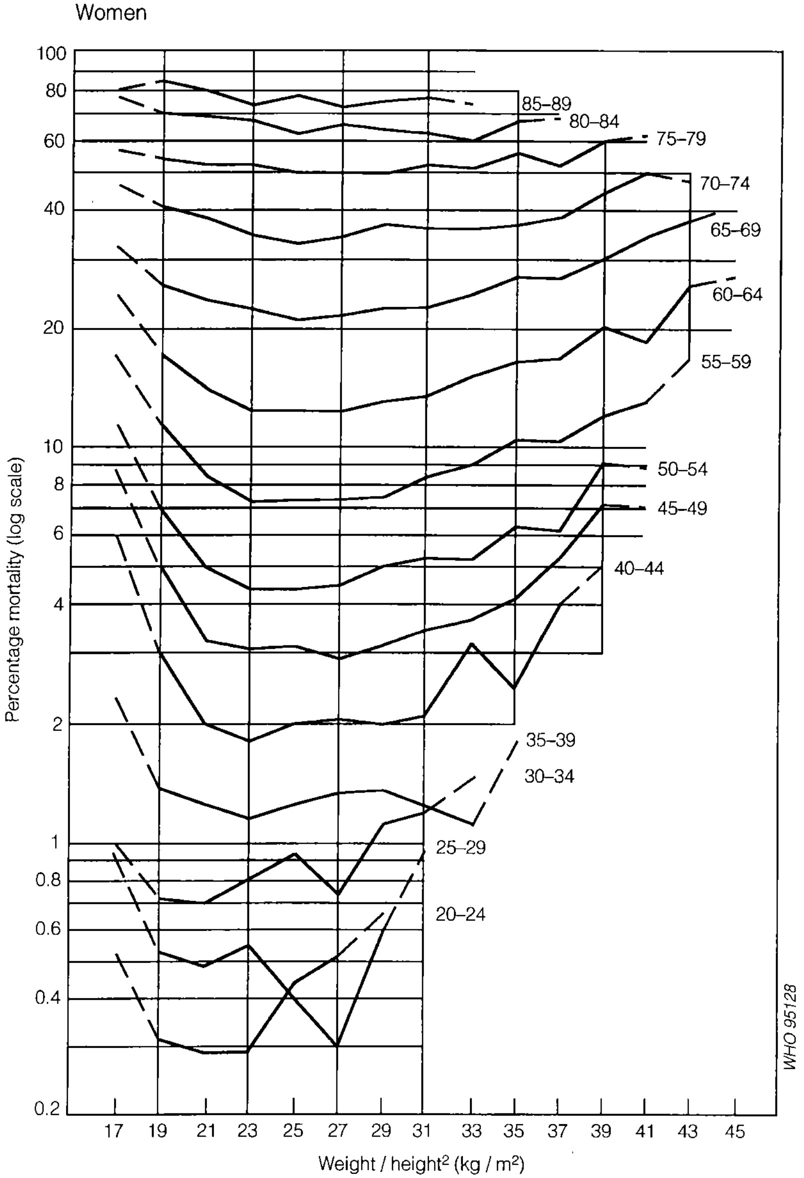
A follow-up study in Finland of 95 men and 431 women over 85 years of age showed that low BMI was a more important predictor of risk of death than high BMI (*23*). Highest 5-year mortality was reported in the group with BMI <20.0 and the lowest in the group with BMI >30.0. It was concluded that overweight ceases to be a risk factor for death in this age group.

Figure 66
Relationship between 10-year mortality and body mass index in different age groups[a]



[a] Reproduced from reference *9* with the permission of the publisher.

Figure 66 (*continued*)



Similar results from a follow-up to the NHANES I in the USA revealed that the moderate additional risk of death associated with weight apparent in older men was not apparent in older women (*24*). When analysis was controlled for poverty, smoking, and elevated blood pressure, high BMI was associated with somewhat increased mortality risk in white men and no increased risk in white women. Other analyses of these data suggested that, compared with older people of moderate BMI, heavier and very thin white women and non-smoking white men were at increased risk of death (*25*). In the Framingham Heart Study in the USA, there was a positive relationship between BMI and mortality in non-smoking men and women over 65 years of age in follow-up studies of from 1 to 23 years (*26*). Survival was lower among individuals in the 70th percentile for BMI (28.5 for men, 28.7 for women) than among thinner individuals with moderate BMI. Those who were overweight at 65 but not at 55 years of age were at lower risk of death than those who gained 0–9% BMI, and those who lost 10% of BMI were at almost twice the risk.

Both overweight and thinness appear to carry risk for mortality, but in the elderly thinness carries a greater risk than overweight. Weight change, especially involuntary weight loss, also poses considerable risk, which may interfere with the interpretation of the data from large studies.

9.1.4 *Interpretation issues in the elderly*

Menopause is an aging phenomenon that influences women's health and is often accompanied by an increase in weight and adiposity. However, the median age of menopause varies among populations. In a randomly sampled group of women in Massachusetts, USA, it was 51 years (*27*), which is also the approximate mean age among European women. There are sparse data from other regions, which show a mean age of 42 years among Mayans and of 46–47 years among uneducated, rural Javanese (*28*).

Differences between young people and the elderly in the relationships between weight and other variables are due, in part, to the influence on body size and fatness of the normal physiological effects of aging, such as loss of height, osteoporosis, changes in the amount and distribution of subcutaneous adipose tissue, and alterations in tissue elasticity and compressibility. There is a considerable lack of understanding of the functional and health-related implications of anthropometric indicators in older people. Moreover, the redistribution of body fat from the extremities to visceral areas in the elderly hampers the adequate estimation of body composition when anthropometric models based on younger adults are applied. Data derived from magnetic resonance imaging or computerized tomographic scanning of the elderly reveal not only a progressive redistribution of fat from the extremities to the visceral area but also the replacement of muscle tissue by intramuscular fat (*29*); this is not reflected in anthropometric measurements of subcutaneous fat. It should therefore be kept in mind that use of anthropometry in the elderly may well result in underestimation of body fat, and that this phenomenon is absent from the young healthy reference population so often used to validate scientific methodology. The use of anthropometric techniques in older adults must be validated on individuals of the appropriate ages. It is unlikely that present methods can avoid this bias.

Traditional measurements of body size may also fail to provide adequate estimates of nutritional status or the effects of nutritional intervention in the elderly. For example, an increase in abdominal circumference with age may reflect shortening of the trunk due to osteoporosis or other spinal deformities: as the length of the trunk decreases, the abdomen increases in girth. In elderly women, there is a significant negative correlation between abdominal circumference and sitting height (*30*).

On retirement, men in developed countries tend to spend an increasing amount of time in sedentary activities (*31*), which may explain some of the age-related loss of fat-free mass. A significant negative correlation between age and calf circumference is noted in elderly men, but not in women, and may be due to general loss of muscle in response to the reported greater reduction in physical activity among men than women. Calf circumference is considered the most sensitive measure of muscle mass in the elderly.

A number of intrinsic limitations are common to the use of anthropometry in all age groups; these include the effect of body fluid changes on weight, skinfolds, and circumferences, and the inability of sick people to stand for height measurements. In the elderly, there are certain additional constraints, such as the difficulty of obtaining measurements of weight, height, and other anthropometric variables when a large proportion of the population of interest is unable to walk or stand. From a clinical standpoint, however, the elderly are often the most important target population for intervention. Surrogate measures, such as knee height or arm span, have therefore been developed for use with bed-fast or chair-fast individuals (see section 9.4). In addition, problems in the interpretation of anthropometric data in the elderly may arise from selective survivorship in cross-sectional studies.

9.2 Using anthropometry in individuals

There is a lack of agreement on the clinical usefulness of anthropometry in the elderly for prognosis and for evaluating response to treatment. In individuals who are not in ideal health, and especially elderly individuals, anthropometry suffers from several limitations, in both application of the methods and interpretation of the results. Age-related changes in height should be taken into consideration when metabolic, circulatory, endocrine, and nutritional parameters are related to BMI. More training, standardization of techniques, and good quality equipment will improve the quality of measurements, but the clinician still needs to recognize the limitations of anthropometry in the elderly.

9.2.1 *Screening for interventions*

Health assessment of an elderly person to evaluate specific risks should include medical and dietary histories, laboratory measurements (e.g. haemoglobin, serum albumin, serum lipids), cellular immune response tests, and anthropometric measurements. Overweight, emaciation, or rapid changes in adipose and muscle tissues are of particular concern. The prevalence of overweight increases with age and results in the loss of mobility (*31*) and an increased burden on cardiovascular and pulmonary function. Increases in weight in elderly men are associated with significant changes in fasting glucose, uric acid levels, and forced vital capacity. Increased adipose tissue on the trunk is independently associated with risk factors for chronic diseases, including glucose intolerance, hyperlipidaemia, and hypertension. Loss of muscle tissue resulting from chronic protein-energy undernutrition increases the risk of morbidity and mortality, partly because it is frequently associated with depressed immune function. General muscle strength, gait, and balance may also be impaired in the elderly, thus increasing the risk of falls and consequent injury (*32*).

Body weight is the sum of all aspects of body composition and is a rough measure of total body energy stores; changes in weight therefore usually parallel energy and protein balance. Weight losses or gains, or a relative change in weight of greater than 10% over a period of less than 6 months, are considered clinically significant. Despite its clinical and nutritional importance, however, body weight is frequently not recorded for elderly people receiving nutritional support because of mobility problems, illness, or unavailability or unreliability of equipment.

The recommended cut-off point for low BMI of 18.5 for adults (see section 8) may be relevant for the elderly, at least from 60–69 years, but whether different cut-offs are more appropriate in individuals of 70 or more years of age is uncertain. Individuals with BMI below this threshold level may be eligible for nutritional supplements. For individuals classified as overweight, the BMI cut-off of 30 recommended for adults (see section 7) may also be considered as a health risk marker, at least in those under the age of 70, who may be considered for counselling in diet and nutrition. When there is no pre-existing chronic disease, older individuals who have remained overweight are probably best advised to maintain their weight; for individuals with pre-existing disease, however, weight control associated with overall clinical treatment is recommended. All groups should be encouraged to increase both physical activity and nutrient density in order to maintain or augment lean body mass.

9.2.2 *Assessing response to an intervention*

The anthropometric measurements that are useful in classifying individuals according to their initial nutritional status and risk often differ from those that are useful for following people over time or for assessing their response to an intervention. The differences arise from the greater importance of accuracy and appropriate reference data for initial classification, in contrast to the precision that is essential in follow-up studies.

Evaluation of the success of an intervention programme often necessitates repeated anthropometric measurements. For clinical purposes it may be assumed that height does not change during follow-up, unless the period is very prolonged. Weight, from which BMI is derived, is the most important single anthropometric measurement. A gain in weight may be caused by an increase in total body water (in oedema, ascites, etc.) or by an increase in fat; conversely, an involuntary loss of weight suggests a loss of lean body mass, with attendant concerns about diagnosis and prognosis. Although there is evidence that weight declines after the age of about 70 years, it is reasonable to set maintenance of weight (within 10% of usual body weight) as a clinical goal.

Body circumferences and skinfold thicknesses are useful for initial classification of patients, but are generally not sufficiently precise for short-term follow-up and monitoring. The interpretation of a small change in triceps skinfold or mid-arm muscle area is difficult, while a change from, for example, the 25th to the 50th percentile, is too insensitive for general use. Yearly changes in BMI, triceps skinfold, mid-arm circumference, and arm muscle area were documented in a longitudinal study of elderly white men and women (*13*). Annual rates of change were small and may have reflected changes in skin compressibility or measurement error or both, in addition to actual changes in body composition. It is unlikely that these measurements will really change if weight does not, and the simplicity of measuring and interpreting a change in weight makes body weight the measurement of choice for short-term follow-up. However, if there is an increase in weight due to ascites or oedema, the clinician may wish to assess somatic protein stores, in which case calf circumference is probably the most useful measurement, being independent of changes occurring in the abdomen.

9.2.3 *Assessment of functional ability*

Assessment of functional ability is important in the evaluation of older people; it is generally rated in terms of daily routine activities as walking, dressing, and eating. At the time of clinical assessment, a variety of simple functional tests may also be performed, including grip strength, 10-metre walking time, time to rise from a chair, and ability to stand on one leg. These tests are good predictors of independence of function, and generally correlate with lean body mass and muscle mass (*32*).

Some evidence suggests that loss of lean body mass predicts functional status, especially in the elderly. Muscle strength, for example, is one of the best predictors of independence and mobility (*29*), and strength is directly determined by the amount of muscle mass (*33*). Thus, functional status and, especially, change in body composition as determined anthropometrically may be extremely helpful in predicting the ability of the elderly to live independently, or to indicate their need for interventions such as nutritional programmes, assistance with daily activities, or even institutionalization.

Poor nutritional status and changes in body composition are believed to be associated with increasing problems of balance and gait in the elderly and thus with risk of falls (*34*). It was shown in one study of aging that fallers had poorer nutritional status than non-fallers, and that nearly all anthropometric measurements, except triceps skinfold, were significantly decreased in men with balance problems (*32*).

9.3 Using anthropometry in populations

9.3.1 *Targeting interventions*

In the public health setting, anthropometry is used to identify groups in need of intervention and to assess response to an intervention; to ascertain determinants or consequences of thinness and overweight; and as a surveillance tool. Population monitoring is more common when there is risk of acute undernutrition, as in the event of war or natural disaster, and the elderly may serve as a sentinel for the entire population. In elderly populations where resources are limited, there is a potential use for triage of need for health care.

Decisions on the implementation of population-wide interventions are made on the basis of anthropometric cut-offs. However, cut-offs developed from samples of younger adults (see sections 7 and 8) are considered provisional for the elderly, since a given BMI does not necessarily imply the same amount of body fat and muscle (*11*), and therefore does not carry an equal health risk, in younger and elderly individuals. The cut-off for undernutrition or thinness is 18.5, and that for overweight, proposed only for ages 60–69 years, is 30. Beyond individual problems of mobility, the health risks of overweight at greater ages are uncertain.

Prevalence of short stature is of considerable interest in population surveys. Short stature is common in Central and South America and much of the developing world, and this may have implications for the interpretation of anthropometry, and possibly for health status, in the elderly. Such populations are likely to have suffered nutritional privations and high rates of infectious diseases in early childhood.

There is little experience of anthropometry of the elderly in field settings in developing countries, largely because of lack of priority for surveys of the elderly in nations dominated by concern for the pressing problems of maternal and child health. Since an increasing proportion of the world's elderly live in developing countries, it is recommended that any survey of adult populations include anthropometric screening of the elderly.

9.3.2 *Assessing response to an intervention*

Interventions in an elderly population may not be expected to produce such obvious responses as, say, increased growth in height among children. The likely response would be a reduction in morbidity and mortality at a specific age. A typical example of intervention would be an exercise programme in a nursing home, designed to improve balance and reduce the incidence of falls. Studies of interventions of this nature are currently being carried out in a number of affluent populations.

9.3.3 *Ascertaining the determinants of thinness and overweight*

In addition to the determinants of adult overweight and thinness already discussed in sections 7 and 8, determinants specific to the elderly are prevalence of depression, institutionalization, injury resulting from falls, poverty, solitary living, illness, and social support networks. However, there is a lack of comprehensive biological and social data in these areas, especially from developing countries.

The importance of monitoring weight in institutionalized settings in developed countries has been stressed in studies by Dwyer et al. (*35*) and Potter et al. (*36*). In the first of these, patients were weighed on admission to nursing homes and again 2 years later; 73% of them either lost or gained at least 4.5 kg. Four-year survival rate was lower among patients who lost weight than among those who gained or remained stable. Lowest mortality occurred at moderate overweight.

9.3.4 *Ascertaining the consequences of thinness and overweight*

Monitoring shifts in the distribution of BMI may reveal changes in the health status of the population. A shift to the left (lower BMI values), for example, may be a warning of impending risk for the entire population. Conversely, in populations with a high prevalence of thinness, a shift of the BMI distribution to the right may be indicative of an improvement in health status. It should be noted, however, that *any* alteration in the distribution of BMI in the elderly may also be due to a cohort effect; a shift to the right may also point to an increasing risk of cardiovascular disease, site-specific cancer, diabetes, and loss of mobility, while a lowering of BMI values is associated with infectious diseases and famine.

9.3.5 *Nutritional surveillance*

Population surveys have often failed to include the elderly, and this situation may be worsened by the reluctance of older people to be measured or interviewed. It is recommended not only that the elderly be included in surveillance, but also that they be specifically targeted for nutritional surveillance since they may be prone to hidden deficiencies that can be corrected by nutritional and health programmes. The elderly should be recognized as a group at risk and as one that may signal nutritional problems in the population as a whole. In long-term planning, efforts should be made to maintain or improve quality of life for the elderly. For this purpose, the ability of the individual to live independently and the proportion of the population capable of a degree of independence in the activities of daily living should be recorded as additional information.

The functional ability of aging individuals varies considerably, and a healthy 80-year-old is not comparable to a healthy 60-year-old. A concept of functional age, similar to that of maturational age of adolescents, should be considered for use in the elderly, but needs further development. For nutritional surveillance of those aged 60 years and more, anthropometric data should ideally be presented by 5-year age groups, but 10-year grouping is more realistic. Biological age groups would be even more appropriate but present difficulties since different organ systems age at different rates and there are no reliable biomarkers of aging. Because anthropometry varies markedly according to sex in the elderly, all data must be analysed by sex.

9.4 Methods of taking measurements

The cooperation of the individual is essential to any anthropometric assessment, but where there is a lack of formal education or where adult children are over-protective of their elderly parents this may be difficult to obtain. Fear of pain and inconvenience are also potential barriers to compliance with the necessary procedures. In randomized studies, the community may fail to understand why some people are to be measured and others not; in such cases, it may cause fewer problems to measure all individuals but use data only for those who were preselected. Communication is essential, and community leaders should be fully consulted. Employing local residents as part of the study team often inspires confidence within the community.

The methods described below include those for individuals confined to bed (bed-fast) or to a chair or wheelchair (chair-fast), which are particularly relevant for elderly populations. However, certain methods may be unsuitable for use in the field or in some developing countries. For other recommended measurements and derivation of indices, such as BMI, that are not specific to the elderly, see Annex 2. Complete and more simplified versions of BMI tables, which will facilitate the utilization of this index, can be found in Annexes 2 and 3, respectively. A nomogram is also provided in Annex 2 (Fig. A2.1).

Note: For consistency with the recommended reference data, arm circumferences and skinfolds should be measured on the right side of the body.

9.4.1 *Weight*

Weighing chair-fast and bed-fast individuals

If an elderly person can sit but is unable to stand, a movable wheelchair scale can be used; the individual should sit upright in the centre of the chair. It is also possible to adapt a pair of bathroom scales to accommodate a wheelchair.

Bed scales incorporating a weighing sling are available for determining the weight of bed-fast patients. The individual is positioned comfortably in the weighing sling, and the sling is raised slowly until the individual is fully suspended. One important drawback is that chair and bed scales are expensive instruments.

Estimating weight from anthropometry

Weight can be estimated by anthropometric means when it cannot be measured directly because of an individual's infirmity or injuries, such as fractures requiring traction or casting. Weight estimates can also be used for calculating indices such as BMI or for estimating energy expenditure.

Weight can also be estimated from calf circumference, knee height, mid-upper arm circumference, and subscapular skinfold. The following equations have been developed for the elderly in the USA (*37*):

Weight (men) = (0.98×calf circ.) + (1.16×knee height) + (1.73×MUAC) + (0.37×subscap. skinfold) - 81.69

Weight (women) = (1.27×calf circ.) + (0.87×knee height) + (0.98×MUAC) + (0.4× subscap. skinfold) - 62.35

These equations estimate weight within 95% confidence limits of 8.96 kg and 7.60 kg for men and women respectively. Using these equations is not an ideal solution, but may be a reasonable approach in patients who cannot be moved (e.g. after hip fracture). However, since they were developed for the USA, the equations may not be appropriate for use elsewhere, and it may be necessary to develop population-specific equations.

9.4.2 ***Height***

At present, there are no guidelines regarding the degree of spinal curvature that would invalidate the measurement of height, but there are obviously individuals whose height should not be measured because of kyphosis or other postural problems. In such cases, height should be estimated or – preferably – knee height should be used as a surrogate. Arm span has also been used as a surrogate for height, but may be less satisfactory than knee height because of joint stiffness in the elderly and because the number of joints involved can reduce the accuracy of measurement. Arm span is also believed to yield young adult height rather than the current (reduced) height of the older individual, since there is little reduction in the length of long bones with aging.

Knee height

The following equations have been developed for estimating height from knee height for white and black Americans aged 60–80 years (*38*):

Height (white men) = (2.08 × knee height) + 59.01

Height (white women) = (1.91 × knee height) - (0.17 × age) + 75.00

Height (black men) = (1.37 × knee height) + 95.79

Height (black women) = (1.96 × knee height) + 58.72

The standard errors are rather large: 7.84 cm for white men, 8.82 cm for white women, 8.44 cm for black men, and 8.26 cm for black women. The equations were developed from a selected population living in the USA and may be inappropriate for other populations; it may therefore be necessary to develop population-specific equations.

Knee height may also be used as an independent measurement, since it is not affected by height loss due to vertebral compression.

It can be measured with a sliding broad-blade calliper: the shaft of the calliper is held parallel to the shaft of the tibia and pressure is applied to compress the tissues. Measurements are recorded to the nearest 0.1 cm, and two measurements taken in immediate succession should be within 0.5 cm of each other.

Height estimated from knee height can be used to derive BMI as an index of the degree of overweight in almost all elderly persons.

For measuring the knee height of an elderly person seated in a wheelchair it is important that the leg is supported so that the knee and ankle are each bent to a 90° angle. Kneeling at the side of the lower leg, the observer places the fixed blade of the calliper under the heel of the foot. The shaft of the calliper is positioned so that it passes over the lateral malleolus and just posterior to the head of the fibula. The movable blade is placed over the anterior surface of the thigh, above the condyles of the femur, about 4.0 cm proximal to the patella. The shaft of the calliper is held parallel to the shaft of the tibia and pressure is applied to compress the tissues.

Bed-fast individuals should lie supine, with the knee and ankle each bent to 90°. Standing to the side of the lower leg, the observer places the fixed blade of the calliper under the heel of the foot, and positions the shaft of the calliper so that it passes over the lateral malleolus and just posterior to the head of the fibula. The movable blade is placed over the anterior surface of the thigh, above the condyles of the femur, about 4.0 cm proximal to the patella. The shaft of the calliper is held parallel to the shaft of the tibia and pressure is applied to compress the tissues.

Arm span

Arm span is a further alternative measurement for use when it is impossible to measure actual height, although – as mentioned – it yields an estimate more closely correlated with young adult height. The individual should stand against a wall, with the arms extended laterally. The arms should be kept at shoulder height during the measurement, although this may be difficult in older people. The measurement is made with a measuring tape at least 2 metres long, with an observer at each end of the tape, and recorded to the nearest 0.1 cm.

Arm span can also be measured with the subject supine, but this presents some difficulty and is a less accurate method.

9.4.3 *Calf circumference*

Calf circumference is considered to provide the most sensitive measure of muscle mass in the elderly, and is superior to arm circumference. It indicates the changes in fat-free mass that occur with aging and with decreased activity (*31, 39*).

To measure the calf circumference of an elderly person seated in a wheelchair it is important that the leg is supported so that the knee and ankle are each bent to a 90° angle. Kneeling at the side of the calf, the observer passes a loop of the measuring tape around the calf, moving it up and down to locate the largest circumference.

A similar procedure is followed for the bed-fast individual. Lying supine, the patient bends the knee to a 90° angle with the sole of the foot resting on the bed or examination table. It may be helpful to place a sandbag under the foot for support. Standing at the side of the calf, the observer places a loop of the measuring tape around the calf, moving it up and down to locate the largest circumference.

9.4.4 *Subscapular skinfold thickness*

Subscapular skinfold thickness is measured with the bed-fast individual lying on the left side with the left arm extending from the front of the body. The trunk should be in a straight line, the legs should be bent and slightly tucked up, and the right arm should rest along the trunk, palm down. An imaginary line through the acromion processes should be perpendicular to the bed. The skinfold thickness is measured just posterior to the inferior angle of the right scapula. The observer gently grasps a double fold of skin and subcutaneous adipose tissue between the fingers and thumb, on a line from the inferior angle of the right scapula to the right elbow. Grasping the skinfold separates subcutaneous adipose tissue from the underlying muscle. The calliper is positioned perpendicular to the length of the skinfold and the jaws of the calliper are applied medial to the fingers, at a point lateral and just inferior to the inferior angle of the scapula.

9.4.5 *Mid-upper arm circumference*

The circumference of the upper arm is measured at its mid-point, located after bending the right elbow to a 90° angle and placing the forearm palm down across the trunk. The upper arm should be approximately parallel to the trunk. Using a measuring tape, the observer identifies and marks the mid-point of the arm, halfway between the tip of the acromion process and the tip of the olecranon process. The skin should be marked at this point before the arm is repositioned for the circumference measurement. The right arm is then extended alongside the body, with the palm facing upwards. It should be raised slightly off the surface of the bed or examination table by placing a sandbag or towel under the elbow, and the hand is placed through the loop of an inelastic, flexible tape measure. At the marked mid-point the tape is pulled just snug around the arm without compressing the tissues. The circumference is recorded to the nearest 0.1 cm, and successive measurements should be within 0.5 cm of each other.

9.4.6 *Triceps skinfold thickness*

Triceps skinfold thickness is measured with the bed-fast individual lying on the left side, with the left arm extending from the front of the body. The trunk should be in a straight line, the legs should be bent and tucked up slightly, and the right arm should rest along the trunk, palm down. An imaginary line through the acromion processes should be perpendicular to the bed. The skinfold thickness measurement is taken on the back of the right arm over the triceps muscle, at the level marked as the mid-point for measurement of MUAC; repeated measurements can vary markedly if they are made at different sites. The observer gently grasps a double fold of skin and subcutaneous adipose tissue between the fingers and thumb, about 1.0 cm from the marked level. The fold of skin must be on the back of the arm, in the midline and parallel to the long axis of the upper arm. Grasping the skinfold separates subcutaneous adipose tissue from the underlying muscle. The jaws of the calliper are placed perpendicular to the length of the skinfold at the level of the marked mid-point, and the observer should bend down to read the calliper to avoid errors due to parallax.

9.5 Sources and characteristics of reference data

Appropriate use of anthropometry requires the comparison of data from individuals with data from healthy people of the same age, sex, and – as far as possible – genetic and environmental background. Currently available normative data, however, rarely include the very old. Even the US Second National Health and Nutrition Examination Survey (NHANES II), which is the most comprehensive data set for anthropometry, does not include people over 74 years of age (*40*). Another data set, the Metropolitan Life tables, much used in the USA, does not include life insurance policy holders over the age of 59 years and is thus of no value for the elderly. Canadian normative data cover people up to the age of 70 years, data from Japan people of more than 80 years (*41*), and United Kingdom data people up to 64 years (*42*). Few normative data exist for the elderly in developing countries, and there is no evidence that what is normal for, say, a 75-year-old man in the USA is also normal for a 75-year-old man in a developing country.

The Expert Committee considered the validity of various data sets for use as references, applying the criteria that data should be presented by 10-year age groups and by sex; that means, standard deviations, and percentiles should be available for each anthropometric parameter and age group; and that data for people over 80 years of age should be included (since it was felt that data from people in their 60s should not be extrapolated to those in their 80s). Moreover, the population-based sample should be free from major disabilities and living in a healthy environment, although it would be likely to contain some unhealthy individuals, since most elderly people probably have one or more disease conditions. The definition of health used to select the sample has a major influence on the reference data. The high prevalence of disease and multiple disease conditions in the elderly means that very few, if any, individuals are completely free of disease. An additional confounder is the influence of differential survivorship as age increases. There may also be significant cohort differences in the elderly: the elderly of today grew up under quite different conditions from those who will be elderly 20 or 40 years hence.

Table 52 summarizes some of the few population-based data sets and their characteristics. The data of Master et al. (*43*), though old, appear to be still much in use in clinics in the USA, and have the advantage of avoiding use of indices such as BMI – the tables give weight range for each inch of height. However, their present-day application may not be entirely appropriate: many of those included in the original sample were born in the last century and grew up under very different socioeconomic conditions from today's elderly.

Recognizing the limitations of available reference data, the Expert Committee did not recommend universal reference data at this time but, rather, the collection of data to describe local levels and patterns. For those countries that have no local data or that lack the resources to develop them, the Committee recommended use of the NHANES III data for comparison between different population groups. The NHANES III survey collected data over the period 1988-1991 on a sample of 600 elderly individuals (equal numbers of whites, blacks, and Hispanics) with no upper age limit and with oversampling of the oldest age-group.

Two levels of implementation are relevant here: use of the recommended measurements and use of available reference data. It should be recognized that many of the available reference data have limitations, but could be used by countries that lack such data for initial evaluation of the status of their elderly populations; this could provide some early indications of future problems. These data are pertinent if used exclusively as reference data for comparison purposes, that is, to compare means and standard deviations across populations. They are not for use as standards. This distinction is especially important, and the Expert Committee expressed particular concern regarding the applicability of any available data to other populations. Different populations show large geographical and ethnic variation in height, weight, and BMI, much of which reflects differences in lifestyle and environment throughout life, genetic differences, and – to an uncertain extent – differences in health status.

Table 52

Reference data for adults aged 60 years and over

Location (and name) of study	Population characteristics	Sample size	Ages (years)	Parameters	Comments	Reference
USA	Whites; nationwide sample	2925 men 2694 women	65–94	Height, weight, body surface area, weight range for each inch of height	Sample drawn from all socioeconomic strata. Height and weight measured in inches and pounds	*43*
USA	Whites and blacks; randomly sampled	1261 men 1392 women	60–74	Height, weight, sitting height, triceps and subscapular skinfolds, MUAC, elbow breadth, BMI, AMA	Random sampling; data presented as means and percentiles	*40*
Japan	Asians; nationwide sample	110 men 526 women	60–80 +	Height, weight, triceps and subscapular skinfolds	Means and SDs	*41*
China (Chinese Nationwide Nutrition Survey)	Asians; nationwide sample	796 men 968 women	60–94	Height, weight, BMI	Means, SDs, percentiles	*16*
USA	Whites; Ohio sample	119 men 150 women	65–90	Height, weight, knee height, triceps and subscapular skinfolds, arm and calf circumferences, BMI, AMA	Percentiles, charts	*44*
Sweden	Whites; Uppsala sample	> 250 for each 10-year age group	60–80	Height, weight, weight-for-height	Data for 1964–1971; SDs; not random sample	*45*

Table 52 (*continued*)

Location (and name) of study	Population characteristics	Sample size	Ages (years)	Parameters	Comments	Reference
Italy	Whites; 5 small towns in 5 regions	522 men 725 women	65–95	Height, weight, BMI, arm circumference, triceps, biceps, iliac, and subscapular skinfolds, AMA	Percentiles	*46*
Brazil (Brazilian National Survey of Health and Nutrition)	Mixed; nationwide sample	4419	60–70	Height, weight, BMI		*16*
Europe (EURONUT-SENECA Study on Nutrition and the Elderly)	Whites born 1913/1914 and 1917/1918; 19 towns	2586	70–75	Height, weight, BMI, triceps skinfold, arm circumference, AMA, waist: hip ratio		*47*
Guatemala (Nutritional Assessment of Guatemalan Ambulatory Elderly)	Ladinos; urban and rural	202	60–103	Height, weight, BMI		*16*
Hong Kong (Longitudinal Study of Health and Social Support in the Hong Kong Chinese Elderly Cohort)	Asians	977	70–100	Height, weight, BMI		*16*
Italy (Nutrition in Old Age in Italy)	Whites; 17 sites	921	60–97	Height, weight, BMI		*16*
Italy (Italian Nutrition Examination Survey of the Elderly)	Whites; 5 sites	1248	65–95	Height, weight, BMI		*16*

Table 52 (*continued*)

Location (and name) of study	Population characteristics	Sample size	Ages (years)	Parameters	Comments	Reference
China (Province of Taiwan)	Asians	3818	60–97	Height, weight, BMI		*16*
USA (Established Populations for Epidemiologic Studies of the Elderly)	Whites; Boston and Iowa	3164 (Boston) 3647 (Iowa)	65–90 +	Height, weight, BMI		*16*
IUNS Study of Food Habits in Later Life[a]						
Australia[a]	Whites	111	60–79	Height, weight, BMI, arm, waist, and hip circumferences, skinfolds		*48*
Sweden[a]	Whites	204	60–91	Height, weight, BMI, arm, waist, and hip circumferences, skinfolds		*48*
China[a]	Asians	441	70–96	Height, weight, BMI, arm, waist, and hip circumferences, skinfolds		*48*
Australia[a]	Greek descent	186	70–104	Height, weight, BMI, arm, waist, and hip circumferences, skinfolds		*48*

Table 52 (*continued*)

Location (and name) of study	Population characteristics	Sample size	Ages (years)	Parameters	Comments	Reference
IUNS Study of Food Habits in Later Life[a] (*continued*)						
Greece[a]	Whites; Sparta	70	70–94	Height, weight, BMI, arm, waist, and hip circumferences, skinfolds		*48*

[a] The IUNS Study of Food Habits in Later Life includes populations in four countries.

9.6 Recommendations

9.6.1 *For practical implementation*

For Member countries

Member countries are encouraged to collect anthropometric data on adults aged 60 years and above, and to monitor the health of this sector of the population through anthropometric surveys at regular intervals. It is important that countries extend their knowledge of the anthropometric characteristics and health status of the elderly. Special attention should be paid to selection criteria in choosing population-based samples, taking into consideration the heterogeneity of the elderly and the high prevalence of chronic conditions that may affect nutritional status.

For WHO

The Expert Committee recommends that a further consultation be organized by WHO, several years hence, to review the current recommendations in the light of available new data.

9.6.2 *For future research*

Numerous gaps exist in knowledge of the use of anthropometry to assess physical status in the elderly. It has been a common practice to extrapolate data collected on young adults to the elderly, yet it is not known to what extent comparison in the elderly has the same meaning as similar comparison in younger individuals or how this affects interpretation in the case of the elderly. The Expert Committee identified the following areas of research as essential for improving the use of anthropometry in the elderly.

Body composition

1. Establishing determinants of changes in body composition in the elderly.
2. Determining the best methods of measuring body composition in the elderly.
3. Determining the relationship between body composition and morbidity and mortality in the elderly.
4. Investigating and validating different methods of determining body composition, such as bioelectrical impedance.
5. In populations of short stature and stocky build, BMI values may indicate relative affluence and adequate nutrition. Conversely, in populations with relatively long legs compared with the trunk, BMI may indicate undernutrition in individuals who are in fact healthy. It is therefore important to determine whether different cut-off points for BMI should be used in such populations, or whether a different measurement or index should be used.
6. Determining what, other than nutritional interventions, can be done to alter body composition and reduce loss of fat-free mass.

7. Evaluating the use of ultrasound to measure fat in areas that cannot be measured by anthropometric means.
8. Determining why muscle mass is lost with age and the types of muscle changes that occur.
9. Carrying out prospective studies of the abdomen:hip circumference ratio, which is an important predictor of morbidity in the elderly.
10. Determining whether undernutrition is a greater health problem than overweight in the elderly, and whether the health risk changes with age.
11. Determining the prevalence of low (18.5) and high (30) BMI among the elderly.

Body size

1. Determining whether height is the best measurement in the elderly, in view of its age-related decrease, and whether another measurement would give better information on body length. Also determining whether a better index (than BMI) would be one in which body weight is related to some parameter other than height.
2. Determining whether the side of the body (left or right) on which measurements are taken makes a difference in the elderly.
3. Determining whether arm span is as valid a measurement as knee height as a surrogate for height and whether it can be reliably measured in bed-fast individuals.
4. Assessing whether current height or young adult height should be used in deriving indices such as BMI.
5. Determining the age-related changes in BMI and BMI distribution in different populations and assessing whether BMI has the same meaning in every population.
6. Determining whether tall individuals lose height more rapidly than short individuals.

Value of anthropometry

1. Assessing how accurately body composition in the elderly can be estimated by anthropometric methods.
2. Determining what further information anthropometry can yield on health risk and disability.
3. Determining the role of anthropometry in measuring increased function after exercise training.
4. Establishing the different contributions of environmental factors and lifestyle throughout life and of genetic factors to the geographical and ethnic variations in height, weight, and BMI across populations. Determining the extent to which much of the variation across populations is the result of differences in disease and health status. Determining whether population-specific or universal reference data should be used to assess nutritional and health status in the elderly.
5. Identifying the situations in which health status can be evaluated by anthropometry and assessing what anthropometry can reveal about specific health outcomes in the elderly.

6. Determining what factors can be identified in early adulthood that might be markers for risk of mortality later in life.
7. Longitudinal studies of BMI and its components – fat-free mass and fat mass. Determining whether fat distribution provides a better indicator of cardiovascular morbidity and mortality in the elderly, and whether the increase of intra-abdominal fat indicates an increased risk of morbidity or whether it is protective. Data are also needed on lean body mass other than shortly before death as a predictor of long-range morbidity or mortality.
8. If high BMI is a protective factor with regard to total mortality in the elderly, determining the relative contributions to this of fat and lean body mass.

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