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Anthropometric measurements in the elderly: age and gender differences

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In clinical practice and epidemiological surveys, anthropometric measurements represent an important component of nutritional assessment in the elderly. The anthropometric standards derived from adult populations may not be appropriate for the elderly because of body composition changes occurring during ageing. Specific anthropometric reference data for the elderly are necessary. In the present study we investigated anthropometric characteristics and their relationship to gender and age in a cross-sectional sample of 3356 subjects, randomly selected from an elderly Italian population. In both sexes, weight and height significantly decreased with age while knee height did not. The BMI was significantly higher in women than in men (27·6 SD 5·7 *v.* 26·4 SD 3·7; $P<0·001$) and it was lower in the oldest than in the youngest subjects ($P<0·05$) of both genders. The 75th year of age was a turning point for BMI as for other anthropometric measurements. According to BMI values, the prevalence of malnutrition was lower than 5 % in both genders, whereas obesity was shown to have a higher prevalence in women than in men (28 % *v.* 16 %; $P<0·001$). Waist circumference and waist : hip ratio values were higher for the youngest men than for the oldest men ($P<0·05$), whereas in women the waist : hip ratio values were higher in the oldest women, suggesting that visceral redistribution in old age predominantly affects females. In conclusion, in the elderly the oldest subjects showed a thinner body frame than the youngest of both genders, and there was a more marked fat redistribution in women.

Anthropometry: Nutritional status: Elderly: Cross-sectional

Anthropometric and nutritional characteristics are related to genetic, environmental, sociocultural conditions and to lifestyle, health and functional status. This makes it difficult to give a standard interpretation of their values. Anthropometry is an essential tool in geriatric nutritional assessment to evaluate underweight and obesity conditions, which are both important risk factors for severe diseases and disability in the elderly (Jensen & Rogers, 1998; Visser *et al.* 1998).

An accurate evaluation of nutritional status should include an estimate of body compartments (fat-free mass and fat mass) by instrumental methods such as bioelectrical impedance analysis and dual X-ray absorptiometry (Enzi *et al.* 1997). Nevertheless, in clinical practice and in epidemiological surveys, body composition can be indirectly estimated by anthropometric measurements, which are non-invasive, easy and inexpensive to collect.

The ageing process involves modifications in nutritional and physiological status, such as a decrease in body weight and height (Dey *et al.* 1999), and a reduction in fat-free mass associated with an increase in fat mass. Moreover, a redistribution of adipose tissue occurs with accumulation in the trunk and visceral sites (Steen, 1988; Schwartz, 1998). Body composition changes occur differently in men and women and in the various phases of ageing, influencing anthropometry. Consequently, the anthropometric standard values derived from adult populations may not be applicable to the elderly.

Non-pathological factors affecting the distribution of anthropometric characteristics, such as age, gender and geographic area, should be taken into account. The WHO Expert Committee on Physical Status stressed the need for local gender- and age-specific reference values for the elderly (de Onis & Habicht, 1996). In Europe, only a few anthropometric and nutritional studies have been carried out in the elderly (de Groot *et al.* 1996; Launer & Harris, 1996;

Abbreviation: ILSA, Italian Longitudinal Study on Ageing.
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Dey *et al.* 1999). The use of non-standardised methods for data collection and insufficient sample sizes make it difficult to compare reference values for clinical and epidemiological purposes.

Longitudinal studies are required to determine the magnitude of changes in anthropometric measures with ageing, but cross-sectional data have often been used, even though they might be affected by secular trend or cohort effect. Longitudinal and cross-sectional studies have, however, reported similar results on the effect of ageing on anthropometric and nutritional characteristics (Rea *et al.* 1997; Sorkin *et al.* 1999).

The principal aims of the present study were: (1) to provide distribution values for anthropometric characteristics based on a large cross-sectional sample randomly drawn from an elderly Italian population; (2) to quantify the prevalence of obesity and underweight conditions among the elderly in Italy; (3) to describe the age and gender differences of anthropometric characteristics in the elderly.

Methods

The present survey was based on anthropometric data derived from the Italian Longitudinal Study on Ageing (ILSA). The study had both a cross-sectional and a longitudinal component. Prevalence data obtained between March 1992 and June 1993 are considered here.

The design and methods of the study have been reported elsewhere (Maggi *et al.* 1994). Briefly, a gender- and age-stratified sample of 5462 subjects aged 65–84 years was randomly drawn from the demographic lists of the registry office in eight municipalities: Genoa, Segrate (Milan), Selvazzano-Rubano (Padua), Impruneta (Florence), Fermo (Ascoli Piceno), Naples, Casamassima (Bari) and Catania. In order to oversample older people, an equal allocation strategy was used. The participation rate was 83 % (4521 subjects). The study had two phases: a screening phase and a disease diagnosis phase. The screening phase of the study included a personal interview, a nurse visit and a clinical evaluation. The clinical evaluation included cognitive, psychological and physical examinations, anthropometric measurements and diet information. The second phase consisted of clinical confirmation of disease by a specialist. Details about diagnostic criteria and the health status of the sample have been described elsewhere (The ILSA Group, 1997).

Anthropometric measurements were collected from 74·2 % (3356/4521) of the participants. The principal causes for missing data were, in decreasing order: refusal (81 %), death (10 %), upright incapability (4 %). The non-measurement rate depended on gender ($P<0·05$) and age ($P<0·01$), being higher for the oldest women. Subjects who were measured and those who were not measured also differed regarding health status and disability. The prevalence rates of myocardial infarction, cardiac arrythmia and hypertension were higher ($P<0·001$) in subjects who were measured, while dementia, distal symmetric neuropathy of lower limbs and disability were more frequent ($P<0·001$) among those not measured. The two groups did not significantly differ in the prevalence of diabetes, stroke, angina pectoris, congestive heart failure or peripheral artery disease.

Anthropometric measures

Anthropometric measurements were taken by trained personnel during clinical evaluation. Height and weight were measured with the subject barefooted and lightly dressed. Knee height was measured with a sliding caliper on the leg of the participant while seated and represented the distance from the sole of the foot to the anterior surface of the thigh, with the ankle and knee each flexed to a right angle, according to Chumlea *et al.* (1985). Body weight was measured on a balance beam platform scale (Salus, Milan, Italy) to the nearest 0·1 kg. Height was taken by a stadiometer (Salus) at head level to the nearest centimetre with the subject standing barefoot, with feet together. BMI was calculated (Quetelet, 1835). Three measurements of four skinfold thicknesses (triceps, subscapular, suprailiac, thigh) were taken by means of a calibrated caliper (precision 0·2 mm; Harpenden skinfold caliper, John Bull British Indictor Ltd, UK) and averaged. The triceps skinfold was taken at the posterior mid-point between the acromion and the olecranon. The subscapular skinfold was measured just to the inferior angle of the scapula. The suprailiac skinfold was taken at the upper point of the iliac crest, the angle of inclination being 45° towards the pubic symphysis. The thigh skinfold was measured at the medial point of the anterior surface of the thigh.

Circumferences were measured to the nearest centimetre using a flexible steel tape, with the subject standing. The abdominal circumference (waist) was measured at the end of expiration, by wrapping the tape at the level of the umbilicus. The hip circumference was measured at the maximum posterior protrusion of the buttocks. The waist : hip ratio was obtained by dividing the values of the two circumferences.

To evaluate the prevalence of undernutrition and obesity in our sample, we classified subjects on the basis of two cut-off points commonly used in clinical practice: BMI $<20\,kg/m^2$ was used to identify underweight subjects; BMI $\geq 30\,kg/m^2$ was used to indicate obesity.

Statistical analysis

Anthropometric measurements were presented as mean value, standard deviation and centiles (5th, 10th, 25th, 50th, 75th, 90th, 95th) by gender and age group (65–69, 70–74, 75–79, 80–84 years). For the whole sample, the means, standard deviations and prevalences were adjusted by weighting for the 1991 Italian population, to avoid bias derived from oversampling of the oldest subjects and different rates of response across strata (Kish, 1965). Variability was also expressed by the CV. Data were verified for their consistency. Missing data were not replaced by estimated values. The statistical analysis was performed by computation using the SAS Statistical Software Package version 6.12 (SAS Institute, Cary, NC, USA). The statistical significance of differences between genders was tested using Student's *t* test ($\alpha = 0·05$). The effect of age was investigated by ANOVA (SAS GLM procedure) and Tukey's multiple comparisons procedure ($\alpha = 0{\cdot}05$). Differences among prevalences were tested by the χ^2 test and expressed as odds ratio. The association between age and anthropometric values, both considered as continuous variables, was evaluated using linear and quadratic regression models. To test the hypothesis of parallelism of regression lines we used a single regression model (SAS GLM procedure) containing dummy variables, to distinguish the groups being compared and verifying the interaction effect (Kleinbaum *et al.* 1998).

Results

Gender- and age-specific values (mean, standard deviation and centiles) are presented in the following analysis. Specific age and gender values neutralise selection bias deriving from different response rates in age and gender strata.

Men were taller than women (165·7 SD 6·7 *v.* 152·2 SD 7·5 cm) and the difference in the total group, as in each age group, was statistically significant ($P<0{\cdot}001$). The variability was similar (CV about 5 %) in the two genders. Height was close to the normal distribution and showed a significant decrease with age in both sexes ($P<0{\cdot}001$). Older men were 2·7 % shorter than younger men (167·1 SD 7·5 *v.* 162·7 SD 7·2 cm), while women had an age-related reduction in height of 4 % (154·1 SD 6·7 *v.* 149·3 SD 7·0 cm).

In women, height decreased at a constant rate with age, while in men Tukey's test indicated a significant difference between the first two and the second two age groups (Tables 1 and 2). For both genders, the linear regression model applied to crude data (Fig. 1) was more suitable for representing the age-related height decrease, showing the two linear equations as having the same mean decrement per year (−0·30 cm/year).

Knee height was significantly higher in men than in women (50·4 SD 4·3 *v.* 45·8 SD 3·8 cm) but it did not vary significantly with age.

Tables 1 and 2 show that men were heavier than women in each age group ($P<0{\cdot}001$). In both genders the mean weight significantly decreased with age ($P<0{\cdot}001$). In men this age-related reduction represented 11 % of the weight of younger men (8 kg), while in women this reduction was about 9 % of the weight of younger women (6 kg). In both genders, mean values of weight were slightly higher than medians (0·5–1 kg for males; 1–1·5 kg for females) showing a slight right asymmetry in the distribution, as has been described by other authors (Fanelli Kuczmarski *et al.* 2000). The variability in women (CV 20·5 %) was higher than in men (CV 14·7 %).

Table 1. Anthropometric indices in men (Italian Longitudinal Study on Ageing survey)
(Mean values, standard deviations and centiles)

					Centile						
	Age group	*n*	Mean	SD	5	10	25	50	75	90	95
Weight (kg)†‡	65–69	466	74·6[a]	11·2	58	61	67	74	81	89	94
	70–74	451	74·4[a]	11·9	57	60	66	73	81	91	96
	75–79	392	69·5[b]	10·7	53	55	62	69	77	84	86
	80–84	365	66·7[c]	10·7	50	53	59	66	74	80	84
	All men	1674	72·6*	10·7*	54	57	64	71	78	86	92
Height (cm)†‡	65–69	469	167·1[a]	7·5	155	157	162	167	172	177	180
	70–74	457	166·3[a]	6·4	156	159	162	166	170	175	177
	75–79	407	163·8[b]	6·6	153	156	159	163	168	172	175
	80–84	384	162·7[c]	7·2	151	153	158	162	168	172	175
	All men	1717	165·7*	6·7*	154	156	160	165	170	175	177
BMI†‡ (kg/m^2)	65–69	465	26·8[a]	4·2	21·2	22·3	24·3	26·6	28·7	31·2	32·5
	70–74	448	27·0[a]	3·9	20·8	22·2	24·3	26·5	29·1	32·0	33·9
	75–79	391	26·0[b]	3·6	20·4	21·4	23·4	26·0	28·2	31·2	32·4
	80–84	362	25·2[c]	3·6	19·6	20·8	23·0	25·0	27·4	29·6	30·8
	All men	1666	26·4*	3·7*	20·7	21·7	23·7	26·0	28·4	31·2	32·7
Waist circumference (cm)‡	65–69	467	98·1[a]	10·2	82	85	92	98	104	111	116
	70–74	458	98·5[a]	11·1	81	85	92	98	105	112	117
	75–79	409	96·4[b]	10·7	79	83	89	97	103	110	114
	80–84	395	94·8[c]	11·3	77	82	88	95	102	108	112
	All men	1729	97·5*	9·9*	80	84	90	97	104	110	115
Hip circumference (cm)†‡	65–69	467	100·6[a]	8·4	89	92	96	100	105	111	115
	70–74	458	101·0[a]	9·6	89	92	96	101	106	112	117
	75–79	409	99·6[a]	8·9	87	90	94	100	105	110	115
	80–84	387	98·3[b]	9·6	86	89	94	98	104	109	112
	All men	1721	100·2*	8·3*	88	91	95	100	105	110	115
Waist:hip ratio†‡	65–69	466	0·97[a]	0·05	0·88	0·90	0·93	0·97	1·01	1·04	1·06
	70–74	456	0·97[a]	0·06	0·88	0·90	0·94	0·97	1·00	1·04	1·07
	75–79	404	0·96[b]	0·05	0·87	0·90	0·93	0·96	1·00	1·03	1·05
	80–84	384	0·95[c]	0·06	0·86	0·88	0·92	0·95	0·99	1·02	1·04
	All men	1710	0·97*	0·05*	0·87	0·89	0·93	0·96	1·00	1·03	1·05

[a,b,c] For the same variable, mean values with unlike superscript letters were significantly different ($P<0{\cdot}05$).
* Weighted mean and standard deviation values.
† Statistically significant difference of mean values between genders (Student's *t* test).
‡ Statistically significant difference of mean values across age groups (ANOVA).

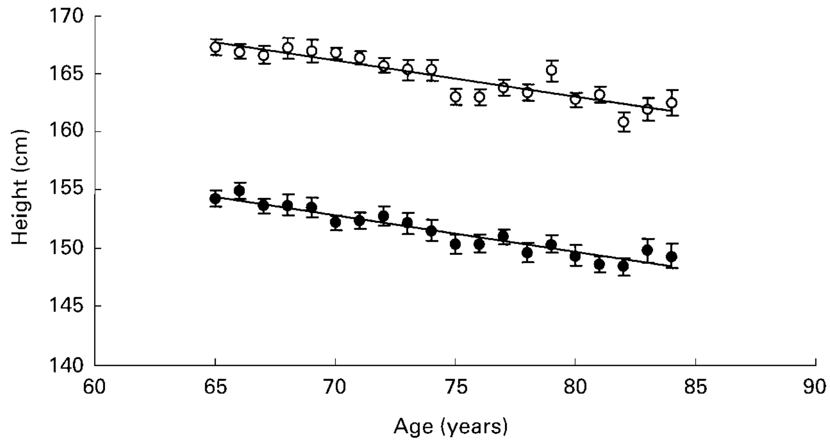

Fig. 1. Height by age (1-year age groups) and gender: men (○) $y = -0{\cdot}30\ x + 187{\cdot}2$; women (•) $y = -0{\cdot}30\ x + 174{\cdot}2$. Points are means with their standard errors represented by vertical bars.

In examining the trend of weight by age, the rate of decrease was found to be more evident for men than for women, showing a more consistent loss of fat-free mass (Gallagher *et al.* 1997). In men, Tukey's multiple comparisons test showed a significant difference between the mean values of weight of the three oldest age groups of 5-year periods taken two-by-two, while in women only the first two age groups were significantly heavier than the second two age groups. In both genders, Tukey's test indicated the 75th year of age as a starting point for significant weight loss (Tables 1 and 2). Linear regression between weight and age is shown in Fig. 2. The slopes of the

Table 2. Anthropometric indices in women (Italian Longitudinal Study on Ageing survey)
(Mean values, standard deviations and centiles)

					Centile						
	Age group	*n*	Mean	SD	5	10	25	50	75	90	95
Weight (kg)†‡	65–69	418	66·2[a]	12·0	49	52	58	65	73	81	90
	70–74	370	64·8[a]	12·5	46	51	55	63	73	81	85
	75–79	361	61·1[b]	10·6	45	48	54	61	68	76	79
	80–84	313	60·0[b]	11·7	42	46	52	59	67	77	80
	All women	1462	63·8*	13·1*	45	49	55	62	71	79	84
Height (cm)†‡	65–69	436	154·1[a]	6·7	143	146	150	154	159	163	165
	70–74	379	152·3[b]	6·5	142	144	148	152	157	160	163
	75–79	373	150·6[c]	6·4	141	143	146	151	155	159	161
	80–84	329	149·3[d]	7·00	138	141	144	149	154	158	160
	All women	1517	152·2*	7·5*	141	143	147	152	156	160	163
BMI†‡ (kg/m^2)	65–69	417	28·0[a]	5·2	21·0	22·1	24·4	27·3	30·6	35·2	37·4
	70–74	368	27·9[a]	5·0	20·4	21·9	24·3	27·4	31·2	33·8	36·0
	75–79	361	27·1[b]	5·2	20·0	21·2	23·7	26·5	29·9	32·4	34·4
	80–84	308	27·1[b]	5·8	18·9	20·4	23·5	26·7	30·1	33·4	35·6
	All women	1454	27·6*	5·7*	20·1	21·5	24	27	30	34	36·4
Waist circumference (cm)	65–69	440	97·2[a]	13·2	75·5	80	89	97	105·5	114	121·5
	70–74	389	97·4[a]	12·9	76	80	89	98	106	114	119
	75–79	375	96·2[a]	12·4	75	80	88	96	104	112	117
	80–84	346	96·5[a]	12·8	75	80	89	97	105	113	117
	All women	1550	96·9*	14·1*	75	80	88	97	106	113	118
Hip circumference (cm)†‡	65–69	440	104·5[a]	11·5	88	91	97	103	110	119	125
	70–74	390	104·0[a]	10·7	88	92	96	103	111	117·5	123
	75–79	373	102·3[b]	10·4	87	90	96	101	109	116	122
	80–84	347	101·5[b]	11·4	85	89	95	102	108	116	120
	All women	1550	103·4*	12·1*	87	90	96	102	110	117	123
Waist:hip ratio†	65–69	438	0·93[a]	0·06	0·80	0·83	0·88	0·93	0·97	1·01	1·04
	70–74	389	0·93[a]	0·07	0·81	0·84	0·89	0·93	0·98	1·02	1·04
	75–79	372	0·94[a]	0·07	0·82	0·85	0·90	0·93	0·98	1·02	1·04
	80–84	345	0·95[b]	0·06	0·83	0·86	0·90	0·95	0·99	1·03	1·05
	All women	1544	0·94*	0·08*	0·81	0·84	0·89	0·94	0·98	1·02	1·04

[a,b,c,d] For the same variable, mean values with unlike superscript letters were significantly different ($P<0{\cdot}05$).
* Weighted mean and standard deviation values.
† Statistically significant difference of mean values between genders (Student's *t* test).
‡ Statistically significant difference of mean values across age groups (ANOVA).

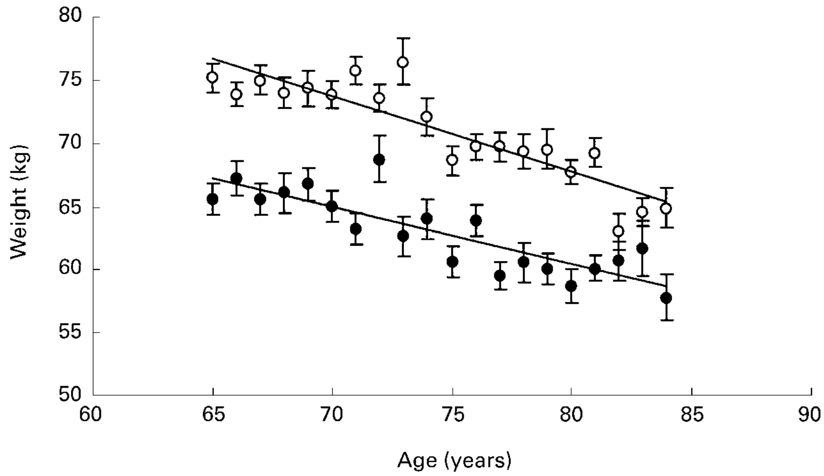

Fig. 2. Weight by age (1-year age groups) and gender: men (○) $y = -0{\cdot}59\ x + 115{\cdot}2$; women (•) $y = -0{\cdot}44\ x + 95{\cdot}7$. Points are means with their standard errors represented by vertical bars.

regression lines seem to indicate a greater rate of weight decrease in men (−0·59 kg/year) than in women (−0·44 kg/year), but the difference was not significant (P=0·08), perhaps owing to the high variability of weight. The quadratic regression model, applied to crude data, provided a slightly better fit of the distribution than the linear model in the men only, indicating an increasing rate of weight loss with age.

The mean BMI was significantly higher in women than in men in the whole group (27·6 SD 5·7 *v.* 26·4 SD 3·7 kg/m^2) and in each age class. This index decreased significantly with age in both genders, showing a reduction of about 1 unit over two decades. The slight asymmetric distribution of the BMI reflects the asymmetry reported for weight. Moreover, women presented a higher variability (CV 20·7 %) than men (CV 14·0 %), reflecting the higher variability in weight.

The BMI reduction was regular in men only (Fig. 3). Tukey's test showed that in men the decrease became statistically significant after the 75th year of age, while in women, after a significant change at about the same age, the mean of the index did not change. The 75th year of age was a turning point in age-related changes for BMI as well as for other anthropometric measurements.

The adjusted prevalence of underweight was 3·6 % in the whole sample and higher in women (4·3 %) than in men (2·7 %). The higher risk for women to be underweight was quantified by odds ratio 1·5 (95 % CI 1·0, 2·1).

Obesity was a diffuse condition among the elderly, with an overall adjusted prevalence of 22·3 %. The problem was more frequent in women (27·9 %) than in men (15·5 %) (Fig. 4). The higher risk of obesity for women was evaluated by odds ratio 2·2 (95% CI 1·9, 2·6).

The mean value of waist circumference did not differ significantly between the two genders (97·5 SD 9·9 in men *v.* 96·9 SD 14·1 cm in women), and decreased significantly with age, in men only. Differing from waist circumference, the mean value of hip circumference was significantly higher in women than in men (103·4 SD 12·1 *v.* 100·2 SD 8·3 cm), reflecting the thicker gluteal subcutaneous fat in

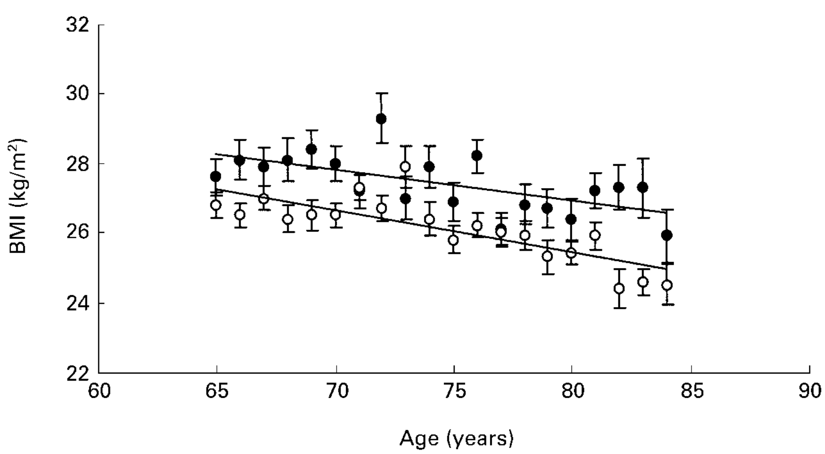

Fig. 3. BMI by age (1-year age groups) and gender: men (○) $y = -0{\cdot}12\ x + 35{\cdot}3$; women (•) $y = -0{\cdot}09\ x + 33{\cdot}9$. Points are means with their standard errors represented by vertical bars.

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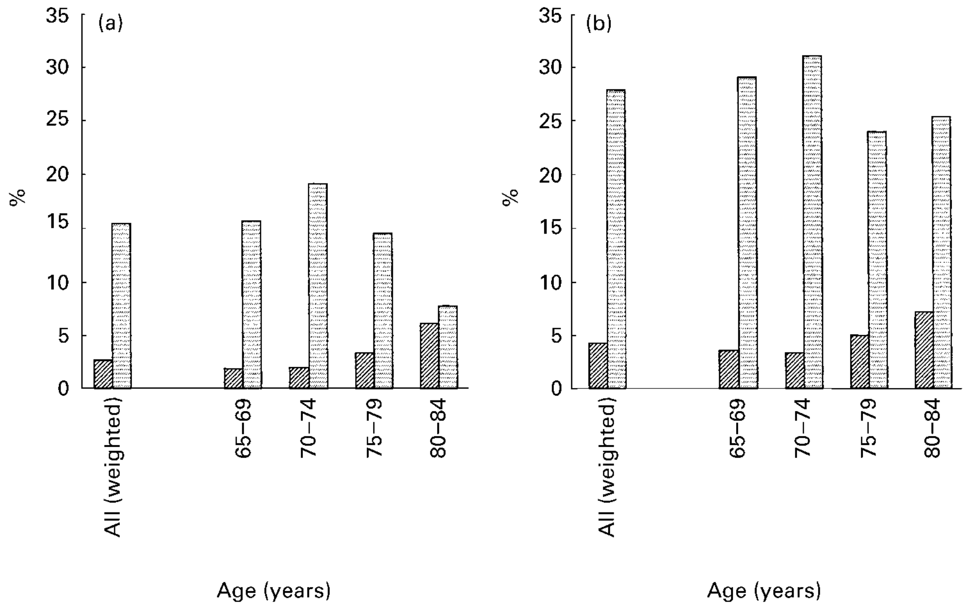

Fig. 4. Underweight (BMI <20 kg/m^2; ▨); and obesity (BMI ≥30 kg/m^2; ▤) prevalences by gender (men (a) and women (b)) for 5-year age categories.

women. The hip circumference decreased significantly with age in both sexes.

The mean waist : hip ratio was significantly higher in men (0·97 SD 0·05 *v.* 0·94 SD 0·08), where it showed a significant age-related reduction, while in women this rate slightly but significantly increased with age.

The mean values of the four skinfold thicknesses were significantly ($P<0·001$) higher in women than in men (triceps 20·5 SD 8·3 *v.* 12·3 SD 5·8 mm; subscapular 19·3 SD 9·1 *v.* 16·7 SD 6·1 mm; suprailiac 19·8 SD 9·7 *v.* 14·0 SD 6·6 mm; thigh 24·3 SD 10·6 *v.* 14·3 SD 6·7 mm). For these variables, in both genders the age-related reduction (data not shown) was statistically significant ($P<0·01$).

Discussion

In the present cross-sectional study we investigated anthropometric measurements in an elderly population and compared our findings with those provided by similar studies. The lack of anthropometric cross-sectional surveys in Italian populations limits the comparison of our gender- and age-specific results with those produced by other studies. Between 1988 and 1993 a European multicentre study (Euronut Seneca Study) on nutrition and anthropometric characteristics was carried out on a sample of 2332 elderly subjects born between 1913 and 1918 in twelve European countries (de Groot *et al.* 1992, 1996). For the same age group, our sample somatotype was similar to that described by the Seneca Study (Table 3) for Italian men and women (de Groot *et al.* 1991). The comparison between the characteristics of our subjects and those of European populations confirms that the Italian elderly population is in the lower mid-section of the distribution (Table 3). With reference to a typical Mediterranean somatotype, our

Table 3. Weight, height and BMI by gender, in subjects 70–75 years of age. Comparison of results of the Italian Longitudinal Study on Ageing (ILSA) with the values provided by de Groot *et al.* (1991) for selected European sites

(Mean values and standard deviations)

Country	Men						Women					
	Weight (kg)		Height (m)		BMI (kg/m^2)		Weight (kg)		Height (m)		BMI (kg/m^2)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Denmark (Roskilde)	75·0	10·4	1·71	0·07	25·5	3·2	64·5	12·4	1·59	0·05	25·2	4·7
The Netherlands (Culemborg)	78·2	10·7	1·73	0·08	26·1	3·0	71·4	11·4	1·60	0·06	27·6	4·2
Belgium (Hamme)	71·4	10·5	1·69	0·07	25·2	3·3	68·2	10·3	1·53	0·06	28·3	4·2
France (Haguenau)	77·9	12·7	1·68	0·06	27·1	3·6	68·1	14·4	1·57	0·06	27·6	3·6
Greece (Markopoulo)	76·8	12·7	1·67	0·06	27·5	4·3	69·3	10·3	1·52	0·06	29·7	2·6
Spain (Bentazos)	77·2	10·6	1·62	0·08	27·7	3·6	65·5	11·2	1·49	0·06	28·6	4·4
Portugal (Vila Franca de Xira)	70·6	11·2	1·61	0·06	27·0	3·6	60·2	11·0	1·46	0·05	27·5	4·5
Italy (Padua)	73·6	10·0	1·67	0·06	26·1	3·5	61·0	10·9	1·56	0·06	24·9	4·2
Italy (Fara Sabina, Magliano Sabina, Poggio Mirteto)	77·6	15·2	1·60	0·05	30·3	5·2	68·2	13·4	1·49	0·06	30·5	(5·1)
ILSA	74·4	11·9	1·66	0·06	27·0	3·9	64·8	12·5	1·52	0·06	27·9	5·0

subjects are smaller, and the women, in relation to height, are heavier than Northern European subjects. Further comparisons with data provided by other European studies confirmed these findings (Delarue *et al.* 1994; Bannerman *et al.* 1997). Considering American anthropometric data from the third National Health and Nutrition Examination Survey (NHANES III), our subjects appeared shorter and the women, adjusting for height, heavier than the Americans (Fanelli Kuczmarski *et al.* 2000).

In considering anthropometric indicators, it is crucial to establish the pattern of their relationship with selected characterising factors such as age and gender. Even though derived from a cross-sectional study, the highlighted patterns of gender- and age-related changes in weight and stature seem to correspond to those described in some longitudinal studies (de Groot *et al.* 1996; Dey *et al.* 1999; Sorkin *et al.* 1999).

In our 65–84-year sample, age was inversely and significantly associated with ten out of twelve anthropometric indices in both genders with the exception of waist circumference in women and knee height in both men and women. The mean values of all anthropometric measurements significantly differed between gender, except for waist circumference. Weight, height, knee height and waist : hip ratio were higher in men; BMI, hip circumference, thigh circumference and skinfold thickness were greater in women.

Height

The remarkable entity of height decrease observed in our present study (2–3 cm/decade) is comparable with the results of other Italian and international surveys: the Euronut Seneca Study reported a height decrease in both men and women of 1–2 cm in 4 years, i.e. 2·5–5 cm/decade. For Swedish elderly, Dey *et al.* (1999) quantified a mean decrement of 4–5 cm over 25 years. Baumgartner *et al.* (1995*b*) reported a decrease of 0·5–1·5 cm/decade.

We considered the possible role of a secular trend in the remarkable height decrease observed in our study. As many authors assert, in developed countries a positive trend in stature began about the second part of the nineteenth century and was more evident for men than for women (Malina, 1990; Meadows Janz & Janz, 1999). This occurred also in Italy, where the mean stature of young males called up for the army in 1928 and 1943 (corresponding to our oldest and youngest age group called up by year) differed by 1·5 cm (ISTAT, 1986). Mean stature between our youngest and oldest men differed by 4–5 cm, a decrease three times higher than that potentially due to the secular trend. It should be noted that the positive secular trend was more evident in distal lower limb bones and consequently in knee height (Meadows Janz & Janz, 1999); in our data, knee height did not correlate with age. If the youngest subjects were taller than the oldest subjects because of the positive secular trend, the same relationship would be expected in knee height, but this was not the case. We conclude that the possible effect of the secular positive trend was not the sole cause of the difference in stature of the youngest and oldest subjects observed in our present study.

The above considerations justify the conclusion that our oldest subjects had a basal body height similar to the youngest subjects and that this decreased with age principally because of spinal deformity and thinning of the intervertebral discs.

Weight

In contrast to height, weight may voluntarily or involuntarily fluctuate during adulthood and older life. This makes it more difficult to investigate the role of weight in health by cross-sectional data. Our results indicate a negative association between weight and age in both sexes. This trend may be a consequence of a selection bias due to the death of overweight or obese subjects. However, whole weight distributions of all age groups shifted towards lower values (Tables 1 and 2). The decrease with regard to 65–69-year-old subjects was about 14 % for the 5th centile *v.* about 11 % for the 95th centile.

Furthermore, a cohort effect might have biased our results. There could be a confounding height effect if younger subjects were the tallest (height and weight being positively correlated), but, as previously explained, this was not so. A further matter could be that overweight may be less prevalent in an older population who had lived through a double war experience, but that argument is more complex. In spite of these considerations, longitudinal studies support an age-related weight reduction (Going *et al.* 1995; de Groot *et al.* 1996; Dey *et al.* 1999). Examining longitudinal changes for a sample of 70-year-olds in Sweden, Dey *et al.* (1999) found a mean decrement of the same order as ours (−0·4 kg/year) over a 20-year period.

BMI

Among all anthropometric measurements, the BMI represents the easier and most frequently used index to identify subjects at risk for under- or overnutrition. Many authors agree in considering this index a poor indicator of risk in the elderly (Harris *et al.* 1988; Visser *et al.* 1994, Allison *et al.* 1997; Seidell & Visscher, 2000), because it does not reflect regional distribution of fat or any change in fat distribution in the elderly. The value of the BMI is generally considered to be as a measurement of fatness, while it also gives information about fat-free mass. In the elderly, fat mass increases whereas fat-free mass decreases (Steen, 1988). The same adult BMI value corresponds to a more fatty body composition in the elderly. Thus the BMI has to be differently interpreted for elderly subjects. Undernutrition and obesity BMI thresholds in the elderly are currently being discussed. It is questionable whether cut-off values for obesity should be higher in the elderly, as body weight associated with minimal mortality increases with age (Allison *et al.* 1997) and the relative risk of mortality associated with a higher BMI decreases with age (Stevens *et al.* 1998). On the other side of the scale, undernutrition is a well-known predictor of mortality (Visscher *et al.* 2000), and modification of cut-off values to identify patients at nutritional risk has been suggested (Corish *et al.* 2000).

Some data on the BMI of the Italian population have been produced by the National Research Council through a cross-sectional multicentre study carried out in 1984 on

65–95-year-old subjects (Melchionda *et al.* 1990). Comparing BMI between the ILSA and the National Research Council study, similar values were found for the 50th centile (26·0 kg/m^2 in both studies for men; 27·0 *v.* 27·7 kg/m^2 for women) of the total sample distributions. Differences between the results of the two studies were found for all the centiles related to women in the 65–74-year age group, for which ILSA values were approximately 1 unit smaller than National Research Council values. Given the more recent collection of the ILSA data, the lower BMI values reported by ILSA for the youngest women might reflect a change of the cultural model in controlling nutritional habits. As compared with NHANES III data (Fanelli Kuczmarski *et al.* 2000) our obesity prevalence was similar.

In both genders the prevalence of obesity (Fig. 4) decreased with age, while the prevalence of underweight increased; this is in accordance with the pattern described by other authors for different populations (Launer & Harris, 1996). In our data, a BMI of 30 kg/m^2 corresponded to different centiles in the two sexes: 85th for men and 75th for women. Relating the concept of 'normality' (i.e. non-obesity) to the most frequent values in the population, it seems that this cut-off value could overestimate the obesity in the Italian population, particularly in women. Obesity should probably be identified by different cut-off points for men and women.

In our male and female BMI distributions, a BMI of 20 kg/m^2 approximately corresponded to the 5th centile. This could provide a useful estimate of an underweight condition in the Italian elderly. Whereas for adults a lower cut-off for BMI ($<$18·5 kg/m^2) is considered (WHO, 1995), the criterion of BMI $<$20 kg/m^2 is widely adopted in geriatric clinical practice (Mattila *et al.* 1986; McWhirter & Pennington, 1994; Launer & Harris, 1996; Corish *et al.* 2000). A lower cut-off value might be inappropriate; because of the higher BMI values amongst older populations, a more severe degree of undernutrition may be selected. However, early detection is more important of those who may be at nutritional risk.

Waist:hip ratio and waist circumference

Metabolic changes occur in the elderly: a lean tissue loss, a decrease in total body water and a more central distribution of adiposity (Enzi *et al.* 1986; Chumlea & Baumgartner, 1989; Schwartz, 1998). The increase in intra-abdominal fat accumulation occurs in both genders, first in men then in women, where it occurs in the postmenopausal period (Enzi *et al.* 1986; Chumlea & Baumgartner, 1989; Kotani *et al.* 1994). In the adult population, the waist:hip ratio (Baumgartner *et al.* 1995*a*) and waist circumference (Pouliot *et al.* 1994; Han *et al.* 1995; Lean *et al.* 1995; Seidell *et al.* 2001) are commonly used as indicators of visceral adiposity. Reference data regarding the waist:hip ratio and waist circumference are not available for the Italian elderly, and other cross-sectional and longitudinal studies have not included subjects older than 75 years of age. Our findings allow consideration of a later phase of physiological ageing.

In the present study, elderly men showed an age-related decrease in waist circumference, hip circumference, waist:hip ratio and all skinfold thicknesses. This may suggest that in men the fat increase with accumulation at visceral sites occurs predominatly in middle age, while the most remarkable phenomenon in the elderly is the reduction in body frame, fat and muscle mass.

Anthropometric variations pointed out for women indicate a different pattern in the relationship between fat distribution and age. Being in a late postmenopausal period, our women presented a morphological evolution markedly reflecting the lack of estrogenic effects. In contrast to increases in anthropometric values (waist and hip circumferences, BMI, weight) found in younger postmenopausal women (Den Tonkelaar *et al.* 1989; Schwartz, 1998) we found a general anthropometric decrement with the only increase in waist:hip ratio, mainly due to the decrease in hip circumference, which has also been reported by other studies (de Groot *et al.* 1996). Our findings are consistent with the hypothesis of an increase in visceral adiposity in postmenopausal women, highlighted by many studies, most of which are based on computed tomography scans (Kotani *et al.* 1994; Zamboni *et al.* 1997). Despite abdominal skinfolds becoming thinner with age, waist circumference does not vary, suggesting an increase in visceral fat.

In younger populations the waist:hip ratio, usually employed to distinguish visceral from subcutaneous obesity, is an independent predictor of CHD and metabolic disturbances. Contrary to the men, our women had mean values of the waist:hip ratio commonly considered to be associated with an increased risk of mortality (Heymsfield *et al.* 1998) in the young. Moreover, many authors consider waist circumference to be better correlated with abdominal visceral adipose tissue, as a potentially 'atherogenic' metabolic disease source, than the waist : hip ratio (Pouliot *et al.* 1994), which depends both on visceral fatness and muscle mass quantified by hip circumference (Seidell *et al.* 1997). This issue is still under debate (Molarius & Seidell, 1998). On the basis of defined upper levels of waist circumference (88 cm for women and 102 cm for men) suggested by Lean *et al.* (1995), over 75 % of our women could be considered obese, in relation to cardiovascular risk. The analysis of our longitudinal data could clarify whether such high mean values of the waist : hip ratio and waist circumference in elderly women are associated with a higher risk of morbidity and mortality.

The present study has some limits. First of all, it was a cross-sectional study and therefore we cannot exclude survival or birth-cohort bias or discount temporal or cohort effects. The cross-sectional part of the study did not allow evaluation of individual changes for anthropometric characteristics. As a consequence, we dealt with the relationship of age with measurements and not with changes in measurements. Nevertheless, our results are largely consistent with longitudinal findings. Second, with regard to health status of subjects who were measured and those who were not measured, differences in the prevalence of disease were generally higher for the subjects with anthropometric measures, mainly for myocardial infarction, arrhythmia and peripheral neuropathy. We do not ascribe this difference to major illness of participating subjects. Health assessment was mostly indirect for non-participating subjects, and as a consequence, diseases could be underreported. On the other hand, participating patients, who screened positive for some diseases, underwent assessment by a specialist, and diagnoses were more accurately made. Among diseases related to nutritional status, diabetes had the same prevalence (13 %) among subjects who were measured and those who were not measured.

The higher level of disability among those not measured was evaluated on a small number of subjects (less than 10 % of the group not measured), who received only a part of the clinician assessment. We do not consider this prevalence representative of subjects not measured.

Our population-based sample included both healthy and unhealthy persons, as they were part of the general population. Most elderly people have one or more diseases or disabilities, and completely disease-free subjects are relatively few. Furthermore, our sample included a relevant number of subjects from more widely distributed areas than previous studies on Italian elderly, providing anthropometric and health status data by means of an objective clinical evaluation.

In conclusion, we provided gender- and age-specific distributions for many anthropometric measurements for the elderly that could be used as reference values for the Italian elderly population to detect individuals at a greater risk of nutritional disorders. The association found between age and anthropometric measurements is consistent with the results of many longitudinal studies. Different anthropometric measurements (BMI, waist:hip ratio, waist circumference) showed a high prevalence of obesity for women, where the visceral fat increase seems to continue.

Appendix

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