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Anthropometric measurements from a cross-sectional survey of Irish free-living elderly subjects with smoothed centile curves

Clare A. Corish* and Nicholas P. Kennedy

Unit of Nutrition and Dietetic Studies, Department of Clinical Medicine, Trinity Centre for Health Sciences, St James's Hospital, Dublin 8, Republic of Ireland

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Anthropometric screening has been recommended for the detection of undernutrition as it is simple, inexpensive and non-invasive. However, a recent study estimating the prevalence of undernutrition on admission to hospital in Dublin, Republic of Ireland, highlighted that the anthropometric reference data currently available in the UK and Republic of Ireland are inadequate to accurately determine nutritional status. In order to provide current anthropometric data, we carried out a cross-sectional study of 874 free-living, apparently healthy Irish-born elderly individuals aged over 65 years. Height, weight, triceps skinfold thickness, mid-arm and calf circumference were measured, values for BMI, mid-arm muscle circumference and arm muscle area were calculated and smoothed centile data derived for each variable. One-third of these elderly individuals had a BMI between 20–25 kg/m^2, approximately two-thirds (68·5 % of males and 61 % of females) were classified as overweight or obese, almost one-fifth having a BMI over 30 kg/m^2 (17 % of men and 20 % of women). Very few were underweight, only 3 % having a BMI below 20 kg/m^2. Height, weight, BMI and muscle reserves decreased with increasing age. The reduction in muscle size was associated with lower handgrip strength. Fat reserves declined with age in females only. Just over half of elderly Irish women reported participating in active leisure of 20 min duration four or more times/week, although 13 % reported having no involvement in active leisure. These data for the Irish elderly extend the data generated from a recent countrywide survey of Irish adults aged 18–64 years, thus providing suitable reference standards for nutritional assessment of elderly Irish individuals.

Elderly: Anthropometry: Reference data

Anthropometry is the single most universally applicable, inexpensive, and non-invasive method to assess the size, proportions, and composition of the human body (World Health Organization, 1995). Anthropometric indices of fat and muscle are advocated as measures of nutritional status and have been widely and successfully applied to the assessment of health and nutritional risk, especially in children. However, the use of anthropometry in elderly populations is limited to relatively few studies so that comparative data are scarce. Its usefulness as an indicator of nutritional status is dependent on the availability of current age- and gender-related data and it has been suggested that local anthropometric data should be collected in healthy older age groups (World Health Organization, 1995). Although the physiological changes which occur due to the ageing process mean that the anthropometric assessment variables used in younger patients may not always be appropriate when assessing nutritional status in the elderly (Taren & Schler, 1990), several recent studies suggest that simple anthropometric measurements can be used to assess the nutritional status of elderly patients (McWhirter & Pennington, 1994; Edington *et al.* 1996, 1997). To date, in the UK and Republic of Ireland, defining nutritional status in the elderly has been generally based on comparison with reference data derived from measurements taken over 25 years ago in South Wales, UK, for those aged 65 years or over (Burr & Phillips, 1984) or occasionally on data from the National Health and Nutrition Examination Survey I in the United States of America for those aged 65 to 74 years (Bishop *et al.* 1981; Grant *et al.* 1981). Although a number of other authors have attempted to produce reference data for the elderly (McEvoy & James, 1982; Frisancho, 1984; Chumlea *et al.* 1986; Latin *et al.* 1987; Falciglia *et al.* 1988; Lehmann

Abbreviations: AMA, arm muscle area; MAC, mid-arm circumference; MAMC, mid-arm muscle circumference; TSF, triceps skinfold thickness.

* **Corresponding author:** Dr C. Corish, fax +353 1 2834858, email tc@clubi.ie

et al. 1991), the measurements used were collected approximately 20 years ago and are probably not appropriate to define the current nutritional status of the Irish population. The recently published Northern Irish data of Rea *et al.* (1997) apply only to those aged over 90 years. In addition, a recent study estimating the prevalence of undernutrition on admission to hospital in Dublin, Republic of Ireland, highlighted that the anthropometric reference data currently available in the UK and Republic of Ireland are inadequate to accurately determine nutritional status (Corish *et al.* 2000).

In establishing these reference data, the recommendations made by the World Health Organization (1995) regarding the validity of anthropometric data sets in the elderly for use as references were followed. The WHO Expert Committee specified that data should be presented at the maximum by 10-year age groups and by gender; that centiles should be available for each anthropometric variable and age group and that data for individuals aged over 80 years should be included. Data from individuals in their sixties should not be extrapolated to those in their eighties. Moreover, the population sample should be free from major disabilities and living in a healthy environment, although it was acknowledged that it would be likely to contain some unhealthy individuals, since most elderly individuals probably have one or more disease conditions. It is recognised that the definition of health used to select the sample has a major influence on the reference data and that the high prevalence of disease in the elderly means that very few are completely free of disease. In addition, there may also be significant cohort and secular effects.

The present study aimed to characterise the current nutritional status of healthy, elderly Irish individuals and to use these measurements to devise reference data for this group. These data could be used both to evaluate the nutritional status of sub-groups of the Irish elderly and for comparison with data from other countries.

Subjects and methods

Subjects

The present survey was a cross-sectional study carried out in the greater Dublin area designed to provide reference data on a group of apparently healthy elderly Irish individuals. Subjects (598 women and 276 men) were recruited through interest groups for the active retired between June 1998 and February 1999. The age distribution of the subjects studied is shown in Table 1. The groups were visited by the research dietitian and all individuals aged 65 years and over who reported themselves as healthy were requested by the group organiser to participate in the survey. All who volunteered were measured by the research dietitian. Each participant was seen on one occasion only. Age and gender were noted, anthropometric and functional measurements were made and all subjects were questioned regarding previous occupation, level of physical activity and amount of time spent in active leisure and domestic activities per week. Unfortunately, it was not possible to provide independent medical verification of health status. Subjects who had an amputated limb or any peripheral oedema were excluded from the study, those who reported arthritis of the hand were excluded from the handgrip measurements while any who had protruding varicose veins or needed to wear support stockings were excluded from the calf measurements. Subjects taking medications, smokers, or those with specific medical conditions (for example, diabetes mellitus) who reported themselves as currently healthy were not excluded. By including only subjects who were free-living, mentally competent and apparently healthy, it was hoped to provide reference values from a group who were nutritionally 'elite' and as free from illness as possible.

Ethical approval was obtained from the local research ethics committee.

Table 1. Number of elderly measured in each age and gender group

Age group (years)	Men (*n*)	Women (*n*)
65–69	96	195
70–74	85	215
75–79	51	120
80+	44	68
Total	276	598

Anthropometric measurements

A total of 874 subjects (276 men and 598 women) had their height measured (with a Leicester Portable Stadiometer (Chasmors Weighing Equipment Ltd, London, UK)). In error, one woman was not weighed. All subjects were weighed in light clothing without shoes (with high-specification portable (Seca 870 digital) scales (Chasmors Weighing Equipment Ltd) which was regularly checked against two others of similar make. No recalibration of the scales was required during the study). BMI (weight (kg)/(height (m))^2) was calculated for all those with height and weight measurements (*n* 873) and was used to grade patients into normal weight, overweight and obese (World Health Organization International Obesity Task Force, 1998). For consistency with the published data (Burr & Phillips, 1984), mid-arm circumference (MAC) and triceps skinfold thickness (TSF) were measured on the left side of the body in all subjects (*n* 874) and mid-arm muscle circumference (MAMC) and arm muscle area (AMA) calculated. Right calf circumference was measured in 860 subjects (274 men and 586 women) while left calf circumference was measured in 859 subjects (272 men and 587 women). All anthropometric measurements were carried out according to standard techniques (World Health Organization, 1995).

Functional measurements

Functional status was measured with a handgrip dynamometer (Takai Scientific Instruments Ltd., Japan). The highest of three readings made with the non-dominant arm was used. Handgrip dynamometry was recorded in 856 subjects (273 men and 583 women).

Physical exercise

All participants were questioned regarding physical activity. Individuals were classified as being poorly, moderately or highly active. Minimal activity was defined as spending most waking time sitting, watching television, writing, reading, knitting or engaged in computer work. Moderate activity was defined as spending a large portion of the day walking, washing the car, doing housework and gardening. High activity was defined as active involvement in sport, cycling, swimming, keeping fit and walking the dog on a daily basis.

All participants were also questioned regarding the number of times spent in active leisure or domestic activities of at least 20 min/week. Active leisure was defined as brisk walking, jogging, cycling, swimming, dancing and playing sports. Examples of domestic activities included mowing the lawn and cleaning windows. The responses classified individuals as engaged in active leisure or domestic activities four or more times weekly, two to three times weekly, once weekly, less than once weekly and never.

Statistical analysis

The LMS statistical procedure of Cole & Green (1992) was used to prepare the centile tables from the raw data collected. In all cases, a log transformation was used to remove skewness in the data. The Cole LMS procedure enables SD scores to be calculated from a data set by deriving values for the Box-Cox power (L), indicating skewness, median (M), and CV (S).

Using the Statistical Package for the Social Sciences for Windows, version 6.0.1 (SPSS UK Ltd, Woking, Surrey, UK), independent sample *t* tests were used to test for differences in mean height, weight, MAC and handgrip strength between the elderly in Dublin and the current UK data (Finch *et al.* 1998) and for differences in BMI, MAC, TSF, MAMC and AMA between the elderly in Dublin and the earlier Welsh, UK data (Burr & Phillips, 1984). Spearman's correlation was calculated to test for associations between the continuous variables measured. *P* values of less than 0·05 were considered to indicate statistical significance.

Results

Subjects

A total of 874 healthy Irish elderly from the greater Dublin area entered the study; 598 females and 276 males. The age range of the participants was 65 to 92 years, mean 72·5 (SD 5·4) years. The subjects were socio-economically representative of the Irish population, 41 % (*v.* 37·2 % nationally) from the higher, and 59 % (*v.* 62·8 % nationally) from the lower socio-economic groups (Central Statistics Office, unpublished results). There were no differences between our data and the data for height, weight, BMI and MAC recently reported for a nationally representative sample (*n* 1052) of free-living elderly in the UK (Finch *et al.* 1998).

Anthropometric measurements

In males, height, weight, BMI, left MAC, left MAMC, left AMA, left and right calf circumference, and handgrip dynamometry followed the normal distribution. In females, only left calf circumference was normally distributed. After application of the Cole LMS statistical procedure with logarithmic transformation to remove skewness, the smoothed centile values for the anthropometric variables for the subject groups are shown in Tables 2–10.

The mean BMI in males was 26·8 kg/m^2 and in females 26·7 kg/m^2. Using the classification of normal BMI as 18·5–24·9 kg/m^2, no males and only five (0·8 %) females could be considered undernourished. Only 31·5 % of males and 38 % of females had a normal BMI, and 68·5 % of males and 61 % of females were either overweight or obese. The proportion of overweight or obese subjects was high at all ages (69 % of those aged 65–69 years, 61 % of those aged 70–74 years, 64 % of those aged 75–80 years and 46 % of those aged over 80 years were either overweight or obese) though BMI declined significantly with increasing age in both men ($P<0·05$) and

Table 2. Smoothed centiles for weight for adults aged 65 years and over*

	Centile (kg)						
Age (years)	5th	10th	25th	50th	75th	90th	95th
Men							
65	62·57	65·98	72·09	79·54	87·77	95·90	101·12
70	61·20	64·54	70·51	77·81	85·85	93·81	98·91
75	59·84	63·10	68·94	76·07	83·94	91·72	96·71
80	58·48	61·66	67·37	74·34	82·03	89·63	88·50
85	57·11	60·22	65·80	72·61	80·11	87·53	92·30
Women							
65	51·75	54·87	60·51	67·46	75·21	82·95	87·95
70	50·10	53·12	58·58	65·31	72·82	80·31	85·15
75	48·45	51·37	56·66	63·17	70·42	77·66	82·35
80	46·80	49·62	54·73	61·02	68·03	75·02	79·55
85	45·15	47·88	52·80	58·87	65·63	72·38	76·75

* For details of participants and procedures, see Table 1 and p. 138.

Table 3. Smoothed centiles for height for adults aged 65 years and over*

	Centile (m)						
Age (years)	5th	10th	25th	50th	75th	90th	95th
Men							
65	1·6080	1·6306	1·6690	1·7128	1·7577	1·7991	1·8244
70	1·6010	1·6234	1·6617	1·7053	1·7500	1·7912	1·8164
75	1·5939	1·6163	1·6544	1·6977	1·7423	1·7833	1·8084
80	1·5868	1·6091	1·6470	1·6902	1·7346	1·7754	1·8004
85	1·5798	1·6019	1·6397	1·6827	1·7268	1·7675	1·7924
Women							
65	1·4816	1·5017	1·5359	1·5747	1·6145	1·6513	1·6736
70	1·4728	1·4927	1·5267	1·5653	1·6049	1·6414	1·6636
75	1·4639	1·4837	1·5175	1·5559	1·5952	1·6315	1·6536
80	1·4550	1·4747	1·5083	1·5464	1·5856	1·6216	1·6436
85	1·4462	1·4658	1·4991	1·5370	1·5759	1·6117	1·6336

* For details of participants and procedures, see Table 1 and p. 138.

women ($P<0·001$), as did height ($P<0·01$) and weight ($P<0·01$) in both genders. Although fat and muscle reserves appeared to decline with increasing age, the reduction in fat mass (inferred from TSF) was significant only in females ($P<0·01$). MAMC and calf circumferences (left and right) declined significantly ($P<0·01$) with increasing age in both sexes. In all subjects, weight correlated with height (r 0·56; $P<0·01$).

Functional measurements

The mean handgrip strength was 30·4 kg in males and 17·3 kg in females. Reduction in muscle size was accompanied by a significant (r 0·58; $P<0·01$) reduction in handgrip strength. The smoothed centile values for handgrip strength are shown in Table 11. A grip strength of 85 % standard for age and sex has been found to be the most effective cut-off for prediction of post-operative complications (Webb *et al.* 1989). The values at 85 % of the derived standard or median for the Irish population are shown in Table 12. Mean values for handgrip dynamometry were significantly lower ($P<0·01$) in the Irish group when compared with the contemporary UK data (males, 30·4 kg *v.* 34·8 kg; females, 17·3 kg *v.* 20·0 kg) (Finch *et al.* 1998).

Physical activity and active leisure

A total of 88 % of both genders claimed to have a moderate to high level of physical activity. Of elderly males, 73 %, and of elderly females, 54 % reported spending at least 20 min engaged in active leisure or domestic activities four or more times weekly.

Higher BMI was associated with reported lower levels of physical activity (r −0·14; $P<0·01$), fewer occasions of active leisure (r −0·19; $P<0·01$) and lower socio-economic group (r −0·10; $P<0·05$).

Discussion

Anthropometric indices of weight, height, BMI, skinfold thickness and muscle circumferences are simple, easily obtainable and inexpensive measures of assessing nutritional status. Based on the recommendation that local anthropometric data should be collected in older age groups so that longitudinal data may evolve (World Health Organization, 1995), and using the Cole LMS procedure, an advanced, flexible technique that has many applications in anthropometry (Haschke *et al.* 2000), to smooth the centile curves, the present study has derived data for weight, height, BMI, TSF, MAC, MAMC,

Table 4. Smoothed centiles for body mass index for adults aged 65 years and over*

	Centile (kg/m^2)						
Age (years)	5th	10th	25th	50th	75th	90th	95th
Men							
65	21·96	23·02	24·89	27·15	29·62	32·03	33·57
70	21·66	22·70	24·55	26·78	29·22	31·60	33·11
75	21·36	22·39	24·21	26·41	28·81	31·16	32·65
80	21·06	22·07	23·87	26·04	28·41	30·72	32·19
85	21·76	21·76	23·53	25·67	28·00	30·28	31·74
Women							
65	21·06	22·29	24·52	27·25	30·29	33·31	35·26
70	20·63	21·83	24·01	26·69	29·66	32·62	34·53
75	20·19	21·38	23·51	26·13	29·04	31·93	33·80
80	19·76	20·92	23·00	25·56	28·41	31·25	33·08
85	19·32	20·46	22·50	25·00	27·79	30·56	32·35

* For details of participants and procedures, see Table 1 and p. 138.

Table 5. Smoothed centiles for mid-arm circumference for adults aged 65 years and over*

	Centile (mm)						
Age (years)	5th	10th	25th	50th	75th	90th	95th
Men							
65	264	273	287	304	321	338	349
70	259	267	281	297	314	331	341
75	253	261	274	291	307	324	334
80	247	255	268	284	300	316	326
85	241	249	262	277	293	309	318
Women							
65	250	261	280	302	326	350	365
70	244	254	272	294	318	341	355
75	237	247	265	286	309	332	346
80	231	240	258	278	301	322	336
85	224	234	250	271	292	313	327

* For details of participants and procedures, see Table 1 and p. 138.

Table 6. Smoothed centiles for mid-arm muscle circumference for adults aged 65 years and over*

	Centile (mm)						
Age (years)	5th	10th	25th	50th	75th	90th	95th
Men							
65	236	242	253	266	280	293	301
70	230	237	248	261	274	287	295
75	225	232	242	255	268	281	288
80	220	226	237	249	262	274	282
85	215	221	231	243	256	268	275
Women							
65	194	202	215	230	246	262	272
70	192	199	212	227	243	259	269
75	190	197	209	224	240	256	265
80	187	194	207	221	237	252	262
85	185	192	204	219	234	249	259

* For details of participants and procedures, see Table 1 and p. 138.

AMA, right and left calf circumference and handgrip strength for a cross-sectional group of Irish elderly aged 65 or more years. Although it is important to realise that the centile values at age 65, 70, 75, 80 and 85 years are for those precise ages, the corresponding values for the intervening ages can be readily obtained by linear interpolation. By including only subjects who were free-living, ambulatory, mentally competent and apparently healthy, we hoped to provide reference values from a group who were nutritionally 'elite' and as free from illness as possible (World Health Organization, 1995).

The internal validity of the data was maximised by using the same trained research dietitian and instruments for data collection and by using an adequate number of homogeneous subjects.

Measuring height reliably in older individuals is one of the most problematic areas of anthropometry. In old age there is a decline in sitting and standing height due to vertebral compression, change in height and shape of the vertebral discs, loss of muscle tone and postural changes (World Health Organization, 1995). When these height measurements are used in the calculation of BMI, BMI will tend to be artificially inflated. In the present study, the reduction in median height between the younger (65–69 years) and older (80+ years) groups was 0·05 m in males and 0·04 m in females. Although various methods to estimate height in the elderly have been developed (World Health Organization, 1995), their validity remains uncertain. Reported height in the elderly is thought to reflect height at a younger age and has been shown to result in over-estimation of height (Haboubi *et al.* 1990). Standing height is still the most widely collected and quoted statistic for height measurement in the elderly (Van Staveren *et al.* 1995; World Health Organization, 1995; Rea *et al.* 1997; Finch *et al.* 1998) and was used and measured by standard methods in the present study. The mean height recorded in the present survey was identical to that of free-living participants in the British National Diet and Nutrition Survey of people aged 65 years and over (Finch *et al.* 1998) (1·70 m in both Irish and British males; 1·56 m in both Irish and British females). These data are also comparable to those obtained in the *Health Survey for England 1995* (Prescott-Clarke & Primatesta, 1997) (1·70 m and 1·57 m for males and females, respectively). In our study, mean height was observed to be significantly higher in the higher socio-economic groups (1·63 m in the higher *v.* 1·59 m in the lower; $P<0·001$), although the reasons for this finding were not determined. However, nutritional factors may be involved as it has been reported recently that the diets of the less affluent in Ireland are less healthy (National Nutrition Surveillance Centre, 1999*a*).

Mean weight in the present study was also similar to that found in the British National Diet and Nutrition Survey of people aged 65 years and over (Finch *et al.* 1998) and comparable to the *Health Survey for England 1995* (Prescott-Clarke & Primatesta, 1997). Similar values were obtained for both the higher and lower socio-economic groups. Although weight decreased significantly ($P<0·01$) with age in both genders in the present study, among those aged 75 years or more, Irish males and females were heavier than their free-living counterparts in Edinburgh, UK (Bannerman *et al.* 1997).

BMI is normally considered the best age-independent index of obesity or underweight with values below

Table 7. Smoothed centiles for arm muscle area for adults aged 65 years and over*

	Centile (mm^2)						
Age (years)	5th	10th	25th	50th	75th	90th	95th
Men							
65	4417	4664	5108	5651	6251	6846	7228
70	4233	4470	4895	5415	5990	6560	6927
75	4049	4275	4682	5179	5730	6275	6625
80	3864	4080	4469	4944	5469	5989	6324
85	3680	3886	4256	4708	5208	5704	6022
Women							
65	3017	3248	3675	4216	4836	5472	5892
70	2943	3169	3586	4113	4718	5339	5749
75	2870	3090	3496	4011	4601	5206	5605
80	2796	3011	3407	3908	4483	5072	5461
85	2723	2931	3317	3805	4365	4939	5318

* For details of participants and procedures, see Table 1 and p. 138.

Table 8. Smoothed centiles for triceps skinfold thickness for adults aged 65 years and over*

	Centile (mm)						
Age (years)	5th	10th	25th	50th	75th	90th	95th
Men							
65	6·83	7·67	9·29	11·51	14·25	17·28	19·39
70	6·64	7·45	9·03	11·18	13·85	16·79	18·84
75	6·44	7·23	8·76	10·85	13·44	16·30	18·29
80	6·25	7·01	8·50	10·53	13·04	15·80	17·73
85	6·05	6·79	8·24	10·20	12·63	15·31	17·18
Women							
65	13·59	15·14	18·15	22·20	27·16	32·55	36·28
70	12·65	14·10	16·90	20·67	25·28	30·31	33·78
75	11·71	13·05	15·65	19·14	23·41	28·07	31·28
80	10·78	12·01	14·40	17·61	21·54	25·82	28·78
85	9·84	10·97	13·15	16·08	19·67	23·58	26·28

* For details of participants and procedures, see Table 1 and p. 138.

$20\,kg/m^2$ (more recently $18{\cdot}5\,kg/m^2$) indicative of undernutrition and values $\geqq 30\,kg/m^2$ consistent with obesity. The mean BMI of the Irish survey participants was similar to that found in the 1998 British survey (Finch *et al*. 1998) (males, $26{\cdot}8\,kg/m^2$ in Dublin *v.* $26{\cdot}5\,kg/m^2$ in Britain; females, $26{\cdot}7\,kg/m^2$ in Dublin *v.* $26{\cdot}8\,kg/m^2$ in Britain) but significantly higher in both males and females ($P<0{\cdot}01$) compared with the earlier Welsh data (Burr & Phillips, 1984). The mean BMI measurements were also significantly higher in the lower socio-economic groups ($27{\cdot}1\,kg/m^2$ in the lower *v.* $26{\cdot}2\,kg/m^2$ in the higher groups; $P=0{\cdot}002$). As there was no difference between mean weights in the two socio-economic groups, this difference was due to the significantly higher ($P<0{\cdot}001$) mean height in the higher socio-economic group. The very high rate of overweight and obesity we observed in those aged 65 years and over (68·5 % in males and 61 % in females) is consistent with the high rates recently reported for those aged 18–64 years in the Irish population (Irish Universities Nutrition Alliance, 2001) and extends our knowledge of the current nutritional status of the Irish population.

In our study, muscle reserves (calculated from left MAMC and from calf circumferences (left and right)) declined significantly ($P<0{\cdot}01$) with age in both sexes. The loss of muscle and fat with age followed a similar pattern as found in the study of Burr & Phillips (1984). Both MAMC and AMA declined steadily with age and at approximately the same rate in men and women. The decline in MAC and TSF was more notable in women. No significant reduction in fat stores (inferred from TSF) was observed with increasing age in Irish males. Both the Irish and Welsh studies can be contrasted with the small (*n* 114) UK study of McEvoy & James (1982) who reported a decrease in MAMC and an increase in TSF measurements in older women and no loss of fat or muscle in older men. These findings may result from the preservation of fat over muscle in older males or may indicate that the measurement of TSF is not sufficiently sensitive to detect loss of fat in males, a view held by Mitchell & Lipschitz (1982) who concluded that extremity skinfold measurements (triceps, biceps and thigh) may be more accurate in elderly females, while skinfold measurements on the trunk (subscapular and supra-iliac) may be more

Table 9. Smoothed centiles for left calf circumference for adults aged 65 years and over*

	Centile (mm)						
Age (years)	5th	10th	25th	50th	75th	90th	95th
Men							
65	326	335	351	369	387	405	416
70	322	331	346	364	382	400	411
75	317	326	341	358	377	394	405
80	313	321	336	353	371	389	399
85	308	317	331	348	366	383	393
Women							
65	308	318	335	354	375	395	407
70	304	314	330	350	370	390	402
75	300	310	326	345	366	385	397
80	296	306	322	341	361	380	392
85	292	301	317	336	356	375	386

* For details of participants and procedures, see Table 1 and p. 138.

Table 10. Smoothed centiles for right calf circumference for adults aged 65 years and over*

	Centile (mm)						
Age (years)	5th	10th	25th	50th	75th	90th	95th
Men							
65	328	337	353	372	391	410	421
70	324	333	348	367	386	404	415
75	319	328	343	361	380	398	409
80	314	323	338	356	375	392	403
85	310	318	333	351	369	386	397
Women							
65	307	317	334	354	375	395	408
70	303	313	329	349	370	390	403
75	299	308	325	345	365	385	397
80	295	304	321	340	360	380	392
85	291	300	316	335	355	375	387

* For details of participants and procedures, see Table 1 and p. 138.

Table 11. Smoothed centiles for handgrip dynamometry for adults aged 65 years and over*

	Centile (kg)						
Age (years)	5th	10th	25th	50th	75th	90th	95th
Men							
65	21·67	24·26	28·60	33·41	38·22	42·55	45·14
70	20·36	22·80	26·87	31·39	35·91	39·98	42·41
75	19·05	21·33	25·14	29·37	33·60	37·41	39·68
80	17·74	19·86	23·41	27·35	31·29	34·83	36·95
85	16·43	18·39	21·68	25·33	28·98	32·26	34·22
Women							
65	12·10	13·75	16·51	19·58	22·65	25·41	27·06
70	11·17	12·69	15·24	18·07	20·90	23·45	24·98
75	10·23	11·62	13·96	16·55	19·14	21·48	22·88
80	9·28	10·55	12·67	15·02	17·38	19·49	20·76
85	8·34	9·48	11·38	13·50	15·61	17·51	18·65

* For details of participants and procedures, see Table 1 and p. 138.

appropriate in elderly males. In our study, elderly women of all age groups had increased subcutaneous fat compared with men of the same age. A higher mean TSF in females aged over 80 years was observed in our study in comparison to that reported from Northern Ireland in females aged over 90 years (18·3 (SD 5·7) mm *v.* 12·3 (SD 4·5) mm), whereas the mean value for triceps skinfold thickness in both male populations was similar (10·4 (SD 3·1) mm in our study *v.* 11·7 (SD 4·1) mm in the Northern Irish study), supporting the hypothesis that fat may be preserved in healthy, elderly men. It is well recognised that reduced subcutaneous fat compromises temperature regulation and increases the risk of hypothermia in the elderly (Fellows *et al.* 1985) and that elderly females are particularly vulnerable to this condition. The higher fat stores observed in women could possibly be due to a lower rate of involvement by older Irish females in active leisure; only 47 % of those aged 75 years or more reported participating in active leisure or domestic activities for a minimum of 20 min four times weekly, and 17 % never participated. This finding is in keeping with the results of the National Health and Lifestyles Survey (National Nutrition Surveillance Centre, 1999*b*) where it was reported that 27 % of women aged 55 years or more took no exercise at all. In contrast, 70 % of Irish males aged 75 years and over in our survey reported participating in active leisure or domestic activities at least four times weekly, a figure higher than that reported in the National Health and Lifestyles Survey (National Nutrition Surveillance Centre, 1999*b*). In addition, a correlation between lower socioeconomic group and fewer times spent in active leisure or domestic activities was observed ($P<0·05$).

Table 12. Lower limits of handgrip strength (85 % of derived standard)*

	Lower limits of grip strength (kg)	
Age (years)	Male grip strength	Female grip strength
65	28·4	16·6
70	26·7	15·4
75	25·0	14·1
80	23·2	12·8
85	21·5	11·5

* For details of participants and procedures, see Table 1 and p. 138.

The Irish study participants recorded significantly lower values ($P<0·01$) for handgrip dynamometry than the free-living group in the UK (Finch *et al.* 1998). Only MAC was measured in the UK survey so it is not possible to determine if this difference was due to lower muscle mass in the Irish group compared with the UK group. However, comparison with the data on those aged over 75 years from Edinburgh shows that Irish females have significantly lower MAMC than their counterparts from Edinburgh though the same is not true for males. It is more probable that the differences observed in handgrip strength are due to differences in the equipment used.

In the British National Diet and Nutrition Survey of people aged 65 years and over (Finch *et al.* 1998), undernutrition was defined as a BMI of 20 kg/m^2 or less. When the same criteria are applied to the present Irish survey a similar proportion of those surveyed were classified as undernourished (3 % of males in both the UK and Ireland; 6·5 % of Irish females *v.* 6 % of UK females). No males, and less than 1 % of females, had a BMI below 18·5 kg/m^2. The Northern Irish study of elderly aged over 90 years reported that no male subjects, but 10 % of females had a BMI below 18·5 kg/m^2. Undernutrition in the elderly is recognised as a risk factor for medical, mental and functional decline, and needs to be recognised and treated (Rea *et al.* 1997; Morley, 1998) but has never been adequately defined. In light of the low prevalence of a BMI below 20 kg/m^2, particularly in males, it may be more appropriate to replace a threshold BMI value of 20 kg/m^2 with an assessment of the extent and rate of weight change when determining which elderly are at nutritional risk.

In contrast to the small number of undernourished subjects, 68·5 % of males and 61 % of females were either overweight or obese (i.e. a BMI of $\geqq$ 25 kg/m^2). These figures are little different to those found in other recent studies on the elderly (Bannerman *et al.* 1997; Finch *et al.* 1998). Our Irish study found that 17 % of men and 20 % of women had a BMI $\geqq$ 30 kg/m^2. The Survey in Europe on Nutrition and the Elderly, a Concerted Action

reported a prevalence of obesity among elderly individuals aged 70–75 years, defined as a BMI $\geqq 30\,kg/m^2$, in at least 20 % of men in eight centres and women in twelve centres (Van Staveren *et al.* 1995). Although a BMI $\geqq 30\,kg/m^2$ may be considered a marker of health risk, there is little evidence that older individuals who have remained overweight and who have no pre-existing chronic disease should be advised to lose weight (World Health Organization, 1995). 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 over a 23-year period (Harris *et al.* 1988). In the Northern Irish study of elderly over 90 years (Rea *et al.* 1997), 11 % of females and 2 % of males had a BMI of $30\,kg/m^2$ or more. Both overweight and thinness appear to carry risk for mortality, but in the elderly, thinness carries a greater risk than overweight. All groups should be encouraged to increase both physical activity and nutrient density in order to maintain or augment lean body mass (World Health Organization, 1995). The percentage of Irish adults aged 15 years and over who report no involvement in any physical activity is 14 % (Institute of European Food Studies, 1999). In our elderly group the corresponding figure for elderly males was 7 %, and for elderly females, 13 %. It would appear that after retirement, healthy elderly men increase their time spent in active leisure, perhaps to replace some of the time normally spent at work. Whether the level of physical activity undertaken by elderly Irish men is sufficient is not clear from the present study. Data from the UK (*Health Survey for England: Cardiovascular Disease 1998*) reported that only 17 % of elderly males aged 65 to 74 years meet the current guidelines for physical activity (i.e. moderate intensity of at least 30 min duration at least five times/week). Among Irish women it would appear that there is no increase in the proportion involved in exercise as they get older and initiatives to encourage younger women to participate in active leisure should be encouraged. It is widely acknowledged that lack of physical activity increases the risk of cardiovascular disease, osteoporosis and other chronic diseases (European Heart Network, 1999).

In summary, our survey is a substantial study in which an extensive number of anthropometric variables were measured in a large group of elderly Irish individuals. It complements the recent Irish survey of the 18–64-year-old age group (Irish Universities Nutrition Alliance, 2001) and the recent survey of elderly in the UK (Finch *et al.* 1998). The data reported here provide a set of anthropometric measurements that may be used by health professionals assessing elderly patients in various settings. Our data demonstrate a high prevalence of overweight and obesity among reasonably active elderly Irish individuals who report themselves to be healthy. BMI declines with increasing age in both males and females, as do both height and weight. It is clear that the use of earlier British data (Burr & Phillips, 1984) and probable that the use of American data (which are only applicable to those aged 65–74 years) (Bishop *et al.* 1981) is inappropriate to define the nutritional status of the Irish elderly and will not satisfactorily identify elderly individuals at nutritional risk who could benefit from nutritional advice. Now that Irish reference data are available, older reference data from other countries should no longer be used routinely for nutritional assessment of the elderly in Ireland. Additionally, in view of the potential health benefits of regular exercise, strategies should be devised and implemented to encourage greater participation in active leisure activities, particularly among women.

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