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Basic Anthropometry and Health Status of Elderly: Findings of the Maracaibo Aging Study

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Abstract

Objective: Determine basic anthropometry for elderly participants in a Venezuelan community and compare results for subgroups with different health status. **Method**: Standardized anthropometric, nutritional, neurological, neuropsychiatric, and cardiovascular assessments generated data on weight, height, and body mass index (BMI) by sex and age for the total sample, for normative groups without health problems that might impact anthropometry, and for reference groups with no major health problems. Centile curves of anthropometric measurements versus age are determined for women and men in the normative group. **Results**: Mean weight and height are significantly different between sexes, but not BMI. All three parameters show gradual declines with age. The mean 90% central interval for BMI in the normative and reference groups is 20-29 kg/m^2. **Conclusion**: The anthropometric data for healthy elderly Venezuelans can be used in monitoring anthropometric changes and disease risk analysis for this population and possibly for other Latin American populations.

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Although the elderly fraction of the human population is growing on a global basis, the proportion is increasing at an unusually high rate in some developing countries, including those of Latin America (Palloni, Pelaez, & Wong, 2006). By 2025, one in seven people in the region will be more than 60 years old (Pelaez, 2004). Problems associated with this increase go beyond higher demand for health services in poor settings. Exposure early in life to deleterious conditions related to poverty, including diseases, malnutrition, and prenatal stress, may influence the aging process (Osmond, Kajantie, Forsen, Eriksson, & Barker, 2007; Reynolds, Godfrey, Barker, Osmond, & Phillips, 2007; Wong, Pelaez, Palloni, & Markides, 2006), so the health status of the elderly is likely to be worse in Latin America than in developed countries (Albala et al., 2005; Wong et al., 2006). There is also evidence that older migrants might require special medical attention in their new host countries (Leao, Sundquist, Johansson, & Sundquist, 2009). Information about the current health status of the elderly Latin Americans populations is not only of epidemiological interest but is also necessary for assessing the present and future needs of this vulnerable population and for improving public health policies.

Anthropometric measurements, such as weight, height, and body mass index (BMI), provide a simple, inexpensive, and noninvasive method for monitoring health and nutritional status and assessing risk of diseases (World Health Organization [WHO], 1995). Due to their ubiquitous use in clinical and epidemiological settings, it is important to develop information that will improve the ability of health professionals to classify an individual as at risk based on these measurements. This information includes baseline data for healthy individuals of the same sex and age group, either from the same population or from a comparable population. Acquiring such data among elderly participants is challenging, as there is a high prevalence of multiple health problems in the older segment of the population, and few are completely free of disease.

The criteria used to determine ranges of anthropometric values that should be considered normal, desirable, or optimum are controversial, particularly among elderly populations. Weight and BMI values change gradually during old age and are influenced by many health conditions (Zafon, 2007). Traditionally, the criterion for setting weight guidelines has been the range of weights that correspond to the lowest mortality (Willett, Dietz, & Colditz, 1999), but many studies have shown that the relationship between BMI and

mortality is attenuated in old age (see Janssen & Mark, 2007, for a review and meta-analysis). Although optimum BMI was reported to not differ significantly between adult Latin Americans and Hispanics, non-Hispanic Whites, and non-Hispanic Blacks residing in the United States (Herrera et al., 2009), several investigators have questioned whether the cut points for obesity currently used in the United States and most European countries are appropriate for use in other countries and in different ethnic groups (Moon, Kim, Jang, Yoon, & Kim, 2002; Stevens, 2003; Stevens, Juhaeri, & Jones, 2002). Multiethnic studies of elderly individuals in the United States showed that weight was lower for Mexican American men and women than for non-Hispanic Blacks and non-Hispanics Whites (Kuczmarski, Kuczmaesky, & Najjar, 2000).

In addition to the difficulty in defining desirable ranges of weight and BMI, criteria for defining participants as "healthy" differ among anthropometric studies. Some studies used only responses to a questionnaire (Corish & Kennedy, 2003; Moon et al., 2002), and some studies subjected participants to physical and/or laboratory examinations (Chiu, Chang, Mau, Lee, & Liu, 2000; Dudeja et al., 2001; Perissinotto, Pisent, Sergi, & Grigoletto, 2002; Rea, Gillen, & Clarke, 1997). Some studies excluded only severe health conditions, and some studies applied stricter exclusion criteria (see review by Janssen & Mark, 2007). Of the previous anthropometric studies of elderly populations that included Latin Americans (Diaz, Meertens, Solano, & Pena, 2005; Falque-Madrid et al., 1996; Herrera et al., 2005; Palloni, McEniry, Wong, & Pelaez, 2006; Rodriguez, Hernandez, Herrera, Barbosa, & Hernandez-Valera, 2005; Sanchez-Garcia et al., 2007; Santos et al., 2004; Tavares & Anjos, 1999), only one specifically assessed healthy participants, and in that case, health status was determined by self-report (Sanchez-Garcia et al., 2007). The Maracaibo Aging Study (MAS) database included anthropometric measurements of more than 2,400 elderly individuals, as well as evaluations of physical and mental health by a multidisciplinary team of health professionals (Maestre et al., 2002). These measurements allowed determination of distributions of height, weight, and BMI by sex and age for participants with well-characterized health status. The primary goal of the present study was to determine basic anthropometric parameters for healthy elderly members in this Venezuelan community. To achieve this goal, it was necessary to determine appropriate criteria for selecting participants to provide reference values. This process resulted in distributions of anthropometric parameters using different criteria to select healthy individuals, which can now be used to help monitor anthropometric changes in the elderly and to identify at risk individuals in Venezuela and other Latin American populations.

Materials and Methods

The Study Population

The first phase of the MAS included 2,438 participants and took place from January 1999 to August 2000. The ethics review board of the Cardiovascular Institute (University of Zulia) approved the study. All participants gave informed written consent. The sample and methods are described in detail elsewhere (Maestre el al., 2002). Briefly, all individuals >55 years, residing in an urban neighborhood in Maracaibo, Venezuela, were invited to participate. The participants underwent a standardized physical exam: nutritional, neuropsychiatric, and cognitive assessments, and blood chemistry. Current medications and dietary supplements were noted. Diagnoses for each participant were generated at a conference of participating health professionals.

Anthropometric Measurements

Measurements were made by trained personnel on participants wearing light clothing and without shoes. Body weight was determined using a calibrated electronic scale with a precision of 0.1 kg (Detecto®, Webb City, United States). Height was determined using a stadiometer with a nonextendable measuring tape accurate to the nearest 0.1 cm (Holtain, United Kingdom). BMI was calculated as weight (kg) divided by the square of height (m^2). Underweight and obesity were defined based on WHO standards (WHO, 1995).

Anthropometric measurements were collected for 2,251 (92.3%) of the MAS participants, including 1,496 women and 755 men. A total 128 participants were excluded due to chronic physical disability, inability to stand upright, peripheral edema, severe cyphosis, or advanced disease that might have affected height measurement. Data for 59 participants were identified as outliers (>3 *SD* from the mean) and excluded from analyses.

Normative and Reference Subpopulations

Four overlapping groups were defined as healthy, based on a posteriori selection from the MAS database according to the recommendations of the International Federation of Clinical Chemistry (IFCC; Solberg, 1987). Groups were defined using exclusion criteria ranging from more relaxed to the strictest definition of "healthy." All groups excluded individuals with major chronic disorders that could potentially affect anthropometric measures, including thyroid disorders, cancer, severe arthritis, history of hip fracture, severe gastric disease, liver cirrhosis, cardiac congestive insufficiency, chronic obstructive pulmonary disease (determined by intake of bronchodilators or history),

chronic kidney insufficiency (serum creatinine >2.50 mg/dl in men and >2.20 mg/dl in women, or history), dementia (clinical dementia rating >0.5; Molero, Pino-Ramirez, & Maestre, 2007), or prescribed intake of warfarin, nitrates, antipsychotics, or anticonvulsants. Normative Group 1 did not have additional exclusion criteria. Reference Group 1 also excluded individuals with hypertension (>140/90 mm Hg or intake of antihypertensives), diabetes mellitus (fasting blood glucose >126 mg/dl, intake of hypoglycemics or insulin, or history), and dislipidemias (total cholesterol level >240 mg/dl, low-density lipoprotein (LDL) cholesterol level >160 mg/dl, or triglyceride level >200 mg/dl). Normative Group 2 and Reference Group 2 additionally excluded underweight individuals with BMI ≤18.4 and obese individuals ≥30 kg/m^2, based on the recommendation of the WHO that a healthy population used to generate reference anthropometric values should exclude individuals that exhibit nutritional problems, such as underfeeding and overfeeding (de Onis & Habicht, 1996).

Statistical Analyses

Means (± SD) of weight, height, and BMI were calculated for different sex and age categories for the total sample and for each of the four normative and reference groups. Differences between sexes within groups and among the four healthy groups were tested for statistical significance ($p < .05$) using Student's *t* test for normally distributed variables and Mann–Whitney *U* test for nonnormal variables. Prevalence of nutritional categories and smoking habit were compared using χ^2 statistics. All analyses were conducted using Analise-It 2.05, Microsoft Excel, version 2003, or the SPSS Statistical Package, version 15.

Selected centiles were calculated for the four reference and normative groups, using parametric and nonparametric approaches suggested by the IFCC (Solberg, 1987) and guidelines of the National Committee for Clinical Laboratory Standards (NCCLS; Sasse et al., 1995). Because the standard deviation for each parameter varied with age, the limits of age-specific intervals were defined by curves that incorporated those changes. A semiparametric approach, applying a nonparametric kernel smoother, but with normally distributed residuals, was used to estimate centiles curves of weight, height, and BMI by age. To ensure normality of the residuals, the data were transformed: natural log transformation gave the best fit for men, and square-root transformation gave the best fit for women. Smoothing parameters were derived by cross-validation, using a public domain package available for the R programming environment (Bowman & Azzilini, 1997). Centiles were fitted assuming normality of the residuals and using an estimate of the error standard deviation produced from the smoothing function.

Results

Characteristics of the Total Sample Population

The ages of participants in the total sample ranged from 55 to 101 years. Men constituted 33.5% of the sample and were slightly, but significantly, younger than women (Table 1). On average, men were heavier and taller than women, but women had a higher BMI. For the total sample, 3.6% were underweight (<18.5 kg/m^2), 30.6% adequate (18.5-24.99 kg/m^2), 36.6% overweight (25-29.99 kg/m^2), and 29.2 % obese (>30 kg/m^2), with no significant difference in these proportions between men and women. Creatinine and glycemia were higher for men, whereas levels of total cholesterol and LDL were higher for women. A smaller percentage of women smoked more than men who smoked.

Selection of the Normative and Reference Groups

A total of 952 individuals fulfilled the criteria for Normative Group 1, 720 for Normative Group 2, 79 for Reference Group 1, and 66 for Reference Group 2. Thus, Normative Group 2 constituted 75% of Normative Group 1, and Reference Group 2 constituted 83% of Reference Group 1. Because the percentage of obese participants was almost 10 times greater than the percentage of underweight participants, Groups 1 and 2 had predictable differences in weight and BMI. The 5th and 95th percentiles of BMI for Normative Group 1 and Reference Group 1 (Table 2) greatly exceeded the current suggested healthy range for both women and men (Prospective Studies Collaboration et al., 2009; Seidell & Flegal, 1997). Based on these results and on WHO recommendations (de Onis & Habicht, 1996), we chose to present an in-depth analysis using Normative Group 2 and Reference Group 2. Because the number of participants in Reference Group 2 was small and because BMI centiles for Normative Group 2 and Reference Group 2 were consistent with each other (Table 2), data for Normative Group 2 were ultimately selected to describe "healthy" participants.

Total Sample Versus Normative and Reference Groups

Women in the Reference Group 2 were younger and more educated than those in Normative Group 2, who in turn were younger and more educated than women in the total sample (Table 1). Mean height was higher for women in Reference Group 2 than for Normative Group 2 and for the total sample. Women in Normative and Reference Groups 2 had lower weight and BMI, as expected, but also lower glycemia, total cholesterol, and triglycerides, and

Table 1. Characteristics of Men and Women in the Total Sample, Normative Group 2, and Reference Group 2

Characteristics	Total population (N = 2,251)	Women			Men		
		All (n = 1496)	Normative (n = 449)	Reference (n = 44)	All (n = 755)	Normative (n = 271)	Reference (n = 22)
Age, years (Mean ± SD)	67.4 ± 9.0[a]***	67.3 ± 8.9[b]***	65.7 ± 7.8[c]***	61.0 ± 6.0	66.0 ± 8.2	65.6 ± 7.7	64.6 ± 6.2
Education, years (Mean ± SD)	5.9 ± 4.1[a]***	5.2 ± 3.8[b]***	5.9 ± 4.0	6.7 ± 3.6	7.29 ± 4.3	7.1 ± 4.0	5.7 ± 3.0
Height, m (Mean ± SD)	1.56 ± 0.08[a]***	1.51 ± 0.06[b]**	1.52 ± 0.06[c]*	1.54 ± 0.05	1.64 ± 0.06	1.64 ± 0.06	1.65 ± 0.04
Weight, kg (Mean ± SD)	66.5 ± 14.4[a]***	63.4 ± 13.2[b]***	58.5 ± 8.5	60.3 ± 7.0	72.8 ± 14.8[d]***	68.0 ± 9.8	67.3 ± 9.5
BMI, kg/m^2 (Mean ± SD)	27.2 ± 5.2[a]**	27.4 ± 5.3[b]***	25.0 ± 3.1	25.2 ± 2.6	26.7 ± 4.9[d]***	25.0 ± 3.1	24.5 ± 3.3
Classification, n (%)							
Underweight	81 (3.6)	50 (3.3)[b]***	—	—	31 (4.1)[d]***	—	—
Adequate	688 (30.6)	449 (30.0)	201 (44.8)	19 (43.2)	239 (31.7)	116 (42.8)	12 (54.5)
Overweight	834 (36.6)	528 (35.3)	248 (55.2)	25 (56.8)	296 (39.2)	155 (57.2)	10 (45.5)
Obese	658 (29.9)	469 (31.4)	—	—	189 (25.0)	—	—
Glycemia, mg/dL (Mean ± SD)	110.4 ± 50.8[a]***	109.6 ± 50.6[b]***	91.5 ± 18.8	89.0 ± 10.6	112.2 ± 51.1[d]***	93.2 ± 13.7	85.4 ± 10.4
Creatinine, mg/dL (Mean ± SD)	0.91 ± 0.48[a]***	0.83 ± 0.42	0.78 ± 0.17	0.77 ± 0.13	1.06 ± 0.54	0.97 ± 0.20	0.90 ± 0.22

(continued)

Table 1. (continued)

Characteristics	Total population (N = 2,251)	Women			Men		
		All (n = 1496)	Normative (n = 449)	Reference (n = 44)	All (n = 755)	Normative (n = 271)	Reference (n = 22)
Total cholesterol, mg/dL (Mean ± SD)	194.9 ± 57.5[a]***	204.7 ± 56.8[b]***	191.4 ± 44.9[c]*	168.9 ± 47.0	175.5 ± 53.8[d]**	164.0 ± 44.5	140.7 ± 49.9
Low-density lipoprotein (LDL) cholestrol, mg/dL (Mean ± SD)	87.3 ± 51.2[a]***	93.7 ± 50.0	87.7 ± 40.3	74.1 ± 40.6	76.9 ± 51.5	71.0 ± 39.5	97.2 ± 46.7
Triglycerides, md/dL, z(Mean ± SD)	159.2 ± 117.1	156.5 ± 109.7[b]***	120.2 ± 68.8	124.8 ± 47.5	164.5 ± 130.7[d]***	116.6 ± 68.3	86.0 ± 39.4
Smoking habit, n (%)							
Never	1,136 (50.5)[a]***	914 (61.1)[b]*	261 (58.1)	27 (61.4)	222 (29.4)	81 (29.9)	4 (18.2)
In the past	765 (33.6)	408 (27.3)	120 (26.7)	9 (20.5)	348 (46.1)	118 (43.5)	8 (36.4)
Currently	359 (15.9)	174 (11.6)	68 (15.1)	8 (18.0)	185 (24.5)	72 (26.6)	10 (45.5)

a. All Maracaibo Aging Study (MAS) participants, both women and men, are significantly different.
b. All MAS women and normative women are significantly different.
c. Normative women and reference women are significantly different.
d. All MAS men and normative men are significantly different.
*p > .01. **p > .001. ***p < .0001.

Table 2. 5th and 95th Percentiles of Body Mass Index (BMI) for Women and Men in Normative Groups 1 and 2 and Reference Groups 1 and 2

Percentile (90% confidence interval)	Group 1 (including BMI <18.5 or >30)		Group 2 (excluding BMI <18.5 or >30)	
	Normative	Reference	Normative	Reference
Women				
5th	19.2 (18.8-19.7)	20.5 (19.3-21.7)	19.6 (19.2-19.9)	20.9 (19.8-21.9)
95th	35.9 (35.1-37.4)	31.6 (30.4-32.8)	29.4 (29.2-29.7)	29.6 (28.6-30.6)
Men				
5th	19.1 (18.1-19.7)	17.1 (15.0-19.3)	19.7 (19.3-20.1)	19.9 (17.2-20.8)
95th	34.7 (33.7-35.9)	32.4. (31.2-34.6)	29.4 (29.0-29.7)	30.1 (28.3-31.9)

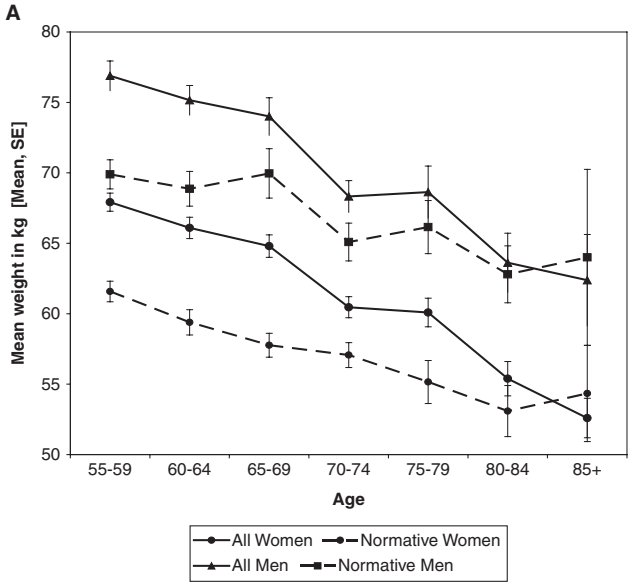
smoked less than women in the total sample. However, women in Normative Group 2 and Reference Group 2 showed no significant differences in weight, BMI, glycemia, creatinine, LDL, triglycerides, or smoking habit.

Average weight, BMI, glycemia, total cholesterol, and triglyceride levels were higher for men in the total sample than for men in Normative and Reference Groups 2, but did not differ significantly between the two latter groups (Table 1). Age, education, height, creatinine, and LDL levels were similar for men in the total sample, normative, and reference groups.

Anthropometric Characteristics of the Total Sample, Normative, and Reference Groups

In the total sample, women showed a relatively steady decrease in weight, height, and BMI with age (Figure 1). Men showed a decline in weight and BMI over most of the age range, but their height did not decline significantly until they were in their 80s. In all but the two oldest age categories, weight of both women and men was significantly lower for Normative Group 2 than for the total sample. In contrast, height did not differ between the normative and total populations of men or women at any age. The decline in BMI with age, furthermore, was smaller for women and men in Normative Group 2 than in the total sample.

Centiles of weight, height, and BMI showed few differences between Normative and Reference Groups 2 (Table 3). The lower centiles of both weight and height were higher for women in Reference Group 2 than for women in Normative Group 2. For men, only the lower centiles of height were higher in the reference group than in the normative group. The centiles



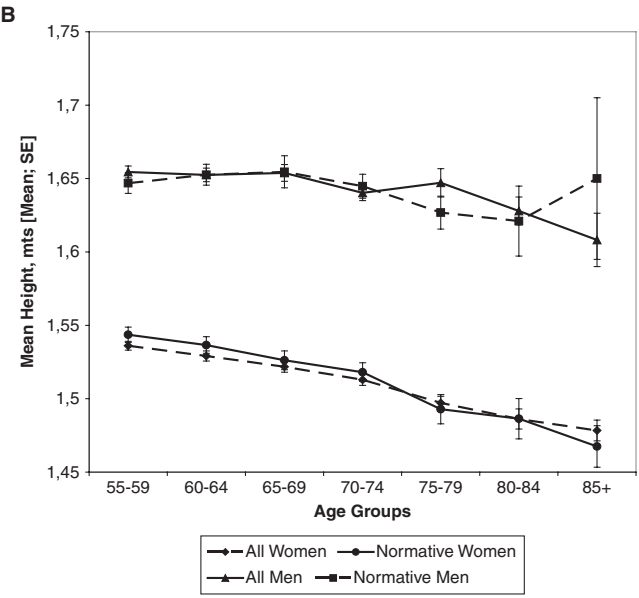


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Figure 1. (continued)

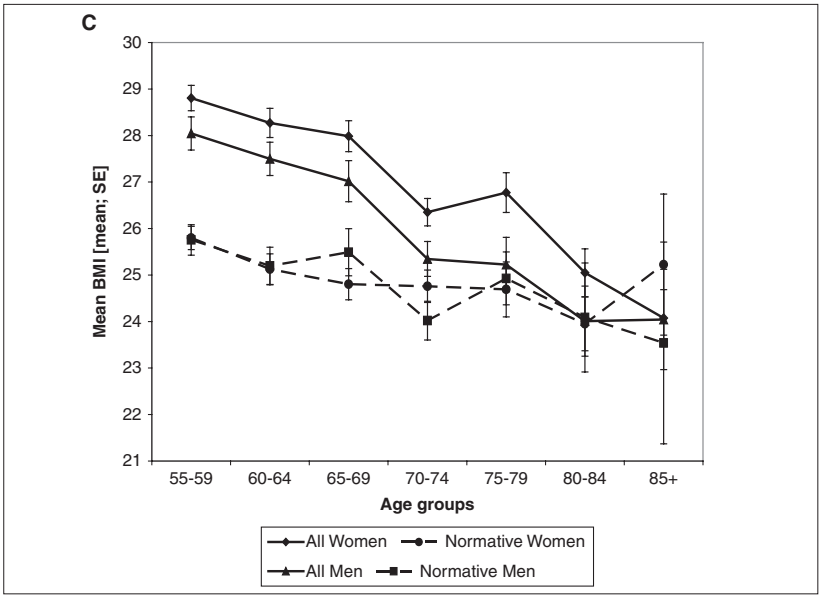

Figure 1. Mean weight (A), height (B), and body mass index (BMI; C) for women and men in different age groups of the total study sample and Normative Group 2
Note: Vertical bars indicate standard error.

of BMI were similar for the reference and normative groups of both men and women. Because anthropometric parameters of Normative Group 2 were so similar to those of Reference Group 2, gender-specific centile curves of weight, height, and BMI, determined for each age group of Normative Group 2 (Figure 2), can be used as a baseline for evaluating the health status of elderly individuals. Healthy women, that is, the central 90th percentile of Normative Group 2, ranged from 44.4 to 72.7 kg in weight, 1.42 to 1.63 m in height, and 19.6 to 29.4 kg/m^2 in BMI (Table 3). Healthy men ranged from 52.5 to 84.0 kg in weight, 1.54 to 1.75 m in height, and 19.7 to 29.4 in BMI (Table 3).

Discussion

Results of the present study provide unique data on the relationship between anthropometry and health status of noninstitutionalized elderly participants residing in a developing country. The identification of a normative group,

Table 3. Selected Centiles of Weight, Height, and Body Mass Index (BMI) for Women and Men in the Normative Group 2 and Reference Group 2

Women						
	Weight, value in kg (90% confidence interval [CI])		Height, value in m (90% CI)		BMI, value in kg/m^2 (90% CI)	
Percentile	Normative	Reference	Normative	Reference	Normative	Reference
2.5	41.7 (40.4-43.1)	46.6 (43.6-49.6)	1.40 (1.38-1.42)	1.45 (1.43-1.47)	19.1 (18.8-19.4)	20.0 (18.9-21.1)
5	44.4 (43.2-45.7)	48.8 (46.1-51.5)	1.42 (1.41-1.48)	1.46 (1.44-1.48)	19.6 (19.2-19.9)	20.9 (19.8-21.9)
10	47.6 (46.5-48.6)	51.3 (48.8-53.7)	1.44 (1.43-1.45)	1.48 (1.46-1.50)	20.4 (19.9-21.1)	21.8 (20.9-22.7)
15	49.7 (48.8-50.5)	53.1 (50.9-55-2)	1.46 (1.45-1.47)	1.50 (1.45-1.53)	21.4 (20.9-21.7)	21.8 (20.9-23.6)
25	52.9 (51.9-63.7)	55.6 (53.7-57.6)	1.49 (1.48-1.50)	1.51 (1.50-1.53)	22.8 (22.2-23.4)	23.5 (21.8-24.2)
50	59.0 (58.0-60.0)	60.4 (59.0-63.8)	1.53 (1.52-1.53)	1.55 (1.54-1.56)	25.4 (25.0-25.9)	25.4 (24.8-26.3)
75	64.3 (63.5-65.3)	65.1 (63.2-67.0)	1.56 (1.55-1.57)	1.58 (1.57-1.60)	28.0 (27.4-28.3)	27.2 (26.3-28.7)
85	67.5 (66.7-68.3)	67.7 (65.5-69.8)	1.58 (1.58-1.60)	1.58 (1.56-1.64)	28.7 (28.4-28.8)	28.7 (27.0-29.4)
90	69.6 (68.5-70.7)	69.4 (67.0-71.7)	1.60 (1.59-1.62)	1.61 (1.60-1.63)	29.0 (28.7-29.2)	28.7 (27.8-29.5)
95	72.7 (71.5-74.0)	71.9 (69.2-74.6)	1.63 (1.62-1.64)	1.63 (1.61-1.65)	29.4 (29.2-29.7)	29.6 (28.6-30.6)
97.5	74.5 (74.1-76.8)	74.1 (71.2-77.1)	1.64 (1.64-1.66)	1.66 (1.63-1.67)	29.8 (29.5-29.8)	30.5 (29.3-31.6)

(continued)

Table 3. (continued)

	Men					
	Weight, value in kg (90% CI)		Height, value in m (90% CI)		BMI (90% CI)	
Percentile	Normative	Reference	Normative	Reference	Normative	Reference
2.5	50.9 (47.2-57.5)	48.5 (42.8-54.3)	1.52 (1.49-1.54)	1.57 (1.54-1.59)	19.6 (18.6-19.7)	17.9 (15.9-20.0)
5	52.5 (51.0-53.5)	51.5 (46.4-56.7)	1.54 (1.52-1.55)	1.58 (1.55-1.60)	19.7 (19.3-20.1)	19.9 (17.2-20.8)
10	55.6 (54.0-57.2)	55.6 (50.5-59.6)	1.56 (1.55-1.58)	1.60 (1.57-1.62)	21.1 (20.6-21.6)	20.2 (18.6 21.8)
15	58.0 (56.8-59.2)	57.4 (53.2-61.6)	1.58 (1.57-1.59)	1.61 (1.56-1.63)	20.8 (20.3-21.8)	20.1 (18.7-22.0)
25	60.5 (59.0-62.5)	60.9 (57.1-64.5)	1.61 (1.60-1.61)	1.63 (1.61-1.64)	22.9 (21.9-23.7)	22.3 (21.0-23.6)
50	68.7 (66.5-70.0)	67.0 (59.0-74.0)	1.65 (1.64-1.66)	1.66 (1.63-1.68)	25.5 (25.1-26.0)	24.9 (21.8-27.7)
75	75.0 (74.0-76.5)	73.8 (70.1-77.5)	1.69 (1.68-1.70)	1.69 (1.67-1.71)	27.7 (27.4-28.1)	26.8 (25.5-28.1)
85	78.2 (77.0-79.4)	77.3 (73.1-82.0)	1.71 (1.70-1.72)	1.70 (1.68-1.76)	28.5 (28.3-28.8)	28.6 (26.9-29.2)
90	80.6 (79.0.-82.2)	79.6 (75.1-84.2)	1.72 (1.71-174)	1.72 (1.70-1.74)	29.1 (28.6-29.6)	28.8 (27.2-30.4)
95	84.0 (81.0-88.0)	83.1 (78.0-78.0)	1.75 (1.73-1.76)	1.73 (1.71-1.76)	29.4 (29.0-29.7)	30.1 (28.3-31.9)
97.5	88.0 (84.0-93.0)	86.6 (80.4-91.9)	1.76 (1.75-1.78)	1.75 (1.72-1.78)	29.7 (29.4-29.9)	31.1 (29.1-33.1)

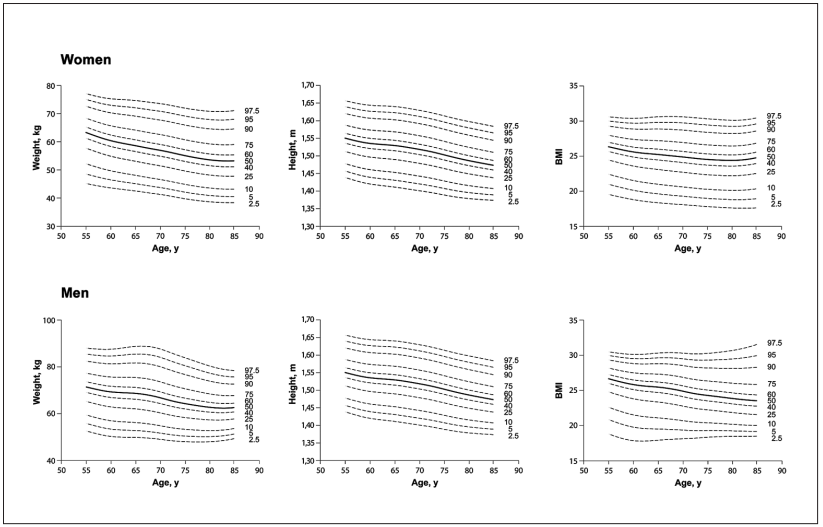

Figure 2. Centile curves for weight, height, and body mass index (BMI) versus age of women and men in Normative Group 2

furthermore, allowed differentiation between the effects of aging and the effects of disease on common anthropometric parameters. The minimal differences between the Normative Group 2 and the even more disease-restricted Reference Group 2 validated the use of the normative sample to represent healthy women and men, as the reference group was too small to provide reliable baseline data. Normative Group 2, therefore, provided a medically useful range of anthropometric values, which can be used to monitor changes throughout old age. Because these measurements varied with age, centile curves for weight, height, and BMI versus age (Figure 2) provide the most useful form of these baseline data. These curves can be used to help discriminate between healthy women and men, and individuals at risk (McCall, 1966) in this population of elderly Venezuelans, and possibly for elderly Hispanics residing elsewhere. A similar approach, selecting participants under different criteria and generating centile curves, has been used in previous studies to determine "healthy" ranges of various parameters, including BMI (Dudeja et al., 2001; Flegal, 2006; Kochanowicz et al., 2009; Molero et al., 2006).

Though only 3.6% of the elderly individuals in the total study population was underweight (BMI <18.5 kg/m^2), almost two thirds were overweight or obese, based on currently accepted BMI thresholds (25 kg/m^2 for overweight and 30 kg/m^2 for obesity; WHO, 1995). The prevalence of overweight and obesity was similar to that in other populations worldwide (e.g., Kaplan,

Huguet, Newsom, McFarland, & Lindsay, 2003; Menendez et al., 2005; Villareal, Apovian, Kushner, & Klein, 2005) but higher than levels in Asian populations (Chiu et al., 2000; Jee et al., 2006). As the primary goal of the current study was to provide a set of parameters that could be used to monitor age-related anthropometric changes in healthy individuals, we selected Normative Group 2 as a baseline sample. This group excluded underweight and obese participants, following the WHO recommendations for establishment of anthropometric reference data for international use (de Onis & Habicht, 1996). Indeed, the largest multicentric collaborative study to date found excess all-cause mortality outside the BMI range of 22.5-25 in all ages, including the elderly (Prospective Studies Collaboration et al., 2009). Although other studies reported no excess mortality in overweight participants (Bender, Jöckel, Trautner, Spraul, & Berger, 1999; Fontaine, Redden, Wang, Westfall, & Allison, 2003), even in obese elderly participants (Thorpe & Ferraro, 2004), obesity is not recommended by health guidelines for elderly individuals. Obesity might not only accelerate cardiovascular and cerebrovascular deterioration (Burke et al., 2008; Singhal, 2005) but increase the risk of other health problems, such as knee problems and gastric disease (Schelbert, 2009) which ultimately affect the quality of life, if not the length of life.

The present study did not aim to establish recommended standards for weight, height, and BMI among elderly Venezuelans, as these values should take into consideration the risks for mortality and morbidity associated with these measurements. However, the results for Normative Group 2 (Table 3) are consistent with studies that recommended a BMI range between 20.0 (Sergi et al., 2005) and 29.9 (Kyle, Genton, & Pichard, 2002) for elderly participants with no major disorders. The ongoing MAS will provide longitudinal data, including mortality and disability information, which can be used to test the validity of the central 90 interval that generated this range for this elderly population.

The current study has several strengths and limitations. In a setting where there is poor access to healthcare services and low levels of education, standardized measurements of weight and height made by trained professionals, as used in this study, are preferable to the self-reported data used in some previous studies (Andreyeva, Michaud, & Van Soest, 2007; Janssen & Mark, 2007). The exclusion criteria for the normative and reference groups were based on clinical history, results of laboratory tests, and physical examination of participants by a team of trained health professionals, including geriatricians, neurologists, psychiatrists, cardiologists, nutritionists, dietitians, psychologists, and nurses, rather than on self-report. Although diseases in the preclinical state could not be ruled out entirely, the clinicians were able to detect previously undiagnosed diseases. The main limitations of the present

study are its transverse nature, the lack of complementary methods to assess body composition, and the relatively small samples for very old individuals, particularly men.

The present study provides baseline information on commonly used anthropometric measurements for elderly Venezuelans, including selected centiles for a healthy normative subpopulation (Table 3, Figure 2) that can be used for reference by healthcare professionals. Applicability of these results and conclusions to other Latin American populations can be determined with much smaller samples than were used in the present study. The great challenge for communities, healthcare workers, and public health officials in Latin America is to promote improved health through changes in lifestyle by people with poor access to healthcare, limited means to change their diet, and urban settings that limit activity levels. Use of the baseline data provided in this report to identify elderly participants who are particularly at risk will allow health care workers to focus their attention on individuals with the greatest need.

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