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Normative values for body compartments of sedentary white people

Abstract

Background: The assessment of the body composition provides information of main constituents of the human body and allows to differentiate between genders and ethnic or to assess changes with age, growth, physical activity, diet and disease. This study shows the evolution of the body compartments, its distribution, and the age and gender related changes in sedentary white people.

Methods: A total of 1136 healthy subjects from Madrid and Castilla-La Mancha Regions (Spain) were recruited and divided into 16 groups according to age. Body compartments (fat mass, lean mass and bone mass) measures were obtained from dual energy X-ray absorptiometry (DXA) scans of all subjects. Total and regional (trunk, arms and legs) body composition were evaluated. Statistical analyses were performed using the statistical and data management package SPSS for Windows.

Results: In males, Total body fat mass increased from birth through 30years of age. In females, total body fat mass increased from birth through 20years of age. The age-adjusted evolutional patterns of trunk fat mass showed gender-related differences. In males, trunk fat mass increased to the age of 55. In females, increased to the age of 70. Males registered larger central fat deposits. There were gender differences for total lean body mass in all age groups except for the 6-10year age group. Values were in all cases higher for males. Total bone mineral content shows significant gender differences form birth. Females reach a peak in bone mass earlier than males.

Conclusion: Contrary to males, females showed from early infancy a smaller proportion of muscle mass and a higher proportion of body fat (from the age of 10), with fat deposits being mostly peripheral. The muscular body component in females is subject to minimal variations during adult age. Bone mass shows significant gender differences between 16 and 70years of age; bone mass values were higher in males. DXA makes it possible to detect differences in body compartments during the life cycle, as well as it shows clear differences between males and females at any age and in different races or population groups.

Keywords: DXA, body composition, bone mass, lean mass, fat mass

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Abbreviations: DXA, dual energy x-ray absorptiometry; BMI, body mass index; WHO, world health organization; BMC, bone mineral content; LBM, lean body mass; FM, fat mass; %FAT, percentage of fat mass; TBFM, total body fat mass; TrFM, fat mass in trunk; AFM, fat mass in arms; LFM, fat mass in legs; ExFM, fat mass in extremities; %LBM, percentage of lean body mass; TLBM, total lean body mass; TrLBM, lean body mass in trunk; ALBM, lean body mass in arms; LLBM, lean body mass in legs; TBMC, total bone mineral content; TrBMC, bone mineral content in trunk; ABMC, bone mineral content in arms; LBMC, bone mineral content in legs; TBMC/H, total bone mineral content-to-height ratio

Introduction

The assessment of the body composition provides information of main constituents of the human body and allows one to differentiate between genders and ethnicity or to assess changes with age, growth, physical activity, diet and disease.

Obesity, type 2 diabetes mellitus (DM) and osteoporosis are the most frequent metabolic disorders that have strong associations with body composition. Although it's certainly clear that obesity, attributable to increased adiposity, can be considered a disorder of body composition, a similar perspective applies to type 2 DM. The metabolic perturbations of type 2 DM have been found to be associated with certain patterns of adipose tissue and fat distribution.[1]

Moreover, the measurement of muscle in the human body has been used mainly for the purpose of assessing the nutritional status of the individual,[2] as the muscle mass constitutes the body's principal reservoir of proteins.

Many different techniques have been used since the initiation of the first anthropometric studies. Analysis of body composition is based on different types of body partitioning, ranging from the traditional model, which considers that there are two body compartments, through multi-compartmental models. The first techniques used and intended to measure body fat are fundamentally anthropometry and hydrodensitometry. Based on the body's electric conductance, bioelectrical impedance is used, but the possibility of measuring the absorption of energy particles by tissues has given way to absorptiometry techniques, first using an isotopic and then a radiological source. Currently, the advantages offered by dual energy X-ray absorptiometry (DXA) make it the most appropriate and widely-used technique, for measuring body composition in individuals of different ages and genders.[3]

This technique was used initially for the determination of bone mass (bone mineral content in gram (g) and bone mineral density in gram per square centimeter (g/cm^2). The bone mineral content and the soft tissue mass are computed on the basis of the attenuation of the energy of the two X-ray beams, making it possible to divide the soft tissue mass between fat and fat free mass, whereby it uses a three-body-compartment model.[4] DXA offers precise estimates of body composition. It can be used to yield estimates of bone mineral, lean soft tissue, and fat mass for regional and total body composition.[5–7]

This research shows in detail the three body compartments (bone, fat and muscle mass) in the Spanish population, in both sexes and for each group by five-year age intervals from 0 to 80years of age.

Subjects and methods

For the purpose of this cross-sectional survey, a sample of the urban population of the Madrid and Castilla-La Mancha Autonomous Regions (Spain) was taken, comprised by 1136 apparently healthy subjects, all Caucasian and whites with a medium socio-economic background, which we divided into 16 groups by five-year age intervals. Broken down by sex, there were 413 males and 723 females, representing 36.4% and 63.6% of the sample, respectively. Age range of the subjects was from 0 (birth) to 80years. The study protocol was approved by the Office for Protection from Research Risks of Alcalá de Henares Medical School. The subjects were randomly selected among the volunteers who presented themselves for the study, who had previously been advised of it in a variety of social areas (schools, factories, businesses, etc). The number of subjects in each age group was fixed according to the proportion of the number of volunteers offered in each of them. The inclusion criteria were the absence of any pathology (diabetes, liver disease, kidney disease, endocrine disease) or pharmacological treatment that could alter the metabolism, and moderate consumption of coffee and alcohol, smoking less than 5 cigarettes/day, only occasional physical exercise (except for the school-age part of the sample, who performed the compulsory exercises organized at their respective schools).

A medical history was taken and the subjects underwent a physical examination at time of the study to confirm a normal health status. Pregnant women were excluded from the study, as was also the case with individuals undergoing diagnostic tests a few days earlier with radio nuclides, ingestion of barium sulphate or injection of radio-opaque substances, as these can alter the photonic absorption of the different tissues. Consent was obtained from each subject's parent or guardian, and assent was obtained from each subject. Weight was measured using a calibrated scale and height was measured using a wall mounted stadiometer. Infants under 2years of age were measured in supine position. Table 1 presents mean values for height, weight and body mass index (BMI) values for each age and gender group. None of the subjects was obese according to the world health organization (WHO) criteria (BMI≥30kg/m^2).

Table 1 Anthropometric characteristics of a healthy white population between 0 and 80 years

Age groups (years)	Males				Females			
	n	Height (cm)	Weight (Kg)	BMI (Kg/m^2)	n	Height (cm)	Weight (Kg)	BMI (Kg/m^2)
1(0-5)	19	101.7(16.6)	17.0(5.4)	16.0(2.1)	19	98.9(25.7)	14.0(4.6)	16.5(3.3)
2(6-10)	45	134.6(12.2)	32.2(8.8)	17.5(2.7)	36	134.7(9.9)	31.2(7.6)	16.9(2.4)
3(11-15)	56	162.6(16.1)	52.4(13.8)	19.4(2.2)	56	158.9(10.3)	50.0(10.5)	19.6(2.8)
4(16-20)	84	177.8(9.3)	72.8(12.7)	22.8(2.6)	116	164.2(7.5)***	56.8(8.4)***	21.0(2.1)***
5(21-25)	39	182.7(8.6)	79.5(12.5)	23.3(3.1)	34	162.2(6.8)***	57.2(9.3)***	21.9(2.8)
6(26-30)	23	173.1(8.6)	77.3(11.7)	25.7(3.3)	44	159.8(7.6)***	56.8(9.0)***	22.1(2.6)***
7(31-35)	22	175.8(10.0)	75.9(12.4)	24.5(3.0)	60	159.4(7.8)***	57.1(8.5)***	22.7(4.1)
8(36-40)	17	169.9(5.8)	74.9(13.1)	24.8(2.0)	48	158.5(6.6)***	58.5(8.0)***	22.9(2.9)
9(41-45)	10	169.9(7.0)	74.6(7.5)	25.9(1.9)	61	159.6(5.6)***	61.2(9.1)***	24.0(2.4)
10(46-50)	13	169.0(6.1)	74.3(7.4)	25.9(2.9)	38	158.8(5.4)***	63.1(8.2)***	25.4(3.5)
11(51-55)	12	165.9(7.0)	78.2(7.1)	28.2(3.4)	43	159.4(5.1)*	66.4(13.8)*	25.8(3.8)
12(56-60)	10	168.1(5.7)	75.5(8.6)	27.0(3.6)	35	156.6(4.8)***	70.4(11.9)	26.6(3.0)
13(61-65)	21	164.7(5.3)	76.8(8.8)	27.9(3.0)	58	157.0(7.8)***	67.8(10.7)**	25.3(3.1)
14(66-70)	14	161.5(5.6)	77.3(14.1)	28.6(7.6)	38	155.8(7.2)*	67.7(9.4)**	25.4(3.8)
15(71-75)	15	162.0(4.2)	68.9(6.1)	25.0(1.1)	23	155.1(7.0)*	63.3(10.5)	24.5(2.6)
16(76-80)	13	163.8(9.1)	68.8(8.2)	23.7(3.3)	7	145.0(4.4)*	59.9(12.4)	24.7(2.9)

Data are shown as mean(standard deviation). BMI: Body mass index. Significant differences between males and females:*p≤0.05; **p≤0.01; ***p≤0.001

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Densitometric studies

A total body scan was performed on each subject with a Norland XR-26 densitometer, software version 2.3 (Norland Co., Fort Atkinson, Wisconsin, USA. Emsor SA. Madrid). The scan was made as long as possible after mealtimes (3-4hours). The subjects were placed in a supine position, and correctly centered on the exploration table. Infants were scanned when asleep. To begin the scan, the starting point was placed 1cm directly above the centre of the patient's head. A baseline point was marked on the abdomen in an area of maximum soft tissue thickness. Various body zones were selected according to the equipment's specific software: on the body image, the upper axis of the thoracic cavity under the chin, the side axes on the scapular-humeral union, laterally adjusted between the upper limb and the trunk, and the lower axis at the caudal limit of the thoracic cavity. The upper axis of the pelvic cavity was placed on the iliac crest, with the lower axis below the pubic symphysis, ensuring that the lateral edges were over the femoral neck. The exploration as defined was completed in an average time of 20minutes. Total radiation dose per individual always remained below 5mrem.

Body compartments calculations were performed for the following magnitudes

STM, soft tissue mass, in g.

BMC, bone mineral content, in g.

TBM, total body mass=TOTAL BMC+TOTAL STM, in g.

TSTM, total STM=in g.

LBM, lean body mass=TSTM–FAT MASS, in g., where 90% its magnitude correspond to muscle mass.

FM (fat mass)=TBM–(BMC+LBM), in g.

%FAT, Fat mass* 100/TBM.

For the fat mass the following variables were analyzed

TBFM, total body fat mass.

% FAT, percentage body fat.

TrFM, fat mass in trunk.

AFM, fat mass in arms.

LFM, fat mass in legs.

Ex FM, Fat mass in extremities=AFM+LFM.

The fat percentage for trunk, extremities and legs is fat/TBFM x 100.

%LBM, percentage lean body mass=LBM/TBMx100.

Relation TrFM/ExFM

Relation TrFM/LFM

For the lean mass the following variables were analyzed

TLBM, total lean body mass.

TrLBM, lean body mass in trunk.

ALBM, lean body mass in arms.

LLBM, lean body mass in legs.

For the bone mass the following variables were analyzed

TBMC, total bone mineral content.

TrBMC, trunk bone mineral content.

ABMC, bone mineral content in arms.

LBMC, bone mineral content in legs.

TBMC/H, tbmc-to-height ratio.

Because of the fact that BMC is defined as the mass of mineral contained in an entire bone or as the mass of mineral per unit bone length, bone mineral content is obviously a size-dependent parameter.[8]

Statistical methods

Statistical analyses were performed using the statistical and data management package SPSS for Windows, Version 10.0. The results were expressed as the mean value (standard deviation) for each densitometric variable by gender and age group. The data were stratified by intervals of 5years. Univariant variance analysis (ANOVA) was used to check the effect of gender on the densitometric variables considered. After calculating the TBMC-to-height ratio and introducing the necessary adjustments for weight gender, differences of the mean values in each age group were tested for significance by means of Student's t-test. The Wilcoxon nonparametric test was performed for age groups with a smaller sample size (15 and 16year olds). Multiple comparisons were made between the mean values of the variables for all the age groups using the Bonferroni test. The level of significance for all statistical tests of hypothesis was 0.05.

Results

Table 1 shows the anthropometric characteristics of sample study and the differences in age- and gender- specific mean values for these magnitudes.

Height, weight and BMI

Height increased progressively to 20years of age in females, and to 25years of age in males, and stabilized thereafter. Weight increased progressively in males to 25years of age and stabilized thereafter. In females, weight increased to 60years of age and slightly decreased thereafter. Generally, males were taller and fatter than females in all age groups, although the BMI only showed significant differences for the 16 to 20 age and 26-30 age groups ($p \leq 0.001$).

Fat mass

Age-and gender-specific means and SDs for TBFM, %fat, TrFM/ExFM ratio and TrFM/LFM ratio are provided in Table 2. Age evolution of TBFM: in males, TBFM increased from birth through 30years of age, registered a slight decrease between the ages of 30 and 35, and increased again to 70years of age. In females, TBFM increased from birth through 20years of age, stabilized between the ages of 20 and 35, increased again to the age of 55, and stabilized thereafter until the age of 70.

In females, %FAT followed an evolutional pattern similar to that of TBFM. In males, %FAT increased to the age of 10, decreased between the ages of 10 and 20, and increased anew to the age of 70. TBFM and %FAT decreased after the ages of 70 in both genders. There were significant gender differences in TBFM and %FAT from the age of 11 to the age of 80, while the mean values were always higher for females.

Table 2 Descriptive statistics of total and regional fat mass and statistical differences between males and females

Age groups (years)	TBFM(Kg)		% FAT		TrFM/ExFM ratio		TrFM/LFM ratio	
	Males	Females	Males	Females	Males	Females	Males	Females
1(0-5)	3.7(2.5)	3.4(1.9)	20.0(8.9)	23.6(6.6)	1.07(0.14)	0.95(0.18)*	2.8(1.3)	2.5(1.3)
2(6-10)	8.5(5.6)	9.2(4.7)	24.9(11.2)	29.1(9.7)	0.91(0.09)	0.87(0.06)*	1.5(0.9)	1.4(0.1)
3(11-15)	10.6(5.3)	17.2(8.1)***	21.1(10.0)	32.0(9.3)***	0.88(0.07)	0.86(0.08)	1.3(0.1)	1.3(0.1)*
4(16-20)	13.5(7.2)	21.5(6.3)***	18.4(8.1)	38.0(7.6)***	0.92(0.07)	0.87(0.07)***	1.4(0.1)	1.3(0.1)***
5(21-25)	16.6(9.7)	22.2(7.9)***	20.7(10.2)	38.5(8.3)***	0.98(0.08)	0.87(0.06)***	1.5(0.2)	1.3(0.1)***
6(26-30)	19.4(11.9)	22.6(5.8)***	24.9(12.8)	40.0(7.2)***	1.01(0.08)	0.94(0.09)*	1.6(0.1)	1.5(0.2)**
7(31-35)	17.8(7.3)	22.1(6.7)***	23.7(8.3)	38.3(6.4)***	1.06(0.11)	0.99(0.10)*	1.6(0.2)	1.5(0.2)*
8(36-40)	19.2(8.6)	24.7(7.1)***	26.8(8.5)	42.0(7.5)***	1.10(0.08)	0.97(0.11)***	1.7(0.2)	1.5(0.1)***
9(41-45)	20.1(3.4)	27.1(8.1)***	27.3(4.0)	44.0(7.8)***	1.17(0.09)	0.96(0.09)***	1.8(0.1)	1.5(0.1)***
10(46-50)	21.9(5.9)	28.8(7.0)***	29.6(6.7)	45.9(6.5)***	1.19(0.08)	1.00(0.10)***	1.9(0.1)	1.6(0.2)***
11(51-55)	25.1(9.3)	32.9(9.5)***	31.4(9.3)	48.8(8.0)***	1.24(0.16)	1.02(0.16)***	2.0(0.2)	1.7(0.2)***
12(56-60)	24.1(6.8)	35.9(13.3)***	32.6(6.9)	48.5(6.3)***	1.15(0.12)	0.99(0.11)***	1.9(0.1)	1.8(0.1)**
13(61-65)	26.4(8.1)	32.3(9.5)***	35.3(7.7)	47.9(7.4)***	1.15(0.08)	1.02(0.14)***	1.9(0.2)	1.8(0.2)*
14(66-70)	27.7(10.1)	33.7(8.5)***	36.1(7.8)	50.9(8.4)***	1.15(0.09)	1.04(0.15)*	2.0(0.1)	1.8(0.2)*
15(71-75)	20.0(5.3)	31.7(8.6)***	29.9(6.1)	48.7(8.2)***	1.20(0.05)	1.05(0.16)*	2.0(0.2)	1.8(0.2)*
16(76-80)	19.7(10.1)	27.8(10.9)*	28.3(11.7)	46.6(8.7)*	1.12(0.07)	1.10(0.06)	1.9(0.2	1.8(0.2)

Data are shown as mean(standard deviation). Significant differences between males and females:* p≤0.05; **p≤0.01; ***p≤0.001

Regional fat distribution

The age-adjusted evolutional pattern of peripheral fat distribution (LFM and ExFM) was very similar for both genders. Peripheral fat deposits increased from birth through the ages of 15-25, and subsequently stabilized.

The age-adjusted evolutional patterns of central fat distribution (TrFM) showed gender-related differences. In males, central fat deposits increased to the age of 55, and stabilized thereafter. In females, central fat deposits increased from birth to the age of 70. Males registered larger central fat deposits. The TrFM/ExFM ratio showed significant gender-related differences from birth to the age of 75, with the exception of the 11 to 15 age group. Mean values were higher in males (Table 2).

The %LBM declined throughout life, although the decline was more significant in females, where the proportion of fat mass and muscle mass reached similar values between the ages of 51 and 65.

Lean mass

Age- and gender- specific means and SDs for TLBM, TrLBM, ALBM and LLBM are provided in Table 3. Gender differences of TLBM: there were gender differences for TLBM in all age groups except for the 6-10 year age group. Values were in all cases higher for males, with a high degree of signification ($p<0.001$), except for the 0-5year age group ($p<0.05$).

Lean mass in males increases progressively until age 20, then remains stable until age 55, after which it starts to decrease. For the

females the increase in lean mass is until age 15, from which age onwards it stabilizes till 80years of age. Apparently the muscular body component in females is subject to minimal variations during lifetime.

For TrLBM, there are differences by sex at all ages, which are, however, more pronounced from age 11years onwards. The difference in lean mass of arms and legs between males and females of adult age is very similar, with no gender differences up to 11years of age in both cases. Female lean mass in the trunk is not affected by age, while a tendency is seen toward loss of lean mass in the lower extremities, albeit not statistically significant.

Table 3 Descriptive statistics of total and regional lean mass and statistical differences between males and females

Age groups (years)	TLBM(Kg)		TrLBM(Kg)		ALBM(Kg)		LLBM(Kg)	
	Males	Females	Males	Females	Males	Females	Males	Females
1(0-5)	12.8(3.4)	10.3(2.9)*	5.4(1.5)	4.1(1.4)*	2.8(0.9)	2.3(0.6)	2.3(1.3)	1.9(1.1)
2(6-10)	22.1(4.4)	20.2(4.1)	9.2(1.8)	8.2(1.8)*	3.8(0.9)	3.4(0.8)	6.2(1.9)	5.7(1.5)***
3(11-15)	39.2(13.1)	31.1(5.1)***	16.9(6.1)	13.1(2.5)***	6.4(2.5)	4.8(0.9)***	12.2(4.6)	9.8(1.9)***
4(16-20)	54.4(8.4)	31.8(4.9)***	24.2(3.9)	13.5(2.3)***	9.1(2.2)	5.0(0.9)***	16.5(3.0)	9.7(1.9)***
5(21-25)	58.0(9.1)	31.6(4.7)***	26.5(4.0)	13.4(2.1)***	9.8(3.4)	5.2(1.3)***	17.1(2.9)	9.5(1.9)***
6(26-30)	52.4(8.6)	30.8(5.0)***	23.1(5.7)	13.5(2.2)***	9.1(2.0)	4.9(0.9)***	15.6(5.3)	8.8(1.9)***
7(31-35)	53.8(9.7)	31.9(3.1)***	25.3(4.4)	14.4(1.8)***	8.7(2.0)	4.9(0.7)***	15.0(3.8)	9.1(1.1)***
8(36-40)	50.6(5.9)	30.4(3.2)***	24.4(2.3)	13.6(1.0)***	8.2(1.7)	4.8(0.8)***	13.4(2.2)	8.6(1.6)***
9(41-45)	50.5(5.6)	30.9(3.4)***	24.9(2.8)	13.7(1.8)***	7.5(1.2)	5.1(0.8)***	13.2(1.7)	8.4(1.2)***
10(46-50)	48.2(2.8)	31.4(4.1)***	24.2(1.7)	14.1(2.2)***	7.1(0.8)	5.2(1.0)***	12.6(0.8)	8.4(1.5)***
11(51-55)	50.2(5.1)	30.7(3.0)***	25.3(2.5)	13.8(1.8)***	7.8(1.3)	5.2(0.7)***	12.3(1.9)	7.8(1.0)***
12(56-60)	46.0(4.2)	30.3(4.9)***	22.3(2.6)	13.5(2.8)***	7.5(1.1)	5.7(0.8)***	11.8(2.0)	7.4(1.6)***
13(61-65)	44.8(5.0)	30.8(5.0)***	21.8(2.9)	14.0(3.0)***	7.3(1.2)	5.5(0.9)***	11.0(1.8)	7.5(1.5)***
14(66-70)	44.5(6.3)	29.6(5.6)***	21.5(3.5)	13.5(3.4)***	7.9(1.6)	5.3(1.0)***	10.4(1.6)	7.0(1.4)***
15(71-75)	43.6(2.3)	30.7(6.2)***	21.6(1.0)	14.0(3.4)***	7.1(1.0)	5.3(1.3)*	10.5(1.1)	7.6(1.8)***
16(76-80)	44.7(4.6)	28.2(1.4)***	21.4(3.0)	12.5(1.5)***	7.9(1.2)	5.3(0.8)*	11.1(1.5)	6.9(0.7)***

Data are shown as mean(standard deviation). Significant differences between males and females:* $p \leq 0.05$; *** $p \leq 0.001$

Bone mass

Age- and gender- specific means and SDs for TBMC, TrBMC, ABMC, LBMC and TBMC/H ratio are provided in Table 4. The most significant TBMC increases were seen in the first 4 age groups (0-20), coinciding with the period of maximum skeletal growth. Evolution of the TBMC/H ratio: in the first three groups (0-15), although TMBC values were higher in males, we did not find any statistically significant differences between genders. In males, TBMC increases from birth to age 25, and decreases between ages 26 to 40 when it also stabilizes. A further decrease begins at age 56. In females, TBMC increases until age 20 and then remains stable at least until age 60. However, from age 15 in males, it rises much more sharply and that increase is prolonged until a later age than in females. The maximum bone mass was measured for males between age 21 and 25 and for females between age 16 and 20. This demonstrates that females reach a peak in bone mass earlier than males. For TBMC/height ratio, there were differences in the level of significance from age 16 to 70, except in the period of age 41 to 45. The amount of TrBMC showing higher values in males at all ages: the statistically most significant gender differences ($p \leq 0.001$) were found between 16 and 25years of age. Gender differences for ABMC were seen between age 16 and 70($p \leq 0.001$) and 71-80($p \leq 0.05$). LBMC showed similar gender differences. Values were also higher in males for both arms and legs, and at all ages.

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Table 4 Descriptive statistics of total and regional bone mineral content and statistical differences between males and females

Age groups (years)	Males					Females				
	TBMC	**TrBMC**	**ABMC**	**LBMC**	**TBMC/H**	**TBMC**	**TrBMC**	**ABMC**	**LBMC**	**TBMC/H**
1(0-5)	579.59	190.46	86.14	77.17	5.49	456.03	149.95	68.41	65.34	4.56
	-214.5	-79.1	-46.2	-67.7	-1.48	-220.1	-78	-42.8	-60.2	-1.72
2(6-10)	1245.11	421.47	150.62	347.99	9.16	1214.27	410.49	137.26	366.47	8.92
	-385	-154.1	-62.1	-159.2	-2.09	-313.8	-130.3	-43	-132.7	-1.78
3(11-15)	2202.19	773.42	293.09	732.22	13.28	2261.71	839.54	274.65	744.09	14.08
	-719.1	-284.6	-148.4	-280.4	-3.07	-607.7	-271	-88.6	-220.4	-3.16
4(16-20)	3213.7	1113.84	498.4	1086.38	17.94	2605.43***	974.20***	319.06***	827.81***	15.80***
	-623.6	-266.7	-261.1	-214.5	-2.79	-469.9	-205.7	-63.5	-184.4	-2.28
5(21-25)	3600.21	1269.44	565.77	1200.25	19.63	2625.08***	997.52***	344.24***	813.09***	16.13***
	-627.5	-258.8	-208.7	-235.6	-2.78	-405.1	-173.5	-88.4	-181.7	-2.06
6(26-30)	3137.05	1101.96	475.88	1056.09	18.04	2561.28***	960.56**	322.68***	782.16***	15.95***
	-576.3	-233.7	-85	-229.8	-2.64	-486.6	-196.6	-69	-200.8	-2.42
7(31-35)	3252.14	1080.27	502.92	1116.21	18.36	2592.68***	958.37	319.90***	798.36***	16.27*
	-827.6	-318.1	-140.3	-347.1	-3.79	-382.2	-168.1	-49.1	-138	-2.27
8(36-40)	2947.86	1003.03	438.06	976.1	17.31	2559.04***	944.83	324.64***	784.00***	16.12*
	-371.6	-117.8	-71.3	-163.7	-1.78	-309.2	-143.9	-40.4	-114.6	-1.72
9(41-45)	2938.03	1031.83	421.04	979.6	17.26	2587.05*	949.6	335.98***	796.38**	16.18
	-381.1	-191.7	-55	-113.1	-1.88	-388.1	-179.3	-55	-164.2	-2.17
10(46-50)	3034.3	1050.58	442.25	1034.75	17.94	2562.05***	925.79*	328.20***	806.87***	16.12**
	-388.6	-204.8	-56.6	-147.6	-2.14	-269.4	-132.4	-32.7	-100.6	-1.54
11(51-55)	3001.12	1040.48	458.96	987.4	18.06	2521.33***	897.05	328.68***	812.47**	15.78*
	-459.8	-321.6	-65.8	-120.6	-3.14	-407.2	-193	-65.2	-169.69	-2.32
12(56-60)	2808.9	926.93	439.68	965.61	16.68	2386.89**	851.96	319.79***	785.65**	15.22*
	-331.4	-172.6	-71.6	-121.2	-1.61	-430.4	-197.6	-66.5	-158.8	-2.77
13(61-65)	2619.01	820.52	425.83	910.37	15.89	2269.27***	765.01	307.19***	758.84***	14.48**
	-388.4	-159.3	-95.3	-145.1	-2.21	-377.1	-135.2	-627	-154.1	-2.03
14(66-70)	2614.3	810.41	420.2	905.24	16.16	2206.74***	780.04	293.07***	731.88***	14.18*
	-480.7	-177.5	-99.6	-155.9	-2.78	-333.2	-155.4	-61.4	-118.4	-1.96
15(71-75)	2329.47	784.37	382.26	729.76	14.35	2098.61	723.6	256.11*	690.34	13.59
	-391.7	-121.6	-162.9	-157.4	-2.26	-344.7	-158.8	-62.4	-148.1	-2.14
16(76-80)	2512.35	796.43	454.4	815.7	15.39	1793.12*	640.71	189.80*	543.74*	11.62
	-551.8	-254.8	-149.8	-137.7	-3.5	-474.4	-171.6	-51.7	-171.5	-2.75

Data are shown as mean(standard deviation). Values in grams. Significant differences between males and females:* p≤0.05 **p≤0.01 ***p≤0.001

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Discussion

Fat mass

Fat mass is the most variable component of body composition, and between-individual variability ranges from approximately 6% to 60% of total body weight.[9] Many studies suggest there are three critical periods for the development of obesity and its complications. These include:

a. Gestation and early infancy,

b. The period of adiposity rebound that occurs between the ages of 5 and 7, and

c. Adolescence.

The obesity that begins at these periods appears to increase the risk of persistent obesity and its complications.[10] Our study of prepubertal children (ages 0 to 10) showed no gender-related differences in age-adjusted weight, height or BMI. Both %FAT and the absolute mean values of total and regional fat mass increased progressively in both genders. Although no statistically significant gender-related differences were found, the values were usually higher in girls. In addition, girls had a significantly higher proportion of fat mass than of lean mass, and larger peripheral (extremities) fat deposits.

Koo et al.[11] found an increase in fat mass in females was accompanied by a similar decrease in lean mass, which is consistent with our findings.

Subsequent studies to assess TBFM and muscle accumulation in prepubertal children using DXA yielded conflicting results. Our study showed that between the ages of 10 and 15, boys experienced an increase in the proportion of muscle mass paired with a decrease in fat mass, the process being the reverse in girls.

The distribution of fat is an accepted criterion in the prediction of cardiovascular risk for both children and adults. With regard to fat distribution, we found that females are gynecoid from birth while males are patently android from the age of 16, a finding that may be consistent with other DXA studies.[12,13]

Revilla et al.[14] found on females aged 65-80years that while TBFM decreased with age, total LBM remained unchanged. Our study showed a similar decrease in fat mass, although from the age of 70. In a previous study no significant changes in LBM were found for this age group.[6]

Douchi et al.[15] using DXA suggest that postmenopausal changes in body fat and fat distribution were more dependent on age than on menopause, in opposition to Tremóllieres et al.[16] No menopause-related differences were evidenced in our study for similar age groups.

Studies using DXA and other techniques have found that LFM seems to protect against a disturbed glucose metabolism and atherogenic lipids.[17–19] Females exhibited greater amounts of fat mass in their legs from birth. TrFM/ExFM and TrFM/LFM values between the ages of 40 and 60 were lower for females. This implies that morphological evidence for a protective factor against cardiovascular disease is present in females of these ages.

BMI serves as good surrogate marker for obesity in population studies. However, a significantly lower correlation existed for BMI vs. body fat distribution, which may be a limitation when BMI is used to study cardiovascular risk factors in epidemiological studies. In addition, the measurement of regional adiposity by DXA is potentially more accurate than anthropometry measures, and more practical and cost-effective than computed tomography or magnetic resonance imaging scans.

Lean mass

In this study, Total LBM was higher in males, although this seemed to diminish during the course of life; by contrast, females do not show a decrease in total LBM, as also occurs in Italian Caucasians.[20]

Evaluation of muscular tissue with DXA is clearly supported in medical literature.[21,22] The study of body compartments in healthy subjects is extremely important, since the relationship between other body parts and muscle has been proven. For example the influence of muscular mass and fat mass on bone mass has been the focus of many research projects concluding that patients with smaller amounts of muscular and adipose tissues also have a smaller bone mass, bone mineral content and bone mineral density, as has been clearly evidenced in boys and girls during growing stages.[23]

Some investigators reported males are generally more muscular than females in all age groups.[24] Progressive growth in lean mass in males may stop at earlier ages than indicated by us.[25] On the other hand, it would seem clear that a reduction of muscular mass among the elderly[26] has a significant impact on physical function and the state of these persons' health: it has been confirmed that moderate physical exercise is highly beneficial for those over 70.[27–29]

The gender differences for trunk muscle tissue are similar to those shown for a Japanese population, although gender differences for arms and legs muscle tissue do not appear in the study of Ito et al until age 20.[30]

It is known that recovery of total body weight of patients with Graves' disease, following adequate treatment, takes place at the expense of reestablishment of trunk and limb muscle mass,[31] so it is of particular interest to have some normal reference values. This is another example of the increasingly numerous clinical applications of assessed muscular mass using DXA;[32,33] a technique that has recently been employed on peritoneal dialysis patients,[34] on women carrying a silicone mammary prostheses[35] and on young patients suffering from Crohn's disease.[36]

Bone mass

In adults, 80% of the skeleton is cortical bone. However, the relative proportions of cortical and trabecular bone vary in different parts of the skeleton. DXA measurements do not distinguish between cortical and trabecular bone.

There is no evidence for gender differences in bone mass of either the axial or appendicular skeleton at birth. This absence of a substantial gender difference in bone mass is maintained until 3years.[37] There is some divergence in prepubescent boys between 6 and 11.[38]

Bone mineral status during childhood is a strong predictor of bone mineral status in the axial and appendicular skeletons in young adulthood. Therefore bone mass measurements may be useful for early identification of children at risk for osteoporosis later in life.[39]

The marked increase demonstrated in bone mineral content during adolescence and youth in our Caucasian population overlaps with that of Asians.[40]

There are a number of studies which corroborate that bone mass peak is reached earlier in females than in males[41] and we agree with Buchanan et al.,[42] that bone mass loss does not begin until after age 20.

BMC values in Spanish males correlate with those obtained by Wittich et al.[43] using a Lunar-DPX in normal males aged between 25 and 30. For the same age range and for both genders, the mean values we obtained for TBMC and regional figures for the head, trunk and lower limbs varied little in relation to other results published which were also secured using a Norland XR-26.[44] TBMC reduction in females from age 60 onward was also observed in other studies.[45] These studies also found significantly lower values in young subjects, in both males and females. We therefore affirm that bone mineral content in females has little variation after the fertile time of their lives. Other authors, also studying Spanish females with the same densitometer, are in agreement with us.[44] Thus, it is very important to encourage the building of a good bone mass in females before the age of 20, so as to avoid many of the problems caused by osteoporosis. For males, the incidence of osteoporotic fractures is much lower, since their geometry and bone mass provide them with a larger and more compact skeleton.[46] On the other hand, our data are primarily based on chronological age, and thus do not account for the TBMC in relation to years since menopause.

Conclusion

Contrary to males, females showed from early infancy a smaller proportion of muscle mass and a higher proportion of body fat (from the age of 10), with fat deposits being mostly peripheral. With age, females showed a greater increase in the adipose compartment paired with an accelerated loss in the muscular compartment. Both proportions tended to level out between the ages of 51 and 65.

The gender differences with respect to the total lean body mass appear to start in adolescence, with the lean body mass of the trunk being significantly greater in males at all ages. Its increase stops earlier in females compared to males. At adult age the onset of muscle loss occurs earlier in males.

TBMC shows significant gender differences between birth and 70years of age. TBMC increases up to 20years age in females and up to 25years age in males. Therefore, the normal densitometric values presented offer useful information as a reference for comparison of populations of different genetic makeup and environmental influences. Similarly, densitometric values have proved to be useful for revealing the state of the skeleton during growth, adult life and ageing.

Dual-energy X-ray absorptiometry (DXA) makes it possible to detect differences in body compartments during the life cycle, as well as it shows clear differences between males and females at any age and in different races or population groups.

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None.

Conflict of interest

The author declares that there is no conflict of interests.

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