Body composition assessment using DXA in six-year-old children: the 2004 Pelotas Birth Cohort, Rio Grande do Sul State, Brazil

Composição corporal avaliada por DXA aos seis anos de idade: Coorte de Nascimentos de Pelotas de 2004, Rio Grande do Sul, Brasil

La composición corporal evaluada por DXA a los seis años de edad: cohorte de nacimientos en Pelotas, 2004, Río Grande do Sul, Brasil

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Abstract

The aim of this study was to describe fat (FM) and lean body mass (LBM) in six-year-old children from the 2004 Pelotas Birth Cohort, stratified by gender. Dual-Energy X-ray Absorptiometry was used to measure FM and LBM, FM and LBM indexes, and percentage (%) of FM and LBM. Mean measures of adiposity were higher among girls (6.3kg, 4.2kg/m² and 23.4% vs. 5kg, 3.3kg/m² and 18%) while LBM measures were higher among boys (19.3kg, 13kg/m² and 78.5% vs. 17.7kg, 12.2kg/m² and 73.2%). In both boys and girls mean measures of adiposity increased with socioeconomic status and maternal education. Mean measures of adiposity were higher among white-skinned children while %LBM was higher among black-skinned children. Preterm compared to full-term children showed lower mean measures of adiposity and LBM. Female sex, white skin color and higher socioeconomic conditions are associated with higher adiposity in childhood.

Body Composition; Child; Longitudinal Studies

Resumo

O objetivo deste estudo foi descrever as massas gorda (MG) e magra (MM) em crianças de seis anos de idade na Coorte de Nascimentos de Pelotas de 2004, Rio Grande do Sul, Brasil, estratificadas por sexo. Dual-Energy X-ray Absorptiometry foi usado para medir MG e MM, índices de MG e MM e percentuais (%) de MG e MM. Médias de adiposidade foram maiores entre as meninas (6,3kg, 4,2kg/m² e 23,4% vs. *5kg, 3,3kg/m² e 18%), enquanto as medidas de MM foram maiores entre os meninos (19,3kg, 13kg/m² e 78,5%* vs. *17,7kg, 12,2kg/m² e 73,2%). Em meninos e meninas as médias de adiposidade aumentaram com o nível socioeconômico e escolaridade materna. Médias de adiposidade foram maiores entre crianças de cor branca, enquanto %MM foi maior entre as de cor preta. Crianças pré-termo mostraram menores médias de adiposidade e MM, em comparação com nascidas a termo. Sexo feminino, cor branca e condições socioeconômicas mais elevadas estão associados à maior adiposidade na infância.*

Composição Corporal; Criança; Estudos Longitudinais

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Introduction

The assessment of body composition in children especially body fat measures has become a focus of scientific research for its ability to detect early changes that may potentially have long-term harmful health effects. Physical changes that occur rapidly in the postnatal period and throughout childhood and adolescence continue at a slower rate into adult life [1]. These changes are apparent both internally and externally throughout childhood and adolescence: body proportion, height, weight and pubertal stage can easily be assessed by means of physical examination and anthropometric measures. To assess internal changes including hormone levels and body composition, however, appropriated methods are required [2]. The approaches currently available for the assessment of body composition are categorized as direct (analysis of cadavers), indirect (densitometry, plethysmography, hydrodensitometry and underwater weighing) and doubly indirect (bioelectrical impedance and anthropometric measures) [3].

The increase in prevalence of obesity, including in childhood, has led to a number of studies on the theme, mainly in developed and in European countries [4,5,6]. In general, these studies showed that greater adiposity in infancy and childhood was associated to female sex [4,5,6,7,8,9], white skin color [7,9,10,11], higher birth [4,12] and current weight [12,13,14], higher pre-gestational maternal [4,7,15] and paternal body mass index [14,16], maternal smoking in pregnancy [15,16,17], and shorter duration of breastfeeding [6,18], whereas the role of socioeconomic conditions is controversial at the literature [7,14,16,19,20]. No studies were found in countries such as Brazil, where epidemiological and nutritional transitions are still playing out [21,22], leaving a gap with regard to the effect of these transitions on body composition in childhood. So, this study aimed to describe fat and lean body mass measurements in six-year-old children from the 2004 Pelotas Birth Cohort, in Southern Brazil.

Subjects and methods

Since the perinatal study in 2004 there were five follow-ups (at 3, 12, 24, 48 and 72 months) of all cohort subjects. Details on the study methods are available elsewhere [23]. The fifth follow-up was from October 2010 to August 2011 when the cohort children were six to seven years old. A total of 3,722 children (90.2% of the original cohort) were followed up, of which 3,556 (95.5%) attended a visit at the study clinic. Of these, 3,437 underwent an assessment of body composition by Dual Energy X-ray Absorptiometry (DXA). Over two thirds of the children (n = 2519) were evaluated at the clinic while 1,037 were initially evaluated at home (when height and weight measures were taken) as they were not brought in by their mothers/guardians after the study visit had been rescheduled more than three times. They then attended a visit at the clinic for the assessment of body composition. The sample studied consisted of 3,373 children excluding twins (n = 64). Outcome measures were obtained using a DXA with enCORE software platform (Lunar Prodigy, GE Healthcare, USA). The children wore light, fitted clothing (shorts and sleeveless shirts; no metal accessories) and a trained technician took all measurements with children in the supine position.

The dependent variables studied included fat mass (FM) and lean body mass (LBM) in kg; fat mass index (FMI) and lean body mass index (LBMI) in kg/m²; and percentage of fat mass (%FM) and percentage of lean body mass (%LBM). All measures in kg were adjusted for body weight obtained in a high precision scale (0.01kg resolution) (model BWB-627-A, Tanita Corporation, Japan, modified by Life Measurement, Inc., USA). This adjustment was calculated as follows:

$$FM_{ajusted} \text{ or } LBM_{ajusted} = \left(\frac{FM \text{ or } LBM}{TBM}\right) \times Weight$$

Where:
FM: fat mass directly provided by DXA (kg)
LBM: lean mass directly provided by DXA (kg)
TBM: total body mass resulting from the sum of (FM + LM + bone mass), directly provided by DXA (kg)
Weight: obtained from a high precision scale (kg)

FMI and LBMI were calculated by dividing the adjusted FM or LBM by height in m². FMI and LBMI were used because children can have different percentages of FM due to different absolute amounts of FM but equivalent amounts of fat free mass (FFM) or different absolute amounts of FFM and same amounts of FM. The normalization of these measures for height squared (kg/m²) may improve the sensitivity to detect changes in body composition measurements [24]. Height was measured at the clinic using a stadiometer with a precision of 1mm and maximum capacity of 2.06m (Harpenden, Holtain, Crymych, UK), and at home using a stadiometer with a precision of 1mm and maximum capacity of 2.13m (Alturexata, Belo Horizonte, Brazil). At the clinic, two independent examiners took at least two height measures and the *average* of the *two* values was recorded, when the difference between the two measures was greater than 0.7cm [25] (n = 73). The %FM and %LBM were directly provided by the equipment with no adjustment: FM or LBM divided by TBM, multiplied by 100. Of 3,373 children, 71 did not have weight measures in a high precision scale, 38 did not have height measures and seven did not have either weight or height measures. Thus, there was FM or LBM data for 3,295 children and FMI or LBMI data for 3,257 children.

The independent variables were derived from information collected in the perinatal study. The socioeconomic index was constructed through principal component analysis based on information about consumer goods and education of the head of the family [26] divided into five socioeconomic quintiles for the city of Pelotas (Q1 lower; Q5 upper). Maternal education level was determined according to the number of full years at school. Gestational age was obtained from the algorithm as proposed by the National Center for Health Statistics (NCHS) [27]. It was estimated from the last menstrual period date (LMPD) when this data was consistent with height, weight and head circumference measures at birth and the parameters of normal growth curves for each GA [28]. When LMPD was unknown or inconsistent, gestational age was estimated from ultrasound examination (up to 20 weeks) if available or from the Dubowitz clinical maturity score calculated in all newborns [29]. Data on skin color of the child was collected at age six reported by the respondent of the questionnaire (usually the mother). Birth weight and length were obtained using electronic pediatric scales with a precision of 10g and infantometers with a precision of 1 mm (Harpenden, Holtain, Crymych, UK), respectively.

The statistical analyses were performed using Stata version 12.0 (Stata Corp., College Station, USA). The analysis of variance was carried out to assess means and standard deviations (SDs) of each outcome by gender. Tests of linear trend and heterogeneity were used according to the variable category. Nonparametric tests were performed when the assumption of homogeneity has not been met. In addition, 95% confidence intervals (95%CI) were calculated. The quality of data collected during the fifth follow-up was ensured by a set of actions taken prior to and during the fieldwork including training of interviewers and equipment technicians, standard examination procedures and weekly meetings with the supervisor. During the perinatal study, data quality control included a small survey administered at home or in the hospital to check interview status [23].

This study was approved by the Research Ethics Committee of the University of Pelotas Medical School. All mothers/guardians signed an informed consent form prior to the interview.

Results

The mean age of the 3,373 children followed up was 80.4 ± 2.4 months. At birth, 23% of these children were in the lower quintile of socioeconomic index and 43% of the mothers had nine years of formal education or more. More than two thirds of the mothers reported having white-skinned children. As for gestational age, 12.3% were preterm children (less than 37 weeks of gestation) (Table 1). In general, boys were bigger than girls at birth, they had greater birth weight ($p < 0.0001$) and birth length ($p < 0.0001$); this difference was also seen at age six for height ($p < 0.0001$), but not for weight ($p = 0.1$) (Table 2). Girls had higher mean adiposity measures (FM, %FM and FMI) compared to boys while boys had higher mean LBM. FM range (minimum and maximum) was similar in boys and girls but girls showed on average an excess 1.3kg of fat compared to boys. After adjusting for height, this difference was smaller with a mean value of 0.9kg/m² greater in girls. Regarding the percentage of body fat, a 5.4 higher percentage was seen in girls compared to boys (Table 2). The range of LBM and LBMI was similar in both boys and girls, but boys had higher means (1.6kg and 0.8kg/m² higher, respectively) than girls. As for %LBM, boys showed greater minimum and maximum values that were on average 5.3% higher than those from girls (Table 2). Weight and height measures in boys and girls age six were positively associated with maternal education levels and socioeconomic index. With respect to skin color, there was a difference in mean height in boys. Compared to full-term children (37 to 41 weeks of gestation), preterm children or those born at 41 weeks of gestation or more were shorter (Table 3).

Mean FM, %FM and FMI in both girls (Table 4), and boys (Table 5) increased with socioeconomic index and maternal education level. Children who were poor at birth had lower FM at age six compared to those who were in a more advantageous position. Among girls, greater differences were observed between Q1 and Q4; those in the upper position showed on average 2.1kg, 4.9% and 1.1kg/m² higher FM, %FM and FMI, respectively, than those in the lower one. Among boys, greater differences were seen between Q1 and Q5; those in the upper position had on average 3.0kg, 7.8% and 1.7kg/m² higher FM, %FM and FMI, respectively, than those in the lower one. Mean LBM increased in the same direction while %LBM showed an inverse association, with greater values among poor children and those born to less educated mothers. In general, mean adiposity measures were higher among white children with a statistically significant differ-

Table 1

Description of the study independent variables, overall and by gender. The 2004 Pelotas Birth Cohort, Pelotas, Rio Grande do Sul State, Brazil, 2013. (N = 3,373).

Variables	Girls		Boys		Overall	
	n	%	n	%	n	%
Socioeconomic Index						
Q1 (20-280)	375	23.1	395	22.7	770	22.9
Q2 (281-367)	356	21.9	357	20.6	713	21.2
Q3 (368-475)	368	22.7	390	22,.5	758	22.6
Q4 (476-618)	260	16.0	291	16.8	551	16.4
Q5 (619-999)	264	16.3	304	17.5	568	16.9
Maternal education (years)						
0-4	244	15.2	260	15.0	504	15.1
5-8	686	42.6	714	41.2	1,400	41.9
9-11	543	33.7	578	33.4	1,121	33.5
12 or more	138	8.6	180	10.4	318	9,5
Skin color						
White	1,094	67.7	1,150	67.1	2,244	67,4
Black	186	11.5	231	13.5	417	12,5
Brown	237	14,7	252	14.7	489	14,7
Other	99	6.1	82	4.8	181	5,4
Gestational age (weeks)						
< 34	32	2.0	39	2.2	71	2,1
34-36	171	10.5	174	10.0	345	10,2
37-41	1,318	80.9	1,421	81.6	2,739	81,3
> 41	108	6.6	108	6.2	216	6,4

* Minimum and maximum values of socioeconomic index score in each category.

ence in FM and FMI among boys and %FM and FMI among girls. The %LBM was greater among black-skinned children. Lower mean FM, %FM, FMI and LBM were found in preterm children compared to those born at 37 to 41 weeks of gestation (Tables 4 and 5).

Discussion

The most important *strengths of the current study* lie in the use of population-based data, low loss to follow-up rates and use of DXA, a valid method for the assessment of body composition in children [30]. The main weakness of this study was the fact that anthropometric measures taken in different settings could have resulted in different height measures. The equipment used and number of measurements was not the same at the clinic and at home. However, a comparison of mean heights of children taken at the clinic and at home showed similar measures in both boys ($p = 0.8$) and girls ($p = 0.3$).

Several studies using DXA assessed children across a wide age range and therefore presented their results as total estimates or by age group but not at individual ages [5,10,31,32]. The analysis of mean FM and LBM including children across a wide age range in the same group makes it difficult to compare our results to those of other studies since the measurements of body composition vary substantially throughout childhood [2,33]. Yet, a review of the literature showed that, throughout childhood (age 0 to 9 years) and in many different countries, girls had higher mean adiposity measures than boys, while boys showed greater mean LBM and LBMI [4,5,6,7,8,9]. Our results support these previous findings.

Mean %FM among boys and girls (respectively, 18% and 23.4%) were equivalent to those observed among British children (boys at centile 75 and girls in between centiles 85 and 91) at six years of age [34]. Mean FM estimates (boys: 5.0 ± 3.9kg and girls: 6.3 ± 4.2kg) found in this study were similar to those found in eight-year-old Chinese children with normal weight (boys: 5.2

Table 2

Means and standard deviations of anthropometric variables and body composition measures. The 2004 Pelotas Birth Cohort, Pelotas, Rio Grande do Sul State, Brazil, 2013. (N = 3,373).

Variable (unit)	Girls				Boys				p-value
	n	Mean ± SD	Minimum	Maximum	n	Mean ± SD	Minimum	Maximum	
Birth weight (g)	1,630	3,140.9 ± 497.3	900	5,265	1,743	3,247.5 ± 522.5	950	5,995	0.0001 *
Birth height (cm)	1,624	47.9 ± 2.4	27.5	55.8	1,736	48.7 ± 2.5	35.0	58.8	< 0.0001 **
Weight *** at age 6 (kg)	1,595	24.3 ± 6.0	13.6	58.0	1,700	24.7 ± 5.8	14.3	60.4	0.02 **
Weight # at age 6 (kg)	1,595	24.8 ± 6.1	14.2	58.9	1,700	25.1 ± 5.8	14.7	60.8	0.1 **
Height at age 6 (m)	1,612	1.20 ± 0.06	1.04	1.41	1,716	1.22 ± 0.06	1.05	1.45	< 0.0001 **
FM ## (kg)	1,595	6.3 ± 4.2	0.9	29.1	1,700	5.0 ± 3.9	0.8	29.4	0.0001 *
FMI ## (kg/m²)	1,578	4.2 ± 2.5	0.7	17.6	1,679	3.3 ± 2.3	0.6	16.4	0.0001 *
%FM (%)	1,630	23.4 ± 9.4	5.9	53.0	1,743	18.0 ± 9.2	4.5	50.2	< 0.0001 **
FM ### (kg)	1,595	6.2 ± 4.1	0.8	28.7	1,700	4.9 ± 3.9	0.8	29.0	0.0001 *
FMI ### (kg/m²)	1,578	4.1 ± 2.5	0.7	17.4	1,679	3.2 ± 2.3	0.5	16.3	0.0001 *
LM ## (kg)	1,595	17.7 ± 2.3	12.1	28.4	1,700	19.3 ± 2.3	13.2	30.0	0.0001 **
LMI ## (kg/m²)	1,578	12.2 ± 0.9	9.9	17.2	1,679	13.0 ± 0.9	10.3	17.0	0.0001 **
%LM (%)	1,630	73.2 ± 9.1	44.2	90.8	1,743	78.5 ± 9,0	46.9	91.7	< 0.0001 **
LM ### (kg)	1,595	17.3 ± 2.3	11.6	27.9	1,700	19.0 ± 2.4	12.9	29.8	< 0.0001 **
LMI ### (kg/m²)	1,578	11.9 ± 0.9	9.4	16.9	1,679	12.8 ± 0.9	10.0	16.8	< 0.0001 **

FM: fat mass; FMI: fat mass index; %FM: percentage of fat mass; LM: lean mass; LMI: lean mass index; %LM: percentage of lean mass.

* Test of homogeneity (non-parametric);

** Test of homogeneity (parametric);

*** Sum of parts from DXA;

From high precision scale;

Adjusted for high precision scale;

Directly provided by DXA.

± 1.6kg; girls: 6.2 ± 1.9kg) (p = 0.9 for both boys and girls) [35]. However, in comparison with Chinese children at the age of seven, children from the Pelotas cohort showed mean measures 1.5kg and 2.5kg higher in boys and girls, respectively [35]. Mean FMIs in our study were similar to those reported in Chinese children age seven and eight, except for girls who showed higher FMI at age seven in Pelotas [35].

A study with Korean children [8] found lower mean FMs in both boys and girls age six to seven compared to our results. FMs were 3.1kg and 3.5kg lower in Korean boys and girls, respectively, compared to mean values found in the Pelotas children. When children aged seven were compared, this difference became less remarkable, decreasing to 1.6kg in boys and 2.7kg in girls [8]. Mean LBM, %LBM and LBMI were higher in boys than girls, which is consistent with findings from other studies [6, 8, 9, 19].

Mean LBM measures found in Pelotas children (boys: 19.3 ± 2.3kg; girls: 17.7 ± 2.3kg) were similar to those reported in Korean children aged six (boys: 19.4 ± 1.4kg; girls: 17.9 ± 1.7kg) [8]. A New Zealand study with children [9] with mean age of eight among boys and mean age of seven among girls reported slightly higher means (boys: 21.8 ± 5.5kg; girls: 18.8 ± 3.7kg) compared to our study. However, after adjusting for height (boys: 13.1 ± 0.9kg/m²; girls: 12.3 ± 0.7kg/m²), these means were close to those found in Pelotas (boys: 13.0 ± 0.9kg/m²; girls: 12.2 ± 0.9kg/m²) [9]. Nevertheless, population data should be interpreted with caution, as there are no reference curves for body composition measurements obtained by DXA. The differences in means across countries could be associated with genetic and environmental factors.

White boys had higher mean FM, %FM and FMI compared to all other categories, with a larger difference seen between white and black children. These findings are in agreement with the literature; studies conducted in different settings with children at different stages of development found higher mean FM among white compared with black children [7,10,11]. Among girls, no statistically significant difference in mean FM was seen according to skin color. White girls

Table 3

Mean weight and height in children at age six, according to independent variables. The 2004 Pelotas Birth Cohort, Pelotas, Rio Grande do Sul State, Brazil, 2013. (N = 3,373).

Variables	Girls				Boys			
	n	Weight	n	Height	n	Weight	n	Height
Socioeconomic index		p < 0.0001 *		p < 0.0001 **		p < 0.0001 *		p < 0.0001 **
Q1 (lower)	366	23.3 (22.7, 23.9)	367	1.19 (1.18, 1.19)	380	23.1 (22.6, 23.6)	387	1.20 (1.19, 1.20)
Q2	351	24.4 (23.7, 25.0)	351	1.20 (1.20, 1.21)	344	24.6 (24.0, 25.2)	349	1.21 (1.21, 1.22)
Q3	361	25.0 (24.4, 25.6)	367	1.20 (1.20, 1.21)	385	25.4 (24.8, 26.0)	383	1.22 (1.12, 1.22)
Q4	255	26.5 (25.6, 27.3)	258	1.22 (1.21, 1.23)	288	25.9 (25.2, 26.6)	289	1.23 (1.22, 1.23)
Q5 (upper)	255	26.0 (25.2, 26.7)	262	1.22 (1.21, 1.22)	297	27.5 (26.8, 28.2)	302	1.24 (1.23, 1.24)
Maternal education (years)		p < 0.0001 **		p < 0.0001 **		p < 0.0001 *		p < 0.0001 **
0-4	238	23.6 (22.8, 24.5)	240	1.19 (1.18, 1.19)	255	23.2 (22.6, 23.8)	256	1.20 (1.19, 1.20)
5-8	673	24.4 (23.9, 24.8)	681	1.20 (1.19, 1.20)	690	24.4 (24.0, 24.8)	698	1.21 (1.20, 1.21)
9-11	530	25.5 (25.0, 26.1)	535	1.21 (1.21, 1.22)	570	26.4 (25.9, 27.0)	573	1.23 (1.22, 1.23)
12 or more	136	26.6 (25.6, 27.6)	137	1.22 (1.21, 1.23)	175	26.7 (25.8, 27.5)	178	1.24 (1.23, 1.24)
Skin color		p = 0.6 ***		p = 0.7 ***		p = 0.1 ***		p = 0.04 ***
White	1,069	25.0 (24.6, 25.3)	1083	1.20 (1.20; 1,21)	1122	25.4 (25.0, 25.7)	1135	1.22 (1.21, 1.22)
Black	183	24.4 (23.5, 25.3)	183	1.21 (1.20; 1,21)	225	24.8 (24.0, 25.6)	226	1.22 (1.21, 1.22)
Brown	231	24.6 (23.8, 25.3)	234	1.20 (1.20, 1.21)	245	24.7 (23.9, 25.4)	247	1.21 (1.20, 1.21)
Other	98	24.6 (23.4, 25.8)	98	1.20 (1.19, 1.21)	81	24.5 (23.3, 25.6)	81	1.21 (1.20, 1.23)
Gestational age (weeks)		p = 0.002 #		p = 0.0001 ***		p < 0.0001 ***		p = 0.0002 ***
< 34	32	23.0 (21.1, 24.9)	31	1.17 (1.15, 1.19)	36	22.5 (20.5, 24.5)	39	1.19 (1.17, 1.21)
34-36	169	23.5 (22.7, 24.2)	168	1.19 (1.18, 1.20)	172	23.8 (22.9, 24.7)	171	1.21 (1.20, 1.22)
37-41	1287	25.1 (24.8, 25.5)	1304	1.21 (1.20, 1.21)	1386	25.5 (25.1, 25.8)	1399	1.22 (1.22, 1.22)
> 41	106	24.2 (23.2, 25.3)	108	1.20 (1.18, 1.21)	105	24.3 (23.3, 25.3)	106	1.20 (1.19, 1.22)

* Test for linear trend (non-parametric);

** Test for linear trend (parametric);

*** Test of homogeneity (parametric);

Test of homogeneity (non-parametric).

showed higher mean %FM and FMI, with a larger difference observed between white and black girls, which corroborate the findings of other studies [7,10,11].

The highest means %LBMs was seen among black boys and girls. Studies that measured LBM using DXA found marked differences throughout childhood between white and black children,

Table 4

Mean fat mass (FM) and mean lean body mass (LBM) in girls, according to the study independent variables. The 2004 Pelotas Birth Cohort, Pelotas, Rio Grande do Sul State, Brazil, 2013. (N = 3,373).

Variables	kg			%			kg/m²		
	n	FM	LM	n	FM	LM	n	FM	LM
Socioeconomic index		p < 0.0001 *	p < 0.0001 **		p < 0.0001 **	p < 0.0001 **		p < 0.0001 **	p = 0,8 ***
Q1 (lower)	366	5.3	17.2	375	20,8	75.7	359	3.7	12,2
		(4.9, 5.7)	(17.0, 17.5)		(19.9, 21.2)	(74.8, 76.5)		(3.4, 3.9)	(12,1, 12,3)
Q2	351	6.0	17.6	356	22.6	73.9	346	4.0	12,2
		(5.5, 6.4)	(17.3, 17.8)		(21.7, 23.6)	(73.0, 74.9)		(3.7, 4.3)	(12,1, 12,2)
Q3	361	6.4	17.7	368	24.0	72.5	360	4.4	12,2
		(6.0, 6.9)	(17.5, 17.9)		(23.1, 24.9)	(71.7, 73.4)		(4.1, 4.6)	(12,1, 12,3)
Q4	255	7.4	18.2	260	25.7	71.0	253	4.8	12,2
		(6.8, 7.9)	(17.9, 18.5)		(24.5, 26.8)	(69.8, 72.1)		(4.5, 5.2)	(12,1, 12,3)
Q5 (upper)	255	7.0	18.0	264	25.2	71.4	253	4.6	12,2
		(6.5, 7.6)	(17.8, 18.3)		(24.0, 26.3)	(70.3, 72.5)		(4.3, 5.0)	(12,0, 12,3)
Maternal education (years)		p < 0.0001 **	p < 0.0001 *		p < 0.0001 **	p < 0.0001 **		p < 0.0001 **	p = 0,2 ***
0-4	238	5.5	17.3	244	21.0 (19.8, 22.1)	75.6 (74.5, 76.7)	234	3.8 (3.4, 4.1)	12,3 (12,2, 12,4)
		(4.9, 6.0)	(17.0, 17.7)						
5-8	673	6.0	17.5	686	22.9	73.6	669	4.1	12.1
		(5.7, 6.3)	(17.3, 17.7)		(22.2, 23.6)	(72.9, 74.3)		(3.9, 4.3)	(12.1, 12.2)
9-11	530	6.7	18.0	543	24.5	72.1	522	4.5	12.2
		(6.4, 7.1)	(17.8, 18.1)		(23.7, 25.3)	(71.4, 72.9)		(4.3, 4.7)	(12.1, 12.3)
12 or more	136	7.4	18.3 (18.0, 18.7)	138	25.8	70.8	135	4.8	12.2
		(6.6, 8.1)			(24.2, 27.4)	(69.3, 72.4)		(4.4, 5.3)	(12.1, 12.4)
Skin color		p = 0.07 ***	p = 0.6 ***		p = 0.002 ***	p = 0.003 ***		p = 0.04 ***	p = 0.6 ***
White	1,069	6.5	17.6	1,094	24.0	72.6	1,059	4.4	12.2
		(6.2, 6.7)	(17.5, 17.8)		(23.4, 24,5)	(72.1, 73.2)		(4.2, 4.5)	(12.1, 12.2)
Black	183	5.7	17.9	186	21.4	75.1	180	3.8	12.3
		(5.1, 6.3)	(17.5, 18.2)		(20.1, 22.7)	(73.8, 76.3)		(3.5, 4.2)	(12.1, 12.4)
Brown	231	6.0	17.7	237	22.5	74.0	228	4.1	12.2
		(5.5, 6.5)	(17.5, 18.0)		(21.3, 23.7)	(72.8, 75.1)		(3.7, 4.4)	(12.1, 12.3)
Other	98	6.2	17.6	99	23.0	73.6	97	4.1	12.2
		(5.3, 7.1)	(17.2, 18.0)		(21.0, 25.1)	(71.5, 75.6)		(3.6, 4.7)	(12.0, 12.4)
Gestational age (weeks)		p = 0.003 #	p = 0.0005 ***		p = 0.01 ***	p = 0.01 ***		p = 0.01 #	p = 0.5 ***
< 34	32	5.5	16.7	32	21.9	74.6	31	3.9	12.2
		(4.2, 6.8)	(16.1, 17.4)		(18.6, 25.2)	(71.3, 77.9)		(3.1, 4.7)	(11.9, 12.5)
34-36	169	5.4	17.2	171	21.4	75.1	167	3.7	12.1
		(4.9, 6.0)	(16.9, 17.5)		(20.1, 22.7)	(73.8, 76.4)		(3.4, 4.0)	(12.0, 12.2)
37-41	1,287	6.5	17.8	1,318	23.8	72.8	1,273	4.3	12.2
		(6.2, 6.7)	(17.7, 17.9)		(23.2, 24.3)	(72.3, 73.3)		(4.2, 4.5)	(12.2, 12.2)
> 41	106	6.0	17,4	108	22.7	73.8	106	4.1	12.1
		(5.2, 6.7)	(17.0, 17.8)		(20.9, 24.5)	(72.0, 75.5)		(3.6, 4.5)	(12.0, 12.3)

* Test for linear trend (non-parametric);

** Test for linear trend (parametric);

*** Test of homogeneity (parametric);

Test of homogeneity (non-parametric)

with higher means seen among black ones [7,10]. The present study found a mean difference of 0.2kg and 0.3kg of LBM between white and black boys and girls, respectively, but it was not statistically significant.

Mean adiposity measures showed a positive association with socioeconomic variables (socioeconomic index and maternal education level); higher means were seen in boys and girls from better-off families and born to mothers that were

Table 5

Mean fat mass (FM) and mean lean body mass (LBM) in boys, according to the study independent variables. The 2004 Pelotas Birth Cohort. Pelotas, Rio Grande do Sul State, Brazil, 2013, 2013. (N = 3,373).

Variables		**kg**			**%**			**kg/m²**	
	n	**FM**	**LM**	**n**	**FM**	**LM**	**n**	**FM**	**LM**
Socioeconomic index		p < 0.0001 *	p < 0.0001 **		p < 0.0001 *	p < 0.0001 *		p < 0.0001 *	p = 0.8 ***
Q1 (lower)	380	3.6	18.6	395	14.3	82.1	374	2.5	13.0
		(3.3, 3.9)	(18.4, 18,9)		(13.6, 15.0)	(81.4, 82.8)		(2.3, 2.6)	(13.0, 13.1)
Q2	344	4.5	19.2	357	16.6	79.8	339	3.0	13.0
		(4.1, 4.9)	(19.0, 19.5)		(15.7, 17.5)	(78.9, 80.7)		(2.7, 3.2)	(12.9, 13.2)
Q3	385	5.2	19.3	390	18.8	77.7	379	3.4	13.0
		(4.9, 5.6)	(19.0, 19.5)		(17.9, 19.8)	(76.8, 78.6)		(3.2, 3.7)	(12.9, 13.1)
Q4	288	5.4	19.6	291	19.2	77.3	286	3.5	13.0
		(5.0, 5.9)	(19.3, 19.8)		(18.1, 20.3)	(76.2, 78.3)		(3.2, 3.8)	(12.9, 13.1)
Q5 (upper)	297	6.6	20.0	304	22.1	74.5	295	4.2	13.0
		(6.1, 7.1)	(19.7, 20.2)		(21.0, 23.2)	(73.4, 75.5)		(3.9, 4.5)	(12.9, 13.1)
Maternal education (years)		p < 0.0001 *	p < 0.0001 **		p < 0.0001 *	p < 0.0001 *		p < 0.0001 *	p = 0.7 ***
0-4	255	3.7	18.7	260	14.7	81.8	251	2.5	13.0
		(3.3, 4.1)	(18.4, 18.9)		(13.8, 15.6)	(80.9, 82.6)		(2.3, 2.7)	(12.9, 13.1)
5-8	690	4.5	19.1	714	16.7	79.7	679	3.0	13.0
		(4.2, 4.7)	(18.9, 19.2)		(16.1, 17.3)	(79.1, 80.4)		(2.8, 3.1)	(13.0, 13.1)
9-11	570	5.9	19.7	578	20.3	76.2	565	3.8	13.0
		(5.5, 6.2)	(19.5, 19.9)		(19.5, 21.1)	(75.4, 77.0)		(3.6, 4.0)	(12.9, 13.1)
12 or more	175	5.9	19.9	180	20.2	76.3	174	3.7	13.0
		(5.3, 6.5)	(19.5, 20.2)		(18.9, 21.6)	(75.0, 77.6)		(3.4, 4.1)	(12.8, 13.1)
Skin color		p = 0.0001 #	p = 0.3 ***		p = 0.2 ***	p < 0.0001 ***		p = 0.0001 #	p = 0.02 ***
White	1,122	5.2	19.3	1150	18.9	77.7	1,109	3.4	13.0
		(5.0, 5.4)	(19.1, 19.4)		(18.3, 19.4)	(77.1, 78.2)		(3.3, 3.5)	(12.9, 13.0)
Black	225	4.4	19.5	231	15.3	81.1	221	2.8	13.1
		(3.8, 4.9)	(19.2, 19.8)		(14.1, 16.5)	(79.9, 82.3)		(2.5, 3.2)	(13.0, 13.2)
Brown	245	4.7	19.1	252	16.9	79.5	243	3.1	13.1
		(4.2, 5.2)	(18.8, 19.4)		(15.8, 18.1)	(78.3, 80.6)		(2.8, 3.4)	(13.0, 13.2)
Other	81	4.4	19.2	82	16.4	80.0	80	2.9	13.1
		(3.6, 5.1)	(18.7, 19.7)		(14.7, 18.1)	(78.3, 81.7)		(2.5, 3.3)	(12,9. 13,3)
Gestational age (weeks)		p = 0.001 ***	p < 0.0001 ***		p = 0.3 ***	p < 0.0001 ***		p = 0.0007 ***	p = 0.002 ***
< 34	36	3.7	18.0	39	14.1	82.2	36	2.4	12.7
		(2.5, 4.9)	(17.1, 18.9)		(11.5, 16.7)	(79.7, 84.7)		(1.8, 3.1)	(12.5, 13.0)
34-36	172	4.1	18.8	174	15.5	80.9	169	2.7	12.8
		(3.5, 4.7)	(18.4, 19.2)		(14.3, 16.8)	(79.6, 82.1)		(2.4, 3.1)	(12.7, 12.9)
37-41	1,386	5.2	19.4	1,421	18.5	78.0	1,370	3.4	13.1
		(4.9, 5.4)	(19.3, 19.5)		(18.0, 18.9)	(77.6, 78.5)		(3.2, 3.5)	(13.0, 13.1)
> 41	105	4.5	18.9	108	16.9	79.6	103	3.0	13.0
		(3.9, 5.2)	(18.5, 19.3)		(15.1, 18.6)	(77.9, 81.2)		(2.6, 3.4)	(12.8, 13.2)

* Test for linear trend (non-parametric);

** Test for linear trend (parametric);

*** Test of homogeneity (parametric);

\# Test of homogeneity (non-parametric).

more educated. Mean LBM also increased with socioeconomic index and maternal education level; however, after adjusting for height, these differences disappeared. These results suggest that, similar to LBM, height also increased with socioeconomic index and maternal education levels in both boys and girls. A study with children from the Soweto birth cohort in South Africa [19] found only an association of mean LBM with maternal marital status (higher mean LBM in children of mothers living with a partner). But children from households that owned television sets and a car and in which no family member was unemployed showed higher mean FMI in late childhood [19].

Socioeconomic conditions assessed through household income did not show any association with FM in US children at age five [7]. However, studies that used type of parental employment to assess socioeconomic level found higher mean adiposity measures and fat-free mass among children of parents with less specialized-skill occupations [14,20]. Studies that used parental education level as a socioeconomic indicator found different associations with adiposity measures during childhood: a negative association with maternal and paternal education level [16]; a negative association with paternal education only [20]; and lack of association [7]. When assessed, LBM measures did not show any association with socioeconomic indicators [20].

Mean adiposity measures were significantly lower among preterm children. An association between prematurity and mean LBM was seen in boys and girls, but it remained significant only in boys after adjusting for height. Means in late preterm (34 to 36 weeks of gestation) for boys and girls were closer to those seen in preterm children born at less than 34 weeks of gestation than to those seen in full-term children, which is consistent with a disadvantaged nutritional status described in these children [36]. It is well established that preterm children have lower levels of FM at birth [13], a state that can be attributed to reduced fat deposition which occurs largely in the last trimester of pregnancy. This reduced fat content seems to persist throughout childhood [37]. Magnetic resonance imaging studies have suggested that preterm children have a more central distribution of fat tissue [38] suggesting that this state persists in later years [39].

In conclusion, despite of the fact that Brazil is in epidemiological and nutritional transitions, this study confirms the difference between child sexes and emphasizes the important role of skin color over body composition as reported from other countries. Although prevalence of overweight/obesity (> +1 SD of BMI Z-score) is high among children from all SES stratum (25% among the poorest and 48% among the richest from the 2004 Pelotas Birth Cohort) the finding of this study raises the hypothesis that better socioeconomic conditions may contribute to increased adiposity in childhood. There is still a dearth of studies concerned with the long-term consequences of body composition due to prematurity.

Resumen

El objetivo de este estudio fue describir la masa grasa (MG) y la masa libre de grasa (MLG), estratificadas por sexo en niños de seis años de edad, dentro de una cohorte de nacimientos de 2004 en Pelotas,. La absorciometría de doble fotón (DXA por sus siglas en inglés) fue utilizada para medir la MG y la MLG, los índices de MG y MLG, y el porcentaje (%) de MG y MLG. Las medias de adiposidad fueron mayores entre las niñas (6,3kg, 4,2kg/m² y 23,4% vs. 5,0kg, 3,3kg/m² y 18%), mientras que las medidas de MLG fueron mayores entre los niños (19,3kg, 13kg/m² y 78,5% vs. 17,7kg, 12,2kg/m² y 73,2%). En niños y niñas, las medias de adiposidad aumentan con el nivel socioeconómico y la educación materna. Las medias de adiposidad fueron mayores entre niños de piel blanca, mientras que el %MLG fue mayor entre los de piel negra. Los prematuros presentaron medias más bajas de adiposidad y MLG, en comparación con el resto. El sexo femenino, color de piel blanca y condiciones socioeconómicas más altas están asociados a una mayor adiposidad en la niñez.

Composición Corporal; Niño; Estudios Longitudinales

Contributors

R. V. Zanini designed and developed this research study, conducted data collection, analyzed the data, prepared the manuscript draft, was responsible for reviewing its content and read and approved the final manuscript. I. S. Santos designed and developed this research study, conducted data collection, prepared the manuscript draft and read and approved the final manuscript. D. P. Gigante designed and developed this research study, prepared the manuscript draft and read and approved the final manuscript. A. Matijasevich, F. C. Barros and A. J. D. Barros conducted data collection and read and approved the final manuscript. F. C. Barros conducted data collection and read and approved the final manuscript.

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