

Body fat percentage in adolescents from Curitiba-PR metropolitan region: reference data using LMS method

Percentual de gordura corporal em adolescentes de Curitiba-PR e região metropolitana: dados de referência utilizando o método LMS

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Abstract – Percentile indicators, aided in its development by biomedical engineering, relative to body fat distribution in adolescents are able to help health professionals in better diagnosing overweight and obesity. The aim of this study was to calculate percentile values to body fat in adolescents aged between 12 and 17 years from the Curitiba-PR and its metropolitan region composed of 29 municipalities, having as reference method the dual energy x-ray absorptiometry (DXA) technology. After applying inclusion criteria for the adolescents, anthropometric measures of body fat and stature were taken, as well as evaluation of the body composition through DXA. The statistical analysis was grounded in the presentation of percentilic values developed by Cole and Green's LMS method, where L stands for the skewness curve, M for the mean curve and S for the variance curve. In total, 390 boys were evaluated. The fat percentage values tend to show a decrease between the ages of 12 ($22.8 \pm 5.1\%$) and 16 years ($17.9 \pm 2.9\%$). Moreover, for the superior percentiles: 90th and 97th re-start to increase at the age of 17 after showing a decrease in the previous years. The L, M and S parameters, altogether with the percentiles created to evaluate body fat are interesting tools to tendency and evolution analyses, as well as to enable inferences to be made about the body composition of adolescents.

Key words: Adolescents; Body composition; Body fat distribution.

Resumo – Indicadores percentílicos referentes a distribuição da gordura corporal em adolescentes auxiliam profissionais da saúde em um melhor diagnóstico de sobrepeso e obesidade. O objetivo deste estudo foi calcular valores percentílicos para a gordura corporal de adolescentes com idades entre 12-17 anos de Curitiba-PR e região metropolitana formada ao todo por 29 municípios, tendo como método de referência a tecnologia de absorciometria de raios-X de dupla energia (DXA). Após a aplicação dos critérios de inclusão os adolescentes foram coletadas medidas antropométricas de massa corporal e estatura, além da avaliação da composição corporal com auxílio da DXA. A análise estatística teve como base a apresentação de valores percentílicos a partir do método LMS de Cole e Green, onde L representa a curva de assimetria, M a curva da média e S a curva da variação. Foram avaliados 390 meninos. Os valores de percentual de gordura tendem a apresentar um decréscimo entre as idades de 12 ($22.8 \pm 5.1\%$) e 16 anos ($17.9 \pm 2.9\%$). Além disso, para os percentis superiores: 90th e 97th voltam a crescer na faixa de 17 anos após redução nas idades anteriores. Os parâmetros L, M e S e os percentis criados para percentual de gordura são ferramentas interessantes para análises de tendência e evolução, bem como para que se façam inferências sobre a composição corporal de adolescentes.

Palavras-chave: Adolescentes; Composição corporal; Distribuição gordura corporal.

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Received: April 17, 2018
Accepted: July 14, 2018



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INTRODUCTION

The excess of fat mass in adolescents is widely related to the appearance of clinical evidence, such as: coronary heart diseases¹, respiratory problems², type 2 diabetes³ and psycho-social complications⁴. Regarding its diagnosis, several direct and indirect methods are applied in clinical practice of body fat assessment. Furthermore, the body-mass index (BMI), the skinfold thickness (ST) and the bioelectrical impedance analysis (BIA) are the most common methods applied to children and adolescents⁵⁻¹³.

Another technique that ought to be highlighted is the dual energy x-ray absorptiometry (DXA), based in photons' attenuation measure, generated by X-ray sources, in low and high density tissues, and it is also considered, in various situations, as a reference method to the evaluation of body composition¹⁴⁻¹⁶.

Related to the chosen technique, another important factor is the creation of reference curves to present body fat values to teenagers, specially to aid at diagnosis¹⁷⁻¹⁹. In countries like Brazil, where more than two thirds of the population use the public and free health system, the absence of a proper classification of children and adolescents who are overweight or obese might delay the diagnosis and consequent treatment of this condition, resulting in additional costs with comorbidity factors²⁰.

Therefore, this study aims to present percentile values to body fat from Curitiba-PR metropolitan region, aged between 12 and 17, through the use of the DXA technology as a reference method.

METHODOLOGICAL PROCEDURES

This research's data were collected by convenience throughout the years of 2014 and 2016, and included male adolescents, students, aged between 12 and 17 years, whose parents authorized their participation signing a consent term. For the sample size, an error of 4.5% was specified at 91% confidence level of a universe of 82,414 individuals obtained through the national Brazilian database system (data of 2013 - Datasus). From this research were excluded: a) students whose parents did not consent; b) did not make use of medicines containing calcium; c) students who had undergone radiography/CT scan procedures up to seven days prior to the evaluation²¹. The subjects of the study were gathered from public and private schools, as well as sports training centers from Curitiba-PR and its metropolitan region composed of 29 municipalities. Data was collected via suitably trained professionals.

Body mass was collected using a mechanical scale and the height was measured with the aid of a stadiometer attached to the scale (Filizola, São Paulo, Brazil). The evaluation via DXA was made through the use of a Hologic Discovery A fan-beam scan type (Hologic, Inc., Bedford, USA). In this evaluation, the individuals were positioned in supine position on the scanner. Metal objects such as earrings, necklaces or rings were not allowed,

neither were permitted clothing that had any kind of metal on it. The DXA functioning for the evaluation of body composition is related to the capacity of technology to analyze low and high-density tissue simultaneously, which would lead to a reduction in errors of body fat estimation. In this way, the x-ray attenuation differences allow the body to be divided into fat, non-bone tissue and bone. The body fat percentage (%BF) was obtained automatically by the equipment's software according to specifications of the study's age range.

The data were presented with mean and standard deviations values to the group, and segmented by age. The construction of the percentiles was made using the LMS method by Cole and Green^{21,22}, where L is the skewness curve, M is the mean curve and S is the variance curve. These three parameters were fit as cubic splines by nonlinear regression, and the extent of smoothness required is expressed in terms of equivalent degrees of freedom. Centiles are computed by using the values of the three parameters to a given age with the formula:

$$C_{100\alpha} = M(1 + L \times S \times z_{\alpha})^{1/L}$$

Where: z_{α} is the α -th centile to the distribution. The statistical analysis and further chart generation were performed using the LMS Chartmaker Pro Version 2.54 software program (Cambridge, UK)²².

This study was approved by the ethics committee *Plataforma Brasil* under the number: 11583113.7.0000.5547 at *Universidade Tecnológica Federal do Paraná*, in agreement with rules constant on the Resolution 196/96 from the National Health Council (Conselho Nacional de Saúde). All parents or legally responsible signed a consent term authorizing the participation of the adolescents.

RESULTS

In total, 390 adolescents were evaluated. The descriptive analysis to body fat percentage by age is shown in Table 1. The values of %BF decreased between the ages of 12 (22.8±5.1%) and 16 (17.9±2.9%) years.

Table 1. Descriptive of sample. Mean and standard deviation for body fat percentage in adolescents (12-17 years).

Age(years)	n	Weight (kg)	Height (m)	BMI (kg/m ²)	Body Fat %
12	31	55,65±16.14	1,60±0.13	21,26±4.04	27.2±6.4
13	51	56,93±12.62	1,66±0.12	20,36±2.57	22.8±5.1
14	81	59,78±10.61	1,71±0.07	20,37±2.89	19.3±3.6
15	74	61,73±10.81	1,72±0.08	20,79±2.65	19.2±4.1
16	84	62,27±9.73	1,72±0.08	20,85±2.39	17.9±2.9
17	69	66,70±10.01	1,74±0.06	22,09±2.69	19.0±4.5

The smoothed age-specific percentiles and the corresponding parameters are shown in Table 2 and in Figure 1. The mean parameter decreases until the age of 17 years, a body fat progressive fall due to the age. From this point onwards, the upper centiles 90th and 97th start to rise again.

Table 2. L, M and S values, and percentile of body fat percentage for adolescents aged 12 to 17 years.

Age (y)	L	M	S	3th	10th	25th	50th	75th	90th	97th
12	0.04	28.46	0.22	18.71	21.40	24.50	28.46	33.02	37.71	42.97
13	-0.78	23.64	0.20	17.10	18.80	20.85	23.64	27.17	31.25	36.48
14	-1.53	19.93	0.17	15.31	16.47	17.90	19.93	22.65	26.10	31.18
15	-2.02	18.33	0.16	14.55	15.49	16.66	18.33	20.65	23.72	28.68
16	-2.19	17.69	0.15	14.17	15.04	16.13	17.69	19.87	22.80	27.70
17	-2.20	17.44	0.16	13.90	14.77	15.86	17.44	19.66	22.90	27.97

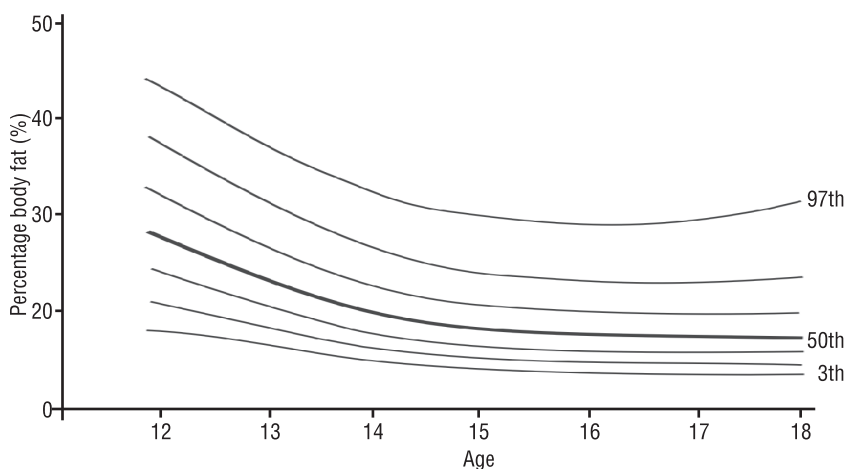


Figure 1. Smoothed LMS percentile curves for body fat percentage. Curves are for 3th, 10th, 25th, 50th, 75th, 90th, and 97th percentiles for male adolescents.

Figures 2 A and B illustrate a comparison between the 50th and the 90th percentiles from this study and researches involving U.S., Korean and Turkish adolescents. In the 50th percentile the greatest values occur in adolescents aging 12 years, with tendency to decrease the body fat at the ages of 13, 14 and 15 years in all studies.

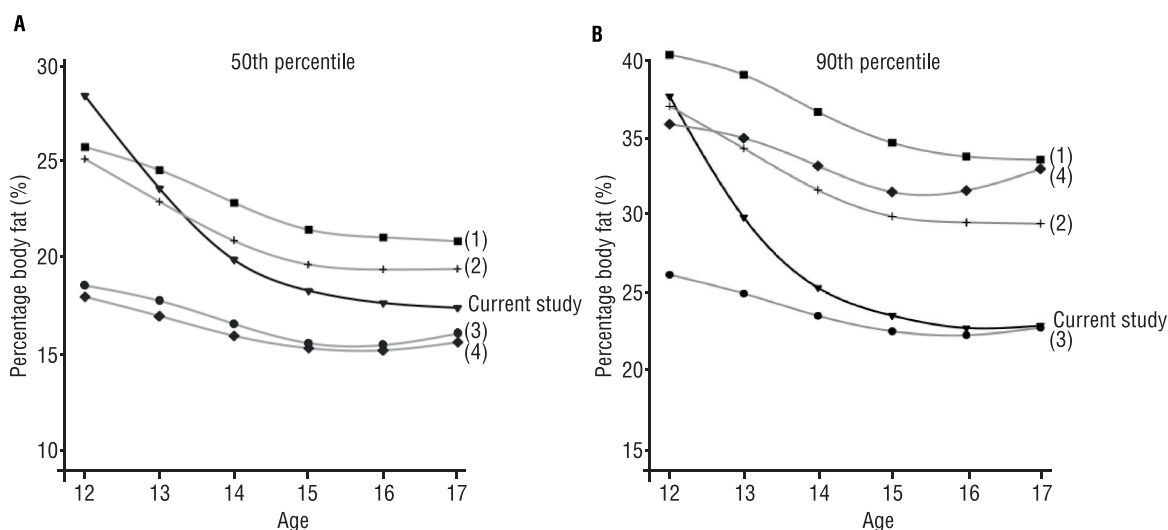


Figure 2. The comparison of the 50th (A) and 90th (B) percentiles curves of Brazil, USA, and Korean. (1) Odgen et al.23 with U.S sample; (2) Park et al.11 with Korean sample; (3) Kortuglu et al.9 with Turkish sample based on BIA; (4) Laurson, Eisenmann and Welk8 with U.S sample based on ST.

The values that were found in the 90th percentile do not show any regularity in their behavior.

DISCUSSION

There are no findings regarding other studies utilizing DXA combined with LMS analysis to generate percentile curves to Brazilian adolescents (12 to 17 years). It should be noted that about 50% of the body mass is obtained during the teenage hood. As a consequence, its monitoring becomes important to the development of actions that might contribute to the health of this population²³. Moreover, using the LMS method to create reference curves has been widely done around the globe, as it removes the skewness of the distribution.

Around the world, studies of reference values based on fat percentage of children and adolescents obtained through ST were related in Germany (3-18 years)⁵; Canada (6-19 years)⁷; United States (5-18 years)⁸; Turkey (6-18 years)⁹; Brazil (7-10 years old)¹⁹ and India (10-19 years)¹¹. On the other hand, studies that used DXA were found of the population of Denmark (8-14 years)²; United States (8-19 years)²⁵ and Korea (10-18 years)¹⁰ (10-19 years)¹¹.

For those who had DXA as a reference: Park et al.¹¹ evaluated 689 asian teenagers aged between 12 and 16 years who reported a decrease of the %BF in this age range, as shown in our results. In the 50th percentile the values varied from 25.2% to 19.4%; in the 90th percentile the values varied between 37.1% and 29.5%. In an epidemiologic study with 2.642 north-American adolescents, Odgen et al.² also identified a reduction in the %BF values in the 50th and 90th percentiles in the age range, 25.8–20.9% and 40.4–33.8%, respectively. In this study the values varied between 27.22–17.45% (50th percentile) and 37.71–22.80% (90th percentile). The %BF values reduction could be explained could be explain by the physiological tendency to increase the lean mass and reduce the fat mass of puberty¹¹. Corroborating this information, a North American study of 8,269 children and adolescents (5 to 18 years) found that the peak of %BF was in the range of 11-12 years for boys with subsequent decrease in ages²⁶. Another factor to be highlighted is the variability of the samples' profile, where different countries have different ethnic and anthropometric characteristics which can influence the percentile curves²⁷. Strengthening the need for different distribution curves for different countries.

Regarding the creation of Brazilian reference values there should be highlighted Conde and Monteiro's¹³ study, in which values were proposed based on the BMI of 26.102 people aging between 2 and 19 years, collected in the national study. However, to use this index as an indicator to overweight and obesity should be done carefully, since the technique applied is not able to differentiate muscular mass from lean mass²⁸.

In addition, two other researches proposed the monitoring of corporal composition through the ST measures in different regions of the country: one in the south-east region with 2.135 boys (10-15 years)⁶; another in the north-

east region with 2.352 individuals (1.129 between 12-16 years)²⁹. Despite in all studies the LMS method was used to generate reference curves, the tools chosen to obtain the %BF limit the comparison to this present study.

Silva, Baxter-Jones and Maia²⁹ found smaller values of all ages and percentiles compared to this study. The 50th percentile values are: 12.60% (12 years), 12.00% (13 years), 11.23%(14 years), 10.89%(15years) and 10.98% (16 years). Whereas Cintra et al.⁶ present values that are close to this study, 16.4% (50th percentile) and 29.7% (90th percentile), considering a group of 909 individuals aging between 13 and 15 years. As to the ST, authors report that this method's limitation is primarily due to the evaluator's hability, given that their experience is a fundamental factor on the collected data precision. Moreover, the second reason is that the obtention of the body fat percentage depends on the choice of a great variety of equations that might make the results less precise^{16, 30}.

The DXA provides better results for the %BF estimate when compared to anthropometric techniques such as BMI, ST or BIA^{10,14,16}. In fact, all methods have limitations and some measurement error in the evaluation of %BF, however the advantages of indirect laboratory tests include good accuracy and reproducibility²⁸. Thus, the use of DXA for development of reference curves for body fat may represent an advancement in how health professionals interpret body composition, strengthening the data presented in this study.

Nevertheless, some limitations ought to be raised in this research. Firstly, the fact that the sample does not represent the whole Brazilian population nor a whole region, to each age. Secondly, the maturity state of the adolescents is not controlled, even though it contributes to body fat changes.

CONCLUSION

In conclusion, the parameters L, M and S, and the percentiles created to body fat percentage are interesting tools to tendency and evolution analyses, as well as to infer about nutritional status of adolescents. Due to the fact Brazil is a country of continental dimensions, it is strongly advised constant evaluation and correction of the reference parameters of fat percentage in Brazilian children and teenagers, specially since this phase is critical as to the acquisition of anthropometric characteristics.

COMPLIANCE WITH ETHICAL STANDARDS

Funding

This research was funded by Research Program of *Sistema Único de Saúde: Gestão Compartilhada em Saúde* PPSUS - edition 04/2012.

Conflict of interest statement

The authors have no conflict of interests to declare.

Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee at *Universidade Tecnológica Federal do Paraná* under the number: 11583113.7.0000.5547, and the protocol was written in accordance with the standards set by the Declaration of Helsinki.

Author Contributions

Conceived and designed the experiments: WLR, LU. Performed the experiments: WLR and EM. Analyzed the data: WLR. Contributed reagents/materials/analysis tools: LU. Wrote the paper: WLR and EM.

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