

Establishing a normative table for classifying body fat percentage in adolescents

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Abstract

Background: The World Health Organization (WHO) recommends the use of the body mass index (BMI) as a cost-effective method to assess the nutritional status at the population level. The increase of BMI is linked to a higher risk of other chronic non-communicable diseases (NCDs), particularly hypertension, type 2 diabetes mellitus (T2DM), dyslipidemias, and some types of cancer. The prevalence of obesity has increased worldwide, and this condition has dramatically affected children and adolescents. Obesity at a young age increases the chances of severe obesity and its complications in adults.

Objective: This study aimed to establish cut-off points for body fat percentage in male and female adolescents aged 16 to 18 years using bioelectrical impedance (InBody 570®).

Methods: Gender specific tables were proposed based on the percentiles 3, 5, 10, 15, 25, 50, 75, 85, 95 and 97. A total of 546 adolescents were included.

Results: The body fat percentage cut-off points for the male group were: P3 = 6.0-7.0%; P5 = 7.1-8.9%; P10 = 9.0-9.8%; P15 = 9.9-11.7%; P25 = 11.8-15.5%; P50 = 15.6-21.9%; P75 = 22.0-27.8%; P85 = 27.9-36.0%; P95 = 36.1-38.0% and P97 ≥ 38.1%. For females, the cut-off points were: P3 = 9.5-10.0%; P5 = 10.1-11.0%; P10 = 11.1-11.8%; P15 = 11.9-14.0%; P25 = 14.1-19.0%; P50 = 19.1-27.1%; P75 = 27.2-29.0%; P85 = 29.1-39.9%; P95 = 40.0-51.0% and P97 ≥ 51.0%.

Conclusion: The establishment of cut-off points for body fat percentage may improve the clinical assessment and management of overweight and obese adolescents.

Keywords: adiposity, adolescent health, body composition, body mass index, bioelectrical impedance.

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Authors summary

Why was this study done?

The researchers identified specific cut-off points for body fat percentage using percentiles 3, 5, 10, 15, 25, 50, 75, 85, 95, and 97 in male and female Brazilian adolescents. Besides that, the researchers identified moderate, strong, and very strong correlations among body mass index, body fat percentage, fat mass, neck circumference, and waist circumference in female and male Brazilian adolescents.

What did the researchers do and find?

The researchers identified specific cut-off points for body fat percentage using percentiles 3, 5, 10, 15, 25, 50, 75, 85, 95, and 97 in male and female Brazilian adolescents. Besides that, the researchers identified moderate, strong, and very strong correlations among body mass index, body fat percentage, fat mass, neck circumference, and waist circumference in female and male Brazilian adolescents.

What do these findings mean?

These findings could help medical doctors, nutritionists, physiologists, and other health professionals manage overweight and obesity with body composition parameters (e.g., body fat percentage) and not only anthropometrical measures, such as body mass index.

INTRODUCTION

The World Health Organization (WHO) recommends the use of the body mass index (BMI) as a cost-effective method to assess the nutritional status at the population level¹. The increase of BMI is linked to a higher risk of other chronic non-communicable diseases (NCDs), particularly hypertension, type 2 diabetes mellitus (T2DM), dyslipidemias, and some types of cancer². The prevalence of obesity has increased worldwide, and this condition has dramatically affected children and adolescents^{3,4}. Obesity at a young age increases the chances of severe obesity and its complications in adults⁵. Therefore, health promotion actions to improve the population's quality of life and promote healthy longevity are desirable and inevitable.

Despite the epidemics, following the authors' knowledge, there is no international consensus on the cut-off point of body fat percentage (BFP) for Brazilian adolescents. Also, BMI contains significant flaws at the individual level because it cannot identify body composition⁵. For instance, BMI can only evaluate the effects of combined physical activity and dietary intervention programs^{6,7}. The application of physical activity, especially resistance exercises, promotes an increase in musculoskeletal mass (MME) and a reduction of the body fat mass (FM) without significant changes in the BMI⁷. The consequent decrease in BFP can improve health parameters in overweight or obese adolescents independent of the BMI^{6,7}. Hence, BMI can be considered a non-specific method to assess the changes induced by a resistance training program.

The success of an obesity treatment program in adolescents can be evaluated by assessing the improvement of cardiorespiratory fitness, reduction of FM, reduction of BMI z-score, improvement of health-related quality of life scores (inferred from the HRQoL questionnaire), increased lean mass (LM) and reduced waist circumference (WC)⁴. The World Health Organization⁸ and the Brazilian Association for the Study of Obesity and Metabolic Syndrome⁹ suggest that the percentiles and the BMI z-score are the leading indicators of the nutritional status of children and adolescents. On the other hand, Cole *et al.*^{10,11} presented specific cut-off points for healthy status classification based on children and adolescents' BMI. Neither measurement take into consideration the BFP and may misclassify some individuals.

Hence, a study that included percentiles for the

BFP in adolescents of both genders could inform the health professionals involved in adolescents' nutritional assessment. Since most methods used in professional practice are double indirect methods, e.g., skinfold thickness, bioelectrical impedance analysis (BIA), and others; because of this, the construction of a normative table with data from BIA that has high reproducibility may improve the nutritional assessment of young people in the clinical practicing². Thus, the present study aimed to develop a normative table for the classification of BFP in adolescents.

METHODS

Participants

This study shows a cross-sectional and observational design. We included 546 adolescents aged 16 years until 18 years and 11 months (16 years, n= 75; 17 years, n= 75; 18 years, n= 148, totaling 298 female adolescents) and (16 years, n= 62; 17 years, n= 61; 18 years, n= 123, totaling 246 male adolescents). As an inclusion criterion was accepted: (1) adolescents between 16-18 years old; (2) residents in metropolitan Maringá's region and (3) municipal or state students of Maringá city. As an exclusion criteria: (1) adolescent athletes; (2) female adolescents menstruated; (3) pregnant adolescents; (4) enrolled adolescents in private schools; (5) adolescents that lived outside of metropolitan Maringá's region, and (6) wheelchair users, people with quadriplegia, patients with musculoskeletal diseases, and degenerative diseases, were not accepted in this study. As for nutritional status, the female sample showed 65% within the normal BMI standard, 23% overweight, and 7% obese. Of the males, 68% were within the normal BMI standard, 24% were overweight, and 8% were obese. The research followed all the recommendations proposed in resolution 466/2012 of the Ministry of Health and the Declaration of Helsinki. Informed written consent was obtained from all parents and adolescents. This study was approved by the Ethics and Research Committee of the local committee under number 2,505.200/2018.

Data collection

The data collection occurred between March/2019 until September/2019 and was performed in three public schools of Maringá/PR. Firstly, the school's direction was contacted. After the contact, the parents or guardians and the adolescents were informed about the present study's

objectives. Medical clearance was performed with an interview with personal and family history, pre-existing diseases, physical activity level, and general health conditions. Subsequently, the adolescents received a folder with information about pubertal development and BIA protocol. Twenty-four hours after, the adolescents performed anthropometric and body composition analyses.

Anthropometry

Stature was measured using a wall stadiometer (Standard ES2030, Sao Paulo, Brazil), with a measuring field of 2.20 meters. The adolescent stood with the heels together for the measurement, the spine aligned, and the heels, buttocks, shoulders, and head against the wall aligned to the Frankfurt plane [12]. Body weight was measured using the tetrapolar bioelectrical impedance (BIA) of eight tactile points (model 570, In Body, Seoul, Korea). The adolescent was instructed to remain barefoot, loading body weight equally on both feet and wearing light clothes for weighing, such as shorts and a t-shirt. BMI was calculated by dividing body weight in kilograms by stature in meters squared, according to WHO [1]. Neck circumference (NC) and WC were measured following Heyward's [13] indications. It was used BFP, FM, and BMI of BIA results. All adolescents and guardians were informed about the necessary procedures for the assessment of body composition mean by BIA: (a) fasting for 4 hours, without consuming any solid or liquid food; (b) evacuation before the measurement; (c) not practicing moderate or vigorous physical activity 24 hours before the measurement; (d) not taking diuretic drugs seven days before the measurement; (e) not ingesting caffeine 24 hours before the measurement; (f) not having a pacemaker installed, (g) menstruating female adolescents were invited to evaluate after their menstrual period and (h) pregnant adolescents were excluded from the present study [2].

Tanner stage

The Tanner stage was applied to identify male and female adolescents' pubertal levels. This scale is divided into five classifications, following pubertal development¹⁴. The adolescents carried out a folder with photos of pubertal

development, and in subsequent days, they informed the researchers about their respective pubertal stages.

Statistical analysis

After the data tabulation, the percentiles were calculated: P3, P5, P10, P15, P25, P50, P75, P85, P95, and P97. The WHO's adapted cut-off points¹² were used to classify percentiles in adolescents, and a previous proposal for the classification of BFP was elaborated by Branco *et al.*². The participants were included in the statistical analysis and separated by age and sex, according to Cintra *et al.*¹⁵. Besides, the data normality was tested utilizing the Kolmogorov-Smirnov test. After normality confirmation, the BMI, FM, BFP, NC, and WC were correlated using the Pearson correlation, assuming a $p \leq 0.05$. The correlations were classified: 0.00-0.10 [negligible correlation]; >0.10 to ≤ 0.39 [weak correlation]; ≥ 0.40 to ≤ 0.69 [moderate correlation]; ≥ 0.70 to ≤ 0.89 [strong correlation] and ≥ 0.90 to 1.00 [very strong correlation]; conforming Schober *et al.*¹⁶. All analyses were performed in the Statistica 12.0 software (TIBCO, Palo Alto, CA, USA).

RESULTS

75% of female adolescents were classified in the fifth stage, and 25% were in the fourth stage of pubertal development. 68% of male adolescents were classified in the fifth stage, and 32% were in the fourth stage of pubertal development. Table 1 shows the cut-off points for the BFP in female adolescents aged 16 to 18 years old (n= 298) in bioelectrical impedance.

Table 2 shows the cut-off points for BFP in male adolescents aged 16 to 18 years old (n= 246) in bioelectrical impedance.

Table 3 shows the correlation matrix between BMI, absolute fat mass, BFP, neck circumference, and waist circumference in female (n = 298) adolescents aged 16 to 18 years old.

Table 4 shows the correlation matrix between BMI, absolute fat mass, BFP, neck circumference, and waist circumference in male (n = 246) adolescents aged 16 to 18 years old.

Table 1: Cut-off points for the body fat percentage in female adolescents aged 16 to 18 years (n= 298) in bioelectrical impedance.

Percentiles	P3	P5	P10	P15	P25	P50	P75	P85	P95	P97
BFP (%)	9.5	10.1	11.1	11.9	14.1	19.1	27.2	29.1	40.0	≥ 51.0

Note: BFP = body fat percentage.

Table 2: Cut-off points for the body fat percentage in male adolescents aged 16 to 19 years (n= 246) in bioelectrical impedance.

Percentiles	P3	P5	P10	P15	P25	P50	P75	P85	P95	P97
BFP (%)	6.0	7.1	9.0	9.9	11.8	15.6	22.0	27.9	36.1	≥ 38.1

Note: BFP= body fat percentage.

Table 3: Correlation matrix between body mass index, absolute fat mass, body fat percentage, neck circumference, and waist circumference in female adolescents aged 16 to 18 years (n = 298).

Variables	BMI	BFP	FM	NC	WC
BMI	1	r = 0.81* strong	r = 0.96* very strong	r = 0.93* very strong	r = 0.94* very strong
BFP	r = 0.81* strong	1	r = 0.90* very strong	r = 0.74* strong	r = 0.85* strong
FM	r = 0.97* very strong	r = 0.90* very strong	1	r = 0.92* very strong	r = 0.97* very strong
NC	r = 0.93* strong	r = 0.74* strong	r = 0.92* very strong	1	r = 0.95* very strong
WC	r = 0.94* very strong	r = 0.85* very strong	r = 0.97* very strong	r = 0.95* very strong	1

Note: BMI = body mass index; BFP = body fat percentage; FM = fat mass; NC = neck circumference; WC = waist circumference; * = p<0.01.

Table 4: Correlation matrix between body mass index, absolute fat mass, body fat percentage, neck circumference, and waist circumference in male adolescents aged 16 to 18 years (n = 246).

Variables	BMI	BFP	FM	NC	WC
BMI	1	r = 0.84* strong	r = 0.92* very strong	r = 0.74* strong	r = 0.93* very strong
BFP	r = 0.81* strong	1	r = 0.94* very strong	r = 0.47* moderate	r = 0.89* strong
FM	r = 0.92* very strong	r = 0.94* very strong	1	r = 0.67* moderate	r = 0.94* very strong
NC	r = 0.74* strong	r = 0.47* moderate	r = 0.67* moderate	1	r = 0.75* strong
WC	r = 0.93* very strong	r = 0.89* strong	r = 0.94* very strong	r = 0.75* strong	1

Note: BMI = body mass index; BFP = body fat percentage; FM = fat mass; NC = neck circumference; WC = waist circumference; * = p<0.01.

DISCUSSION

Given the need to determine cut-off points for the BFP classification in male and female adolescents between 16 and 18 years old, the BIA was used with the proposition of 10 cut-off points based on percentiles already used in previous studies with adolescents¹⁵ and adults². According to the authors' knowledge, the applicability of establishing cut-off points via BIA is highly relevant since the literature is still silent concerning the application of cut-off points for the classification of BFP in male and female adolescents in the age range in question². The cut-off points denote values from the 3rd percentile, representing low values, to the 97th percentile, indicating too high. In this regard, the BFP classification proposal is recommended for both sedentary and physically active adolescents. In the sample used, adolescent athletes were not included.

BMI has been used worldwide to classify nutritional status to identify possible health risks for adolescents¹⁴ since obesity is associated with a higher risk of T2DM, dyslipidemias, and hypertension¹⁷. However, Nuttal⁵ concludes that BMI is a low indicator for quantifying BFP as BMI does not distinguish body composition in different human body regions. Therefore, on individual analysis, BFP has been advocated to reduce the diagnosis of false positives and negatives since BMI can over

or underestimate the BFP in some cases. To minimize eventual diagnostic errors, we recommend using different anthropometric indexes to verify general and central obesity in adolescents since the correlations observed presented a strong correlation between BFP and BMI, FM, NC, and WC in female and male adolescents. This condition suggests that several anthropometric variables are correlated with excessive fatness conditions.

On the other hand, Pelegrini *et al.*¹⁸ point out that BMI, waist-to-height ratio (WHR), and WC can be good anthropometric indicators for quantifying obesity in adolescents. However, the same authors argue that body composition assessment through skinfolds is more accurate than anthropometric measurements. One must remember that skinfolds' significant limitation is that this method depends on evaluator training to provide precise measurements¹⁹. In general, BIA seems to be a relevant tool since the standardization necessary to assess the body composition precisely requires only compliance with the protocol^{2,13}.

The BMI cannot identify significant body composition changes caused by nutritional intervention and physical exercise. This question is particularly evident with resistance exercise programs that increase MME and reduce FM in adolescents^{6,7}. Consequently,

neither the body weight nor BMI may show a significant reduction despite the increase in MME and decrease in FM, and considerable decrease of BFP^{6,7}. Thus, BFP is a more accurate method for determining body composition changes than BMI. Most studies that measured BFP in Brazilian adolescents used different ways to evaluate body composition. To our knowledge, this is the only study assessing BFP in this population using BIA. In comparison to other Brazilian studies using skinfolds²⁰ and dual-energy x-ray absorptiometry²¹, our adolescents have similar BFP at percentile 50th²⁰ but much higher BFP at 87th and 97th. This condition may be explained by the different methodologies and populations included.

The study by Escobar-Cardoso *et al.*²² aimed to establish cut-off points for BFP in Colombian adolescents measured via BIA (model BF-689, Tanita, Tokyo, Japan). The authors mentioned above have determined the 90th percentile, equivalent to 23.4–28.3% of BFP, as the cardiovascular risk threshold for male children and adolescents. The cut-off value for high cardiovascular risk ranged from 31.0–34.1% for female children and adolescents. In our study, the adolescents' 90th percentile's absolute values were higher, already in the 85th percentile. Such divergences may refer to the sample's equipment used and specific characteristics. Corroborating the points indicated above, the literature points out that the various types of BIA equipment may differ between them, which may be related to the frequencies of the equipment (mono frequential and multifrequency, with some devices, only doing an extracellular reading, while others do both); the readings (i.e., extra, and intracellular) and the number of poles: bipolar or tetrapolar, with 2 to 8 tactile points^{23–25}.

It is also noteworthy that the cut-off points proposed in the study by Branco *et al.*² for the BFP classification, with young Brazilian adults, suggested that the 50th percentile is equivalent to the range from overweight to class I obesity. This question reflects the Brazilian government's latest population estimates, which show that more than 50% of

the adult Brazilian population is overweight or obese²⁶. In congruence with the Brazilian Institute of Geography and Statistics²⁷, values greater than the 85th percentile and less than the 97th percentile are classified as overweight. In contrast, values above the 97th percentile are categorized as obese for children and adolescents. Therefore, because of the sample that analyzed adolescents within the normal standards for BMI – even those classified as overweight or obese within the percentiles established by the WHO²⁸ – it is identified that overweight and obese states have increased their prevalence the Brazilian population²⁹.

Finally, we consider the strong points in our research: (1) the possibility of classifying female and male adolescents by BFP, not only by BMI classification; (2) the possibility of analyzing BFP behavior during nutritional and physical exercise interventions. Our study has some limitations: (1) our sample does not represent the whole Brazilian population, ethnic mixed, and varies in different regions; (2) we have only included a narrow age range; and (3) we do not have other health parameters to identify the BFP associated with higher metabolic risk, although this point is a lot discussed in the scientific literature^{2,6–7}. Due to the relevance of obesity at a young age in Brazil, we suggest a multicentric study with a similar methodology to establish the BFP cut-off point. The risk of complications related to excessive BFP is increased. The definition of this BFP threshold would significantly improve the health care of children and adolescents and may prevent NCD in the long term.

CONCLUSION

Based on the responses of the present study, the BFP cut-off points differ between female and male adolescents. Medical doctors, nutritionists, physiologists, and other health professionals need to consider the physiological differences. The establishment of cut-off points for body fat percentage may improve the clinical assessment and management of overweight and obese adolescents.

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Resumo

Introdução: A Organização Mundial da Saúde (OMS) recomenda o uso do índice de massa corporal (IMC) como método custo-efetivo nível 1 para avaliar o estado nutricional na população. O aumento do IMC está associado a um maior risco de outras doenças crônicas não transmissíveis (DCNT), particularmente a hipertensão arterial sistêmica (HAS), diabetes mellitus tipo 2 (DM2), dislipidemias e alguns tipos de cânceres. A prevalência da obesidade tem aumentado em todo o mundo e essa condição tem afetado dramaticamente crianças e adolescentes. A obesidade em jovens, por sua vez, aumenta as chances de obesidade grave e suas complicações em adultos.

Objetivo: Este estudo teve como objetivo estabelecer pontos de corte para o percentual de gordura corporal em adolescentes do sexo masculino e feminino de 16 a 18 anos, utilizando a bioimpedância elétrica (InBody 570®).

Método: Tabelas específicas para o sexo masculino e feminino foram propostas, com base nos percentis 3, 5, 10, 15, 25, 50, 75, 85, 95 e 97. Foram incluídos 546 adolescentes.

Resultados: Os pontos de corte do percentual de gordura corporal para o grupo masculino foram: P3 = 6,0-7,0%; P5 = 7,1-8,9%; P10 = 9,0-9,8%; P15 = 9,9-11,7%; P25 = 11,8-15,5%; P50 = 15,6-21,9%; P75 = 22,0-27,8%; P85 = 27,9-36,0%; P95 = 36,1-38,0% and P97 ≥ 38,1%. Para as mulheres, os pontos de corte foram: P3 = 9,5-10,0%; P5 = 10,1-11,0%; P10 = 11,1-11,8%; P15 = 11,9-14,0%; P25 = 14,1-19,0%; P50 = 19,1-27,1%; P75 = 27,2-29,0%; P85 = 29,1-39,9%; P95 = 40,0-51,0% e P97 ≥ 51,0%.

Conclusão: O estabelecimento de pontos de corte para percentual de gordura corporal pode propiciar parâmetros para a melhoria da avaliação clínica, bem como para o tratamento da obesidade em adolescentes.

Palavras-chave: adiposidade, bioimpedância elétrica, composição corporal, índice de massa corporal, saúde do adolescente.

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