Nutritional status evaluation in schoolchildren according to three references

Avaliação do estado nutricional de escolares segundo três referências

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ABSTRACT

Objective: To compare the nutritional status of school-children according to three different reference curves.

Methods: The weight and height of 181 children aged 5-10 years were obtained from a database for the nutritional surveillance of schoolchildren from Paquetá Island, RJ, Brazil, which had been designed in compliance with recommendations of the Brazilian Food and Nutrition Surveillance System (Sistema de Vigilância Alimentar e Nutricional, Sisvan). Bland-Altman plot and deviation ratios were used to produce profiles of agreement between pairs of nutritional assessment references using body mass index values. Cutoff values of the following standards were used in order to determine the prevalence of overweight and weight and height deficit: Cole, Centers for Disease Control and Prevention (CDC), and Conde & Monteiro.

Results: The prevalence rates for obesity in girls were similar using the Cole and Conde & Monteiro (3.1%) cut-offs, but the prevalence rate according to the CDC standard was significantly lower (2.0%). For boys, the prevalence of obesity using the Conde & Monteiro cutoff (4.8%) was lower than the rates obtained using the cutoffs suggested by Cole (7.2%) and by the CDC (7.2%).

Conclusions: These results suggest that the choice of the Brazilian reference curve (Conde & Monteiro) does not impair the comparison with other international standards, particularly for obesity in male schoolchildren.

Key words: Overweight, obesity, nutritional surveillance, child.

RESUMO

Objetivo: Comparar a avaliação do estado nutricional de escolares de acordo com as três curvas de referências.

Métodos: As variáveis peso e estatura de 181 crianças na faixa etária de cinco a dez anos foram obtidas de um banco de dados de vigilância nutricional de escolares da Ilha de Paquetá, organizado de acordo com as recomendações do Sistema de Vigilância Alimentar e Nutricional (Sisvan). O gráfico de Bland Altman e a razão de desvios foram empregados para construir perfis de concordância entre as três curvas de referência de avaliação nutricional dois a dois, utilizando-se os valores do índice de massa corporal. Na determinação da prevalência de déficit pôdero-estatural e sobrepeso, utilizaram-se os pontos de cortes recomendados por Cole, pelo *Centers for Diseases Control and Prevention* e por Conde e Monteiro.

Resultados: A prevalência de obesidade em meninas foi igual (3,1%) para Cole e Conde e Monteiro e ambas se sobrepuseram à obtida por meio da curva do *Centers for Diseases Control and Prevention* de 2000 (2,0%). Em relação aos meninos, a prevalência de obesidade obtida por Conde e Monteiro (4,8%) foi menor do que os percentuais encontrados por Cole (7,2%) e pelo CDC (7,2%).

Conclusões: Os resultados sugerem que a escolha do referencial brasileiro (Conde e Monteiro) não dificulta a comparação com outros critérios internacionais, principalmente no que tange à classificação de obesidade em escolares do gênero masculino.

Palavras-chave: sobrepeso; obesidade; vigilância nutricional; criança.

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Introduction

Anthropometry is an important diagnostic method both in clinical practice and in population studies, providing estimates of the prevalence and severity of nutritional disorders. Anthropometric assessment takes on great importance in the nutritional diagnosis of children due to its ease of application, objectivity of measurements, and the fact that it is possible to compare results against a reference standard that is relatively simple to deal with, particularly in population studies[1].

Many different references are used for the nutritional diagnosis of children. In 1977, the National Center for Health Statistics (NCHS)[2] published a set of reference data for both sexes within the age group of zero to 18 years based on weight-for-age (W/A), weight-for-height (W/H), length-for-age (L/A), height-for-age (H/A), and head circumference-for-age (HC/A), and recommended their use within the United States. Following their publication, the World Health Organization (WHO) recognized the NCHS standard (1977)[2] as appropriate for assessing other racial groups and recommended it for international use. It was also adopted by the Brazilian Ministry of Health[3].

Starting in 1985, the NCHS[2] growth charts that had been used worldwide since 1977 were revised with the objective of reflecting secular changes and correcting and/or minimizing a series of failures that indicated that they were an imperfect indicator of growth. All of the criticisms made to the NCHS/1977[2] were considered and analyzed in detail. In general, the main innovations were: improvement of the statistical techniques; use of larger samples in order to guarantee racial representativity and to reflect the ethnic diversity of the American population; standardization of data collection methods; incorporation of data from five American studies; extension of all of the curves up to the age of 20 years; development of body mass index for age (BMI/age); publication of the lower limits for length (45 *versus* 49 cm) and height (77 *versus* 90 cm); development of the third and 97th percentiles for all curves and of the 85th percentile for the W/H and BMI/age curves. Furthermore, data from the Fels[3] study were eliminated from the weight and height datasets because they had been primarily obtained from children fed on formula, and it is known that the growth rate of these children is substantially different from that of breastfed children during the first two years of life[4]. The new anthropometric reference standard was published by the Centers for Disease Control and Prevention (CDC) in 2000[4].

Also in 2000, Cole *et al*[5] defined age- and sex-dependent BMI cutoff points for children and adolescents to classify overweight and obesity. The dataset used for that reference came from six studies that were representative of the following countries: Brazil, Great Britain, Hong Kong, the Netherlands, and the United States, including children and adolescents aged six to 18 years. In that study, the authors established a relationship between adult cutoff points and BMI percentiles for children with the objective of establishing cutoff points for overweight and obesity for each age group. According to Cole *et al*[5], the BMI percentile curves were constructed using the LMS method (lambda, mu, sigma), where M expresses the median value of the index observed within each stratum, S represents the coefficient of variation of each stratum, and L is the mathematical transformation coefficient (Box-Cox) applied to the BMI values with the objective of obtaining a normal distribution within each stratum. The curves for each parameter were smoothed using polynomials for each sex, making it possible to establish cutoff points for BMI, overweight and obesity on the basis of international data and these were then recommended by the International Obesity Taskforce (IOTF)[6]. In 2007 and using the same methodology, Cole *et al*[6] established age- and sex-dependent BMI cutoff points for children and adolescents in order to classify underweight[6].

Recently, in 2006, Conde and Monteiro[7] published a reference system for assessing the nutritional status of Brazilian children and adolescents. Their system was based on BMI, included a reference curve, and established static and functional critical limits for diagnosing underweight, overweight, and obesity. The dataset used for these Brazilian BMI reference curves came from the National Health and Nutrition Survey (Pesquisa Nacional Saúde e Nutrição)[8], carried out in 1989 by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística, IBGE)[8], and covered children and adolescents aged two to 19 years. The method employed to produce the Brazilian curves was basically the same as that used in the development of international BMI standards[5].

The fact that existing references for assessing the nutritional status of children are not interchangeable demonstrates the need to perform investigations comparing these references. Therefore, the objective of this study was to compare assessments of the nutritional status of schoolchildren made using three different reference curves: CDC[4], Cole *et al*[5,6] and Conde and Monteiro[7].

Methods

This study was approved by the Research Ethics Committee at Hospital Universitário Pedro Ernesto, Universidade do Estado do Rio de Janeiro. The data needed to compare the references used to assess nutritional status (underweight, overweight and obesity) were obtained from a database employed in the nutritional surveillance of schoolchildren living on Paquetá Island, RJ, Brazil, designed according to the recommendations of the Food and Nutrition Surveillance System (Sistema de Vigilância Alimentar e Nutricional, Sisvan). The database contains the age, weight and height of 181 schoolchildren, 98 girls and 83 boys, aged five to 10 years.

The surveillance project records revealed that weight (kg) was measured using a digital balance (Plenna®) with a capacity of 150kg and an accuracy of 0.1kg, and that the children were wearing light clothing when weighed. Height (cm) was measured using a measuring tape (in millimeters) fixed to the wall with zero at ground level. Children were measured barefoot with nothing on their heads and in an orthostatic position.

Weight and height measurements were used to calculate the children's body mass index (BMI). Prevalence rates were determined using the cutoff points recommended by the three reference standards: CDC (2000)[4], Conde and Monteiro (2006)[7], and Cole et al [5,6]. The figures used by the CDC[4] to define underweight, overweight and obesity are BMI<5th percentile, BMI≥85th percentile and BMI≥95th percentile, respectively. Conde and Monteiro[7] used the following BMI values as cutoff points: $<17.5 \text{kg/m}^2$ for underweight, $\geq 25 \text{kg/m}^2$ for overweight, and $\geq 30 \text{kg/m}^2$ for obesity. Cole et al[5] used the same cutoff points for overweight and obesity as Conde and Monteiro[7]. However, in contrast to Conde and Monteiro, Cole et al[6] defined the cutoff point for underweight as $<18.5 \text{kg/m}^2$.

When comparing two methods, one common goal is to establish the degree of agreement between them. Bland and Altman[9] did not agree that a measure of correlation could measure the degree of agreement between two methods and so they proposed an alternative analysis. They suggested plotting the difference between measurements provided by the two methods on the y-axis of a Cartesian graph and the means of these measurements on the x-axis. Plotting the difference against the mean allows to assess whether or not there is a relationship between the error of the measurement and the true value. If there is no relationship between the difference and the mean, the authors indicate the lack of

agreement by calculating the estimated divergence in terms of the mean difference ($\bar{d}$) and the standard deviation of the difference(s). It is expected that the majority of differences will be within the interval between the mean difference ($\bar{d}$) less 2 standard deviations and the mean difference ($\bar{d}$) plus 2 standard deviations, which are the limits of agreement. If there is good agreement, the majority of points should be distributed around the y-axis, where difference is 0. The precision of the estimated limits of agreement is given by Student's *t* distribution, and the advantage of the method is that it does not demand robust samples.

Delcourt et al[10] suggest that the agreement of nutritional assessment methods should be verified using a standard deviation ratio, calculated by dividing the standard deviation of the differences in BMI by the standard deviation of the means of BMI, thereby producing a quantitative definition of the relative agreement between methods. In this relationship, smaller ratios correspond to a better agreement between the two methods.

Therefore, the agreement profiles between pairs of nutritional assessment references were produced using BMI values (weight/height^2). The descriptive statistical analysis used frequency and range (CI - confidence interval), with significance set at $p<0.05$. The inferential analysis used Bland-Altman[9] measures of agreement and deviation ratios[10].

Results

Table 1 shows that there was a statistically significant difference in the calculated prevalence of obesity among the girls depending on the reference used, where Cole et al[2] and Conde and Monteiro[7] resulted in the same value (3.1%), which was greater than that obtained using the CDC[4] reference (2.0%). For the boys, the prevalence of obesity calculated using the cutoff suggested by Conde and Monteiro[7] (4.8%) was lower than the percentage according to both Cole et al[5] and the CDC[4] (7.2%).

The prevalence of overweight was greatest according to Conde and Monteiro[7] for both girls and boys (not significant). Calculating the percentage difference between results according to Conde and Monteiro[7] and the other two references, it was observed that obesity was more expressive for girls (5.1 and 8.2%, respectively) than for boys (2.4 and 3.6%, respectively).

A greater prevalence of underweight for both sexes was observed using Cole et al[6] when compared with the other two references. It should be emphasized that there was a signifi-

Table 1 – Nutritional status prevalence rates in schoolchildren according to three reference standards and sex

	Cole *et al*[5]			Conde e Monteiro[7]			CDC[4]		
	n	%	*p*	n	%	*p*	n	%	*p*
Girls (n=98)									
Underweight	13	13.2	0.06	5	5.1	0.04*	8	8.2	0.05
Eutrophy	68	69.4	0.09	71	72.4	0.09	77	78.6	0.08
Overweight	14	14.3	0.07	19	19.4	0.08	11	11.2	0.06
Obesity	3	3.1	0.03*	3	3.1	0.03*	2	2	0.03*
Boys (n=83)									
Underweight	14	16.9	0.07	4	4.8	0.04*	10	12	0.12
Eutrophy	56	67.5	0.09	66	79.5	0.08	61	73.5	0.73
Overweight	7	8.4	0.05	9	10.8	0.06	6	7.2	0.07
Obesity	6	7.2	0.05	4	4.8	0.04*	6	7.2	0.07

cantly lower prevalence for both sexes (p=0.04) using Conde and Monteiro[7] when compared to the other two references. Figures 1 and 2 show the agreement between pairs of references using the Bland and Altman method[9]. These results show that, for boys and girls, the points were displaced from the zero difference axis, but did not pass the limits of agreement at ±2 standard deviations, with the exception of Conde and Monteiro *versus* CDC for obesity in Figure 2 (boys).

Table 2 shows that the ratio of deviations was particularly low only for the obesity classification in boys (0.04) when comparing Conde & Monteiro[7] with the CDC[4], whereas the ratio for Conde and Monteiro[7] *versus* Cole *et al* was 0.16[5]. The ratios of deviations for girls were 0.29 and 0.32. According to Delcourt *et al*[10], the lower the ratio, the better the relative agreement between the two methods.

Discussion

The main limitation of this study is the use of secondary data. Nevertheless, it should be pointed out that the techniques used to measure weight and height are routinely used in anthropometric assessment and are of easy access.

According to Conde and Monteiro[7], using curves based on BMI/age to classify the nutritional status of children and adolescents leads, on one hand, to practical solutions, and on the other hand, to debates about the use of these curves to assess the nutritional status of population groups in growth phases. The main point to be taken into account is the universal or specific nature of body composition, which is reflected in the discussion over the adoption of local or international reference curves[11,12]. Another aspect refers to the bases and properties of classification systems based

on BMI for age, which leads on to the debate about the appropriateness of the use of statistical or epidemiological criteria[13], since the cutoff points that are the basis of BMI classifications are chosen according to expected prevalence rates, thus making it possible for healthcare management professionals to direct the distribution of available healthcare resources to groups at nutritional risk. Finally, the influence of sexual maturity on body composition and the need (or not) to take into account the stage of sexual maturity should also be discussed[14,15].

The three references used for nutritional assessment in the present study are different from one another. We found a higher prevalence of overweight among schoolchildren (girls 19.4% and boys 10.8%) when the Conde and Monteiro curves were applied[7]. Similar findings were reported by Vitolo *et al*[16] when they assessed the prevalence of overweight and obesity among adolescents (n=418) aged ten to 19 years using the reference curves by Cole *et al*[5] and Conde and Monteiro[7]. They also found that the prevalence of overweight was greater according to Conde and Monteiro (29% boys and 24.8% girls) than according to Cole *et al*[5] (27% boys and 19.3% girls), with a greater percentage difference for the girls. According to Vitolo *et al*[16], the reference published by Conde and Monteiro[7] showed greater sensitivity (83.3%) and positive predictive value (31.3%) than the international reference. Cutoffs on the Brazilian reference showed greater sensitivity for diagnosing excess adiposity among adolescents, reducing the number of false-negative results.

A study by Sotelo *et al*[17] used WHO criteria (1995)[18], as well as the reference curves published by Must *et al*[19] and Cole *et al*[5], to diagnose overweight and obesity in

Underweight
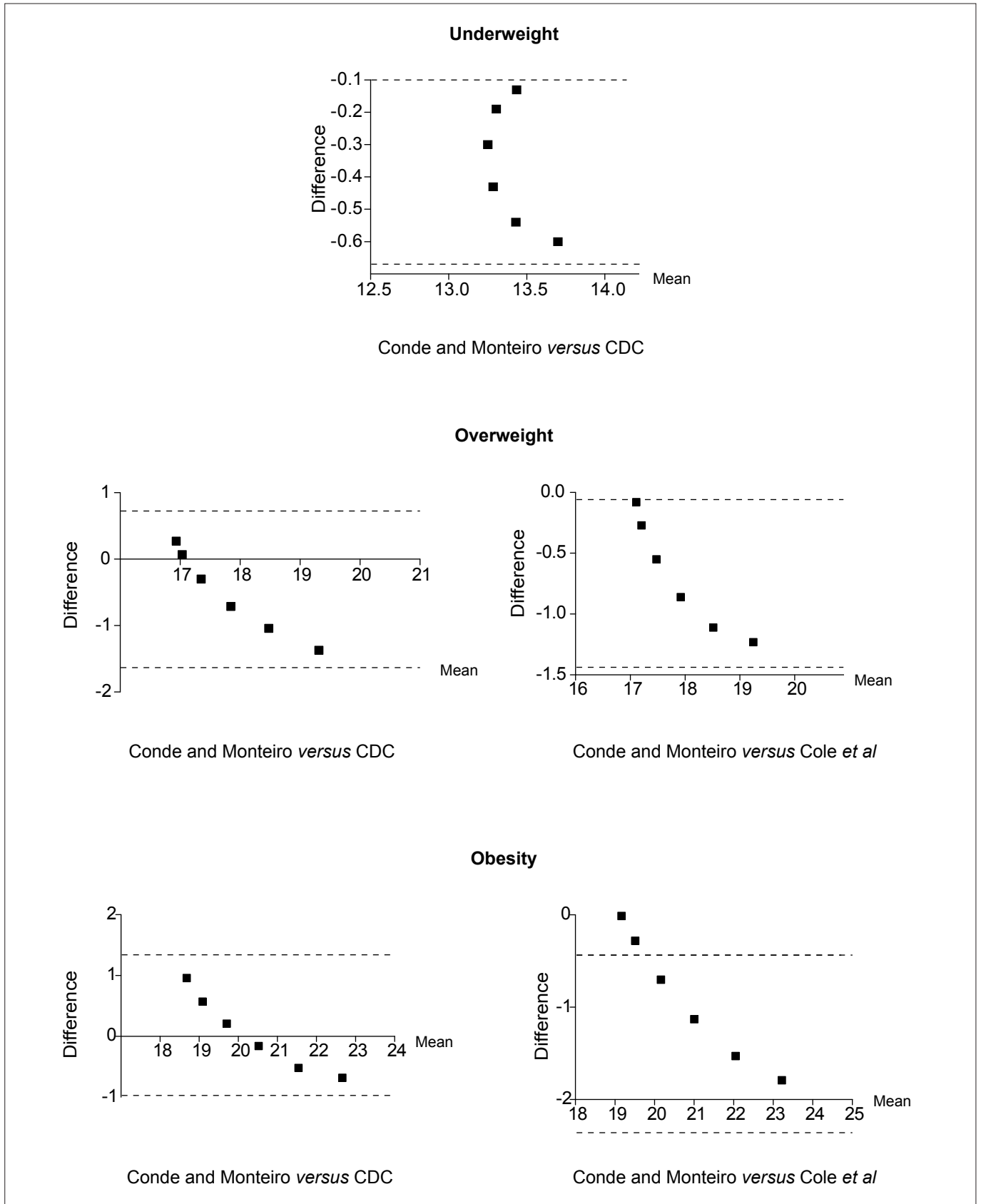
Overweight

Obesity

Figure 1 – Comparisons, using the Bland and Altman method[9], of reference standards by Conde and Monteiro[7] *versus* CDC[4] and Conde and Monteiro[7] *versus* Cole *et al*[5,6], according to body mass index in girls.

Underweight

Conde and Monteiro *versus* CDC

Overweight

Conde and Monteiro *versus* CDC

Conde and Monteiro *versus* Cole *et al*

Obesity

Conde and Monteiro *versus* CDC

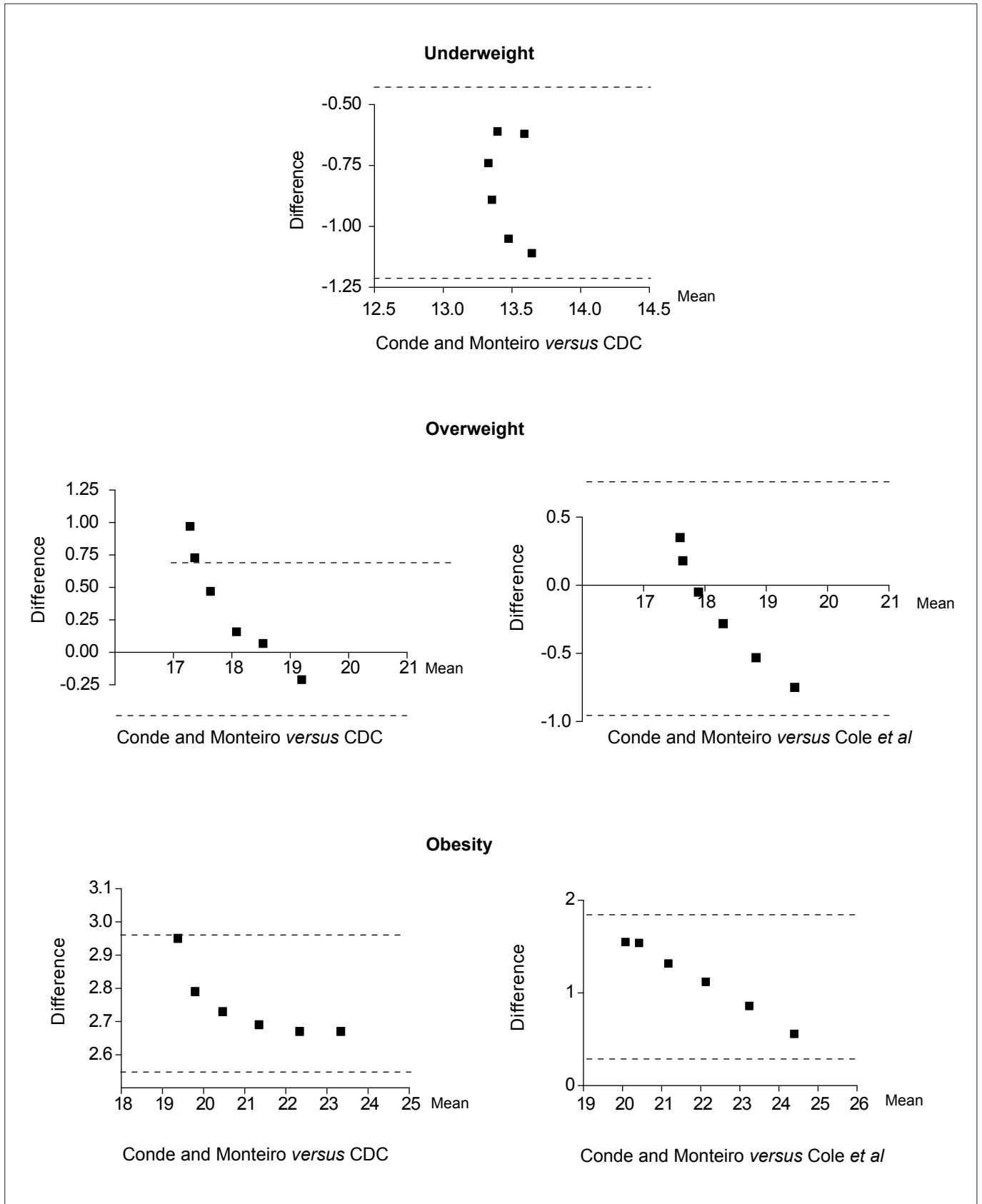Conde and Monteiro *versus* Cole *et al*

Figure 2 – Comparisons, using the Bland and Altman method[9], of reference standards by Conde and Monteiro[7] *versus* CDC[4] and Conde and Monteiro[7] *versus* Cole *et al*[5,6], according to body mass index in boys.

Table 2 – Ratios of deviations for comparisons using the Bland and Altman method, according to body mass index and sex

	Underweight		Overweight		Obesity	
	CM *versus* CDC	CM *versus* Cole	CM *versus* CDC	CM *versus* Cole	CM *versus* CDC	CM *versus* Cole
Girls	0.84	0.74	0.51	0.40	0.29	0.32
Boys	1.17	1.72	0.43	0.41	0.04	0.16

CM: Conde and Monteiro[7]; CDC: Centers for Disease Control and Prevention[4]; Cole: Cole *et al*[5].

schoolchildren aged six to nine years. They observed that the criteria suggested by Must *et al*[19] offered early diagnosis of anthropometric risk of obesity, leading to overestimation of the prevalence in relation to WHO standards[18], whereas Cole *et al*[5] underestimated the prevalence.

Another study carried out by Bueno and Fisberg[20] compared the prevalence of overweight and obesity according to three reference standards (WHO, 1995[18]; CDC, 2000[4]; and Cole *et al*, 2000[5]), in children from two to seven years. They found prevalence rates of overweight of 18.6, 13.2, and 12.2% according to the WHO[18], CDC[4], and Cole *et al*[5] criteria, respectively. Among children aged four to seven years, the difference was 2.3% for girls and 0.6% for boys. Our study found percentage differences of 3.1 and 1.2% for girls and boys (Table 1). Bueno and Fisberg[20] also calculated an agreement ratio for the criteria, assessed using kappa statistics, and observed that it was weaker for male overweight according to the CDC[4] and Cole *et al* criteria[5]. It can be observed that the variety of references for the diagnosis of nutritional status in children creates limitations and difficulties for comparing the prevalence rates reported by several different studies.

In our study, the prevalence of underweight was greater according to Cole *et al*[6], probably as a result of the cutoff point chosen (BMI <18.5kg/m²), which is a diagnosis of grade 1 thinness. According to the authors, the cutoff represents a -1 score, in contrast with the CDC[4], which classifies underweight as <5th percentile. A difference between the prevalence of underweight was observed when Cole *et al*[5] and the CDC[4] criteria were compared, reaching 5% for both sexes. In contrast, the prevalence rates of underweight were the lowest according to Conde and Monteiro[7], although in their article these authors stress that the use of 17.5kg/m² as the critical value for weight deficit in children and adolescents requires further analyses and wider discussion before its possible adoption.

Although the deviation ratio for male obesity was low for the comparison between the Conde and Monteiro[7] and CDC[4] references, it was not possible to detect any marked agreement on the Cartesian graph, since the points were dispersed. As it may be observed, these references are not interchangeable, and each one should be used in line with the study objectives.

Classifications of nutritional status obtained using the references most commonly adopted in scientific circles and by health services can result in discrepancies in terms of prevalence rates. The choice of a procedure for the classification of nutritional status should be on the basis of the objectives of the study. There is no consensus on the validity of international references for developing countries, although the choice of a Brazilian reference does not appear to create difficulties for comparisons with international criteria, particularly with reference to the classification of obesity in male schoolchildren.

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