BODY FAT DISTRIBUTION IN SCHOOLCHILDREN: A STUDY USING THE LMS METHOD

ORIGINAL ARTICLE

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ABSTRACT

Introduction: Assessment of overweight and obesity in populations has still been based on the body mass index, which is considered the universal indicator of adiposity. Objective: To analyze 7-10 year-old schoolchildren body fat distribution by building percentiles reference of skinfold thickness, using LMS parameters. Method: Data were taken from a representative sample of 7-10-year-old schoolchildren attending public and private schools that participated in a comprehensive research study conducted in 2002, in the city of Florianopolis (Santa Catarina, Brazil), and composed of 2,918 children. In this study, the anthropometric data used were height, subscapular, suprailiac, triciptal and medial calf skinfolds. The LMS method, which propitiates normalizing data with asymmetric distribution, was used to analyze and compare skinfold thickness patterns by sex and age group. Results: Both sexes presented higher values of subcutaneous fat in the triceps and calf regions; nevertheless, in male subjects theses values were lower than in females and with low increment along the age group investigated. The skinfold with the highest increment in median values was the suprailiac for females, which reached values close to those of the triciptal skinfold at 10 yr old. Conclusions: The LMS method propitiates analysis of the skinfolds thickness, which is important to perform analyses of the evolution of the body fat and the nutritional status of children.

Keywords: skinfold thickness, body fat distribution, nutritional assessment, child.

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INTRODUCTION

Assessment of overweight and obesity has still been predominately based on the body mass index, which is considered its universal indicator[1,2].

Skinfold thickness has been used since it provides complementary data about body fat distribution due to its little invasive and high sensitivity in obesity diagnosis during childhood[3-5].

Subcutaneous fat constitutes 40 to 60% of the total body fat and is distributed through the different body parts[3,4]. Its analysis becomes useful to indicate health risks to the health of children. Studies have shown that children and adolescents with more centralized body fat present higher risk factors for cardiovascular diseases[6,7]. Percentile values of the skinfolds[1,4] have been proposed for populations in the United States of America[8] and England[9]. In Brazil, three studies present skinfold data which can be considered representative of the different regions.

The study by Goldberg *et al.*[10], carried out in 1978, with schoolchildren between 10 and 17 years old from the city of Santo André; the study by Böhme[11], carried out between 1986-1988, with schoolchildren aged between seven and 17 years, from the city of Viçosa (MG); and the study by Guedes and Guedes[12], carried out in 1989, with students aged between seven and 17 years, from the city of Londrina (PR).

The LMS method has been used for the construction of these percentile reference since it makes it possible to remove the asymmetry in the distribution of the assessed variable and build the percentiles through estimation of three independent parameters: the L parameter, which is the box-cox coefficient; the M parameter, which represents the median, and the S parameter, which is the variation coefficient[13].

In addition to the mentioned studies, the LMS method has also been used in other studies. For instance, in the study by Hatipoglu *et al.*[28], which tried to develop percentile values of waist circumference for Turkish children. A study by Brannsether *et al.*[29], which tried to establish reference values for waist circumference and waist-hip ratio of Norwegian children.

The LMS method was also used in a study by Fetuga *et al.*[30], for determination of anthropometric parameters, in the comparison with reference values of the World Health Organization – 2007 (WHO) and the Center of Control and Prevention of Diseases – 2000 (CCD) of weight, height and body mass index of students in Nigeria.

In Brazil, a study by Guedes *et al.*[31], has built percentile measurements for comparison of physical growth of children and adolescent from the Jequitinhonha Valley (MG) with reference values of the CCD – 2000.

Considering that the knowledge on the body fat distribution, mainly in Brazilian children and adolescents, is important to public health as an stimulus to the improvement in health programs and the possibility to better interpret this distribution using suitable parameters for this goal, we tried in the present study to analyze the body fat distribution of students aged between seven and 10 years, through the designing of percentile reference of the skinfolds using the LMS parameters.

METHOD

Population and sample

A representative sample of 3,522 students aged between seven and 10 years from Florianópolis was selected in the year of 2002 based on stratification by two-stage conglomerate.

The sample size was calculated considering 10% of obesity prevalence and limit reliability of 95%. The sample error was of 2.0 and the design effect of 2%. The methodological outlining of this study was previously described[14].

On the first sampling stage, the public and private schools of Florianópolis city were first stratified by geographical area and administrative dependence.

Subsequently, on the second stage of the sampling, 16 schools were randomly selected (nine public and seven private) with probability having been proportionally measured in relation to the school size.

In each selected school, all classes were included and all children from the first to the fourth grade were invited to participate in the study, but only the children between seven and 10 year old made part of it.

Out of the 3,522 children from the first to the fourth grades of the selected elementary schools, 209 were eliminated for not being the minimal age stated in the study (< 7.0 and > 10.0 years) and 377 were eliminated due to data loss (child's absence, refusal in participating in the study). The total sample was of n = 2,936 students aged between seven and 10 years.

Data collection occurred between September and December, 2002. The instruments of the research were built with the adaptation of the protocol recommend by the *European Childhood Obesity Group* (*ECOG*)[14]. The research protocol included anthropometrical (height, weight, skinfolds and circumferences), socioeconomical and food consumption data. Anthropometrical data, height and tricipital, subscapular, suprailiac and medial calf skinfolds of a sample of n = 2,918 students aged between seven and 10 years (1,501 boys and 1,417 girls) were analyzed in the present study.

Anthropometric measurements

The anthropometric measurements were performed at each school by a team of five physical education professionals bearing in mind the grounding of the procedures standardized by Lohman *et al.*[15] and recommended by the World Health Organization. The measures were taken with the students wearing light clothes, being barefoot and during the morning (n = 1,497) and the afternoon (n = 1,439), depending on the child's school shift[14].

Height was measured with metallic stadiometer (1 mm precision), with the child at orthostatic position and body weight distributed on both legs. The skinfolds were measured with a CESCORF® plicometer with 0.1 mm resolution. The skinfolds were measured according to standardization proposed by Lohman *et al.*[15] as follows:

- Tricipital skinfold – vertically measured at the posterior medial point of the arm, between the acromial neck of the scapula and the lower border of the ulnar olecranon process.
- Subscapular skinfold – diagonally measured (approximately 45 degrees), 2 cm below the lower angle of the scapula.
- Suprailiac skinfold – diagonally measured in relation to the medial axillary line, 2 cm above the iliac crest.
- Medial calf skinfold – vertically measured at the medial point of greatest perimeter (volume) of the calf.

Data analysis

The Z scores values for the height variable (table 1) were built through reference values for children from the United States of America, whose most recent data are found in the study published by McDowel *et al.*[16] and are available in the *National Center of Health Statistics* (*NCHS*) site.

Table 1. Central dispersion and of the Z score values for the height variable, according to age and sex of the students aged between seven and 10 years from Florianópolis, SC, Brazil, 2002.

	Age (years)	n	Mean	CI 95%		Standard deviation	Mínimum	Maximum
				bottom	upper			
Boys	7*	337	0.26	0.15	0.37	1.02	-2.60	4.73
	8*	385	0.15	0.05	0.26	1.02	-2.89	3.74
	9	423	0.08	-0.03	0.18	1.07	-3.28	3.40
	10	356	0.04	-0.06	0.15	1.01	-4.32	3.09
	Total	1.501	0.13	0.08	0.18	1.04	-4.32	4.73
Girls	7	323	0.06	-0.03	0.16	0.90	-2.77	2.52
	8	384	-0.02	-0.13	0.09	1.08	-3.23	3.79
	9	373	0.14	0.03	0.25	1.04	-4.12	3.37
	10	337	0.17	0.07	0.28	0.95	-3.02	2.56
	Total	1.417	0.09	0.04	0.14	1.00	-4.12	3.79

* Significant difference and variance analysis of double entrance ($p < 0.05$). There was no difference between sexes in the different ages.

Designing of the percentile reference of the skinfolds

In order to design the percentile reference the LMS method was used (L = box-cox coefficient; M = median; S = variation coefficient), through which it is possible to remove asymmetry in distribution of the assessed variable and build the percentiles[13]. This method has been widely applied for the analysis of anthropometric and other variables with asymmetric nature in their distribution[17].

The first step performed consisted in excluding data whose values extrapolated the pre-set biological plausibility and statistical consistency criteria. Thus, the values higher and lower than ± 4 standard deviation of the mean according to age and sex were excluded.

According to Conde and Monteiro[18], this criterion, considered non-conventional, guarantees the sample's heterogeneity. The magnitude of data exclusion was small both in the male sex (tricipital skinfold = 3, calf = 5, subscapular = 15 and suprailiac = 5) and in the female sex (tricipital skinfold = 2, calf = 0, subscapular = 12 and suprailiac = 2). The general exclusion proportion was of 1.86% for the male sex and 1.13% for the female sex.

In order to build the percentile values though the LMS method, it is recommended that data are grouped so that strata are obtained with a minimal sample number of 100 cases/individuals[13]. In order to follow this criterion, data of this study were grouped in quarters, according to age and sex. After grouping, the *Colelms* command of the *STATA* 9.0 program was used to build the raw LMS values. These values were adjusted and smoothed by spline, which is a mathematical interpolation technique which consists in dividing the interval of interest in subintervals and interpolate as smoothly as possible (in these subintervals), with polynomials of small degree. After the LMS values were smoothed in quarters, the technique of linear interpolation was used to find the monthly values. In the possession of these parameters (L, M and S), it becomes possible to build the curve concerning the expected percentile with the application of the following formula:

$$P(z) = M\,(1 + LSz)^{1/L}, \text{ if } L \neq 0$$
$$P(z) = M \exp(Sz), \text{ if } L = 0$$

In the formula: P(z) corresponds to the expected percentile according to the z area of the normal curve. The L, M and S values indicate the corresponding values to each curve at the established age; z is the number of standard deviations of the normal curve corresponding to the area which is expected to be found the percentile for each age.

Statistical analyses

The data of descriptive characterization of the sample were analyzed from mean, confidence intervals of the mean above and below 95% (± CI95%), standard deviation, minimum and maximum values. Two--way *ANOVA test with Bonferroni post-hoc* was used for comparison of the values between ages in the same sex, and between sexes.

The skinfold values were compared from the graphic visualization of the dispersion of the L, M and S values, according to the age and sex spectrum.

The statistical packages used for the analyses and built of the charts were: *SPSS* 15.0, *STATA* 9.0 and *Excel* 2003.

Ethical criteria of the research

The research protocol was approved on 27/05/2002, by the Committee of Ethics in Research with Humans of the Federal University of Santa Catarina/CCS, according to the guidelines set by the Resolution 196/96 of the National Health Board (legal opinion nº 037/02).

The students voluntarily accepted to participate in the study and received previous authorization form their parents with the signature of the Free and Clarified Consent Form (TCLE), which guaranteed information confidentiality and data return to the schools which participated and further interested individuals.

RESULTS

Sample characterization by the population height

Table 1 evidences the Z score values[1] for the height variable, using the data from the *NCHS as reference*[16], according to age and sex of the students from Florianópolis (2002).

Positive values of Z score were verifed in mean, for each age in the male and female sexes and only aat eight years old in the female sex there was negative value of the Z score. Generally speaking, the boys presented Z score of 0.13 (0.08-0.18 ± CI95%) and the girls of 0.09 (0.04-0.14 ± CI95%), what denotes that the children of Florianópolis present growth higher than the reference population. There was difference in height between sexes at seven and eight years old, which was equal from that age on. There were no significant differences between ages in any of the sexes.

Values of the LMS parameters of the skinfolds

Figure 1 presents the percentile values 25, 50 and 75 of the skinfolds according to each age and sex.

Dispersion of the L parameters of the skinfolds presents behavior dependent to age, sex and site where subcutaneous fat is concentrated. The majority of the skinfolds present negative values for the L parameter, which means that there are higher frequencies of skinfolds values on the right side of the distribution. Since none value of the L parameter of the skinfolds was higher than 1 or lower than −1, it can be stated that asymmetry of the variable is not remarkable.

The skinfold which needed greater adjustment for normality was the subscapular in boys, with L values (normalization coefficient) of −0.8 to −0.9, which means that the fat on the trunk region of boys does not remarkably accumulate. In girls, there was light tendency to decrease of the asymmetry values along the age, demonstrating hence that there is higher fat accumulation in the subscapular region as age progresses. In the remaining skinfolds the L values were low, from −0.35 to 0.20, but with different tendency in its distribution.

Comparing the L parameters values between sexes, it can be observed that in the male sex there is higher asymmetry to the right side of the distribution of the skinfolds values, which means that, between seven and 10 years old, boys present lower body fat accumulation than girls. However, in female sex the data suggest that there is alteration in its distribution pattern of the body fat from 10 years old, according to the tendency of the dispersion of the L values, also start presenting more asymmetry to the right side of the distribution curve. Nevertheless, it can only be confirmed when the behavior of the L parameter dispersion at the ages older than 10 years are investigated.

It is observed that all median values of the skinfolds (M parameter) increase within the age group investigated, demonstrating that both for girls and boys, progressive increase of subcutaneous fat due to age function occurs. Higher values of subcutaneous fat are verified in girls in the tricipital, medial calf and suprailiac skinfolds, from eight years old. The boys present lower values in the median; however, the area where more subcutaneous fat is found is similar to the girls'. The subscapular skinfold presents lower values in the median in both sexes.

The progressive increase of the suprailiac skinfold due to age in girls is remarkable. At seven years old is the third skinfold concerning median values, and at 10 years old similar values to the tricipital skinfold, which is the one with the highest volume, is observed.

Interestingly, in the dispersion of the S parameter concerning age, the kinetics with parabolic aspect present that the variation coefficient progressively increases from seven years old, reaching the highest values at around 8.5 and 9 years old for girls and between 9.5 and 10.5 years old for boys, with a tendency to decrease the variation values (suprailiac, tricipital and subscapular skinfolds) or maintain the peak values (calf skinfold). The variation values were 0.3 to 0.45 (30 to 45%) for the tricipital, calf, medial and subscapular skinfolds. Concerning the suprailiac one, much higher variation values have been observed, namely 0.55 to 0.75 (55 to 75%).

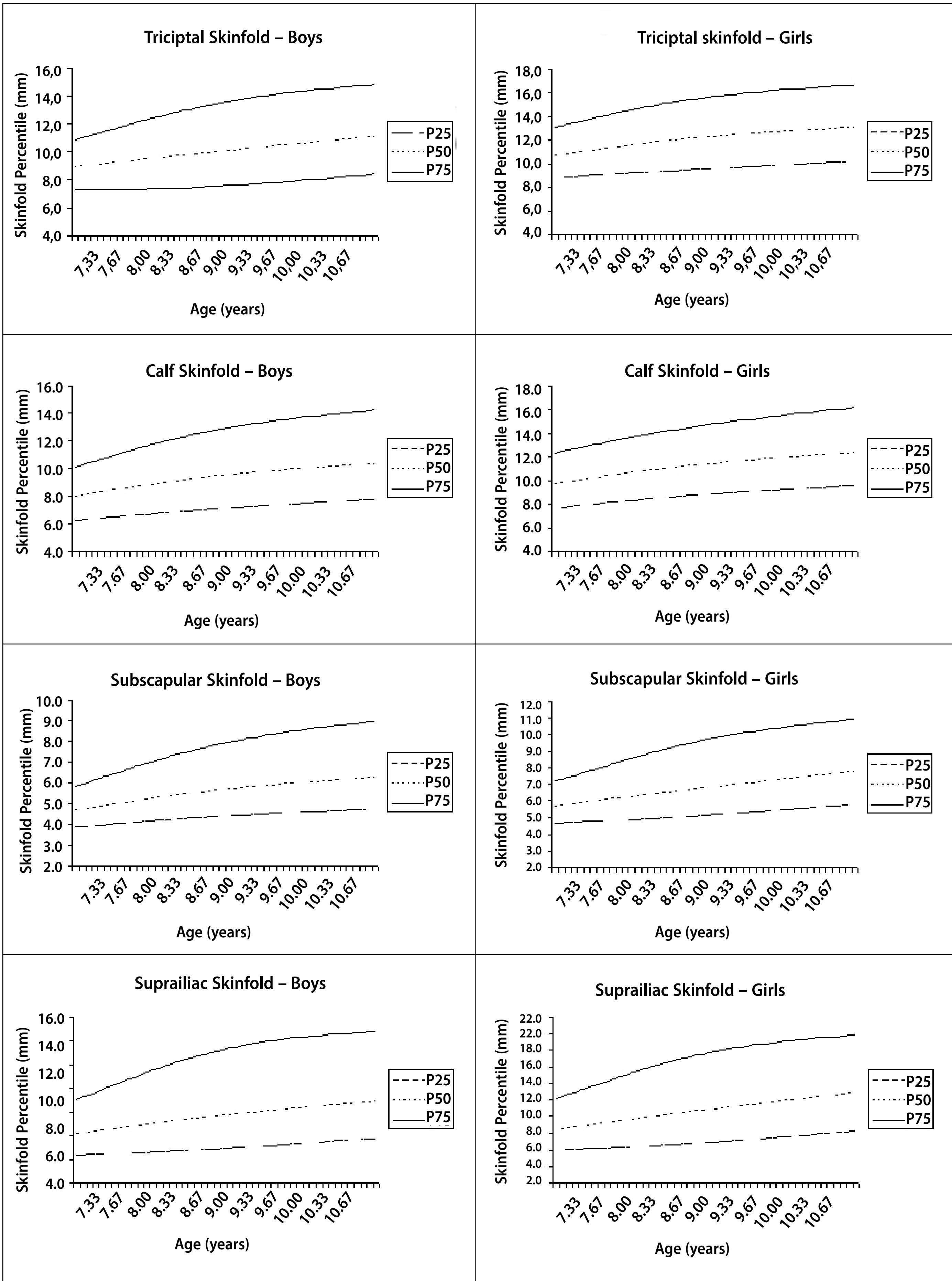

Figure 1. Dispersion of the percentiles 25, 50 and 75 of the tricipital, medial calf, subscapular and suprailiac skinfolds, according to sex and age, student population of Florianópolis, SC, 2002.

DISCUSSION

This is the first study in Brazil to use the LMS method for analyzing the body fat evolution through skinfolds and build symmetrically adjusted percentiles.

It is a regional study which limits to study students aged between seven and 10 years from Florianópolis (SC). No information about ethnical and maturational aspects was obtained, elements which influence on the body fat distribution. The lack of this information limits possible associations and direct comparisons between studies.

Additionally, the measurement technical error of the anthropometrists was not determined, which is currently recommended in anthropometric studies. Nevertheless, we made sure that the technicians who participated in the data collection had full theoretical and technical domain in measurement, due to their long time of experience and it is supported in the literature[15].

In this study, the boys and girls of Florianópolis and aged between seven and 10 years presented height growth higher than the reference population. This finding probably justifies by the fact the south of Brazil presents lower prevalence of height deficit in the children population than in other regions of the country[19]. In Florianópolis, the prevalence of height deficit (eight/age ≤ -2 Z score) in the students between seven and 10 years old, in 2002, was of 2.13% in boys and 1.91% in girls (unpublished data). Corso *et al.*[20] found prevalence of 3.1% of height deficit in pre-schoolers in Florianópolis, an index below the average to the Central-South region of the country.

These results may be a reflexion of the good index of human development (IHD)[2] the Santa Catarina state presents, being the second place in the country and Florianópolis city the Brazilian capital with the best IHD of the country[3].

In the revised literature, the only study which presents values of the L parameter for skinfolds and can be used to compare with our values is the study by Davies *et al.*[21]. In this study, the tricipital skinfold values of the study by Tanner and Whitehouse[9] were converted by the LMS method. Both boys and girls presented asymmetry values higher than the ones in the study by Davies *et al.*[21]. In girls the behavior observed in asymmetry is differentiated, since in the study by Davies *et al.*[21] there is no alteration of asymmetry direction. The median values for the tricipital skinfold of boys are very close to the ones of studies with white children in the USA published by Frisancho[22], McDowel *et al.*[16] and Must *et al.*[8]. Among the national studies, our values are very close to the ones found by Guedes and Guedes[12], at the ages of seven and eight years, and close to the ones found by Böhme[11], at the ages of nine and 10 years. The majority of the studies demonstrate tendency in stabilizing or increasing fat in the arm region, along the age spectrum investigated. Only the study by Potvin *et al.*[23] demonstrates tendency in decreasing the values from eight years old.

Ethnical differences and lifestyle may influence on the subcutaneous fat accumulation. The study by Potvin *et al.*[23], for example, presents skinfold values of Native American children and adolescents much lower than the values here and in other studies in the literature. It is also noticeable in the studies by Frisancho[22] and Must *et al.*[8], that black children of the USA present lower amounts of subcutaneous fat than white children of the USA.

When the values for the tricipital skinfold for girls were verified, tendency in stabilizing or increasing fat in the arm region was also observed along the age spectrum. Among the national studies, our values are closer to the ones found by Guedes and Guedes[12] at seven and eight years old, and are lower than the ones found by Böhme[11]. The values of this study are very close to the values of white children in the USA[8,16], and the black children presented lower values[22].

Concerning the subscapular skinfold of boys there is tendency of stabilization of these values in relation to age. The values of our study are very close to the ones for white American children[22], Native American children[23], British children[21] and children in from the south of Brazil[12]. Lower values for the black children are found[22], and values considerably higher for the American children[16], the Costa Rican children[24] and children from the southeast of Brazil[11].

Concerning the subscapular skinfold of girls, there is a tendency to increase the values in the age spectrum. The values of the White American girls[8,16,22], the British girls[21] and the girls from Londrina[12] are more similar to the ones in this study, especially from eight to 10 years old. Higher values are presented for the girls from the USA of the study by McDowel *et al.*[18], for Costa Rican girls[24] and children from the southeast of Brazil[11]; and lower values are found in black American girls[22].

Other factors such as beginning of maturational period[25], period of study performance, methodological aspects involving the different sampling constructions, as well as the different statistical analyses for the construction of the percentiles and other differences in the methodologies and materials used for measurements, are mentioned in the literature as factors which could explain the differences found between studies in the skinfold values[12].

The comparison of the S parameter between studies which discuss the subcutaneous fat distribution became limited, since not all of them present the mean and standard deviation values of the variable. Moreover, mean and standard deviation data were not obtained in the age group from seven to 10 years old for the calf skinfolds. Concerning the suprailiac skinfold, only data from a non-probabilistic study held in São Paulo city, with values from eight to 10 years old for the female sex[26], and values from 10 years old of a probabilistic study held in Santo André city, in the 1970-80 decade have been obtained[10].

The study which presents the highest variation for the tricipital and subscapular skinfolds both in girls and boys is the one published by McDowel *et al.*[16].

Studies with probabilistic sampling which bring percentile values of the skinfolds are scarce. Moreover, only the study by Davies *et al.*[21] used the LMS method for designing of the percentiles. The studies by Guedes and Guedes[12], by Frisancho[22] and by Must *et al.*[8], used mathematical regressions to normalize the distribution of the variable and design the percentiles. The remaining studies designed the percentile values with raw data, without adjustments to normalize the variable, which may have created a bias that the variable presents asymmetry in its distribution.

The comparison of the percentile values between this and other studies found in the literature becomes difficult due to the modeling used to build the percentiles. The other studies created percentiles according to the whole age spectrum; that is to say, without using monthly subdivisions, which is different from our study whose matrix of the values was built with age intervals of four months. Only the study by Davies *et al.*[21] divided the sample in semesters.

A recent study[27] used the LMS method to build percentiles to evaluate Young subjects aged 5-18 years in England, with body fat percentage values obtained through bioimpedance method. The dispersion pattern of body fat and asymmetry observed in this study is similarly found for children aged between 7-10 years, in the study by McCarthy[27]. However, it becomes difficult to compare the results since the study di not present the LMS parameters.

CONCLUSIONS

The development of the physical growth potential as well as the low height deficit of children aged between seven and 10 years from Florianópolis seem to be a reflex of the good health status of this population. The findings in this study evidence that the girls present a more symmetrical pattern in the frequency of the skinfold values and tend to present higher values and higher frequencies of the high values than boys. This symmetry seems to increase during the age spectrum investigated in girls and decrease or stabilize in boys, demonstrating that girls tend to increase more the body fat, and boys tend to maintain a more stable pattern and lower quantities of subcutaneous fat.

Girls present higher values of subcutaneous fat in the triceps and calf regions, with the suprailiac skinfold presenting the highest growth rate along the age sprectrum investigated, reaching values close to the tricipital skinfold values at 10 years old.

Boys present more subcutaneous fat in the triceps and calf regions; however, with values much lower than the girls and with slight increase along the age spectrum investigated.

The L, M and S parameters and the tricipital, subscapular, suprailiac and medial calf skinfold percentiles are an interesting instrument to the analyses of tendency and evolution, as well as inference on the nutritional status of children between seven and 10 years old.

We highlight the importance to follow the body adiposity in children during adolescence due to the remarkable increase in the prevalence of overweight and obesity which is affecting the Brazilian population. It is known that obesity in childhood is a predictor of nontransmissible chronic diseases in adulthood. Thus, the monitoring of the body adiposity excess is important and necessary. The skinfold measurement is very viable both in scientific research and other environments such as school or even sports clubs and clinics. However, the results of this study bring an important element, which are the comparison, that is to say, indicators for the evaluation of body adiposity in children and their classification according to pre-set parameters. In order to better analyze the distribution of the skinfold values during childhood as well as the passage by puberty, it would be important that further studies broaden the age group under observation; for instance, from six to 16 years old, and analyze the maturational aspect through studies of longitudinal character. These contributions would be important so that the use of skinfolds for evaluation of children and adolescents, without the use of equations to estimate the fat percentage became even more popular, since the use of equations presents limitations.

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