

Puberty in a sample of Brazilian schoolgirls: timing and anthropometric characteristics

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ABSTRACT

Objective: The objective of this study was to determine the age at which puberty begins, age of menarche and anthropometric data of the participants at different stages of puberty. **Subjects and methods:** This is a cross-sectional study in which we evaluated 665 girls, a sample representing the female schoolchildren population in Uberaba. **Results:** We found that thelarche, pubarche, underarm hair and menarche were attained at the age of 9.8 ± 1.4 , 10.2 ± 1.4 , 10.5 ± 1.5 and 11.7 ± 1.3 years, respectively. The mean interval between thelarche and menarche (ITM) was 1.7 ± 1.3 years. The prevalence of overweight and obesity was 31.3% and 95% of the participants began at thelarche between the age of 7 and 12 years. **Conclusion:** These values indicate a secular tendency to the decrease of the age of menarche and an earlier start of puberty. It is very important to understand these parameters to establish public policies aimed at plans to prevent these early events, especially regarding control of the prevalence of obesity. Arch Endocrinol Metab. 2015;59(2):105-11

Keywords

Puberty; growth; menarche

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INTRODUCTION

Puberty is the period of transition between the immature sexual state and the mature sexual state, culminating in reproductive capacity and attainment of final height after a rapid somatic growth (1). The beginning and progression of this process can vary according to socioeconomic, ethnic and geographic characteristics (1).

In girls, it is considered to be normal for the first sign of puberty to appear between 8 and 13 years of age (2). However, it has been reported that the age and time of progression of puberty have diminished (3,4) worldwide, and studies have indicated a secular reduction in the age of menarche and thelarche (3-5). Based on these data, the Lawson Wilkins Paediatric Endocrine Society (LWPES) even suggested that it could be considered normal for pubertal evolution to begin at 7 years of age for white girls and 6 years of age for black girls (6). These recommendations were found to be very controversial by the medical community worldwide (2).

Less data are available from developing countries, but studies have indicated a persistent and even more marked drop in the age of menarche in these countries than in developed countries (4). In Brazil, previous

studies have confirmed this tendency, and the decline of the age of menarche in our country may reach up to 3.6 months per decade (7,8). Data regarding the age at which puberty begins and evolves in the Brazilian population are scarce (9,10). The most relevant study on this topic was performed in the 1980s (10).

Thus, the objective of this study was to identify at which age sexual development begins and the age of menarche in a sample of schoolgirls in a medium-size Brazilian city with a high Municipal Human Development Index (MHDI = 0.772). Additionally, we compared these data with those found in two classic studies: The Harpenden Growth Study and the PROS study (2,3,11). Considering the importance of ethnicity in puberty timing, sample stratification by ethnicity/skin colour was performed. Moreover, we evaluated differences in the anthropometry of the participants belonging to different stages of puberty.

SUBJECTS AND METHODS

This is a cross-sectional study with a sample extracted from a population of 48,390 schoolchildren aged

5 to 18 years, enrolled at public and private schools in the city of Uberaba, Minas Gerais, Brazil. The data were collected during the period from February 2012 to September 2013. This study was approved by the Ethics Committee of UFTM, under protocol number 1010, and adhered to the ethics criteria of the Declaration of Helsinki VII. Prior to participating in the study, all of the schoolchildren and their parents or guardian signed the Free and Informed Consent. The sample size and sampling techniques were calculated in three stages (12). In the first stage, a simple random sampling of the total population was performed. In the second stage, a proportional division of the sample was performed according to the population distribution among children enrolled in public schools and in private schools. Finally, in the third stage, the technique of sampling by conglomerates was used to determine the number of private and public schools.

To obtain the population sample established above, we randomly selected the schools and the schoolchildren and gave them a sealed envelope containing Free and Informed Consent after an explanation, together with all of the questionnaires and appendices to be completed for the study.

The inclusion criteria to participate in the study were age 5 to 18 years and good health. The exclusion criteria were the use of medications or presence of chronic diseases that might influence the initiation of puberty or physical development and pregnancy.

The physical examination of the subjects consisted of measuring height, weight and six skinfolds as described by Moreno and cols. (13). The weight and height measurements were used to calculate the body mass index (BMI), with a classification based on WHO criteria (14). The skinfolds were used to calculate the percentage of body fat (% BF) based on the formulas of Slaughter and cols. (15). The adequation of this percentage was established according to the reference values described by Deurenberg and cols. (16). To measure the weight and stature of the schoolchildren, the following were used: G-TECH® model BAL-GL3C digital electronic scale (capacity for 180 kg and 50 g precision) and portable Alturaexata® stadiometer (graduated up to 213 cm and 1 mm precision). The skinfolds were measured with a CESCORF® scientific plicometer (sensitivity 0.1 mm, reading range 85 mm, pressure ± 10 g/mB²).

The evaluation of pubertal development was performed by the participants in the study themselves, with

the help of their parents or guardians when necessary. Using the *status quo* method, followed by the recall method, the students answered in a semi-structured questionnaire, whether they did or did not observe any sign of puberty and, if they did, at which stage they first noticed each of the specific secondary sexual characteristics.

Furthermore, they indicated at what stage of puberty they currently were at on printed material consisting of photos that represented the various pubertal phases proposed by Marshall and Tanner (2) and adapted by Chipkevitch (17).

Other data on the participants were obtained by answers to a semi-structured questionnaire. The socioeconomic level was based on the Brazil Economic Classification through the Brazilian Association of Research Companies (ABEP – *Associação Brasileira de Empresas de Pesquisa*) (18). The classes were grouped for analysis purposes as follows: upper class, middle class and lower class, as suggested by the Department of Strategic Affairs (SAE – *Secretaria de Assuntos Estratégicos*) of the Presidency of the Republic, Brazil (19). For stratification by ethnicity, we used the self-reported skin colour as suggested by other authors (20) because there is high rate of miscegenation of ethnic groups in Brazil.

The use of photos and questionnaires employed to define the Tanner stage of the schoolchildren was also validated. The participants in whom any health disorder was identified during the data collection were invited to be evaluated through physical examination and ectoscopy, including pubertal status, in the Endocrinology outpatient clinic of our service by a single researcher who was also an endocrinologist. The Kappa (21) correlation coefficient between the evaluating physician and the participant was 0.626 for breast staging and 0.772 for pubic hair staging ($p < 0.001$), with both values indicating substantial levels of agreement according to Landis and Koch (21).

The data were analysed using the Statsoft program, version 8 and SPSS, version 20. To infer the difference between means, the Student *t* test and ANOVA followed by a Tukey's test for normal and homogeneous data were used. When these criteria were not fulfilled, the non-parametric tests were used: Wilcoxon test to compare two dependent samples, Mann-Whitney tests for independent samples and Kruskal-Wallis test for more than two means followed by the Dunn's multiple comparisons test. The value of $p < 0.05$ was used for statistical significance and a confidence interval for means of 95%.

RESULTS

Data were collected from 665 girls representing a sample of schoolchildren girls from Uberaba city.

The participants were aged between 5.9 and 18 years, and the mean of age, height, weight, z score for BMI and % BF for each group distributed according to the breast stage and total sample are shown in table 1. According to the distribution of girls in relation to the stage of pubic hair, 159 (23.9%) belonged to stage P1 (average age 8.4 ± 1.4 years), 112 (16.8%) to P2 stage (average age = 10.9 ± 1.74 years), 134 (20.2%) to the stage P3 (average age 13.3 ± 2.8 years), 106 (15.9%) to P4 (average age 15.0 ± 1.93 years) and finally 154 (23.2%) to stage P5 (average age 15.6 ± 1.52 years).

According to economic status, 52 (7.8%) of the participants belonged to the upper class, 473 (71.1%) to the middle class and 140 (21.1%) to the lower class. Regarding nutritional status, 20 (3.0%) girls were undernourished or malnourished, 437 (65.7%) were eutrophic, 125 (18.8%) were overweight, and 83 (12.5%) were obese. When classified according to body constitution using the parameter % BF, 314 (47.2%) participants presented an adequate % BF, 162 (24.4%) a moderately high percentage and 189 (28.4%) a high or excessively high percentage.

Regarding secondary sexual characteristics, in order of events, the girls initially presented thelarche at 9.8 ± 1.4 years, followed by pubarche at 10.2 ± 1.4

years, underarm hair at 10.5 ± 1.5 years and finally menarche at 11.7 ± 1.3 years. The mean ITM was 1.7 ± 1.3 years.

The data found in this study regarding mean age of onset of secondary sexual characteristics and ITM were compared to the results of the means and CI at 95% for the means found in two classical studies in the literature: the Harpenden Growth Study performed by Marshall and Tanner (2) and the PROS study performed by Herman-Giddens and cols. (3). These findings are described in table 2.

The distributions of girls according to age and status quo regarding the presence of thelarche, pubarche or menarche when they participated in the study are shown in table 3.

In our sample, we compared 3 groups of girls according to ethnicity/skin colour: white (n = 292), non-black/non-white (n = 293) and black (n = 79). The results found are described in table 4.

Considering the answers obtained in the semi-structured questionnaire (a recall method) about the presence or absence of puberty and the age of attainment of the secondary sexual characteristics, we evaluated the age interval at which 95% of the participants presented different puberty events (percentile 2.5 to percentile 97.5). For thelarche, the interval found was 7.0 to 12.0 years; for pubarche, it was 7.0 to 13 years. For underarm hair, it was 8.0 to 13.0 years; for menarche, it was 9.0 to 14.0 years.

Table 1. Anthropometric characteristics related to Tanner's pubertal stage in schoolgirls evaluated during the period from Feb/2012 to Sep/2014, in the city of Uberaba, Brazil

Pubertal stage	n (%)	Age (years)	Height (cm)	Weight (kg)	Height (z score)	BMI (z score)	%BF
		mean \pm SD (CI95%)					
B1	141 (21.2)	8.2 ± 1.3^a (7.9; 8.4)	129.4 ± 8.4^f (128.0; 130.8)	29.4 ± 7.9^j (28.1; 30.7)	0.28 ± 1.05^p (0.10; 0.45)	0.46 ± 1.47^q (0.22; 0.71)	23.7 ± 7.4^s (22.5; 24.9)
B2	123 (18.5)	10.7 ± 1.9^b (10.3; 11.0)	143.9 ± 10.9^g (142; 145.9)	40.9 ± 11.0^k (39.0; 42.9)	0.35 ± 1.08^p (0.16; 0.54)	0.71 ± 1.41^{qr} (0.46; 0.96)	27.6 ± 8.1^t (26.1; 29.0)
B3	135 (20.3)	13.4 ± 2.1^c (13.0; 13.7)	156.2 ± 8.6^h (154.8; 157.7)	49.5 ± 10.76^l (47.7; 51.7)	0.24 ± 1.01^p (0.07; 0.41)	0.25 ± 1.18^{qr} (0.05; 0.45)	26.7 ± 7.2^t (25.4; 27.9)
B4	137 (20.6)	14.8 ± 1.9^d (14.5; 15.1)	160.2 ± 6.5^i (159.0; 161.2)	53.5 ± 10.5^m (51.7; 55.2)	0.11 ± 0.93^p (-0.04; 0.27)	0.12 ± 1.19^{qr} (-0.08; 0.32)	27.5 ± 6.9^t (26.3; 28.7)
B5	129 (19.4)	15.7 ± 1.4^e (15.5; 16.0)	159.6 ± 6.7^i (158.5; 160.8)	56.7 ± 10.8^n (54.8; 58.5)	-0.28 ± 1.00^p (-0.46; -0.11)	0.40 ± 1.07^r (0.21; 0.58)	30.4 ± 8.1^u (29.0; 31.8)

B1-B5 = Tanner's pubertal stage according to the evolution of the breasts; n(%) = number of subjects and percentage according to the total; cm = centimeters; kg = kilograms; BMI = body mass index; %BF = percentage of body fat.* Different letters mean statistical difference between the groups regarding the variables evaluated. † Letters must be interpreted by variable, i.e., by column. a≠b≠c≠d≠e (Kruskal-Wallis test, p < 0.001); f≠g≠h≠i (Kruskal-Wallis test, p < 0.001); j≠k≠l≠m≠n (ANOVA, p < 0.0001); o≠p (ANOVA, p < 0.0001); q≠r (ANOVA, p < 0.001); s≠t≠u (ANOVA, p < 0.0001).

Table 2. Age of onset of the secondary sexual characteristics of schoolgirls evaluated during the period from Feb/2012 to Sep/2014, in the city of Uberaba (Brazil), compared to the results found by Marshall and Tanner (1964) and Herman-Giddens and cols. (1997)

Study	Group evaluated	n (%)	Characteristics evaluated (years) n (%) mean ± SD (CI95%)			
			Thelarche	Pubarche	Menarche	PTM
Feibelmann and cols. (2014)	Brazilian girls	665 (100)	515 (77.4)	499 (75.0)	355 (53.4)	355 (53.4)
			9.81 ± 1.39 (9.69;9.93) ^b	10.2 ± 1.44 (10.07;10.33) ^e	11.66 ± 1.32 (11.53;11.80) ^h	1.72 ± 1.32 (1.58;1.86) ^j
Marshall and Tanner (1964)	British girls	192 (100)	189 (98.4)	189 (98.4)	173 (90.1)	128 (66.7)
			11.15 ± 1.10 (10.99;11.13) ^c	11.69 ± 1.21 (11.51;11.89) ^g	13.47 ± 1.02 (13.33;13.61) ^k	2.34 ± 1.03 (2.16;2.52) ^m
Herman-Giddens and cols. (1997)	North American White skin girls	15438 (90,4)	3235 (18.9)	2723 (15.9)	387 (2.3)	NA
	African American Black skin girls	1639 (9,6)	431 (2.5)	452 (2.6)	105 (0.6)	NA
			9.96 ± 1.82 (9.93;9.99) ^b	10.51 ± 1.67 (10.48;10.54) ⁱ	12.88 ± 1.20 (12.82;12.94) ^j	
			8.87 ± 1.93 (8.78;8.96) ^a	8.78 ± 2.00 (8.69;8.87) ^d	12.16 ± 1.21 (12.04;12.28) ^l	

SD = standard deviation; CI95% = confidence interval at 95% for the mean; NA = not evaluated. * Different letters mean that there was no intercession between the CI95% for the mean. † The letters must be interpreted by characteristic, i.e., by column.

Table 3. Distribution of participants according to age and *status quo* regarding the presence of any secondary sexual characteristics in schoolgirls evaluated during the period from Feb/2012 to Sep/2013, in the city of Uberaba (Brazil)

Stage	Age* (years)/n							Total
	6/n = 28	7/n = 45	8/n ₁ = 54	9/n = 43	10/n = 45	11/n = 78	≥ 12/n = 371	
≥ B2	2	1	9	11	9	8	4	44
≥ P2	0	2	5	3	5	0	0	15
≥ B2 and ≥ P2	1	3	6	9	27	65	367	478
Total	3	6	20	23	41	73	371	537

N = total number of subjects evaluated in the corresponding age group independent of pubertal stage; ≥ B2 = Tanner stage for breasts B2 or greater; ≥ P2 = Tanner stage for pubic hairs P2 or greater; ≥ B2 and P2 = presence of both (Tanner stage for breasts B2 or greater and ≥ P2 = Tanner stage for pubic hairs P2 or greater) in a same subject. *Age (years) = age in complete years to 11 months within the corresponding age group.

Table 4. Age of onset of the secondary sexual characteristics according to ethnicity/skin color in schoolgirls evaluated during the period from Feb/2012 to Sep/2014, in the city of Uberaba (Brazil)

Ethnicity/Skin color	N (%)	Characteristics evaluated (years) n (%) mean ± SD (CI95%)			
		Thelarche	Pubarche	Menarche	ITM
White	292 (43,9)	229 (78.4)	224 (76.7)	173 (59.2)	173 (59.2)
		9.93 ± 1.46 (9.74-10.12) ^a	10.32 ± 1.39 (10.13-10.50) ^c	11.74 ± 1.31 (11.54-11.93) ^d	1.74 ± 1.36 (1.53-1.94) ^e
Black	80 (12,0)	62 (77.5)	60 (75)	42 (52.5)	42 (52.5)
		9.44 ± 1.33 (9.10-9.77) ^b	10.07 ± 1.65 (9.64-10.49) ^c	11.81 ± 1.63 (11.30-12.32) ^d	2.26 ± 1.38 (1.83-2.69) ^f
Nonwhite/nonblack	293 (44,1)	224 (76.4)	215 (73.4)	140 (47.8)	139 (47.4)
		9.80 ± 1.31 (9.63-9.97) ^{ab}	10.12 ± 1.42 (9.93-10.31) ^c	11.53 ± 1.23 (11.33-11.74) ^d	1.54 ± 1.20 (1.34-1.74) ^e

N(%) = number of subjects according to ethnicity/skin color and percentage in relation to the total number of subjects evaluated; n(%) = number of subjects that presented the characteristic evaluated and percentage in relation to the total number of subject of the ethnicity/skin color mentioned on the line; SD = standard deviation; CI95% = confidence interval of 95% for the mean; PTM: Period between Thelarche and Menarche.

* Different letters mean that there was a statistical difference considering p < 0.05. † The interpretation must be done by column, i.e., by characteristic evaluated. a=b (Kruskal-Wallis test; p = 0,0359); e=f (Kruskal-Wallis test; p = 0,0028).

Analysis of girls who present secondary sexual characteristics before the expected time

The schoolgirls who reported the onset of any secondary sexual characteristic before the expected time were called in for a specific evaluation at the Outpatient Service of Endocrinology at the University Hospital of UFTM.

They were distributed into 3 groups according to the characteristic presented: group 1 – premature thelarche (n = 14), group 2 – premature pubarche (n = 9) and group 3 – both premature thelarche and premature pubarche (n = 8). Within each group, we separately evaluated the children who began puberty events before the age of 7 years and the children who began over the age of 7 years and less than 8 years.

Those children were subjected to clinical examination, laboratory tests, bone age and imaging studies including MRI of the central nervous system and sella when considered to be necessary. After evaluation and clinical follow-up, these girls were diagnosed as described in figure 1.

DISCUSSION

In our study, we found that the beginning of puberty and the age of menarche in this group of Brazilian girls occurred earlier than reported in previous Brazilian and international studies (2,4,9,22-26).

When we compared our results to the study performed by Marshall and Tanner (2), all characteristics evaluated were attained earlier in our group. This difference could be due to the contribution of ethnic differences because we have noticed that our sample is miscegenated with genetic characteristics that are definitely different from those of the British girls evaluated by those authors. Moreover, our study is much more recent, and it is recognised that there is a phenomenon of secular reduction in the age of onset of the secondary sexual characteristics in several populations, especially in developing countries such as Brazil (4,5).

However, in accordance with this hypothesis, it was noted that the average age of the thelarche appearance in our sample of Brazilian girls was similar to that found by Herman-Giddens and cols. (3). The girls evaluated in that study were North American white girls.

In addition, the observation of the results found by our group after stratification of the sample according to ethnicity and skin colour also shows results that are in accordance with Herman-Giddens and cols. (3), i.e., one can expect an early appearance of breasts in black skin girls at a younger age than in other ethnic groups, although there was no difference in age at menarche between groups in our study.

Nevertheless, surprisingly, the mean age at menarche in our sample was lower than that found by any other study in the literature, including regarding the

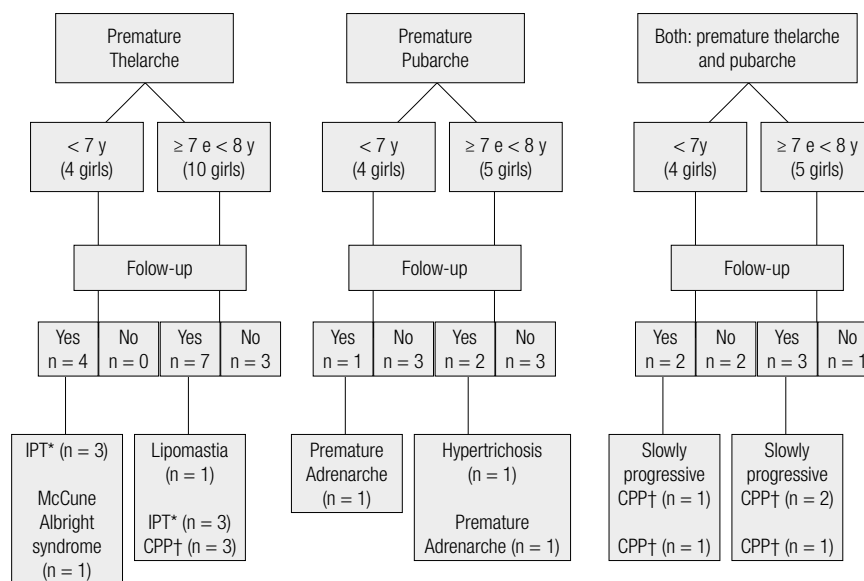


Figure 1. Follow up of girls with early secondary sexual characteristics.

* Isolated Premature Telarche; † Central Precocious Puberty.

interval between thelarche and menarche and data on the Brazilian population (4,10). Although it is possible that there was a bias because this age was self-reported by the participants, the method was similar to that described by previous authors. While in our sample the girls presented a mean age at menarche of 11.66 ± 1.32 years, the other Brazilian studies performed found mean values between 12.20 and 13.98 years (10). The statistical comparison of these results to those of our study was not performed because of methodological differences, number and age of the participants evaluated in each study. However, there is an apparent tendency for the age of menarche to become lower in Brazilian adolescents.

The factors posited that could explain a faster pubertal evolution in our sample include racial miscegenation, environmental, social and cultural factors. Although Brazil is a developing country, in the last few years, one of our most significant social problems, malnutrition, was geometrically replaced by the opposite phenomenon, obesity and overweight, even in the poorer populations. This excess weight and exposure to endocrine disruptors might explain both the earlier onset of the secondary sexual characters and the faster evolution of puberty, culminating in an earlier menarche (26,27).

In our sample, there was a high rate of overweight and obesity (31.3%). Additionally, the children are exposed early to cosmetics manufactured for adult women and subjected to different socio environmental stimuli, especially through the media, which could lead to the beginning and evolution of puberty (27).

In the present study, 95% of the girls attained thelarche between the age of 7.0 and 12.0 years, which would contribute to the discussion raised by the LWPES in 1999 (6) about the need to lower the age limit considered to be normal for the beginning of puberty. However, we believe that more important than defining a new cut-off value to investigate early puberty, we need to understand the factors responsible for these changes and whether there is a difference between the severity of puberty that began before the age of 7 years and puberty occurring between 7 and 8 years. Accordingly, regarding the clinical and laboratory evaluation of the girls who began puberty according to the different criteria, we find that the age of beginning puberty does not by itself distinguish the aetiology from the disorder.

Regarding the anthropometric parameters of the participants in our study compared among girls at dif-

ferent pubertal stages, we found that, as expected, the time spent between the B2 and B3 stages appears to be longer than between the other stages (2,3). This result coincides with the knowledge that, at the beginning of puberty, the hypothalamic-pituitary-gonadal axis, although activated, is not yet completely mature (1).

Weight also increases over the pubertal evolution, but the z score for BMI was similar between stage B1 and stage B5. This finding suggests that at the beginning of puberty, there is a proportional weight gain in relation to the girls' height, and the prepubertal pattern returns in the final phases. However, when evaluating the percentage of body fat, we find that the girls present a lower rate of BF in the pre-pubertal phase than during all of the other stages, most likely due to oestrogen production and to the progressive accumulation of fat mediated by this hormone (1).

Regarding height, there is a progressive increase throughout the development of these girls, but the final or almost final stature is most likely still achieved at stage B4 because the values found for stature during this phase were similar to those found in B5. The z score of this parameter is only different between the B5 stage and the other stages and is progressively lowering. This result leads us to speculate that we may be overestimating the final stature of the girls.

The present study does not allow the generalisation of data among the Brazilian population once it contemplated a restricted sample of students of a Brazilian city located in a well-developed area. In addition, because it is a cross-sectional study, there may have been biases related to adherence of the participants, the sample usage by conglomerates and especially because it was a timely evaluation of a dynamic event, limiting the validity of analysis related to the puberty progression. For this purpose, it would be ideal to perform a longitudinal evaluation of the same individual. Despite these limitations, it should be emphasised that the study participants were part of a single sample, independent of their pubertal stage, thus minimising biases that may occur in relation to genetic and ethnic background.

CONCLUSION

The girls evaluated in this study showed the beginning of secondary sexual characteristics and menarche at a younger age than expected, when considering the classical parameters suggested by Marshall and Tanner (2). In addition, the group of black girls started thelarche

earlier than girls from the other ethnic groups studied, despite reaching the final puberty at similar ages. Despite the limitations of this research, the results discussed cannot be neglected and indicate the need to conduct longitudinal, multicentre studies with the support of the Federal Government in order to better understand the reality of a representative sample of children and adolescents from the Brazilian population.

Author contributions: all authors participated in the reference research, design, planning, execution, analysis, data interpretation, writing and critical review of the work.

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