Sexual maturation associated with anthropometric measurements in elementary school adolescents

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ABSTRACT

Adolescence is an important phase of life where the body undergoes significant changes, transitioning from a child's body to an adult body. The influence of physical growth and sexual maturation can interfere with the individual's body composition. The objective of this study was to verify sexual maturation in boys and girls and its possible association with anthropometric measurements from two schools in Porto Velho-RO participating in the Pedagogical Residency Program. This work is characterized as a descriptive, cross-sectional field research, with a convenience sample, non-probabilistic and with a quantitative focus. The population of the present study was composed of 163 male and female schoolchildren aged 10 to 18 years, enrolled in 2 elementary schools. neck circumference (NC) and waist circumference (WC). In the descriptive analysis, the measures of central tendency and dispersion were represented by means, standard deviations, and median and interquartile median. For categorical variables, absolute frequency measures were performed. All statistical analyses were performed using the SPSS statistical software package, version 17.0. The results showed that, in relation to BMI, the mean of girls was 21.30 (SD=5.23), and that of boys was 19.69 (SD=4.42). The mean NC of boys was 31.56 (SD=3.15), while that of girls was 33.12 (SD=3.15). The WC of boys was 70.35 (SD=9.48) and girls 70.98 (SD=10.75), in which there was a close variation between both sexes. It was found that girls stood out in relation to weight, height, waist circumference and neck circumference, and there was no significant correlation with BMI. The findings show that there is a positive association between the female gender and the measurements of NC and WC. Thus, this study evidences results that affirm the association between maturation indicators and obesity, especially in girls.

Keywords: Sexual maturation, Schoolchildren, Anthropometric measurements.

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INTRODUCTION

The Pedagogical Residency Program (PRP) has an initiative aimed at the integral training of future teachers who think about health through physical education, giving opportunity to students of undergraduate courses, experiencing the profession, knowing the school environment with greater precision, expanding their means of teaching, developing their creativity and didactics of a reflective and active teacher, and especially to future Physical Education professionals, as it provides a greater contact of experience and experience in the field of work, which corroborates an improvement of a more attentive, cautious look and a sense of research and projects. The Physical Education subproject is articulated with the CAPES improvement program with the objective of teacher training in licentiate courses, allowing the experience of school management and pedagogical intervention. In view of this, the PRP of the Federal University of Rondônia decided to investigate the existence of the relationship between the nutritional status of boys and girls with their sexual maturation.

Within the school environment, Physical Education plays a very important role when it comes to overweight/obesity in adolescents, as it is a discipline that aims to provide and influence the student with a healthy and active lifestyle, controlling the obesity rate in schoolchildren. It should be emphasized that physical exercise should not be ended as an obligation, but as a pleasurable and fun act. Teachers should convey this message to students so that they associate physical exercise with well-being (GOMES, 2019).

It is known that adolescence is an important phase of life where the body undergoes significant changes, transitioning from a child's body to an adult body. According to Sawyer et al (2018), it considers this period where growth, maturation, and human development are enhanced.

Puberty is the period where the change in secondary sexual characteristics and sexual maturation in the human body is present (Hercowitz, 2021). Neta (2023) states that the entry of Precocious Puberty, being the passage from childhood to adulthood earlier than expected, can cause health risks, both psychic and physical for the child who goes through this stage. Such a condition brings with it psychosocial changes, changes in the formation of the individual's identity and subjectivity, so that the impacts are evidenced through the development of behavioral disorders, emotional immaturity and mental retardation (LÓPEZ-MIRALLES M, et al., 2022).

The influence of physical growth and sexual maturation can interfere with the individual's body composition and physical fitness, and physical activity is an important factor so that at this stage, adolescents can prevent numerous risk factors for chronic degenerative diseases throughout life, such as diabetes *mellitus*, respiratory problems, systemic arterial hypertension and dyslipidemia, which increases the risk of cardiovascular problems, in addition to multiple problems (ALVARENGA, 2013).

An increase in adipose mass is observed in the puberty process in children from generation Z, the World Health Organization (WHO), in 2024 states that the number of children and adolescents between 5 and 19 years old have been diagnosed with overweight or obesity since 1990 in the world has quadrupled. Obesity in adolescence is defined as excess body weight directed to the accumulation of fat cells in adipose tissue distributed throughout the body or regionally, being caused by genetic, endocrine, metabolic diseases or nutritional changes (FISBERG, 2016).

Thus, Abreu (2016) states that pubertal development usually begins between 8 and 13 years of age in girls, is characterized by the development of thelarche, followed by pubarche and after about 2 years, menarche; and, between 9 and 14 years of age in boys, with an increase in testicular volume, followed by pubarche and penile enlargement.

In Brazil, a retrospective cohort study by Cavalcante et al. (2014), conducted at the University Hospital of the Federal University of Ceará, observed 342 children diagnosed with central precocious puberty. Regarding the nutritional assessment, it can be observed that 177 (52.2%) had some level of overweight. However, only 89 (26.4%) sought treatment in a specialized service.

Currently in the literature it is notable that there is a visible relationship between overweight/obesity and early entry into puberty compared to children of normal weight, this relationship is often stronger when analyzed in girls, as studies have consistently shown that early or late sexual maturation, for example, is a risk factor for a higher incidence of overweight and obesity, especially in females. (XU et al 2022; FERRARI et al 2021; LOHIYA et al 2021; PEREIRA et al, 2021; LIU et al, 2020).

Therefore, the objective of this study was to verify sexual maturation in boys and girls and its possible association with anthropometric measurements from two schools in Porto Velho-RO participating in the PRP, since overweight/obese children often enter the puberty phase before the expected time.

METHODOLOGY

This work is characterized as a descriptive, cross-sectional field research, with a convenience sample, non-probabilistic and with a quantitative focus. The population of the present study was composed of 163 students aged 10 to 17 years, male and female, and enrolled in 2 elementary schools, the two selected schools are part of the PRP. Data were collected at the Bela Vista State School and the Dr. Oswaldo Pianna State School, both located in the city of Porto Velho - Rondônia.

The following data were collected for collection: weight and height for calculating the Body Mass Index; neck circumference and waist circumference.

DATA COLLECTION

The sample was intentional, starting in two schools in which preceptors and residents worked in data collection.   During the collection period, the following data were obtained: weight and height for calculating the Body Mass Index (BMI); neck circumference (NC) and waist circumference (WC).

Height was measured using a tape measure with a resolution in millimeters and a maximum height of 200 cm, glued to the wall with adhesive tape. To measure height, the adolescents removed their shoes, they were positioned standing, motionless, upright, with their arms relaxed along their sides and their spine leaning against the wall with the tape in the center of the head.

To measure weight, a digital scale with a capacity of 200 kg and a precision of 50 g was used. The teenagers were weighed without their shoes and extra items of clothing or objects were removed from the pockets of their school uniforms. They positioned themselves with their feet together in the center of the scales, body upright, the weight distributed equally on both feet, motionless, with arms relaxed along the body, head in the anatomical position and with their gaze fixed on the wall ahead. The classification of body mass index (BMI) for age was carried out according to the World Health Organization (WHO, 2007) references for adolescents aged 10 to 19 years. The classification categories included: thinness, normal weight, overweight and obesity. Cutoff points adopted: normal weight = z score ≥ 1 and $+ <1$, overweight $= \geq +1$ z score.

Waist circumference (WC) was measured using an inelastic tape measure, with resolution in millimeters and a length of 1.5 meters. To measure this measurement, the adolescent was placed upright, keeping the abdomen relaxed and the arms crossed over the chest. WC was measured at the midpoint between the last costal arch and the iliac crest, using a flexible anthropometric tape with a scale of 0.1 centimeters 9. WC was measured in duplicate and a third measurement was performed when there were differences greater than 0.1 cm between the measurements. The mean of the two measurements was used in the analyses. The subjects were classified according to the proposal of Freedman et al.10: increased risk $\geq$ 90th percentile. In the present sample, this percentile represented 77.2 cm for boys and 71.44 cm for girls.

To measure Neck Circumference (NC), the team of researchers in the present study, composed of undergraduate students in Physical Education, duly trained to standardize the technique, used a tape measure with resolution in millimeters and extension of 1.5 meters. NC was measured with the adolescent standing and the head positioned in the Frankfurt horizontal plane. The resident positioned the tape measure exerting minimal pressure at the time of taking the measurement for better contact of the tape with the skin, and the measurement was considered just below the epiglottis. The neck circumference classification for boys (< 33 cm = normal and $\geq$ 33 cm = excess fat) and girls ($\leq$ 31 cm = normal and >31 cm = excess fat).

It is noteworthy that the ethical aspects of the research took into account the guidelines of Resolution No. 466, of December 12, 2012, of the National Health Council. The research has been approved by the Research Ethics Committee of the Federal University Foundation, under opinion number 4.630.406 (CAAE: 06783119.7.0000.5300).

DATA ANALYSIS

In the descriptive analysis, the measures of central tendency and dispersion were represented by means, standard deviations, and median and interquartile median. For categorical variables, absolute frequency measures were performed. For the comparison between the sexes, the Student's t-test was used, while the Shapiro Wilk test ($p>0.05$) showed normal distribution, otherwise by median and interquartile The chi-square test was used to calculate prevalence ($p<0.05$). Binary Logistic Regression was used to verify the association between the exposure variable to the outcome female gender and the independent variables BMI, WC and NC and the following covariates were used for adjustment: age and sexual maturation. Odds ratios and 95% confidence intervals were obtained using multiple binary logistic regressions. $P\leq$ values of 0.05 were considered statistically significant. Calibration was calculated using the Hosmer-Lemeshow test and a p-value greater than 0.05 indicated that the model fits the data. All statistical analyses were performed using the SPSS statistical software package, version 17.0.

RESULTS AND DISCUSSION

The study included 163 students from Elementary School II from three schools in Porto Velho-RO. Table 1 presents the descriptive analysis of the sample, which shows that the mean age of boys and girls is similar, as follows: boys=13.00 (SD=1.86); girls=12.87 (SD=1.85).

Regarding BMI, the mean of the girls was 21.30 (SD=5.23), with 63% (45) classified as normal weight, but 37% (27) were classified as overweight. The mean BMI of the boys was 19.69 (SD=4.42), with 64% (58) classified as normal weight and 36% (33) boys classified as overweight.

The analysis of the NC of boys obtained a mean of 31.56 (SD=3.15), while that of girls was 33.12 (SD=3.15), of those investigated, 34% (31) boys and 55% (50) girls with excess fat and 66% (60) of boys and 45% (22) of girls classified as normal. Boys' WC was 70.35 (SD=9.48) and girls' 70.98 (SD=10.75), where there was a close variation between both sexes, with 20% (18) boys and 46% (33) girls in the risk zone. On the other hand, most of those investigated were classified in the healthy zone and 80% (73) of the boys and 54% (39) of the girls were found.

Table 1. Characterization of the sample of adolescent students in elementary school.

Variables	Average	DP	Variation
Boys = 91			
Age	13	1,86	10,00 – 17,00
Body mass	47,32	13,59	28,70 – 97,00
Body height	1,54	0,09	1,38 – 1,51
IMC	19,69	4,42	13,50 – 36,40
z score	0,69	1,69	-2,58 – 9,30
Waist circumference	70,35	9,48	56,00 – 98,00
Neck circumference	31,56	3,15	26,00 – 43,00
IMC	**n**	**%**	**IC95%**
Normal weight	58	63,7	53,48 – 72,87
Overweight	33	36,3	27,12 – 46,51
Neck Circumference			
Normal	60	65,9	55,72 – 74,84
Excess fat	31	34,1	25,15 – 44,27
Waist circumference			
Healthy zone	73	80,2	
Risk zone	18	19,8	
Girls = 72			
Age	12,87	1,85	10,00 – 18,00
Body mass	56,51	13,91	32,00 – 101,00
Body height	1,63	0,09	1,43 – 1,85
IMC	21,3	5,23	13,80 – 39,60
z score	0,32	1,47	-3,21 – 4,24
Waist circumference	70,98	10,75	56,00 – 116,00
Neck circumference	33,12	3,15	28,00 – 44,00
IMC	**n**	**%**	**IC95%**
Normal weight	45	62,5	50,95 – 72,78
Overweight	27	37,5	27,21 – 49,04
Neck Circumference			
Normal	22	30,6	21,12 – 41,95
Excess fat	50	69,4	58,04 – 78,87
Waist circumference			

Healthy zone	39	54,2	42,73 – 65,17
Risk zone	33	45,8	34,82 – 57,26

Adami (2008) observed that 21.6% of the girls were overweight, 16.5% of whom were classified as overweight and 5.1% as obese. These results suggest that girls exhibit a significant proportion of excess weight, which is considered a positive indicator for the identification of girls who have begun the maturation period. These observations are important because, for many girls, the beginning of maturation is marked by weight change and body fat distribution. Several studies have emphasized an intrinsic relationship between maturation indicators and obesity in girls. (Himes et al, 2004; Ribeiro, 2006). Therefore, it is the role of the physical education professional to identify girls who have started to go through the period. This can allow early interventions that can help prevent or manage excess weight, promoting optimal health for this audience in this period of development.

According to Freitas (2022), adolescents classified as having complete maturation had significantly higher BMI values when compared to those who were classified as having incomplete maturation or delayed. Most of the adolescents investigated in this study had 63% of adequate weight, however, it is worrying when we look at the 37% of all those surveyed who are overweight. Santos (2022) states that, in some cases, the measurements of anthropometric variables increase according to the stages of maturation. It is important to note that weight and BMI are significant indicators for assessing the risks of numerous diseases, including cardiovascular and chronic diseases.

Table 2. Mean, standard deviation, median and interquartile values of body mass (kg), body height (m), body mass index/BMI (kg/m2), waist circumference (cm) and neck circumference (cm) and prevalence (%) according to the sex of the schoolchildren......... Porto Velho, RO. 2024.

Variables		Sex		
		Boys	Girls	P-value
Age		13,00 (11,00-14,00)	13,00 (11,00-14,00)	0,528a
Body mass		42,30 (38,60-53,60)	56,00 (45,00-65,75)	<0,001a
Body height		1.54 ± 0.09	1.63 ± 0.09	<0,001b
IMC		18,60 (16,90-21,50)	20,15 (17,37-23,80)	0,027a
z-score		0.69 ± 1.69	0.32 ±1.48	0,208b
CC		69,00 (63,00-74,00)	69,00 (63,20-76,75)	0,780b
CP		31,00 (29,00-33,00)	33,00 (31,00-35,00)	0,001b
	n (%)	n(%)	n(%)	
Age				0,501
< 14 years	88 (54,0)	47 (53,4)	41 (46,6)	
≥ 14 years	75 (46,0)	44 (58,7)	31 (41,3)	
IMC				0,871
Normal weight	103 (63,2)	58 (56,3)	45 (43,7)	
Overweight	60 (36,8)	33 (55,0)	27 (45,0)	
CP				<0,001*
Normal	82 (50,3)	60 (73,2)	22 (26,8)	
Excess fat	81 (49,7)	31 (38,3)	50 (61,7)	
CC				0,001*
Healthy zone	113 (69,3)	73 (64,6)	40 (35,4)	
Risk zone	50 (30,7)	18 (36,0)	32 (64,0)	

a) Mann-Whitney test: represented by median and interquartile b) Student's t-test: represented by mean and standard deviation. Chi-square test = Prevalence (%) *p<0.05.

Table 2 shows that the mean age of both sexes is 13 (11.00-14.00) years. Regarding body mass, girls are highlighted, the average is 56 (45.00-65.75) kg. Regarding body height, it is important to note that boys obtained an average of 1.54± 0.09 m and girls 1.63 ± 0.09 m. Regarding PC, 81 of the students classified as excess fat, 50 are girls, where a statistically significant value was obtained (p=<0.001). Regarding CC, of the 50 students classified in the risk zone, 32 are girls, which corresponds to 64% of those classified (p=0.001).

Gemelli (2020) addresses that 13-year-old girls with the presence of menarche had an average height of 1.69 m and a median body mass of 50 kg. According to the data collected, girls who started maturing around the age of 14 tend to be taller and heavier, while girls who start the maturation period before the age of 11-12 are smaller and lighter. Thus, it can be said that the girls investigated in this study may also have menarche.

These results underline the relevance of a more detailed approach that takes into account individual stages of maturation when examining the growth and development of girls during the maturation phase. As noted by Karlberg (2002), height serves as a significant indicator of health in

adolescents, with a relationship with the stages of sexual maturation. Traditionally, during this period, boys are expected to have higher weight and height compared to girls. However, the results of this study contradict this trend with a different pattern of growth observed among the participating girls. This discrepancy highlights the complexity of the human development process and the need for further analysis to fully understand individual variations.

Regarding NC, it was identified that there was a positive correlation with gender, indicating that, in its majority, girls have an excessive accumulation of fat in this region. According to the results presented in this study, one study observed an increase in this measure in relation to the evolution of the stages of sexual maturation (Medeiros, 2014). It is notorious that, from the beginning of maturation, adolescents, especially girls, enter a period of remarkable growth.

In addition, with regard to WC, girls are more present in the risk zone. They tend to have a higher body fat percentage than boys, where they obtained a statistically significant result (p=0.001). This is due to the fact that the accumulation of body fat occurs faster in girls. In boys it is mainly influenced by the presence of testosterone. Therefore, girls have a greater tendency to accumulate body fat. According to Campos (2022), boys have a reduction in body fat and an increase in lean mass, while girls have an increase in the proportion of fat. This discrepancy is related to and can be explained by the actions of the sex hormones in each sex. This is a point that can be taken into account in this study.

Graph 1. Values (%) of complete maturation and incomplete maturation of females and males.

*Prevalence (%) Chi-square p>0.05
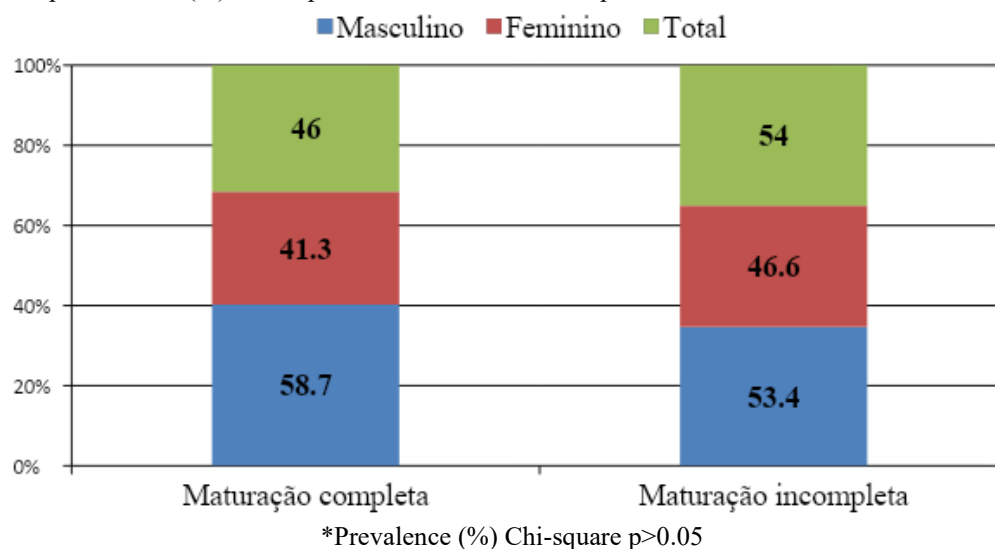
Graph 1 shows that 46% (n=75) of the sample reached complete maturation. Within this percentage, 58.7% (44) are boys and 41.4% (31) are girls. Of the remaining 54% (88) of the sample, which are incompletely matured, 46.6% (41) are girls and 53.4% (47) are boys. The evaluation of sexual maturation was carried out according to the criteria established in the MSD Manual (2022). To determine the stages of sexual maturation based on the age of the students, the following cut-off

point was adopted: the following values: for girls, incomplete maturation was considered < 14 years, while complete maturation was defined ≥14 years of age or older. For boys, incomplete maturation was characterized as <14 years, while complete maturation was ≥14 years of age or older.

It is noted that 54 adolescents, 46.6% girls and 55.4% boys, were classified as having incomplete maturation, where it can be deduced that the signs of sexual development of the investigated patients are still in progress, but have not yet reached the stage of fullness in terms of anatomical and functional that are necessary for reproduction. Several studies have some characteristics, in boys the enlargement of the penis and testicles are presented and in girls the development of breast tissue (Oliveira et al, 2023), the appearance of female and male pubic hair (Marshall WA, Tanner, 1969), occurrence of the first menstruation (Gemelli, 2020) and among other characteristics (Sawyer, 2018; Ré, 2011; Santos, 2022).

Table 3 – Association between female gender and body mass index (BMI), neck circumference (NC) and waist circumference (WC) variables in adolescent schoolchildren, 2023, using Logistic Regression Analysis.

Variables	β (Standard Error)	Gross Odds Ratio (95% CI)*	p	β (Standard Error)	Adjusted Odds Ratio (95% CI)*	p
Age						
Constant						
IMC						
Normal weight		1			1	
Overweight	0,053	1,06 (0,56 -2,00)	0,871	0,092	1,10 (0,57-2,10)	0,782
Constant	-0,254			-0,392		
CP						
Normal		1				
Excess fat	1,481	4,40 (2,27 – 8,53)	<0,001	1,571	4,81 (2,43-9,54)	<0,001
Constant	-1,003					
CC						
Healthy zone	1,177	1			1	
Risk zone	-0,602	3,24 (1,62 – 6,50)	0,001	1,228	3,41 (1,69-6,91)	0,001

*Adjusted for age and sexual maturation

According to the results of Table 3, which deals with the association between the female gender and the variables: BMI, NC and WC, it was observed that there was no significant correlation with BMI (p=0.782). However, in relation to NC, a positive association was identified, with girls presenting a higher NC in the adjusted ratio of 4.81 (95% confidence interval: 2.43-9.54), reaching statistical significance (p=<0.001). In addition, a significant association with WC of 3.41 (1.69-6.91) was found, also demonstrating a significant correlation (p=0.001). The findings show that there is a positive association between the female gender and the measurements of NC and WC. This

information suggests that the girls in this study tend to have higher WC and NC measurements compared to boys in the period of sexual maturation.

Regarding PC, there are few studies that address this anthropometric measurement with adolescent girls. In this study, we observed that older girls tend to be taller and heavier. In addition, after the analysis of the confidence interval, we found that the measures evaluated were correlated with age. Table 3 shows that NC is significantly linked to gender (p=<0.001), i.e., girls in the maturation phase tend to have higher NC.

The amount of fat in waist circumference in girls can vary significantly according to multiple factors, including age, stage of maturation, physical activity levels, eating habits, and genetics. Waist circumference is a measure that is often used in assessing abdominal fat accumulation and assessing the risk of certain health conditions, such as cardiovascular disease and type 2 diabetes. (Kurtoglu et al, 2012). Ortega et al (2021), longitudinally followed a group of 90 girls, aged between 8 and 15 years, over a period of four years. The results of this study suggest that girls who had higher adiposity in childhood had early thelarche (breast development). This finding suggests a possible influence of early adiposity on the process of sexual maturation in girls.

The authors emphasize the health promotion and prevention of adolescent students and can be important instruments for the process of reducing excess weight in this age group. It is the role of the Physical Education professional to monitor and plan activities adapted to the students' context, recognizing that excess weight is a risk factor for numerous diseases and that the consequences of these can interfere with other stages of life (Ferreira et al, 2018). Therefore, it is essential that there is the implementation of early interventions in these circumstances.

CONCLUSION

Based on the data analyzed in this study, it is evident that girls had higher WC and NC measurements during the period of sexual maturation, different data when looking at boys. This study highlights the results of other studies, affirming the association between maturation indicators and obesity, especially in girls. It is important to recognize that, with the beginning of the maturation period, adolescents go through a period of spurt, where significant growth is present.

In this context, it is of paramount importance that Physical Education professionals are attentive to their students so that they can identify the beginning of the maturation period, whether early or late. Early identification enables the application of effective health promotion strategies, aiming to avoid triggering problems during this period and ensuring that these young people reach their maximum potential for physical and psychosocial development.

REFERENCES

1. Sawyer, S. M., Azzopardi, P. S., Wickremarathne, D., & Patton, G. C. (2018). The age of adolescence. *Lancet Child Adolesc Health, 2*(3), 223-228. https://doi.org/10.1016/S2352-4642(18)30022-1

2. Alvarenga, W. A., Silva, S. S., Resende, M. R., & Santos, G. N. (2013). Fatores determinantes e condicionantes para o sobrepeso e a obesidade em pré-escolares: uma revisão integrativa. *Revista Interdisciplinar, 6*(4), 216-222.

3. Neta, J. A. B., et al. (2023). Fatores relacionados ao desenvolvimento da puberdade precoce em meninas. *Revista Eletrônica Acervo Científico, 46*, e14466. https://doi.org/10.24863/REC-2023v46e14466

4. López-Miralles, M., et al. (2022). Psychological aspects of pre-adolescents or adolescents with precocious puberty: A systematic review. *J Pediatr Nurs, 64*, 61-68. https://doi.org/10.1016/j.pedn.2022.01.006

5. Hercowitz, A. D., & D'souza-Li, L. (2021). Importância da detecção e acompanhamento pelo pediatra da puberdade precoce. *Boletim da Sociedade de Pediatria de São Paulo, 6*(4). Recuperado de https://www.spsp.org.br/site/asp/boletins/AtualizeA6N4.pdf

6. Organização Mundial de Saúde - OMS. (2007). Growth reference data for 5-19 years. Recuperado de https://www.who.int/growthref/who2007_bmi_for_age/en/index.html

7. Organização Mundial de Saúde - OMS. (2024). Uma em cada oito pessoas, no mundo, vive com obesidade. Recuperado de https://www.paho.org/pt/noticias/1-3-2024-uma-em-cada-oito-pessoas-no-mundo-vive-com-obesidade

8. Fisberg, M. (2016). Obesidade na Infância e adolescência. *Rev. Bras. Educ. Fís. Esp, 20*(1), 163-164.

9. Abreu, A. P., & Kaiser, U. B. (2016). Pubertal development and regulation. *Lancet Diabetes Endocrinol, 4*, 254-264. https://doi.org/10.1016/S2213-8587(16)30053-5

10. Xu, X. Q., et al. (2022). Relationship between body mass index and sexual development in Chinese children. *Zhonghua Er Ke Za Zhi, 60*(4), 311-316. Chinese. https://doi.org/10.3760/cma.j.cn112140-20210906-00754

11. Ferrari, V., et al.; Tuscany Menarche Study Group. (2022). Analysis of the Timing of Puberty in a Recent Cohort of Italian Girls: Evidence for Earlier Onset Compared to Previous Studies. *J Pediatr Adolesc Gynecol, 35*(1), 23-29. https://doi.org/10.1016/j.jpag.2021.06.007

12. Adami, F., & Vasconcelos, F. A. G. de. (2008). Obesidade e maturação sexual precoce em escolares de Florianópolis-SC. *Revista Brasileira de Epidemiologia, 11*, 549-560.

13. Cavalcante, C. J. W. (2012). Puberdade precoce central em crianças atendidas em serviço especializado de Fortaleza: características epidemiológicas e perspectivas em saúde pública.

14. Piola, T. S., et al. (2022). Associação entre sexo, maturação sexual, faixa etária, classe econômica e estado nutricional com os diferentes pontos de corte do tempo de tela em adolescentes. *Revista Brasileira de Saúde Materno Infantil, 22*, 337-342.

15. Lohiya, N., et al. (2021). Avaliação da maturidade sexual em crianças indianas – um estudo do oeste da Índia. *Revista de Endocrinologia e Metabolismo Pediátrico, 5*, 567-572.

16. Pereira, A., et al. (2021). Total and central adiposity are associated with age at gonadarche and incidence of precocious gonadarche in boys. *The Journal of Clinical Endocrinology & Metabolism, 106*(5), 1352-1361. https://doi.org/10.1210/clinem/dgab025

17. Liu, Y., et al. (2021). Prevalência de puberdade precoce entre crianças chinesas: um estudo de base populacional escolar. *Endócrino, 72*, 573-581.

18. Gomes, J. A., et al. (2019). Participação dos alunos com sobrepeso nas aulas de Educação física escolar. *Revista Científica Trajetória Multicursos, 11*(1), 32-48. Recuperado de http://sys.facos.edu.br/ojs/index.php/trajetoria/article/view/507

19. Ribeiro, J., Santos, P., Duarte, J., & Mota, J. (2006). Association between overweight and early sexual maturation in Portuguese boys and girls. *Ann Hum Biol, 33*(1), 55-63.

20. Himes, J. H., Obarzanek, E., Baranowski, T., Wilson, D. M., Rochon, J., & McClanahan, B. S. (2004). Early sexual maturation, body composition, and obesity in African–American girls. *Obes Res, 12*, 64-72S.

21. Freitas, A. S. (2022). Obesidade e maturação biológica em crianças e adolescentes. Tese de Doutorado.

22. Santos, L. E. S. dos, et al. (2022). Relação entre maturação sexual e indicadores antropométricos e pressóricos em adolescentes. *Ciência & Saúde Coletiva, 27*, 3615-3626.

23. Karlberg, J. (2002). Tendências seculares no desenvolvimento puberal. *Pesquisa Hormonal, 57*(Suplemento 2), 19-30.

24. Medeiros, R. M. V., et al. (2014). Contribution of anthropometric characteristics to pubertal stage prediction in young male individuals. *Revista Paulista de Pediatria, 32*, 229-235.

25. Oliveira, G., et al. (2023). Maturação sexual e sua relação com o excesso de peso entre escolares brasileiros: Estudo ERICA. *Revista da Faculdade de Ciências Médicas de Sorocaba, 25*, e63043.

26. Marshall, W. A., & Tanner, J. M. (1969). Variações no padrão de mudanças puberais em meninas. *Arquivos de Doenças na Infância, 44*(235), 291.

27. Gemelli, I. F. B., Farias, E. dos S., & Spritzer, P. M. (2020). Associação entre composição corporal e idade da menarca em meninas e adolescentes na Amazônia Legal Brasileira. *Jornal de Pediatria, 96*, 240-246.

28. Sawyer, S. M., et al. (2018). A idade da adolescência. *A Lancet Saúde da Criança e do Adolescente, 2*(3), 223-228.

29. Ré, A. H. N. (2011). Crescimento, maturação e desenvolvimento na infância e adolescência: Implicações para o esporte. *Motricidade, 7*(3), 55-67.

30. Santos, L. E. S. dos, et al. (2022). Relação entre maturação sexual e indicadores antropométricos e pressóricos em adolescentes. *Ciência & Saúde Coletiva, 27*, 3615-3626.

31. Merck Sharp & Dohme Corp. (2022). Manual MSD - Versão para Profissionais de Saúde. Puberdade Precoce. Recuperado de https://www.msdmanuals.com/pt/casa/problemas-de-sa%C3%BAde-infantil/dist%C3%BArbios-hormonais-em-crian%C3%A7as/puberdade-precoce#Puberdade-normal_v42289831_pt

32. Kurtoglu, S., et al. (2012). Neck circumference as a novel parameter to determine metabolic risk factors in obese children. *European Journal of Clinical Investigation, 42*(6), 623-630. https://doi.org/10.1111/j.1365-2362.2012.02660.x

33. Ortega, M. T., et al. (2021). Longitudinal investigation of pubertal milestones and hormones as a function of body fat in girls. *The Journal of Clinical Endocrinology & Metabolism, 106*(6), 1668-1683. https://doi.org/10.1210/clinem/dgab092

34. Ferreira, S. R. G., et al. (2019). Doenças cardiometabólicas. *Revista Brasileira de Epidemiologia, 21*, e180008.