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Relationship between sexual maturation and anthropometric and blood pressure indicators in teenagers

Luís Eduardo Soares dos Santos (https://orcid.org/0000-0003-4771-3342) [1]
Maísa de Lima Claro (https://orcid.org/0000-0001-8986-5753) [1]
David de Sousa Carvalho (https://orcid.org/0000-0001-6535-3841) [2]
Edina Araújo Rodrigues Oliveira (https://orcid.org/0000-0002-6352-4202) [2]
Ana Roberta Vilarouca da Silva (https://orcid.org/0000-0001-5087-4310) [1]
Ana Larissa Gomes Machado (https://orcid.org/0000-0002-7937-6996) [2]
Wolney Lisboa Conde (https://orcid.org/0000-0003-0493-134X) [3]
Luisa Helena de Oliveira Lima (https://orcid.org/0000-0002-1890-859X) [1]

Abstract *This study aimed to investigate the relationship between sexual maturation and anthropometric and blood pressure indicators in teenagers. This was a population-based cross-sectional study, conducted with 345 teenagers, aged 10 to 19 years, between 2018 and 2020. In this study, data referent to sociodemographic and anthropometric variables, blood pressure, and sexual maturation were collected. The data analysis was performed by applying the Principle Component Analysis (PCA), which generated three components and then tested the correlation between sexual maturation and the generated components. Most of the teenagers were female (53%), normotensive (66.1%), and with a normal weight (73%). A positive correlation was found between breast development and component 1 and component 2, as well as a negative correlation between the breasts and component 3. In the boys, the development of genitals and pubic hair was positively correlated with component 2 and inversely correlated with component 3. It could therefore be concluded that there is a relationship between sexual maturation and the anthropometric and blood pressure indicators, which proved to be representative variables for cardiovascular risk in teenagers, even if not in their entirety.*

Key words *Adolescent, Sexual maturation, Anthropometric Indicators, Blood Pressure*

[1] Programa de Pós-Graduação em Ciências e Saúde, Universidade Federal do Piauí (UFPI). Campus Universitário Ministro Petrônio Portella s/n, Bairro Ininga. 64049-550 Teresina PI Brasil.
luisedu.edu19@gmail.com
[2] Curso de Enfermagem, UFPI. Picos PI Brasil.
[3] Faculdade de Saúde Pública, Universidade de São Paulo. São Paulo SP Brasil.

Introduction

Adolescence is a stage of life that extends from childhood to adulthood, considering a period in which the growth, maturation, and human development are enhanced[1]. It is in this period that bodily changes arise, influenced by puberty and by the maturity of sexual organs[2], which result in the emergence of secondary sexual features, changes in body mass, the distribution of body fat, and growth spurts[3-5].

It has been observed that the changes in adipose tissue, as well as its distribution throughout the body during adolescence, are heavily influenced by puberty. In this sense, anthropometric evaluations are essential in order to investigate possible cardiovascular risk factors in this group. However, for this evaluation to be more complete, it is necessary to consider the process of sexual maturation as an important variable[6], given that studies that have shown that early sexual maturation, for example, appears as a risk factor for the large incidence of excess weight and obesity, especially in females[7-9].

Due to these bodily changes, another point that deserves due attention is blood pressure (BP) during adolescence, given that it has already been reported that sexual maturation can influence variations in BP due to bodily growth[10]. One study, which investigates BP levels and sexual maturation among black and white youth, verified that the sexual maturation, as well as the body size, of black girls, when compared to white girls, contributes significantly to BP levels. This condition reiterates that the stage of a subject's sexual maturation when measuring one's BP can be as important as measuring one's height and weight[11].

In this context, even though there are data about sexual maturation, anthropometric measures, and BP alterations, little evidence has stood out on these variables in clusters, but they do show that sexual maturation has a direct effect on BP and the distribution of body fat among teenagers[12]. However, the understanding about this condition is still in its initial stages and is poorly grasped. The scarcity of studies about the theme illustrates the need for new investigations that seek to understand how this phenomenon occurs in an attempt to bring scientific contributions to the scope of research in the area of collective health and teenager health, as a way to offer, above all, in-depth subsidies for health care in this group during adolescence.

Therefore, the present study aimed to investigate the relationship between sexual maturation and anthropometric and blood pressure indicators among teenagers.

Method

This work was a population-based, cross-sectional study, developed using the Home Health Survey (ISAD), conducted by the Collective Health Research Group from the Federal University of Piauí (UFPI) in partnership with the Department of Nutrition of the Public Health College (FSP) of the University of São Paulo (USP). This study resulted from the Interinstitutional Doctoral Program in Nutrition in Public Health (DINTER/FSP-UFPI), which is a partnership between the FSP-USP and UFPI, carried out in the municipality of Picos, Piauí, Brazil, between 2018 and 2020. The survey sought to analyze the health conditions of the urban population, considering all age groups.

The state of Piauí is located in the Northeastern region of Brazil. It is made up of 224 municipalities, with a population estimated, in 2019, at 3,273,227 people, and borders with the states of Maranhão, Bahia, Tocantins, Ceará, and Pernambuco. The state presents four demographic mesoregions: North, Center-North, Southeast, and Southwest, and the municipality included in this study, Picos, is known for having the highest population density in the Southeast region, in addition to being the third largest city in the state (at a distance of 320 km from the capital city of Teresina). The estimated population in 2020 for Picos was 78,431 inhabitants[13]. In the city, there is a UFPI campus, responsible for research projects, which made it possible to collect and process the data.

The participants of the study were teenagers from both sexes, from 10 to 19 years of age, who reside in private houses in urban areas of Picos. Excluded from this study were teenagers with cognitive disorders that hindered their communication and pregnant teenagers.

The sample was estimated based on the data from the Census conducted by the Brazilian Institute of Geography and Statistics (IBGE), through the stratification of the population by age groups. In 2010, 73,414 inhabitants lived in Picos, which had approximately 16,944 private houses[14], calculating the average number of individuals in each age group per household.

Participant selection was performed through the cluster sampling process in two stages: Primary Sampling Units (PSUs) and households.

Ciência & Saúde Coletiva, 27(9):3615-3626, 2022

Considering that the census sector is the smallest geographic unit available that includes data of the residents with similar socioeconomic characteristics and can be comprised of around 300 families (about 1,000 inhabitants). These were then – as necessary – divided or grouped in such a way that the coefficient of variation for its dimensions did not exceed 10% so as to improve the efficiency of the sample. In this sense, the formulated PSUs could be constructed by only one single census sector, a fraction of a census sector, or a cluster of census sectors[15].

Thus, the PSUs sample was created in a systematic manner, based on an ordered list of PSUs within the municipality, with the probability proportional to the size of the municipality, with the quantitative result defined for 24 PSUs. In addition, the number of households to be randomly selected in the second stage of sampling at each PSU was 26[15]. Therefore, 345 teenagers participated in this study.

Data collection was performed in the households of participants. To record the information, the researchers used smartphones and tablets containing the Epicollect5 application, a tool used to create and store digital forms. To characterize the sociodemographic data, information referent to age, sex, self-reported skin color, marital status, education level, and work status were collected.

The anthropometric variables were: height, weight, neck circumference (NC), triceps skinfold thickness (TST), subcapular skinfold thickness (SCT), and waist circumference (WC). The equipment used to measure these included: a portable stadiometer, an OMRON (HN-289LA) digital scale, a CESCORF inelastic and flexible anthropometric tape measure of 200 cm in length, and a CESCORF traditional scientific adipometer. All of the collections were carried out in duplicate in order to verify and guarantee the standardization of the technique, with the data obtained in the measurements expressed by the average of the two values[16,17].

In this sense, the body mass index (BMI) was calculated by dividing the weight (kg) by the height in square meters (m²), while the nutritional state was classified by means of the curves defined by the World Health Organization as: severe thinness (BMI Z-score <-3), thinness (-3 BMI Z-score <-2), and eutrophic (-2 BMI Z-score < BMI overweight Z-score <2 and obesity 2 BMI Z-score)[18]. The measurement of the waist circumference was performed above the average point between one rib and the iliac crest[19]. The calculation of the conicity index (CI) was performed by using the measures of weight, height, and WC[20], according to the formula presented below:

$$CI = \frac{\text{Waist Circumferences (m)}}{\sqrt{\frac{\text{Body weight (kg)}}{\text{Height (m)}}}}$$

The blood pressure was checked twice, using the classic auscultation method, with a calibrated aneroid sphygmomanometer, according to the procedures recommended in the *VII Diretriz Brasileira de Hipertensão* (7th Brazilian Guidelines on Hypertension). Among the teenagers, aged 10 to 17 years, the BP was classified according to the percentage: normotensive: Systolic Blood Pressure (SBP)/Diastolic Blood Pressure (DBP) <p90; prehypertension: SBP/DBP ≥p90<p95 and ≥120/80 mmHg and <p95; stage 1 hypertension: p95 and 5 mmHg above p99). Those aged 18 and 19 years had their BP classified as normotensive (SBP ≤120/DBP ≤80), prehypertension (SBP 121-139/DBP 81-89) and stage 1 hypertension (SBP 140-139/DBP 90-99)[21].

The characterization of puberty among the teenagers was performed by using a self-assessment instrument referent to the stages (scaled from 1 to 5) of sexual maturation, as proposed by Marshall and Tanner[22], where the evaluated features are the breasts, testicles, and pubic hair.

To ensure an effective data collection, with minimal bias, the research group went through a training session, which was conducted over a three-week period, in order to guarantee standardization in the study's data collection process, including the items mentioned above.

The analyses were performed using the Statistical Package for the Social Sciences (SPSS), with a statistical significance of $p<0.05$ and a 95% confidence interval (CI). In the descriptive analysis of the quantitative variable, central and dispersion tendency measures were used. To evaluate the normality of the data, the Kolmogorov-Smirnov (KS) test was used, considering a significance level of 5%. For the qualitative variables, the absolute and percentage frequencies were used. Still in this category of analysis, the description of the averages and the frequencies of the sociodemographic, anthropometric, blood pressure, and sexual maturation variables were performed.

In the inference analysis, for the comparison of the averages between the groups of variables that did not follow the normal distribution, the Kruskal-Wallis test was used between the stages of sexual maturation and the anthropometric and blood pressure variables. To evaluate which groups differed among themselves, the Mann-Whitney post-hoc analysis was used.

In addition, the Principle Component Analysis (PCA) was applied between the anthropometric (height, weight, neck circumference, triceps skinfold thickness, subcapular skinfold thickness, and waist circumference), and blood pressure variables. Beginning with the PCA, three latent variables were generated, called Cardiovascular Risk Components (CVRC). This study considered components with eigenvalues of above 0.7 and eigenvectors of above 0.2. After the extraction of the components, Varimax orthogonal rotation was applied. For the adequacy of the sample according to the degree of correlation, the values estimated by the Kaiser-Meyer-Olkin (KMO) test were considered[23]. Finally, the correlation between the stages of sexual maturation and the CVRC generated through the PCA were verified by applying Spearman's correlation test, considering a statistical significance of $p<0.05$ and $p<0.01$.

The present study was submitted to and approved by the Federal University of Piauí Research Ethics Committee, logged under protocol number 2.552.426, complying with the formal requirements, as set forth in Resolution 466/12, of the National Health Council (NHC).

Results

In the descriptive analysis, it was observed that 53% (n=183) of the evaluated teenagers were female, 57.9% (n=191) self-declared themselves as brown skinned and 82.3% (n=284) as single; 17.9% (n=59) were in the third year of high school, and 93.5% (n=288) declared that they had no formal job. The average age was 14.58 years (±2.38; 10-19).

As regards blood pressure, it was observed that 66.1% (n=228) of the teenagers were classified as normotensive. Nevertheless, a significant quantity of individuals was found to have high blood pressure (prehypertension + stage 1 hypertension), representing 33.9% (n=117) of the total sample (Table 1).

By contrast, in the anthropometric variable, the average height was 1.61 meters (±0.10; 1.24-1.90), while the average weight was 54.69 kilograms (±13.67; 24-136.6). As regards the BMI, the prevalence was of normal weight (73%) (n=252; ±3.99; 13.10-40.09); however, 22.6% (n=78) were overweight (overweight + obesity). The average NC was 30.11 cm (±2.43; 18-45), while the TST showed an average of 16.22 cm (±6.67; 1-35), an average SCT of 13.73 cm (±5.85; 1-40), an average WC of 76.46 cm (±71.55; 35-99.75), and an average CI of 1.12 (±0.0804; 0.6-186) (Table 1).

Upon analyzing the intergroups, Table 2 shows that the BMI was related to the girls' breast development ($p<0.001$). SBP was notably related to the development of the genitals and public hair ($p<0.001$), while the SBP was only related to the pubic hair growth in the boys ($p<0.001$). As regards the NC, it was observed that the measure was related to breast development in the girls, and related to the development of genitals and pubic hair in the boys ($p<0.001$). In the other variables, no statistically significant difference was observed.

By contrast, in the intergroup analysis, it was possible to observe that, when the anthropometric and blood pressure variables were compared according to the stages of breast maturation among the girls, the BMI of those who were in stages 1, 2, and 5 differed among themselves, while those that were in stages 3 and 4 presented similar BMIs, also differing from the other stages. This information proved to be similar to that found in NC. When compared with the TST, the girls that were in stages 1 and 2 differed among themselves and from the others; however, they were similar in stages 3, 4, and 5. In the SCT, it could be noted that those who were in stages 1 and 5 were different among themselves and in comparison to the other stages, while those that were in stages 2, 3, and 4 presented the same value statistically. The other variables (SBP, DBP, WC, and CI), when compared to breasts and pubic hairs, showed no variations, appearing statistically similar regardless of the stage of sexual maturation.

The investigation of the correlation among the anthropometric variables, blood pressure, and sexual maturation of the teenagers was strong and positive (Table 3). Added to this, a positive correlation was observed among some variables of sexual maturation with some anthropometric variables (breasts with BMI, NC, TST, SST, and WC; genitals with NC and WC). A positive correlation was observed among some variables of maturation among the boys (genitals and pubic hair) with SBP and DBP. Nevertheless, some variables presented negative correlations, proving to be inversely proportional, as is the

Ciência & Saúde Coletiva, 27(9):3615-3626, 2022

Table 1. Characterization of blood pressure and anthropometric variables among the teenagers in this study. Picos-PI, Brazil, 2020 (N=345).

Variables	N(%)	Average (95%CI)	Min	Max	SD	P-value
Clinical Variables						
Blood Pressure (BP)						
Systolic Blood Pressure (SBP)		109.75(108.11-110.73)	50	145	11.87	<0.001
Diastolic Blood Pressure (DBP)		71.91(70.76-72.91)	35	100	9.69	<0.001
Classification of BP						
Normotensive	228(66.1)					
Prehypertension	74(21.4)					
Stage 1 hypertension	43(12.5)					
Anthropometric Variables						
Height		1.61(1.59-1.61)	1.24	1.9	0.10	0.200
Weight		54.69(53.06-56.02)	24.00	136.6	13.67	<0.001
BMI		21.00(20.42-21.34)	13.10	40.09	3.99	<0.001
Classification of BMI						
Severe thinness	4(1.2)					
Thinness	11(3.2)					
Normal	252(73.0)					
Excess weight	49(14.2)					
Obseity	29(8.4)					
Neck Circumference (NC)		30.11(29.95-30.47)	18.00	45.0	2.43	<0.001
Triceps Skinfold Thickness (TST)		16.22(15.39-16.87)	1.00	35.0	6.67	<0.001
Subcapular Skinfold Thickness (SST)		13.73(1294-14.22)	1.00	40.0	5.85	<0.001
Waist Circumference (WC)		76.46(68.58-84.89)	35.00	99.75	71.55	<0.001
Conicity Index (CI)		1.12(1.2-1.13)	0.6	1.86	0.0804	<0.001

Kolmogorov-Smirnov normality test, at a significance level of 5%.

Source: Authors.

Table 2. Analysis of the comparison of the groups (stages of maturation) with BMI, SBP, DBP, NC, TST, SST, WC, and CI of the teenagers in this study. Picos-PI, Brazil, 2020 (N=345).

	BMI	SBP	DBP	NC	TST	SST	WC	CI
Breasts	<0.001	0.229	0.374	<0.001	0.004	0.006	0.002	0.109
GPH*	0.192	0.306	0.547	0.103	0.532	0.230	0.188	0.340
Genitals	0.737	<0.001	0.010	<0.001	0.109	0.976	0.249	0.012
BPH†	0.576	<0.001	<0.001	<0.001	0.121	0.925	0.217	0.072

*GPH: Girls' Pubic Hairs; † BPH: Boys Pubic Hairs. Kruskal-Wallis Test.

Source: Authors.

case of the boys' genitals and pubic hairs with SST and CI, much like the girls' breasts with CI.

In the Principle Component Analysis, the rotation matrix generated 3 components (CVRC1, CVRC2, CVRC3). In this sense, the 3 components explained 69.37% of the data variance, where the KMO test value was 0.725. Thus, CVRC1 contains the majority of variance found, and this component offers a better and more specific explanation about some of the anthropometric variables of body composition, such as the skinfold thickness and the BMI. CVRC2 is more well-defined by the mixture of blood pressure and anthropometric variables (SBP, DBP, and WC). Finally, CVRC3 was best explained by two anthropometric variables (WC and CI), as shown in Table 4.

The correlation test between the components found and the stages of sexual maturation indicated that, in the girls, a positive correlation was found between breast development and CRVC1 (r=0.229; p=0.002) and CRCV2 (r=0.226; p=0.002), as well as a negative correla-

Table 3. Correlation among the anthropometric, blood pressure, and sexual maturation variables of the teenagers in this study. Picos-PI, Brazil, 2020 (N=345).

	A	B	C	D	E	F	G	H	I	J	L	M
BMI(A)	1	0.362	0.353	0.350	0.670	0.728	0.806	0.154	0.295	0.144	0.102	0.125
SBP(B)*	0.362	1	0.583	0.339	0.072	0.217	0.397	0.067	0.086	0.057	0.372	0.440
DBP(C)†	0.353	0.583	1	0.299	0.174	0.284	0.381	0.114	0.108	-0.005	0.273	0.365
NC(D)‡	0.350	0.339	0.299	1	0.099	0.285	0.420	0.026	0.354	0.198	0.400	0.355
TST(E)§	0.670	0.072	0.174	0.099	1	0.766	0.504	0.182	0.155	0.041	-0.204	-0.208
SST(F)‖	0.728	0.217	0.284	0.285	0.766	1	0.649	0.279	0.180	0.050	-0.012	-0.042
WC(G)**	0.806	0.397	0.381	0.420	0.504	0.649	1	0.578	0.202	0.154	0.180	0.188
CI(H)††	0.154	0.067	0.114	0.026	0.182	0.279	0.578	1	-0.150	0.003	-0.218	-0.224
B(I)‡‡	0.295	0.086	0.108	0.354	0.155	0.180	0.202	-0.150	1	0.431	-	-
GPH(J)§§	0.144	0.057	-0.005	0.198	0.041	0.050	0.154	0.003	0.431	1	-	-
GT(L)‖‖	0.102	0.372	0.273	0.400	-0.204	-0.012	0.180	-0.218	-	-	1	0.641
BPH(M)***	0.125	0.440	0.365	0.355	-0.208	-0.042	0.188	-0.224	-	-	0.641	1

*SBP: systolic blood pressure; † DBP: Diastolic blood pressure; ‡ NC: Neck circumference; §TST: triceps skinfold thickness; ‖ SST: Subcapular skinfold thickness; ** WC: Waist circumference; †† CI: Conicity index; ‡‡ B: Breasts; §§ GPH: Girls' pubic hairs; ‖‖ GT: Genitals; ***BPH: boys' pubic hairs. Spearman's correlation test.

Source: Authors.

Table 4. Description of factorial components for the characterization of cardiovascular risks in the teenagers in this study using the rotational matrix. Picos-PI, Brazil, 2020 (N=345).

	Components		
	CRCV 1†	CRCV 2†	CRCV 3†
CVR variables*			
Triceps Skinfold Thickness (TST)	0.943		
Subcapular Skinfold Thickness (SST)	0.887		
BMI			
Systolic Blood Pressure (SBP)		0.872	
Diastolic Blood Pressure (DBP)		0.818	
Neck Circumference (NC)		0.597	
Waist Circumference (WC)			0,814
Conicity Index (CI)			0,632
Eigenvalues	3,087	1.461	1.002
% of variance	38,586	18.267	12.525
% of accumulative variance	38,586	56.852	69.377
Kaiser-Meyer-Olkin (KMO)	0.725		

*CVR: Cardiovascular Risk; † CVRC: Cardiovascular Risk Component.

Source: Authors.

tion between the breasts and CVRC3 (r=-0.155; p=0.038). Among the boys, it was observed that the development of genitals and pubic hairs was positively correlated with CVRC2 (r=0.417, p=0.000; r=0.465; p=0.000) and inversely correlated with CRVC3 (r=-0.233, p=0.004; r=-0.207; p=0.010) (Table 5).

Discussion

The verification of blood pressure showed that, among the teenagers, a major part of the total quantity was considered to be prehypertensive, given that 21.4% and 12.5% were classified with stage 1 hypertension, which is in accordance with

Ciência & Saúde Coletiva, 27(9):3615-3626, 2022

Table 5. Correlation between the components (factors) and the stages of maturation of the teenagers in this study. Picos-PI, Brazil, 2020 (N=345).

		Breasts	Hairs (girls)	Testicles	Hairs (boys)
CRCV 1[†]	r	0.229**	0.059	-0.054	-0.081
	p	0.002	0.430	0.501	0.317
CRCV 2[†]	r	0.226**	0.075	0.417**	0.465**
	p	0.002	0.319	0.000	0.000
CRCV 3[†]	r	-0.155*	-0.041	-0.233**	-0.207**
	p	0.038	0.589	0.004	0.010

* The correlation is significant at a level of 0.05 (2 extremities); ** The correlation is significant at a level of 0.01 (2 extremities); † CVRC: Cardiovascular Risk Component.

Source: Authors.

a study conducted in Texas, where 29% of the teenagers were also prehypertensive[24].

Hypertension has been showing growing rates among the younger populations worldwide. Despite this problem, the diagnosis has often been performed too late, due mainly to the lack of the inclusion of blood pressure measurements as a routine in physical exams[25]. In the Brazilian reality, there are indications of a rise in blood pressure levels within the specific group, characterizing it as a public health problem that demands real strategies to be overcome. As this is not a condition isolated to our country; this health problem is also a reality among teenagers worldwide, as studies in North America and Europe, for example, have also shown altered blood pressure levels among teenagers[26,27].

This can be explained primarily by the relationship with multifactorial causes, such as the increase in excess weight, obesity, sedentarism, heredity, among others. The teenagers of this study presented, to a great extent, adequate weight (73%); however, it is worrisome to see that, when clustered, excess weight and obesity add up to 22.6% of the total number of teenagers in this study, given that the weight and the BMI are recognized as the major determinants of high BP levels in children and teenagers, since the higher the BMI, the higher the blood pressure levels[28,29].

As pointed out in a study conducted with 8,579 British children and teenagers who were overweight or obese, it was found that those who were classified with a higher severity of obesity presented higher blood pressure levels, both systolic and diastolic[30]. In addition, it was also possible to observe that the teenagers considered to be obese had twice a high a risk to develop hypertension when compared to subjects that had normal weight[31].

As regards the characterization of sexual maturation, it was observed that the majority of the teenagers, both boys and girls, were in stage 4 of maturation for the gonads and pubic hairs, data similar, in part, to that found by Minatto[32], where there was a prevalence in stages 2 and 4 for both sexes.

By contrast, the girls studied in this work presented a chronological similarity between breast development and pubic hairs in all of the stages of sexual maturation, which did not occur with the boys. Nonetheless, a certain variability among the stages is to be expected, since each teenager evolves in a different manner from stage to stage according to one's age[33].

For each sex, the evaluation of sexual maturation is performed in two stages: breasts and pubic hairs for the girls, and genitals and pubic hairs for the boys. With this, some teenagers may be at different stages for each one of the characteristics, considering that the maturation of these obeys different hormonal and genetic mechanisms. The correlation of some events of puberty is greater with a specific component of staging than with another, for example, the age of the menarche is more often correlated with breast development than with pubic hairs[34].

The results of this study also demonstrate that, in some cases, the averages of some anthropometric variables increased gradually according to the increase in the stages of sexual maturation. This fact can be observed in the BMI of the girls, which was greater in those in stage 5 as compared to those in the other stages. For Karlberg[35] and Suliga[36], the height is characterized as a good health indicator for teenagers and is heavily associated with the stages of sexual maturation. According to Tanner[37], height is associated with all of the changes in the puberty stage, and presents no association with weight. However, in the present study, it was not possible to evaluate this type of result, considering that neither variable was analyzed in an isolated manner, but rather the relation to each other (BMI).

In one study that evaluated the association among the nutritional state, body composition, and sexual maturation in teenagers, what stood out was the prevalence of the excess weight among females (26.4%), in addition to a large body composition (66.5). Also noted was the relationship between excess weight and excess body fat and abdominal obesity; the percentage of body fat was the most influenced by the BMI and age among the boys and by the BMI and maturation stage among the girls ($p<0.001$). When associating the nutritional stage with the sexual maturation, 48.8% of the individuals who were overweight were also at the limit of the speed of growth[38]. Pinto *et al.*[39] highlighted that there was a significant increase in excess weight and abdominal obesity, especially in the final stages of sexual maturation.

The maturation of the genitals and pubic hairs was significantly related to systolic blood pressure, while diastolic blood pressure was only related to pubic hairs among the boys. In one study, conducted with 416 teenagers, it was observed that the influence of sexual maturation upon blood pressure is mainly due to the dissociated effects of the variables of height and body mass[40]. By contrast, another study that compared the proportions between puberty and post-puberty boys and girls, showed no significant differences in blood pressure[41].

In relation to neck circumference, it was observed that the measurement was related to breast development in the girls and to the development of the genitals and pubic hairs in the boys. Much like the results for the present study, another study affirmed a constant increase in the neck circumference, which was concomitant with the evolution of the stages of sexual maturation[42]. Nevertheless, no studies were found that explained or analyzed the relationship between this variable and sexual maturation.

In the other anthropometric variables, no significant difference was found among the groups. In the case of skinfold thickness, no significant difference was found among the stages of sexual maturation, corroborating findings from other studies[42-46]. In this sense, this condition can be explained because, in the boys, the increase in weight at this stage is mainly accompanied by a gain in muscle mass (of 80-90%) and by stabilization in the levels of body fat, which ends up producing little change in the absolute levels of subcutaneous fat[47,48].

Nonetheless, when anthropometric, clinical, and sexual maturation variables are clustered and their correlations within the PCA matrix are analyzed, a strong and positive correlation was found among them. Confirming this condition, other studies with similar designs illustrated that the BMI or the body adiposity may not be decisive enough to trigger sexual maturation, but the increase in body mass and adiposity can be a consequence of sexual maturation[45,48-50].

Another point that deserves attention is the positive correlation between maturation variables and clinical variables, such as the development of the genitals and pubic hairs with both systolic blood pressure and diastolic blood pressure, since the gradual increase in blood pressure can be associated with diverse biological alterations that the teenager is passing through, such as sexual maturation[51]. In the literature, no data was found referent to the relationship of the points that constitute the evaluation of sexual maturation with conicity index.

As regards CVRCs and their correlation with sexual maturation, no data was found that could justify this condition theoretically. Nevertheless, it is suggested that, in the anthropometric evaluation of female teenagers, it is important to consider which maturation stage – specifically of the breasts – that she is in, since obesity can lead to early breast development[52]. Moreover, it can be inferred that, in the evaluation of blood pressure levels among teenagers, it is necessary to investigate their sexual maturation.

One longitudinal study that conducted a one-year follow-up on children and teenagers, classified as Metabolic Healthy Obese (MHO) and Metabolic Unhealthy Obese (MUO), that is, those that, even if they presented a certain degree of obesity, were still considered metabolically healthy and those that, together with the degree of obesity, present other cardiovascular risk factors, respectively, illustrated that the best predictor for MUO was the puberty stage and the best predictor for the change from MHO to MUO was the teenager's entrance into puberty. Furthermore, the entrance into puberty was associated with a worsening of the levels of blood pressure, lipids, and glucose, as well as the increase in the insulin resistance index, while the change from

Ciência & Saúde Coletiva, 27(9):3615-3626, 2022

average puberty to late puberty was associated with improvements in these factors[53].

More recent data point out results that are a bit different form those reported above, in which one study identified that the excess weight was associated with the post-puberty maturation stage. Even so, the authors recognize that this is a contradictory fact, since the excess weight was also associated with a younger chronological age. Thus, the chronological age plays a secondary role, given that the teenagers of the same age are in fact in different stages of puberty. For this reason, the authors also recognize that the nutritional evaluation of the teenager is still quite complex[54].

Although the present study has generated a number of affirmations, it has also presented some inherent limitations to its implementation, such as that fact that it is a cross-sectional study, as this makes it difficult to establish a direct relationship between cause and effect, the impossibility of conducting biochemical data collection, and the difficulty to verify blood pressure at distinct moments, since it is recommended to perform the measurement in at least three different moments and on distinct days.

Scientific research concerning the relationship between sexual maturation and cardiovascular risks is still in its initial stages, which can hinder and even limit a more consolidated theoretical foundation when dealing with this theme. By contrast, this shows the authenticity and differential of this study as regards the unique data found in our research, thus laying the ground for new and future debates on the issue.

Conclusion

The present study identified a relationship between the process of sexual maturation and anthropometric and blood pressure indicators, which proved to be representative variables of cardiovascular risks among teenagers, even if not in their entirety. Therefore, it is of utmost importance, within the evaluations of body and blood pressure assessments, to consider these subjects' stages of puberty, bearing in mind that there is evidence of a genuine influence of one measurement upon another.

The results of this study show the need to clinically evaluate teenagers, considering a wide range of parameters, taking into consideration that the relationship between sexual maturation and cardiovascular risk indicators were proven. It is hoped that the data presented herein will serve as a basis for reflection for care practices in complete health care and, above all, that they can be used as foundational tools for the implementation of health promotion actions among teenagers.

Collaborations

LES Santos assisted in the conception and design of the study; data analysis; writing and critical revision of its contents; approving the manuscript's final version. ML Claro assisted in writing and critical revision of its contents; approving the manuscript's final version. DS Carvalho assisted in writing and critical revision of its contents; approving the manuscript's final version. EAR Oliveira assisted in revision of its contents; approving the manuscript's final version. ARV Silva assisted in revision of its contents; approving the manuscript's final version. ALG Machado assisted in revision of its contents; approving the manuscript's final version. WL Conde assisted in revision of its contents; approving the manuscript's final version. LHO Lima assisted in the conception and design of the study; data analysis; writing and critical revision of its contents; approving the manuscript's final version.

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