Jornal de Pediatria 2023;**99(1)**: 45–52

sociedade brasileira de pediatria

Jornal de Pediatria

www.jped.com.br

ORIGINAL ARTICLE

Association between abdominal obesity, screen time and sleep in adolescents

Isabela dos Reis de Oliveira, Nathália Maximiano Soares Maciel, Bianca Tomaz da Costa, Anne Danieli Nascimento Soares, Júnia Maria Geraldo Gomes *

Instituto Federal de Educação, Ciência e Tecnologia do Sudeste de Minas Gerais, Barbacena, MG, Brazil

Received 3 September 2021; accepted 11 February 2022
Available online 11 June 2022

KEYWORDS
Overweight;
Obesity, Abdominal;
Sedentary behavior;
Food intake;
Adolescence

Abstract
Objective: To assess the association between abdominal obesity, food intake, sleep deprivation, and screen time in adolescents.
Methods: This cross-sectional study was conducted with 432 adolescents aged 14–19 years, from public and private schools. Anthropometric and body composition measures included body weight, waist circumference, body mass index for age, waist-to-hip ratio, waist-to-height ratio, and body fat percentage. Abdominal obesity was defined by age and sex specific cut-off points for waist circumference. Food intake, screen time, sexual maturation, and sleep duration were evaluated by self-administered questionnaires.
Results: The prevalence of excess body weight and abdominal obesity was 16.7% and 27.5%, respectively. Students in the adult phase (post-puberty), with inadequate waist-to-height ratio, high body fat percentage, and screen time $\geq$ 3 h/day were, respectively, 2.5 (95% CI 1.40–4.46), 7.44 (95% CI 1.08–51.46), 2.79 (95% CI 1.04–7.50), and 1.43 (95% CI 1.24–3.89) more likely to have abdominal obesity. Low intake of unprocessed or minimally processed foods was associated with inadequate sleep duration, while high intake of ultra-processed foods was associated with high screen time.
Conclusions: Abdominal obesity was associated with the adult phase, short sleep duration and high screen time. The degree of food processing was associated with screen time and sleep duration. Assessing the risk factors of abdominal obesity may be a useful strategy for preventing cardiovascular disease in adolescents.

* Corresponding author.
E-mail: junianut@yahoo.com.br (J.M. Gomes).

https://doi.org/10.1016/j.jped.2022.02.007
0021-7557/

Introduction

In the last decades, a nutritional transition that has been occurring in Brazil and in developing countries is characterized by the reduction of hunger and malnutrition and the worrying increase in overweight and obesity.[1] Sedentary behavior (generally associated with high screen time (ST)), high intake of processed and ultra-processed foods (rich in additives, sugar, salt, fat, and energy), and sleep deprivation (a factor that alters circadian rhythm) have been identified as risk factors for obesity.[2,3] Maintaining a healthy sleep routine is essential for hormone secretion in the pubertal phase. Excessive use of electronic devices by adolescents partially results in sleep deprivation, since the screen light suppresses melatonin production, increasing the waking time at night. Sleep delay seems to contribute to eating disorders (anorexia, bulimia, and binge eating disorder), overweight and obesity.[3]

Anthropometry indicators are commonly used to diagnose overweight, and the body mass index-age and sex-specific (BMI/age and sex) is the most used method among adolescents.[4] However, BMI alone is not able to diagnose excess body fat. Indicators of abdominal obesity (AO), such as waist circumference (WC) and waist-to-height ratio (WHtR), have been considered better Cardiovascular disease (CVD) discriminators than overall obesity.[5] These are simple and low-cost indicators that can be used for early intervention.[5] In Brazil, the prevalence of obesity increased from 11.8% in 2006 to 19.8% in 2018, an increase of 67.8% in thirteen years.[6] Therefore, knowing that adolescence is a period of changes in eating behavior and in the formation of habits that will last a lifetime, it is worrying that inappropriate habits are adopted, since they contribute to excess weight and, consequently, the development of chronic non-communicable diseases (NCDs).[1,7] Therefore, this study aimed to assess the association between AO, food intake, sleep deprivation, and ST among adolescents aged 14–19 years from public and private schools in Barbacena, Minas Gerais, Brazil.

Methods

Study design and subjects

This cross-sectional study was conducted with 432 adolescents of both genders aged 14–19 years from Barbacena, Minas Gerais, Brazil. This city is located in the Southeast Region of Brazil and has a total urban population of 138,204 thousand inhabitants.[8] The population aged 15 to 19 years represented 10,744 inhabitants.[8]

Data were collected from August 2018 to July 2019. The study population comprised 4295 adolescents from nine public schools and seven private schools, according to the data provided by the school system. The sample size was calculated considering a 95% confidence level, sample error of 5%, the statistical power of 80%, and prevalence of excess body weight of 50%, being the calculated value of at least 424 subjects. Subjects were randomly selected using two-stage cluster sampling, stratified by type of school, with 3497 (81.4%) students from public schools and 798 (18.6%) from private schools. After the type of school stratification, the authors performed selections by schools and classes according to the geographical stratum of the schools with probability proportional to the number of eligible students in the grades. Thus, 345 adolescents from public schools and 79 from private schools were included. The exclusion criteria adopted were absent from school on the day of data collection, the parent or legal guardian non-consent, physical disabilities that made the anthropometric assessment impossible or pregnant/ breastfeeding adolescents.

Sexual maturation, food intake, sleep duration and ST were self-reported (described below). Subjects attended a training session that covered the purpose of the assessments and how to answer the questionnaires. Physical activity level (PAL) was evaluated using a standard questionary (described below) administered through a face-to-face interview by trained investigators. Body composition and anthropometric variables were evaluated by three trained investigators using standardized techniques and protocols described below.

The study protocol was approved by the Human Research Ethics Committee of Instituto Federal do Sudeste de Minas Gerais (protocol n. 2.894.994). All participants and their respective guardians signed a free and informed consent form.

Self-assessment of sexual maturation

Sexual maturation was assessed by a self-assessment 5-stage scale proposed by Tanner[9] and validated for adolescents,[10,11] based on the development of the pubic hair (both genders), breasts in females, and external genitalia in males.[9] The breasts and genitals were evaluated for size, shape, and characteristics. Stage 1 corresponds to childhood (pre-puberty), stages 2 to 4 to a pubertal period (puberty), and stage 5 to adult stage (post-puberty). In the present study, only the puberty phase (stages 2–4) and adult phase (stage 5) were considered.[9]

Food intake assessment

A Food Frequency Questionnaire (FFQ) validated for adolescents was used to assess food intake.[12] Foods were classified into three groups, according to the level of processing: fresh or minimally processed foods (group 1 - G1), such as fresh meat, milk, cereals, fruits, and vegetables; processed foods used as ingredients for culinary preparations (group 2 - G2), such as oils and fats, flour, pasta, starch, and sugars; ultra-processed foods (group 3 - G3), such as bread, cookies, ice cream, chocolates, candies/sweets, snacks, chips, soft drinks, nuggets, hot dogs, hamburgers and sausages.[2]

Food frequency records obtained through FFQ were converted into energy (kcal) / day, using the Brazilian Food Composition Table[13] and the Table for the Assessment of Household Measures.[14] Some foods were absent from these tables, and their nutritional information was taken from labels available online (mate tea and diet yogurt). Values of energy intake $<$500 kcal/day or $\geq$7500 kcal/day were excluded from the analyses.

Sleep duration and screen time (ST) assessment

Subjects were asked, “On average, how many hours of sleep do you get in a 24 h period?”. The hours of sleep were assessed according to the National Sleep Foundation consensus panel, which recommends ideal sleep duration and acceptable variability for each age group. According to the document, adolescents aged 14 to 17 years need between 8 and 10 h of sleep/day, while young adults aged 18 to 25 years need between 7 and 9 h of sleep/day.[15]

Adolescents also indicated the range of time they spent using an electronic device during a 24 h period (TV, tablet, phone, electronic games, using the internet, or other screen-based devices). The ST was considered adequate for less than 3 h/day.[16]

Physical activity assessment

The PAL was obtained using the International Physical Activity Questionnaire (IPAQ) short version,[10] validated for the Brazilian adolescents.[17] The participants were classified as being insufficiently active (< 300 min of moderate-vigorous intensity physical activity per week) and active ($\geq$ 300 min of moderate-vigorous intensity physical activity per week).[10]

Anthropometric and body composition measurements

Anthropometry and body composition were assessed using the following measures: height, weight, waist circumference (WC), hip circumference, tricipital and subscapular skinfolds, according to the techniques proposed by Schlossberger et al.[11] Circumferences and height measures were taken using a Cerscorf® inelastic measuring tape, with measuring range between 0 and 2 m, and graduation of 0.1 cm. Tricipital and subscapular skinfolds were measured using a Cescorf® scientific skinfold caliper, with a measuring range between 0 and 80 mm, and a graduation of 0.1 mm. Bodyweight was measured using a Balmak Actlife® calibrated digital portable scale, with a load capacity of 150 kg, with a graduation of 100 g. The body mass index (BMI) was calculated using the formula weight (kg)/ [height (m)].[18] Nutritional status was determined by the BMI/ age- and sex-specific Z-score.[4]

The circumferences and skinfold measures were obtained at three different, non-consecutive moments, using the means of the values for analysis. The cardiovascular risk related to WC was classified according to Taylor et al.[19] Body fat percentage was estimated by the values of the sum of skinfolds, whereas percentiles > 90 were classified as inadequate and percentiles < 10 were considered appropriate, following the proposition by Frisancho.[20] The waist-to-hip (WHR) and waist-to-height ratios (WHtR) were calculated by dividing waist/hip circumference and waist/height circumference, respectively. WHR was classified as inadequate if percentiles $\geq$ 90, and as adequate if percentiles < 90, according to Li et al.[21] WHtR values $\geq$ 0.5 were considered as AO.[22]

Statistical analysis

Statistical procedures were performed using the SPSS software (SPSS Inc., Chicago, IL, 2008), version 20.0. The Kolmogorov-Smirnov test was applied to assess the normality of data distribution. Continuous variables were expressed in median and interquartile ranges, and were analyzed using the Mann-Whitney test. Categorical variables were analyzed using frequency distribution and compared using Pearson’s Chi-square or Fisher’s exact test, when appropriate. Binary logistic regression models were derived, odds ratios (OR) were calculated and confidence intervals were set at 95% (95% CI). In the adjusted analysis of nutritional status (according to BMI / age and sex) and AO (according to WC) with the other independent variables, all variables were inserted at the same level, regardless of the p-value in the crude analysis, with those with $p < 0.20$, according to the backward method. The level of statistical significance was set at $p < 0.05$.

The study protocol was approved by the Human Research Ethics Committee of the Federal Institute of Education, Science, and Technology of the Southeast of Minas Gerais (protocol n. 2.894.994). All participants and their respective guardians signed a free and informed consent form.

Results

The study sample included 432 participants, most of them female (57,4%), aged between 14 and 16 years (59.3%), public school students (81.9%), in the pubertal stage of sexual maturation (58.3%), with an active level of physical activity (71.1%) (Table 1). The prevalence of overweight, obesity and underweight were 121%, 4.6%, and 2.5%, respectively. Only 1 (0.23%) student had low height-for-age (data not shown in table). The prevalence of AO was 27.5% and 6.7% according to WC and WHtR, respectively (Table 1).

Type of school, sexual maturation, level of physical activity, most of the anthropometric variables, and body adiposity differ between genders. Daily sleep duration, ST, food intake, and the prevalence of excess body weight (overweight and obesity) and AO did not differ between genders (Table 1).

Excess body weight and AO were more prevalent among adolescents with inadequate BMI/age, WC, WHR , and body fat percentage. Students in the adult stage of sexual maturation, with shorter sleep duration, and with higher ST had a higher prevalence of AO, according to WC. The other sociodemographic and lifestyle variables did not differ between adolescents with and without overweight and AO (Table 2). Sleep duration did not differ between adolescents with and without excess body weight (p = 0.958) (data not shown on the table).

In the adjusted analysis, adolescents in the adult stage, with high body adiposity and high ST were associated with AO according to WC (OR = 2.5, 95% CI 1.40−4.46; OR = 7.44, 95% CI 1.08−51.46; OR = 2.79, 95% CI 1.04−7.50; and OR = 1.43, 95% CI 1.24−3.89, respectively) (Table 3). Adolescents with inadequate sleep duration and with higher ST had a lower intake of unprocessed or minimally processed foods and higher intake of ultra-processed foods, respectively

Table 1 General characteristics of the total sample and according to gender.

Variable	Total (n = 432)	Girls (n = 248)	Boys (n = 184)	p
Age (years)				
14–16	256 (59.3%)	147 (62.1%)	102 (55.4%)	0.163
17–19	176 (40.7%)	94 (37.9%)	82 (44.6%)	
Type of school				
Private	78 (18.1%)	22 (8.9%)	56 (30.4%)	0.000[a]
Public	354 (81.9%)	226 (91.1%)	128 (69.6%)	
Sexual maturation				
Pubertal phase	252 (58.3%)	169 (68.1%)	83 (45.1%)	0.000[a]
Adult phase	180 (41.7%)	79 (31.9%)	101 (54.9%)	
Physical activity level				
Insufficiently active	125 (28.9%)	96 (38.7%)	29 (15.8%)	0.000[a]
Active	307 (71.1%)	152 (61.3%)	155 (84.2%)	
Anthropometry and body composition				
Weight (kg)	56.6 (50.6–65.2)	48.6 (53.7–61.8)	60.9 (54.5–68.8)	0.000[a]
Height (m)	1.70 (1.60–1.73)	1.61 (1.57–1.66)	1.73 (1.68–1.77)	0.000[a]
WC (cm)	69.3 (65.3–74.7)	67.3 (64.0–73.0)	71.8 (68.3–77.0)	0.000[a]
WHtR	0.41 (0.39–0.44)	0.42 (0.39–0.44)	0.41 (0.39–0.44)	0.252
WHR	0.75 (0.71–0.78)	0.72 (0.70–0.75)	0.78 (0.75–0.80)	0.000[a]
Tricipital skinfold (mm)	16.0 (11.6–20.7)	18.5 (14.7–22.2)	11.7 (8.9–17.0)	0.000[a]
Subscapular skinfold (mm)	12.0 (9.9–15.0)	13.3 (11.0–16.2)	10.6 (9.1–13.2)	0.000[a]
Σ2S (mm)	27.9 (22.0–35.8)	32.0 (26.3–38.3)	22.3 (18.7–30.6)	0.000[a]
Excessive body weight according to BMI/age (n (%))				
No	359 (83.1%)	203 (81.9%)	156 (84.8%)	0.422
Yes	73 (16.9%)	45 (18.1%)	28 (15.2%)	
Abdominal obesity according to WC (n (%))				
No	313 (72.5%)	188 (75.8%)	125 (67.9%)	0.070
Yes	119 (27.5%)	60 (24.2%)	59 (32.1%)	
Abdominal obesity according to WHtR (n (%))				
No	403 (93.3%)	228 (91.9%)	175 (95.1%)	0.192
Yes	29 (6.7%)	20 (8.1%)	9 (4.9%)	
Excessive body adiposity (skinfolds)				
No	377 (87.3%)	227 (91.5%)	150 (81.5%)	0.002[a]
Yes	55 (12.7%)	21 (8.5%)	34 (18.5%)	
Sleep duration				
Adequate	179 (41.4%)	99 (39.9%)	80 (43.5%)	0.490
Inadequate	253 (58.6%)	149 (60.1%)	104 (56.5%)	
Screen time				
$<$ 3 h/day	135 (31.2%)	74 (29.8%)	61 (33.2%)	0.529
$\geq$ 3 h/day	297 (68.8%)	174 (70.2%)	123 (66.8%)	
Food intake				
Total energy (kcal/day)	2545.2 (1815.3–3613.9)	2465.5 (1785.2–3514.4)	2611.8 (1833.9 –3807.5)	0.494
G1 (kcal/day)	823.7 (518.0–1289.1)	796.1 (510.5–1249.8)	893.9 (524.2–1388.5)	0.252
G2 (kcal/day)	980.2 (623.3–1295.8)	973.5 (613.4–1479.3)	999.0 (661.1–1521.2)	0.839
G3 (kcal/day)	633.9 (379.5–1178.4)	640.2 (388.8–1256.9)	597.2 (376.2–1030.2)	0.273

Data presented as median (interquartile range) for continuous variables and n (%) for categorical variables. WC, waist circumference; WHtR, waist/height ratio; WHR, waist//hip ratio; Σ2S, sum of the skin folds; G1, unprocessed or minimally processed foods; G2, processed foods; G3, ultra-processed foods.

[a] $p < 0.05$. Mann-Whitney test (continuous variables) and Chi-square test (categorical variables).

(Table 4). The graphical abstract summarizes the authors' methods and results (Supplementary Material 1).

Discussion

In this study, a high prevalence of overweight and obesity (16.7%) and AO (27.5%) was observed among the participating adolescents. AO was more prevalent in adolescents in the adult stage of sexual maturation, in those with shorter sleep duration and with higher ST. Still, adolescents in the adult stage with high ST were more likely to have AO. The authors' findings also indicated that students with short sleep duration consumed less unprocessed or minimally processed foods, while adolescents with high ST consumed high amounts of ultra-processed foods. Thus, the main highlight of this study

Table 2 Excessive body weight and abdominal obesity according to socio-demographic, anthropometric and lifestyle characteristics (n = 432).

Variables	Excessive body weight (according to BMI/Age)			Abdominal obesity according to WC			Abdominal obesity according to WHtR		
	Absent *n* (%)	Present *n* (%)	*p*	Absent *n* (%)	Present *n* (%)	*p*	Absent *n* (%)	Present *n* (%)	*p*
Gender									
Girls	203 (56.5%)	45 (61.6%)	0.422	188 (60.1%)	60 (50.4%)	0.070	228 (56.6%)	20 (69%)	0.192
Boys	156 (43.5%)	28 (38.4%)		125 (39.9%)	59 (49.6%)		175 (43.4%)	9 (31%)	
Age									
14–16 years	211 (58.8%)	45 (61.6%)	0.696	189 (60.4%)	67 (56.3%)	0.441	238 (59.1%)	18 (62.1%)	0.750
17–19 years	148 (41.2%)	28 (38.4%)		124 (39.6%)	52 (43.7%)		165 (40.9%)	11 (37.9%)	
Type of school									
Private	64 (17.8%)	13(16.7%)	1.000	64 (17.8%)	23 (19.3%)	0.703	73 (19.4%)	5 (0%)	0.906
Public	295 (82.2%)	65 (83.3%)		295 (82.2%)	96 (80.7%)		330 (80.6%)	24 (100%)	
Sexual maturation									
Pubertal phase	216 (60.2%)	36 (14.3%)	0.086	199 (63.6%)	53 (44.5%)	0.000[a]	236 (58.6%)	16 (55.2%)	0.721
Adult phase	143 (39.8%)	37 (61.7%)		114 (36.4%)	66 (55.5%)		167 (41.4%)	13 (44.8%)	
Physical activity level									
Insufficiently active	102 (28.4%)	23 (31.5%)	0.595	86 (27.5%)	39 (32.8%)	0.278	114 (28.3%)	18 (62.1%)	0.269
Active	257 (71.6%)	50 (68.5%)		227 (72.5%)	80 (67.2%)		289 (71.7%)	11 (37.9%)	
Anthropometric indicators and indices									
H/I adequate	358 (99.7%)	73 (100%)	0.652	1 (0.3%)	0 (0%)	1.000	402 (99.8%)	29 (100%)	1.000
H/I inadequate	1 (0.3%)	0 (0%)		312 (99.7%)	119 (100%)		1 (0.2%)	0 (0%)	
BMI/Age adequate	–	–	–	299 (95.5%)	60 (50.4%)	0.000 [a]	357 (88.6%)	2 (6.9%)	0.000 [a]
BMI/Age inadequate	–	–		14 (4.5%)	59 (49.6%)		46 (11.4%)	27 (93.1%)	
WC adequate	299 (83.3%)	14 (19.2%)	0.000 [a]	–	–	–	311 (72.5%)	2 (6.9%)	
WC inadequate	60 (16.7%)	59 (80.8%)		–	–		92 (27.5%)	27 (93.1%)	
WHtR adequate	357 (99.4%)	46 (63%)	0.000 [a]	311 (99.4%)	92 (77.3%)	0.000 [a]	–	–	–
WHtR inadequate	2 (0.6%)	27 (37%)		2 (0.6%)	27 (22.7%)		–	–	
WHR adequate	359 (100%)	46 (63%)	0.000 [a]	313 (100%)	92 (77.3%)	0.000 [a]	392 (97.3%)	13 (44.8%)	0.000 [a]
WHR ≥ inadequate	0 (0%)	27 (37%)		0 (0%)	27 (22.7%)		11 (2.7%)	16 (55.2%)	
Body fat percentage adequate	355 (93.7%)	42 (57.5%)	0.000 [a]	295 (94.2%)	82 (68.9%)	0.000 [a]	366 (90.8%)	11 (37.9%)	0.000 [a]
Body fat percentage inadequate	4 (6.3%)	31 (42.5%)		18 (5.8%)	37 (31.1%)		37 (9.2%)	18 (62.1%)	
Sleep duration									
Adequate	150 (41.7%)	29 (40.3%)	0,896	129 (41.2%)	50 (30.1%)	0.003 [a]	169 (41.9%)	10 (34.5%)	0.446
Inadequate	209 (58.3%)	44 (59.7%)		184 (58.8%)	69 (60.9%)		234 (58.1%)	19 (65.5%)	
Screen time									
< 3 h/day	119 (33.1%)	16 (31.2%)	0.094	107 (34.2%)	28 (23.5%)	0.044 [a]	130 (32.4%)	5 (17.2%)	0.101
≥ 3 h/day	240 (66.9%)	57 (68.8%)		206 (65.8%)	91 (76.5%)		273 (67.7%)	24 (82.2%)	

Chi-Square or Fisher's Exact Test (when N equal to or less than 5). WC, waist circumference; BMI, body mass index; WHtR, waist-to-height ratio; WHR, waist-to-hip ratio; H/I, height by age.

Table 3 Odds ratios (OR) and 95% confidence intervals (95% CI) for excessive body weight (overweight and obesity) and abdominal obesity according to risk factors in binary logistic regression.

	Excessive body weight				Abdominal obesity according to WC			
	Crude OR	95% CI	Adjusted OR	95% CI	Crude OR	95% CI	Adjusted OR	95% CI
Pubertal phase	1	(0.78–3.34)	1	(0.84–4.44)	1	(1.45–4.71)[a]	1	(1.40–4.46)[a]
Adult phase	1.61		1.07		2.62		2.50	
WHtR Adequate	1	(8.23–201.4)[a]	1	(8.55–206.94)[a]	1	(1.11–50.51)	1	(1.08–51.46)[a]
Inadequate	40.7		42.07		7.47		7,44	
Body fat percentage Adequate	1	(1.34–10.74)[a]	1	(1.62–12.17)[a]	1	(1.09–7.32)[a]	1	(1.04–7.50)[a]
Inadequate	3.85		4.45		2.69		2.79	
Sleep duration Adequate	1	(1.09–3.32)[a]	1	(1.21–3.69)	1	(0.62–1.68)	1	(0.91–1.46)
Inadequate	1.81		1.73		1.02		1.00	
Screen time < 3 h/day	1	(0.60–1.72)	1	(0.92–1.93)	1	(1.04–2.35)[a]	1	(1.24–3.89)[a]
≥ 3 h/day	1.01		1.00		1.36		1.43	

WC, waist circumference; WHtR, waist-to-height ratio.
[a] $p < 0{,}05$.

is that high ST and short sleep duration were associated with AO and inadequate food intake in adolescents.

Compared to the present results, the prevalence of excess body weight among adolescents was higher in the Brazilian Study of Cardiovascular Risks in Adolescents (ERICA) (25.5%)[23] and in the National School Health Survey - PeNSE (31.5%).[7] Otherwise, a lower prevalence of AO was found in the states of Santa Catarina (10.6%),[24] Rio de Janeiro (8%),[25] and Maranhão (22.7 %).[26] This distinct prevalence of AO and excess body weight may be a result of geographical characteristics, including social and cultural differences and similarities. Except for the Rio de Janeiro study,[25] which adopted WHtR $\geq$ 0.5 as the cutoff point for AO, the other aforementioned studies adopted the cutoff points proposed by Taylor et al.[19] In the present study, the prevalence of AO according to the WHtR and WC was of 6.7% and 27.5%, respectively. Both anthropometric indicators are simple, have low cost, excellent correlation with dual-energy X-ray absorptiometry (DXA), and are considered excellent predictors of body fat and metabolic outcomes in adolescents.[5,27]

In the present study, AO was higher in adolescents who have reached the adult stage of sexual maturation. Obese children and girls with central obesity seem to mature earlier than those without obesity or AO.[28,29] Furthermore, the adult stage has a strong association with a sedentary lifestyle and inappropriate eating habits, when compared to the pubertal stage.[24] The central adiposity observed in the adult stage of sexual maturation deserves attention, since it may imply a higher probability of developing morbidities in adulthood, such as insulin resistance, type 2 diabetes, sleep apnea, coronary disease, arterial hypertension, and dyslipidemia.[5,22,24,28]

The excessive use of electronic devices (ST) by the studied population (68.8%) is considered risky behavior since it was associated with a higher intake of ultra-processed foods. In addition, adolescents with high ST had more chances of having inadequate WC. According to the Brazilian Society of Pediatrics, digital dependence in adolescents increases the risk of diseases related to inappropriate eating habits, such as eating disorders, overweight, and obesity.[16]

Some vectors may explain the changes in the eating patterns of the Brazilian population, such as: (a) the constant use of technology, even in leisure activities (computers, video games, tablets, and cell phones), increased sedentary behavior, and reduced energy expenditure; (b) the price reduction of processed and ultra-processed foods; (c) the increased supply of processed and ultra-processed foods (high energy density, high sugar and fat content and low fiber content) as a result of urbanization.[1] Still, the Family Budget Survey – POF/IBGE (2017–2018) reported very high consumption of pizzas, sandwiches, dairy drinks, and snacks by adolescents compared to the elderly age group.[30] Furthermore, the consumption of high-calorie foods often concurs with TV viewing.[24] Dietary patterns characterized by the consumption of foods rich in sodium, animal fat, refined carbohydrates, and low in fiber are associated with increased blood pressure and body adiposity in adolescents.[31]

In the present study, AO was also more prevalent in adolescents with shorter sleep duration, as most of the sample (58.6%) reported sleeping fewer hours than recommended

Table 4 Food intake according to sleep duration and screen time (n = 432).

Food intake group	Sleep duration		Screen time	
	Adequate (n = 179)	Inadequate (n = 253)	< 3 h (n = 135)	≥ 3 h (n = 297)
G1 (kcal/day)	996.2 (580.8 - 1582.3)	729.9 (505.0 - 1123.2)[a]	837.8 (526.7 - 1243.8)	821.8 (514.6 - 1353.4)
G2 (kcal/day)	885.0 (673.1 - 1563.7)	954.6 (595.5 - 1441.2)	771.0 (614.7 - 1441.4)	988.3 (633.3 - 1526.8)
G3 (kcal/day)	726.8 (413.9 - 1162.5)	582.9 (353.8 - 1180.7)	523.8 (311.9 - 921.8)	705.6 (422.2 —1295.3)[a]

Data presented in median (interquartile range).
[a] $p < 0.05$; Mann-Whitney test. G1, unprocessed or minimally processed foods; G2, processed foods; G3, ultra-processed foods.

for their age group. Poor sleep is associated with unhealthy habits, such as higher intake of processed foods, tobacco and alcohol, and low consumption of fresh foods, which are factors that trigger AO.[32,33] Sleeping for few hours is associated with hormonal disorders (decreased leptin and increased ghrelin), which prompts increased hunger and food intake, as well as more time available for engaging in sedentary activities, such as watching television.[3,32,33] At puberty, the peak of melatonin secretion occurs later, altering the circadian cycle and making adolescents feel sleepy later than appropriate. The constant use of cell phones, TVs and computers at night also impairs sleep, as they make adolescents more distressed and prone to postpone bedtime.[3,15,32,33]

In this and other studies, shorter sleep duration was associated with a lower intake of unprocessed and minimally processed foods.[32,33] Sleep deprivation prompts a reduction in the secretion of melatonin, leptin and thyroid-stimulating hormone, higher levels of ghrelin and lower glucose tolerance, leading to increased hunger and appetite and resistance to insulin. In addition, the longer period of time to eat, alongside the aforementioned changes, suggests that chronic sleep deprivation contributes to higher food intake and to the consequent increased risk of obesity.[32,33] Therefore, if the authors consider that most adolescents have as their main choice foods with high energy density and low nutritional value (cookies, candies, sweets, snacks, and soft drinks), the lack of sleep becomes even more worrying.[7,18,31,32]

The main limitation of this study was its cross-sectional nature, which does not allow inferring cause-and-effect relationships, limiting the interpretations regarding the observed outcomes. In addition, some questionaries' were self-reported (sexual maturation, FFQ, ST and sleep duration), and consequently, some information may have been omitted. Although self-report of pubertal maturation is not a reliable measure of exact pubertal staging, it has been recommended for epidemiologic studies for a simple distinction between pre-puberty, in, and completing puberty phases.[33] The strengths of the research were its sample, composed of students from public and private schools, the use of cutoff points validated for adolescents to identify the presence of AO and overweight, in order to verify the association between food intake, sleep, and ST.

In conclusion, AO was associated with the adult stage of sexual maturation, short sleep duration and high ST. Excessive ST and inadequate sleep duration were associated with low intake of minimally processed foods and with high intake of ultra-processed foods, respectively. Assessing the risk factors of AO may be a useful strategy for preventing CVD in adolescents.

Funding

Instituto Federal de Educação, Ciência e Tecnologia do Sudeste de Minas Gerais, Barbacena, MG, Brazil.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgments

The authors would like to thank the principals of the schools, the adolescents who participated in the study, and their parents and/or guardians who authorized their participation. The authors would also like to thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG), and Instituto Federal do Sudeste de Minas Gerais (IF Sudeste MG).

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jped.2022.02.007.

References

1. Conde WL, Mazzeti CM, Silva JC, Santos IK, Santos AM. Nutritional status of adolescent schoolchildren in Brazil: the 2015 national school children health survey. Rev Bras Epidemiol. 2018;21:e180008. supl.1.
2. Monteiro CA, Cannon G, Moubarac JC, Levy RB, Louzada ML, Jaime PC. The UN decade of nutrition, the NOVA food classification and the trouble with ultra-processing. Public Health Nutr. 2018;21:5—17.
3. LeBourgeois MK, Hale L, Chang AM, Akacem LD, Montgomery-Downs HE, Buxton OM. Digital media and sleep in childhood and adolescence. Pediatrics. 2017;140:S92—6.
4. Onis MD, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ. 2007;85:660—7.
5. Lichtenauer M, Wheatley SD, Martyn-St James M, Duncan MJ, Cobayashi F, Berg G, et al. Efficacy of anthropometric measures

for identifying cardiovascular disease risk in adolescents: review and meta-analysis. Minerva Pediatr. 2018;70:371—82.
6. Associação Brasileira para o Estudo da Obesidade (ABESO). Mapa da obesidade. São Paulo: ABESO; 2021, [Internet][Cited 2021 Sep 03]. Available from: https://abeso.org.br/obesidade-e-sindrome-metabolica/mapa-da-obesidade/.
7. Alves MA, Souza AM, Barufaldi LA, Tavares BM, Bloch KV, Vasconcelos FAG. Dietary patterns of Brazilian adolescents according to geographic region: an analysis of the Study of Cardiovascular Risk in Adolescents (ERICA). Cad Saude Publica. 2019;35: e00153818.
8. Instituto Brasileiro de Geografia e Estatística (IBGE). Censo Demográfico: população estimada de Barbacena-MG. [Cited 2021 Sep 03]. Available from: https://cidades.ibge.gov.br/brasil/mg/barbacena/panorama.
9. Tanner JM. Growth at Adolescence. 2nd ed. Oxford: Blackwell Scientific; 1962.
10. Matsudo SM, Matsudo VK. Validade da auto-avaliação na determinação da, maturação sexual. Rev Bras Cienc Mov. 1991;5:18—35.
11. Schlossberger NM, Turner RA, Irwin CE. Validity of self-report of pubertal maturation in early adolescents. J Adolesc Health. 1992;13:109—13.
12. Slater B, Philippi ST, Fisberg RM, Latorre MR, Oslater B. Validation of a semi-quantitative adolescent food frequency questionnaire applied at a public school in São Paulo, Brazil. Eur J Clin Nutr. 2003;57:629—35.
13. Universidade Estadual de Campinas. Núcleo de Estudos e Pesquisas em Alimentação. Tabela Brasileira de Composição de Alimentos. Campinas: Nepa/Unicamp; 2011.
14. Pinheiro AB, Lacerda EM, Benzecry EH, Gomes MC, Costa VM. Tabela de Avaliação de Consumo Alimentar em Medidas Caseiras. 5th ed. São Paulo/SP: Atheneu; 2008.
15. Hirshkowitz M, Whiton K, Albert SM, Alessi C, Bruni O, DonCarlos L, et al. National sleep foundation's sleep time duration recommendations: methodology and results summary. Sleep Health. 2015;1:40—4.
16. Sociedade Brasileira de Pediatria (SBP). Manual de Orientação. Grupo de Trabalho Saúde na Era Digital (2019-2021) [Internet]. 2020. [Cited 2021 Sep 03]. Available from: https://www.sbp.com.br/fileadmin/user_upload/_22246c-ManOrient_-__Menos-Telas__MaisSaude.pdf.
17. Guedes D.P., Lopes C.C., Guedes J.E. Reproducibility and validity of the International Physical Activity Questionnaire in adolescents Rev Bras Med Esporte,. 2005;11:151-8.
18. Costa CD, Flores TR, Wendt A, Neves RG, Assunção MC, Santos IS. Sedentary behavior and consumption of ultra-processed foods by Brazilian adolescents: Brazilian National School health survey (PeNSE), 2015. Cad Saude Publica. 2018;34:e00021017.
19. Taylor RW, Jones IE, Williams SM, Goulding A. Evaluation of waist circumference, waist-to-hip ratio, and the conicity index as screening tools for high trunk fat mass, as measured by dual-energy X-ray absorptiometry, in children aged 3—19 y. Am J Clin Nutr. 2000;72:490—5.
20. Frisancho AR. Anthropometric Standards for the Assessment of Growth and Nutritional Status. Ann. Arbor: University of Michigan Press; 1990.
21. Li C, Ford ES, Mokdad AH, Cook S. Recent trends in waist circumference and waist-height ratio among US children and adolescents. Pediatrics. 2006;118:e1390—8.
22. Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. Int J Food Sci Nutr. 2005;56:303—7.
23. Bloch KV, Kelin CH, Szlol M, Kuschnir MC, Abreu GA, Barufaldi LA, et al. ERICA: prevalences of hypertension and obesity in Brazilian adolescents. Rev Saude Publica. 2016;50:S9.
24. Castro JA, Nunes HE, Silva DA. Prevalence of abdominal obesity in adolescents: association between sociodemographic factors and lifestyle. Rev Paul Pediatr. 2016;34:343—51.
25. Silva AM, Hasselmann MH. Association between domestic maltreatment and excess weight and fat among students of the city/state of Rio de Janeiro, Brazil. Cien Saude Colet. 2018;23:4129—42.
26. Nascimento-Ferreira MV, De Moraes AC, Carvalho HB, Moreno LA, Gomes Carneiro AL, dos Reis VM, Torres-Leal FL. Prevalence of cardiovascular risk factors, the association with socioeconomic variables in adolescents from low-income region. Nutr Hosp. 2014;31:217—24.
27. Alves Junior CA, Mocellin MC, Gonçalves EC, Silva DA, Trindade EB. Anthropometric indicators as body fat discriminators in children and adolescents: a systematic review and meta-analysis. Adv Nutr. 2017;8:718—27.
28. Lian Q, Mao Y, Luo S, Zhang S, Tu X, Zuo X, Lou C, Zhou W. Puberty timing associated with obesity and central obesity in Chinese Han girls. BMC Pediatr. 2019;19:1.
29. O'Keeffe LM, Frysz M, Bell JA, Howe LD, Fraser A. Puberty timing and adiposity change across childhood and adolescence: disentangling cause and consequence. Hum Reprod. 2020;35: 2784—92.
30. Instituto Brasileiro de Geografia e Estatística (IBGE). Pesquisa de Orçamentos Familiares (POF) 2017—2018. IBGE; 2020.
31. Neves ME, Souza MR, Gorgulho BM, Cunha DB, Muraro AP, Rodrigues PR. Association of dietary patterns with blood pressure and body adiposity in adolescents: a systematic review. Eur J Clin Nutr. 2021;75:1440—53.
32. Asarnow LD, Greer SM, Walker MP, Harvey AG. The impact of sleep improvement on food choices in adolescents with late bedtimes. J Adolesc Health. 2017;60:570—6.
33. Duraccio KM, Krietsch KN, Chardon ML, Van Dyk TR, Beebe DW. Poor sleep and adolescent obesity risk: a narrative review of potential mechanisms. Adolesc Health Med Ther. 2019;10: 117—30.