British Journal of Nutrition (2021), 126, 276–284 doi:10.1017/S0007114520003992

Skipping breakfast is associated with the presence of cardiometabolic risk factors in adolescents: Study of Cardiovascular Risks in Adolescents – ERICA

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(Submitted 10 May 2020 – Final revision received 16 September 2020 – Accepted 5 October 2020 – First published online 12 October 2020)

Abstract

Breakfast is considered as the most important meal of the day. The habit of skipping this meal in adolescence tends to remain until adulthood and has been associated with cardiometabolic risk factors. The present study estimated the prevalence of skipping breakfast and its association with cardiometabolic risk factors. This is a cross-sectional study with data from the Study of Cardiovascular Risks in Adolescents (ERICA), with a nationally representative sample of 36 956 Brazilian adolescents, aged 12–17 years, enrolled in public and private schools. The outcomes were excess body weight (BMI), central obesity (waist circumference and waist:height ratio), lipid profile (total cholesterol (TC), LDL-cholesterol, HDL-cholesterol and TAG) and glycidic profile (fasting glycaemia, fasting insulin and glycated Hb). The association between skipping breakfast and each outcome was estimated using multiple Poisson regression models (prevalence ratio (PR) and 95 % CI). Prevalence of skipping breakfast was 68·7 % and, after adjustments, it was associated with excess body weight (PR = 1·30; 95 % CI 1·18, 1·43), central obesity both by waist circumference (PR = 1·27; 95 % CI 1·00, 1·61) and by waist:height ratio (PR = 1·32; 95 % CI 1·13, 1·54) and high fasting glucose levels (PR = 1·54; 95 % CI 1·09, 2·18), fasting insulin (PR = 1·64; 95 % CI 1·21, 2·22), glycated Hb (PR = 1·16; 95 % CI 1·03, 1·31) and total cholesterol (PR = 1·14; 95 % CI 1·02, 1·27). Skipping breakfast was associated with cardiometabolic risk factors in adolescence. In this context, the school environment is an ideal space to promote healthy eating habits, favouring the implementation of food and nutrition education activities to make adolescents aware of the importance of consuming breakfast daily.

Key words: **Breakfast: Dyslipidaemia: Obesity: Glycidic profile: Adolescents**

The term cardiometabolic risk was proposed by the American Diabetes Association and the American Heart Association, and it is used to describe a set of clinical signs, such as dyslipidaemias, insulin resistance, obesity and high blood pressure[1,2]. These metabolic changes are related to chronic non-communicable diseases, which have been diagnosed early in childhood and adolescence[3,4].

In adolescence, epidemiological studies have shown an association between unhealthy eating behaviours, such as skipping meals, especially breakfast, and increased cardiometabolic risk[5–7].

Breakfast skipping among adolescents has ranged from 1·3 to 74·7 % worldwide[8]. In general, skipping this meal has been associated with excess body weight and abdominal obesity[9], increased blood pressure[10], deleterious effects on lipid profile[11] and glycidic profile[12,13]. The mechanisms that might explain the relationship between breakfast skipping and metabolic outcomes are related to a possible high energy intake after the long fasting period[14], fasting-induced insulin resistance[15], appetite regulation[16], changes in glycaemic homoeostasis and interruption of gene expression of circadian cycles involved in glucose metabolism[13].

Abbreviations: ERICA, Estudo de Riscos Cardiovasculares em Adolescentes (Study of Cardiovascular Risks in Adolescents); HbA1c, glycated Hb; TC, total cholesterol.

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As far as is known, no nationwide representative study has investigated the association between breakfast skipping and cardiometabolic risk factors in Brazil. Thus, considering the importance of regular breakfast consumption for adolescents' health and that the breakfast skipping habits during adolescence may persist into adulthood which can have deleterious effects on metabolic outcomes, the objective of the present study was to estimate the prevalence of breakfast skipping and its association with cardiometabolic risk factors in Brazilian adolescents.

Methods

Study design and data sources

This is an analysis of data from the Study of Cardiovascular Risks in Adolescents (ERICA – Estudo de Riscos Cardiovasculares em Adolescentes). ERICA is a school-based, cross-sectional study aiming to estimate the prevalence of diabetes mellitus, obesity and cardiovascular risk factors in addition to insulin resistance and inflammatory markers, which examined a nationwide representative sample of 12–17-year-old adolescents enrolled in public and private schools in Brazilian cities with more than 100 thousand inhabitants[17].

The research population was stratified into thirty-two strata, consisting of twenty-seven capitals and five sets of municipalities with more than 100 thousand inhabitants in each of the five geographical regions of the country[18]. For each geographic stratum, schools were selected with probability proportional to the size and inversely proportional to the distance from the capital. Thus, the sample is representative for the set of medium- and large-sized cities (>100 thousand inhabitants) at national and regional levels and for the Brazilian capitals and the Federal District. In addition, the location of the school (urban or rural area) and the type of administration (public or private) were considered, allowing the concentration of the sample around the capitals, which reduced costs and facilitated the logistics of the research project, especially as regards collection of blood samples and adequacy of pre-analytical procedures. In total, 1247 schools (out of 1251 selected ones) were evaluated in 122 municipalities (out of 124). More details on the sampling process can be found in the study of Vasconcellos *et al.*[17].

In the second sampling stage, three classes from each school were selected, considering combinations of shift (morning and afternoon) and eligible years (seventh, eighth and ninth year of elementary school and first, second and third year of high school). In the third stage, in each combination of shift and year, a class was selected, and all students in the respective class were invited to participate in ERICA[17,18]. Because of the need for 12 h of fasting, only students on the morning shift participated in blood collection (Fig. 1).

The students of the selected classes who signed the consent form and presented the Free and Informed Consent Term signed by their parents or guardians were interviewed and examined. Adolescents who did not belong to the age group of 12–17 years

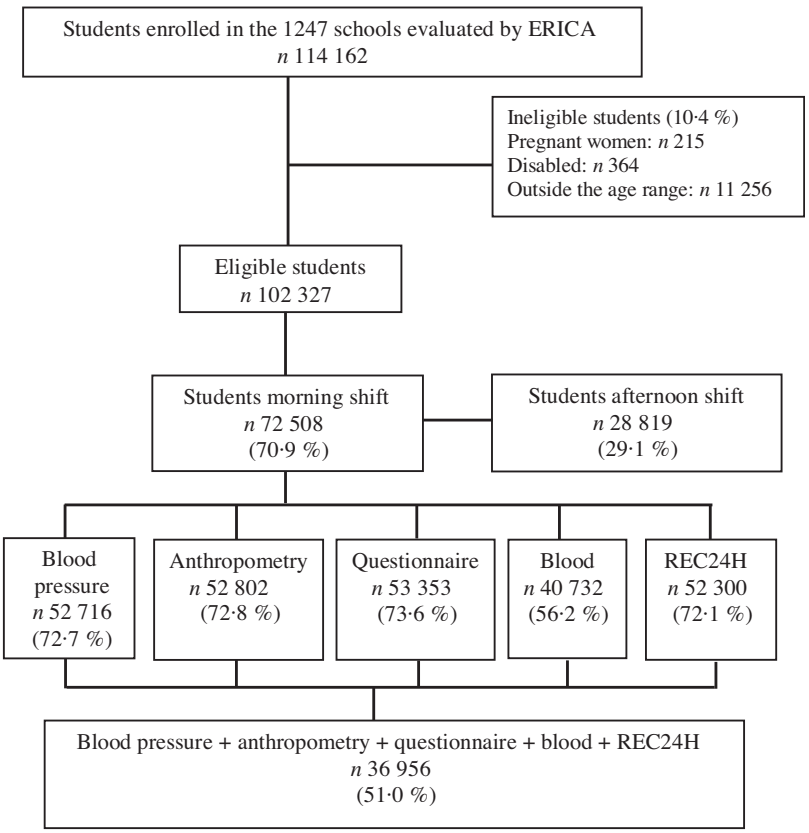

Fig. 1. Flowchart of eligible adolescents from the Adolescent Cardiovascular Risk Study (ERICA), Brazil, 2013–2014. REC24H, 24-h recall. Source: adapted from Silva *et al.*[20].

old, pregnant adolescents and individuals with temporary or permanent physical or mental disabilities were not eligible for the study.

ERICA was conducted according to the principles of the Declaration of Helsinki. The study was approved by the Committee for Ethics in Research of the Institute of Collective Health Studies, Federal University of Rio de Janeiro (Process 45/2008) and of each one of the twenty-six states and the Federal District. Permission to conduct the study was obtained in all State and local Departments of Education and in all schools. The privacy and information confidentiality of students was guaranteed.

Data collection instruments and procedures

Data collection took place between March 2013 and December 2014 and was performed by a team of previously trained evaluators, using standardised techniques to ensure the students' privacy. The questionnaire was self-administered and applied using an electronic data collector, a Personal Digital Assistant (model LG GM750Q). This instrument contained about 100 questions distributed into eleven blocks: socio-demographic aspects, occupational activities, physical activity, eating behaviour, smoking, alcohol consumption, reproductive health, oral health, referred morbidity, sleep duration and common mental disorders[18].

Breakfast skipping. Breakfast skipping was assessed using the question 'Do you have breakfast?', with the following answer options: 'I don't have breakfast', 'I have breakfast sometimes', 'I have breakfast almost every day' and 'I have breakfast every day'. Breakfast skipping was estimated from the combination of the categories: 'I don't have breakfast', 'I have breakfast sometimes' and 'I have breakfast almost every day'.

Cardiometabolic risk factors. Weight and height measurements were used to calculate the BMI (weight/height^2). Weight status was assessed using age- and sex-specific BMI z-scores according to the WHO's curves. Adolescents with BMI z-score $\geq +1$ were classified as excess body weight[19].

Weight was defined by a single measurement on a Líder® P150m electronic scale with 200 kg capacity and 50 g weight change detection. Height was determined by the average of two measurements taken sequentially (a maximum variation of 0·5 cm between the two measurements was accepted), using a Alturexata® portable calibrated and dismountable stadiometer with resolution in millimeter and field of view use of up to 213 cm[18,20]. The specific procedures for each measure are described in detail in Bloch *et al.*[18].

Waist circumference was measured with a Sanny® anthropometric glass fibre tape, with resolution of 1 mm and length of 1·5 m. Waist circumference was considered high when ≥the 90th percentile for adolescents under 16 years[21] and ≥90 cm for boys and ≥80 cm for girls for adolescents ≥16 years[22]. The waist:height ratio was determined by measuring waist circumference (cm) and height (cm), and values ≥0·5 cm were considered as risk[23].

For blood collection, a standardised research protocol was used and applied in the twenty-seven centres. All the biochemical analyses of the study were performed in a single reference laboratory, with strict quality control, supported by the local partner laboratories that managed the collection and receipt of the samples, allowing standardisation of measures and uniformity of results. The laboratories received documentation with a protocol to be followed at all stages, from scheduling to transportation to the central unit, and the labelled kit for collecting blood from each adolescent. The adolescents were instructed to fast for 12 h before collection. A questionnaire was applied before the exam to confirm compliance with fasting[24].

Fasting blood samples were collected for analyses of glucose, insulin, lipid profile (total cholesterol (TC), HDL-cholesterol and TAG) and glycated Hb(HbA1c). Cholesterol associated with LDL-cholesterol was calculated using the Friedewald formula[25]. The presence of high levels of blood glucose, insulin, HbA1c, TC, TAG and LDL-cholesterol and low levels of HDL-cholesterol was considered as inappropriate. Table 1 presents the cut-off points adopted. A full description of the ERICA methods can be found in Bloch *et al.*[18]

Covariables analysed. The covariables analysed in the present study were sex (male and female), age (categorised into age groups: 12–14 and 15–17 years), sexual maturation stage (the latest Tanner stages among male and female students), type of school attended (according to type of administration, public or private, as a proxy for socio-economic status[28,29]), energy consumption (in kcal), estimated from data collected by applying a 24-h dietary recall[30] and behaviours related to lifestyle, namely physical activity (adolescents who did not practise any type of activity were considered to be inactive; those who practised <300 min/week were considered as insufficiently active and those who practised ≥300 min/week were considered to be active)[31], screen time (h/d) considering the following categories: ≤2, 3–5 and ≥6 h/d[32], alcohol consumption (drinking at least one dose of alcohol in the last 30 d[33] and smoking (use of cigarettes at least one day in the last 30 d)[34]. These covariates were analysed because they are observed in the literature as potential confounding factors in the association between breakfast skipping and cardiometabolic factors[15,35–38].

Statistical analysis

Statistical analyses were performed using the software Stata (Statistical Software for Professionals), version 12.0. The survey

Table 1. Cut-off points used for blood testing results: ERICA, Brazil, 2013–2014

	Cut-off points		
Blood tests	Desirable	Borderline	High
TAG (mg/dl)*	<100	100–129	≥130
Cholesterol (mg/dl)*	<150	150–169	≥170
LDL-cholesterol (mg/dl)*	<100	100–129	≥130
HDL-cholesterol (mg/dl)*	≥45	–	–
Glucose (mg/dl)†	70–99	100–125·9	≥126
Insulin (mU/l)‡	<15	15–20	≥20
Glycated Hb	–	–	≥P75

ERICA, Study of Cardiovascular Risks in Adolescents; P75, 75th percentile of population distribution.
* V Brazilian Guidelines on Dyslipidaemias and Prevention of Atherosclerosis[25].
† Diagnosis and Classification of Diabetes Mellitus[26].
‡ I Guidelines of Prevention of Atherosclerosis in Childhood and Adolescence[27].

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(svy) module was used to consider the weight of the sample and the research design.

Prevalence of breakfast skipping (% with the respective 95 % CI) and its association with the covariates (sex, age, Tanner stage, energy consumption, type of school attended, physical activity, screen time, alcohol consumption and smoking) were assessed using the χ^2 test with the second-order Rao-Scott correction, adopting a significance level of 5 %.

The association between breakfast skipping and each outcome of interest was estimated by Poisson regression models, obtaining the crude and adjusted prevalence ratios (PR) with 95 % CI. In the adjusted analysis, we used all analysed covariates and the least informative covariates were successively removed from the model in a backward stepwise elimination based on the Akaike information criterion.

Results

In the present study, 36 956 adolescents were evaluated, 50·2 % of whom were females; 53·4 % were between 15 and 17 years old; 77·7 % studied in public schools; 45·2 % were considered as physically active; 20·5 % had screen time ≥6 h/d, 22·5 % consumed alcoholic beverages, 4·4 % were classified as smokers and average energy consumption was 9623 kJ/d (2300 kcal/d) (Table 2).

Prevalence of breakfast skipping was 68·7 %; it was significantly higher among girls (74·2 %), students from public schools (71·8 %), inactive adolescents (72·1 %), with screen time ≥6 h/d (73·3 %), alcohol drinkers (77·0 %) and smokers (82·0 %), compared, respectively, with boys (63·1 %), private school students (57·8 %), active adolescents (66·4 %), with screen time ≤2 h/d (66·1 %), non-alcohol drinkers (65·9 %) and non-smokers (67·9 %) (Table 2).

Breakfast skipping, excess body weight and central obesity

Higher prevalence of excess body weight (PR = 1·30 (95 % CI 1·18, 1·43)) and central obesity, both considering WC (PR = 1·27 (95 % CI 1·01, 1·61)) as for the waist:height ratio (PR = 1·32 (95 % CI 1·13, 1·54)), was found in adolescents who skipped breakfast (Table 3).

Breakfast skipping and lipid and glycidic profiles

Table 4 shows that, for lipid profile, there was a significant association, after adjustment, between breakfast skipping and TC; adolescents who skipped breakfast had 14 % more prevalence of high TC than those who had breakfast every day.

In addition, there was higher prevalence of high insulin levels among adolescents who skipped breakfast compared with those who did not (5·8 *v.* 3·3 %, $P < 0·001$), and the same result was found

Table 2. Prevalence of skipping breakfast, according to socio-demographic and economic variables, stage of sexual maturation, energy consumption and lifestyle of adolescents (*n* 36 956), ERICA, Brazil, 2013–2014*
(Percentages and 95 % confidence intervals)

		Skipping breakfast†		
Variables	Total (%)	%	95 % CI	*P*‡
Total (%)	36 956	68·7	66·4, 70·8	
Sex				
Female	50·2	74·2	71·8, 76·5	<0·001
Male	49·8	63·1	60·1, 65·9	
Age (years)				
12–14	46·6	67·9	66·2, 69·5	0·458
15–17	53·4	69·3	65·6, 72·9	
Type of school attended				
Public	77·7	71·8	69·0, 74·4	<0·001
Private	22·3	57·8	55·2, 60·4	
Physical activity (min/week)				
Inactive (0)	26·8	72·1[a]	69·3, 74·7	0·002
Insufficiently active (>0 and <300)	28·0	68·9[b]	65·5, 72·1	
Active (≥300)	45·2	66·4[a]	63·9, 68·9	
Screen time (h/d)				
≤2	40·5	66·1[a]	64·3, 67·9	<0·001
3–5	39·0	68·3[b]	64·8, 71·6	
≥6	20·5	73·3[a]	70·2, 76·2	
Alcohol consumption§				
Yes	22·5	77·0	74·3, 79·5	<0·001
No	77·5	65·9	63·4, 68·3	
Smoking‖				
Yes	4·4	82·0	77·7, 85·6	<0·001
No	95·6	67·9	65·6, 70·2	

ERICA, Study of Cardiovascular Risks in Adolescents.
[a,b] Values within a column with unlike superscript letters were significantly different.
* Missing: screen time = 3056, alcohol consumption = 1217 and smoking = 221.
† Skipping breakfast: daily non-consumption.
‡ *P* value associated with the χ^2 test.
§ Ingestion of at least one dose of alcohol in the last 30 d.
‖ Cigarette use at least 1 d in the last 30 d.

Table 3. Prevalence and prevalence ratios of skipping breakfast, according to anthropometric characteristics, ERICA, Brazil, 2013–2014† (Percentages and 95 % confidence intervals)

	Excess body weight‡		High waist circumference§		High waist:height ratio‖	
Total (%)	26·8		12·7		14·4	
Breakfast	%	95 % CI	%	95 % CI	%	95 % CI
Consumption	22·6	20·9, 24·5	10·3	8·4, 12·5	12·0	10·6, 13·5
Skipping	28·7	27·0, 30·5	13·7	12·7, 14·8	15·5	14·4, 16·7
P¶	<0·001		0·003		<0·001	
PR_c	1·26**	1·17, 1·37	1·33**	1·10, 1·62	1·30**	1·14, 1·47
PR_{adj}	1·30**	1·18, 1·43	1·27*	1·01, 1·61	1·32**	1·13, 1·54

ERICA, Study of Cardiovascular Risks in Adolescents; PR_c, crude prevalence ratio; PR_{adj}, prevalence ratio adjusted for: sex, age, Tanner stage, type of school attended, physical activity, screen time, alcohol consumption, smoking and total energy consumption.
* $P < 0·05$, ** $P < 0·01$.
† PR_c and PR_{adj} considering consumption as reference category.
‡ ≥+1 *z*-score[19].
§ ≥90th percentile for adolescents under 16 years of age[21] and ≥80·0 cm for girls and ≥90·0 cm for boys for adolescents ≥16 years old[22].
‖ ≥0·50 cm[23].
¶ *P* value associated with the χ^2 test.

Table 4. Prevalence and prevalence ratios of skipping breakfast, according to the biochemical characteristics of the adolescents, ERICA, Brazil, 2013–2014† (Percentages and 95 % confidence intervals)

	High total cholesterol‡		HDL-cholesterol not desirable§		High LDL-cholesterol‖		Elevated TAG¶		Elevated insulin††		High blood glucose‡‡		Elevated HbA1c§§	
Total (%)	20·3		46·6		3·5		7·7		5·0		4·0		30·7	
Breakfast	%	95 % CI	%	95 % CI	%	95 % CI	%	95 % CI	%	95 % CI	%	95 % CI	%	95 % CI
Consumption	19·1	17·5, 20·7	45·7	43·5, 47·9	3·1	2·5, 3·8	7·8	6·6, 9·3	3·3	2·6, 4·1	3·3	2·6, 4·3	27·9	25·4, 30·5
Skipping	20·8	19·4, 22·4	47·1	44·5, 49·6	3·8	3·3, 4·3	7·7	6·9, 8·5	5·8	5·1, 6·6	4·4	3·7, 5·1	31·9	30·2, 33·7
P‖‖	0·048		0·328		0·084		0·876		<0·001		0·062		0·012	
PR_c	1·09	1·00, 1·19	1·03	0·97, 1·09	1·23	0·97, 1·55	0·99	0·82, 1·19	1·75**	1·42, 2·16	1·31	0·99, 1·75	1·14*	1·03, 1·27
PR_{adj}	1·14*	1·02, 1·27	1·07	1·00, 1·14	1·16	0·87, 1·55	1·03	0·82, 1·29	1·64**	1·21, 2·22	1·54*	1·09, 2·18	1·16*	1·03, 1·31

ERICA, Study of Cardiovascular Risks in Adolescents; HbA1c, glycated Hb; PR_c, crude prevalence ratio; PR_{adj}, prevalence ratio adjusted for: sex, age, Tanner stage, type of school attended, physical activity, screen time, alcohol consumption, smoking and total energy consumption; P75, 75th percentile of population distribution.
* $P < 0·05$, ** $P < 0·01$.
† PR_c and PR_{adj} considering consumption as reference category. Missing: total cholesterol = 105, HDL-cholesterol = 105, LDL-cholesterol = 119, TAG = 107, insulin = 143, glycaemia = 160, HbA1c = 53.
‡ ≥170 mg/dl[25].
§ <45 mg/dl[25].
‖ ≥130 mg/dl[25].
¶ ≥130 mg/dl[25].
†† ≥20 mU/l[30].
‡‡ ≥100 mg/dl[27].
§§ ≥P75.
‖‖ *P* value associated with the χ^2 test.

for HbA1c (31·9 *v.* 27·9 %, $P = 0·012$). In the adjusted analysis, breakfast skipping was associated with all variables of the glycidic profile. Adolescents who skipped breakfast had 64 % more prevalence of high insulin, 54 % more prevalence of high blood glucose and 16 % more prevalence of high HbA1c compared with adolescents who consumed this meal (Table 4).

Discussion

In ERICA, which was conducted with a representative sample of Brazilian adolescents, there was a high frequency of breakfast skipping. The prevalence of cardiometabolic risk factors was higher among adolescents who skipped breakfast, for example, excess body weight, central obesity and high levels of TC, fasting insulin, fasting glycaemia and HbA1c.

Among the studies that considered breakfast skipping among adolescents as non-daily breakfast consumption, the breakfast skipping prevalence was 37·6 % in Turkey[39] and 47·5 % among adolescents in a Brazilian city[36].

Adolescents who skipped breakfast had higher prevalence of excess body weight and central obesity. Similar results were found in studies with adolescents from North America[40,41], Egypt[42], Asia[43], Brazil[36], as well as in a multicentre study with European and Brazilian adolescents[9].

In the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) Study, Hallström *et al.*[5] found that male adolescents who skipped breakfast had higher rates of BMI, waist circumference and skinfold thickness, as well as higher levels of LDL-cholesterol, fasting insulin, fasting glucose and insulin resistance, while girls showed higher levels of skinfold thickness, BMI, fasting insulin and insulin resistance.

Longitudinal studies support the associations observed between breakfast skipping and excess body weight. Wang *et al.*[41], in study with adolescents from New Haven and 4-year

follow-up, considering breakfast skipping was defined as consuming breakfast 0–3 times a week, found that adolescents who skipped breakfast were 2·66 times more likely to be overweight and obese than those who had this meal.

Similarly, in the Childhood Determinants of Adult Health study, breakfast skipping in childhood was defined as not eating anything before going to school and in adulthood as not eating between 06.00 and 09.00 hours in the previous day, it was found that the habit of skipping breakfast in childhood tended to continue until adulthood and was associated with increased waist circumference, and with higher values of fasting insulin, insulin resistance and BMI, as well as higher concentrations of TC and LDL-cholesterol fraction[15].

This association between breakfast skipping and excess body weight can be explained by appetite regulation mechanisms, since not having breakfast can lead to less post-meal energy expenditure and contribute to changes in lipid and glucose metabolism[16]. Thus, adolescents who skip breakfast stay on an empty stomach for a longer time, increasing ghrelin secretion, which leads to increased appetite and hyperphagia throughout the day. As a consequence, weight gain and body fat accumulation are increased[11,16]. It is noteworthy that, in the present study, this association was maintained even after adjustments for total energy intake.

Concerning to lipid profiles, breakfast skipping was associated only with higher levels of TC. This result was different from the one found by Cayres *et al.*[10] and Silva *et al.*[37] in Brazilian adolescents. Neither of them found an association between breakfast skipping and lipid profile markers (TC, HDL-cholesterol, LDL-cholesterol and TAG). On the other hand, results similar to those in the present study were found by Mustafa *et al.*[38] While evaluating Malaysian adolescents, they found that those who never ate breakfast had higher levels of TC and LDL-cholesterol. Among adolescents of both sexes aged 10–18 years and living in Iran[44] and Korean girls of the same age group[14], it was found that breakfast skipping was associated with greater likelihood of hypertriacylglycerolaemia.

Longitudinal studies indicate that the main factors that may explain the association between breakfast skipping and dyslipidaemia are increased appetite and high energy intake after the fasting period[14] and greater intake of saturated fat among adolescents who skip breakfast[15]. Also, fasting-induced insulin resistance increases liver lipase activity[14] and stimulates higher concentrations of hydroxy methyl glutaryl Co-A reductase, which results in higher concentrations of cholesterol[15].

Unlike the findings of other observational studies, adolescents who skipped breakfast in ERICA had higher prevalence of high levels of fasting insulin, fasting glycaemia and HbA1c compared with adolescents who consumed this meal. Studies with Brazilian[37], Malaysian[38], Iranian[44] and American[35] adolescents found no significant association between breakfast skipping and glucose profile.

Changes in the glycidic profile were found among young people in controlled, randomised and repeated measures clinical trials: breakfast skipping was associated with an increase in the mean 24-h blood glucose, even without changes in the 24-h energy expenditure, in lipid oxidation and thermal effect of food. These results indicating that changes in glycaemic homoeostasis precede some effect on energy balance[45,46].

Breakfast skipping may be associated with changes in the glycidic profile because prolonged fasting affects glycaemic homoeostasis, which results in decreased insulin and C peptide secretion and reduced glucagon peptide-1 responses[13]. In addition, the absence of increased glucose levels as a result of fasting can decrease response capacity and memory of pancreatic β cells, leading to a reduction and delay in their response to insulin[12].

In addition, some studies have linked breakfast skipping to interruption of gene expression in circadian cycles involved in glucose metabolism[13,47]. These genes respond to the content and timing of meals, which leads to a coordinated regulation of digestive and absorptive functions, as well as hormonal secretion, thereby preventing metabolic dysregulation during consumption of breakfast[48].

Although breakfast composition was not evaluated in the present study, it had a protective effect on glucose metabolism. Consumption of foods rich in protein and fibre, such as high-fibre cereals, whole grains, fruits and dairy products, contributes to reducing gastric emptying time, glucose digestion and absorption, as well as improving glycaemic control[37,40].

Furthermore, breakfast consumption is associated with better diet quality[40], healthier lifestyle[49] as well as cognitive aspects related to improving school performance and memory[50] and has been observed as a protective factor for obesity and general health[51], providing several benefits in bone and cardiovascular health[52,53].

The cross-sectional design of the present study does not allow inferring causal relationships between breakfast skipping and presence of cardiometabolic risk factors, especially related to excess body weight, because adolescents with excess body weight can skip meals to lose weight[54,55]. However, longitudinal studies have also found similar associations[14,15,41], supporting the results found among adolescents participating in ERICA.

The definition and variations in the cut-off points used by the studies to classify the habit of breakfast skipping can influence the results and their interpretation[7]. For example, Khan *et al.*[43], when evaluating adolescents from Bangladesh, defined skipping as not eating breakfast between 0 and 4 d/week and found a prevalence of 23 %. Among Brazilian adolescents, Hassan *et al.*[55] also found that prevalence depends on how breakfast skipping was defined and categorised. They noted that the prevalence of breakfast skipping ranged from 3·6 %, when the reference period was the previous week, to 39 %, when asked if the adolescent had eaten some solid food in the morning of the interview.

Thus, there is no clear definition or standardised categorisation of breakfast skipping among the different studies, which makes it difficult to compare their findings. The American Heart Association recently proposed definitions to improve and standardise the assessment of consumption and skipping of meals: food consumption occasions were defined as any episode that provides at least 210 kJ with 15 min of time elapsed between separate occasions. The distinction between meals and snacks should be at the discretion of the research

participant, thus encompassing different social norms and cultural behaviours[7].

In the present study, we chose to consider the answers 'I don't have breakfast', 'I have breakfast sometimes' and 'I have breakfast almost every day' as skipping and to consider consumption only for adolescents who marked the option 'I have breakfast every day'. It should be noted that the dietary guidelines for the Brazilian population[56] consider breakfast to be one of the three main meals of the day and recommend the daily consumption of this meal, this is why we chose to consider breakfast skipping as not having breakfast in a regular daily basis. Similar categorisations for breakfast skipping were used in previous studies[36,39].

The questionnaire used in the present study was self-administered and can be considered a possible limitation, as it depended on the adolescent's memory and motivation to answer it. However, this type of questionnaire has been applied in other epidemiological researches conducted with students and it is considered an acceptable method for data collection[43,54,55]. Other limitations that can be considered were the lack of information on other potential confounders which were not evaluated in the present study, for example, family income and race/skin colour. Family income has been associated with breakfast skipping and cardiometabolic outcomes in adolescents[15,55]; likewise other studies with Brazilian adolescents[28,29], in the present study, the type of school was considered as a proxy of the adolescents' socio-economic level. Regarding race/skin colour, although some studies in the literature have used race/ethnicity as a confounding factor[41,54] in the relationship between breakfast skipping and weight status, Hassan *et al.*[55] found no significant association between skin colour and breakfast skipping among Brazilian adolescents.

The main strength of the present study is the school-based probabilistic sample with regional and national representativeness, which provides further insights into the association of food consumption and cardiovascular risk factor profile in adolescents[17,18]. In addition, careful handling of information (training of evaluators for data collection, pilot testing for adequacy of questionnaires and standardised techniques) and use of standardised protocols minimise measurement errors. The wide range of demographic, socio-economic, sexual maturation, energy consumption and lifestyle-related data enabled the assessment of the association between breakfast skipping and multiple cardiometabolic risk markers; therefore, potential confounding factors could be controlled.

Conclusion

Breakfast skipping was very frequent among the studied adolescents, especially in females and public-school students. Adolescents who skipped this meal were more likely to have total and central obesity, as well as high levels of TC, fasting insulin, fasting glycaemia and HbA1c, regardless of lifestyle, sexual maturation, energy consumption, and demographic and socio-economic characteristics. Thus, breakfast skipping can be a harmful habit for adolescents' cardiovascular health.

The present study highlights the importance of encouraging daily consumption of breakfast. In this context, the school environment is an ideal space for the promotion of healthy eating habits, supporting the implementation of nutrition education activities that aim to encourage adolescents to eat breakfast daily and choosing healthy food options for this meal.

Acknowledgements

The authors would like to thank the financial support provided by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Brazil, through a master's grant (M. R. S.; finance code 001). However, CAPES had no role in the design, analysis or writing of this paper.

M. R. S. contributed to the conceptualisation of the study, formal analysis, writing the original draft, and final review. M. E. A. N. contributed to formal analysis, interpretation of the findings, and writing the original draft. A. M. S. and A. P. M. contributed to the conceptualisation of the study, formal analysis, and final review. R. A. P. and M. G. F. contributed to formal analysis, review and editing and supervision. P. R. M. R. contributed to the conceptualisation of the study, formal analysis, writing the original draft, review and editing and supervision. All authors read and approved the final version of the manuscript.

The authors declare that there are no conflicts of interest.

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