Breakfast skipping and cardiometabolic risk factors in adolescents: Systematic review

Marielly Rodrigues SouzaI, Morgana Egle Alves NevesII, Bartira Mendes GorgulhoII, Amanda Moura SouzaIII, Patrícia Simone NogueiraII, Márcia Gonçalves FerreiraII, Paulo Rogério Melo RodriguesII

I Universidade Federal de Mato Grosso. Faculdade de Nutrição. Programa de Pós-Graduação em Nutrição, Alimentos e Metabolismo. Cuiabá, MT, Brasil
II Universidade Federal de Mato Grosso. Faculdade de Nutrição. Departamento de Alimentos e Nutrição. Cuiabá, MT, Brasil
III Universidade Federal do Rio de Janeiro. Instituto de Estudos em Saúde Coletiva. Departamento de Epidemiologia e Bioestatística. Rio de Janeiro, RJ, Brasil

ABSTRACT

OBJECTIVE: To systematically review the results of the association between breakfast skipping and cardiometabolic risk factors in adolescents.

METHODS: The articles were searched in May 2020 from PubMed, Virtual Health Library, Scopus, Web of Science and Scientific Electronic Library Online (SciELO). The review included observational studies conducted with adolescents (10–19 years old), which estimated the association of breakfast skipping with at least one outcome (markers of body adiposity, blood pressure, serum lipid and glucose levels). Regarding the risk of bias, the articles were evaluated using the Research Triangle Institute (RTI) Item Bank on bias risk and accuracy of observational studies. The quality of the evidence was assessed by the Grade rating.

RESULTS: A total of 43 articles involving 192,262 participants met the inclusion criteria and were considered in this review. The prevalence of breakfast skipping ranged from 0.7% to 94% and 60.5% of studies were classified with low risk of bias. The significant association between breakfast skipping and cardiometabolic risk factors was found in twenty-nine cross-sectional articles (n = 106,031) and four longitudinal articles (n = 5,162) for excess adiposity, in three articles (n = 8,511) for high total cholesterol levels, low-density lipoprotein and triglycerides, and in three studies (n = 6,303) for high blood pressure levels. However, there was no significant association between breakfast skipping and glycemic profile. According to the Grade rating, all the associations had low quality of evidence.

CONCLUSION: The results of this review suggest that breakfast skipping is associated with cardiometabolic risk factors in adolescents aged 10 to 19 years. However, considering the low quality of the evidence, the present results should be interpreted carefully. In addition, our findings highlight the importance of standardizing the definition of breakfast skipping and that more prospective studies are needed to determine how skipping breakfast can affect cardiometabolic risk factors in the long time.

DESCRIPTORS: Adolescent. Breakfast. Food Deprivation. Metabolic Syndrome. Cardiometabolic Risk Factors. Review.
INTRODUCTION

In recent decades, the meal consumption pattern has been associated with adolescents’ physical growth and various health outcomes. Among behaviors related to that, we highlight the unfavorable effect of skipping meals, especially breakfast.

Breakfast is the first and most important meal of the day, and contributes to maintaining adolescents’ overall health and diet quality. This meal usually occurs before the start of daily activities, after a period of rest (sleep) of approximately 8 to 10 hours without any food consumption.

Regular consumption of breakfast has been considered as a marker of healthy eating habits, and plays an important role in nutritional adequacy, bone and cardiovascular health, school performance, cognitive performance, and improved attention and mood.

In adolescence, unhealthy eating habits, such as skipping breakfast, can compromise growth, development, and long-term health. Skipping this meal is also associated with cardiometabolic risk factors in adolescents, such as increased central and total adiposity, insulin resistance, and dyslipidemia.

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: dyslipidemia, insulin resistance, obesity, and high blood pressure.

Some physiological and metabolic mechanisms may explain how breakfast skipping may be associated with cardiometabolic risk factors, including its contribution to an unfavorable energy balance causing weight gain and changes in serum lipid levels. Another explanation is that breakfast skipping increases hunger and leads to excessive consumption throughout the day, resulting in increased body weight. Prolonged fasting time alters glucose homeostasis, resulting in decreased insulin secretion and intact glucagon-like peptide-1 (iGLP-1) responses and increased post meal plasma glucose.

Therefore, this study sought to systematically review the association between breakfast skipping and cardiometabolic risk factors in adolescents.

METHODS

This is a systematic review of the literature, aiming to answer the questions: “Is breakfast skipping associated with serum lipid and glucose levels in adolescents?”; “Is breakfast skipping associated with blood pressure in adolescents?”; “Is breakfast skipping associated with markers of body adiposity in adolescents?” This review was developed and structured according to the acronym PECO components (Population: adolescents; Exposure: breakfast skipping; Control: without control; Outcome: Lipid and glycemic profile, high blood pressure, systemic arterial hypertension, and markers of body adiposity). The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO), National Institute for Health Research, under the registration number: CRD42018105003.

The records were searched independently by two researchers in the following databases: MEDLINE via PubMed, Web of Science (WoS), Scopus, Virtual Health Library (VHL) and SciELO. The searches were carried out in May 2020. No country restrictions have been established. Descriptors were used for skipping breakfast, blood pressure, lipid and glycemic profile, and adolescents, combining the terms through the Boolean operators OR and AND, as shown in Supplementary Table 1.

Inclusion and Exclusion Criteria of the Studies

This review included cross-sectional and longitudinal observational studies published between 2008 and 2019 in English, Spanish, or Portuguese, conducted with adolescents.
Table 1. General characteristics of the studies included in the systematic review, main results, and scores in the risk of bias assessment.

| Author/Place       | Breakfast skipping assessment | Confounding factors | Prevalence of breakfast skipping | Main results                                                                 | Risk of bias Points¹ |
|--------------------|-------------------------------|--------------------|----------------------------------|------------------------------------------------------------------------------|----------------------|
| Cohort studies     |                               |                    |                                 |                                                                              |                      |
| Timlin et al.21 Mn | “During the last week, how many days did you have breakfast?” The frequency of breakfast was recoded into three categories: Daily (every day), Intermittent (1 to 6 days/week), Never (daily omitters). Age, sex, race, NSE, exercise, cigarettes, alcoholic beverage, total energy, carbohydrates, fiber, food items (milk, cold cereals, juices and bread), psychosocial variables, fast eating, skipping weight management meals, dieting last year, be teased about weight loss in the current weight. | Age 1: 16.4% (girls) and 13.0% (boys). Time 2: 13.8% (girls) and 18.9% (boys). Adolescents who never ate breakfast had a higher mean increase in BMI (model 1: 2.2 ± 0.19, model 2: 2.2 ± 0.20, p < 0.05) than those who consumed daily (model 1: 1.6 ± 0.16, p < 0.05) and intermittent (model 1: 2.2 ± 0.09, p < 0.05). | Outcome not evaluated. Outcome not evaluated. Outcome not evaluated. 9 (Present). |
| Wang et al.16 Nh   | (1) Frequent skippers (2) Inconsistent school eaters (3) Inconsistent home eaters (4) Regular home eaters (5) Regular school eaters (6) Double breakfast eaters. Schooling, year of follow-up, weight status, classroom breakfast program, race/ethnicity. | Adolescents in the group that frequently skipping breakfast were more likely to be overweight and obese compared to adolescents in the group that consumed double breakfast (OR = 2.66, 95%CI = 1.67; 4.24). | Outcome not evaluated. Outcome not evaluated. Outcome not evaluated. 10 (Low). |
| Cayres et al.22 Br | “How many days a week do you usually have breakfast? Zero (score 0), 1 to 2 days (score 1), 3 to 5 days (score 2), Every day of the week (score 3). Sex, age and level of sexual maturation. | Not shown. | At the beginning of the study, adolescents who skipping breakfast had higher BMI (p = 0.032), abdominal fat (p = 0.019) and total body fat (p = 0.012) than those who ate breakfast regularly. After 12 months of follow-up abdominal fat (0.4% [95%CI = -1.2; 2.2]) and total body fat (0.08% [95%CI = -0.8; 1.0]) of adolescents who skipped breakfast increased more than those who ate regularly. | Outcome not evaluated. Outcome not evaluated. Outcome not evaluated. 11 (Low). |
| Hassan et al.23 Br | Breakfast Frequency: Never or almost never (1) 1 to 2 times a week (2) 3 to 4 times a week (3) 5 to 6 times a week (4) Daily | Weight status, family breakfast and diet. 9.6% | There was no association between skipping breakfast and weight status in girls (RR = 0.88, 95%CI = 0.53; 1.45) and boys (RR = 1.29, 95%CI = 0.73; 2.30). | Outcome not evaluated. Outcome not evaluated. Outcome not evaluated. 11 (Low). |

¹ Bias risk assessment: Low (1-4 points), Moderate (5-8), High (9-11).
Table 1. General characteristics of the studies included in the systematic review, main results, and scores in the risk of bias assessment. Continuation

| Study                        | Country | n     | Age range | Gender | Breakfast consumption frequency | Type of school (public and private), screen time, diet, sexual maturation and energy expenditure of physical activity | There was no significant association between skipping of breakfast, BMI and% BF over time (p > 0.05). | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Risk of Bias Score |
|------------------------------|---------|-------|-----------|--------|----------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------|----------------------------------|----------------------------------|---------------------|
| Hassan et al.24               | Brazil  | 809   | 10–16 years M/F | Period: 3 years | Skip breakfast: Never or almost never (no consumption) | 9.6%                                                                                                | No significant association between skipping of breakfast, BMI and% BF over time (p > 0.05).                                      | Outcome not evaluated.  | Outcome not evaluated.  | Outcome not evaluated.  | 10 (Low).         |
| Wu et al.11                   | Taiwan  | 1,326 | 10–18 years M 52.0% | Period: 5 years | Skip breakfast: Yes | Family structure, household income, and self-assessment of available money. | Skipping breakfast was associated with overweight only in female adolescents (OR = 1.63, 95% CI = 1.20; 2.22.) | Outcome not evaluated.  | Outcome not evaluated.  | Outcome not evaluated.  | 9 (Present).        |
| Harding et al.25              | London  | 6,599 | 11–13 years M 53.0% | “How many times during the week do you have breakfast?” | Skipping breakfast sometimes or always vs. rarely. | NSE, family type, height, pubertal stage, age. | Skipping was associated with overweight (girls: OR = 1.66, 95% CI = 1.38; 2.01; boys OR = 1.53, 95% CI = 1.27; 1.84) and obesity (girls: OR = 1.74; 95% CI = 1.30; 2.34; boys OR = 2.06; 95% CI = 1.57; 2.70) | Outcome not evaluated.  | Outcome not evaluated.  | Outcome not evaluated.  | 8 (Low).           |
| Maddah26                      | Iran    | 2,090 | 14–17 years F 100% | “How many times during the week do you have breakfast?” | Skipping breakfast: | Maternal education, watching TV, walking, age, birth weight, and age at menarche. | Skipping breakfast was associated with overweight in both urban and rural schools (OR = 2.23; 95% CI = 1.37; 3.65). | Outcome not evaluated.  | Outcome not evaluated.  | Outcome not evaluated.  | 9 (Low).           |
| Mota et al.27                 | Portugal| 886   | 13–17 years F 52.0% | Skipping breakfast: | | Not adjusted. | Regardless of gender, breakfast skipping is not seen as a predictor of being at risk of obesity (girls: OR = 0.98, 95% CI = 0.43; 2.20; Boys: OR = 1.39, 95% CI = 0.59; 3.31). | Outcome not evaluated.  | Outcome not evaluated.  | Outcome not evaluated.  | 7 (Present).       |
| Sánchez et al.28              | Gran Canaria | 1,002 | 12–14 years M 50.0% | Breakfast: | | Not adjusted. | Adolescents who skipped breakfast had a higher prevalence of overweight and obesity than those who did not omit (girls: 30.0% vs 17.5%, p = 0.031; boys: 27.3 vs 18.2%, p = 0.028) | Outcome not evaluated.  | Outcome not evaluated.  | Outcome not evaluated.  | 7 (Present).       |

**Note:** The table continues with additional studies and data as necessary.
| Study | Country | n | Age | Gender | Breakfast Categorization | Scores in the risk of bias assessment | Continuous variables | Continuous results |
|-------|---------|---|-----|--------|--------------------------|--------------------------------------|----------------------|-------------------|
| Alexander et al. | California | 110 | 10–17 years | M 59.1% | Breakfast was defined as consumption of any food or drink between 5:00 am and 10:00 am with combined total energy ≥ 100 kcal. R24h in 2 days (not eating breakfast on both days was defined as skipping). Breakfast Categorization: Breakfast eater; Occasional breakfast eater; Breakfast skipper. | 21.5% | Age, Tanner stage, sex, total fat, total lean tissue mass, and total energy consumed. | There was no significant difference between breakfast consumption categories for BMI (p = 0.282), total lean mass (p = 0.796), total fat (p = 0.063) and subcutaneous abdominal fat (p = 0.817). The adolescents who skipped breakfast had higher intra-abdominal fat than occasional consumers (47.2 vs. 32.1 cm², p = 0.004) and regular consumers (47.2 vs. 32.0 cm², p = 0.05). | Outcome not evaluated. |
| Croezen et al. | Netherlands | 25,176 | 13–16 years | F 51.2% | Skipping breakfast frequency: 7 days/week 5–6 days/week 3–4 days/week 1–2 days/week 0 days/week | 8 (Low). | Gender, family status, ethnicity, education and smoking. | Skipping breakfast 7 days/week was associated with overweight and obesity among adolescents 2nd grade (OR = 2.17; 95%CI = 1.66; 2.85) and 4th grade (OR = 1.75; 95%CI = 1.39; 2.21). | Outcome not evaluated. |
| Kollias et al. | Greece | 558 | 12–17 years | M 50.0% | Have breakfast: Yes Not* | 68% | Age and BMI. | Skipping breakfast was associated with increased SBP in boys (2.81 ± 1.35 mmHg, p < 0.05). | Outcome not evaluated. |
| Maddah et al. | Iran | 2,255 | 14–18 years | F 100% | “How many times during the week do you have breakfast?” Never 1–2 times/week 3 times or more per week. | Not shown. | Not adjusted. | Breakfast skipping was more prevalent in overweight/obese girls than in those with normal weight in urban (62.7 vs. 53.5%, p < 0.001) and rural (65.8 vs. 48.8; p < 0.001) areas. | Outcome not evaluated. |
| Sun et al. | Japan | 5,753 | 12–13 years | F 50.6% | Breakfast Consumption: Daily Almost daily Sometimes Rarely* | 1.1% (boys) and 0.7% (girls). | Age, paternal overweight, maternal overweight, and lifestyle variables. | Breakfast skipping was associated with overweight (Boys: OR = 2.59, 95%CI = 1.05; 6.40; Girls: OR = 7.93, 95%CI = 2.79; 22.53). | Outcome not evaluated. |
| Deshmukh-Taskar et al. | United States of America | 5,339 | 14–18 years | M 51.6% | Consumption of any food or drink on a meal occasion named by the respondent as breakfast at R24h No consumption of food or drink, excluding water* | 31.5% | Age, sex, ethnicity, NSE, physical activity, and energy intake. | Those who skipped breakfast had higher WC (78.5 vs. 75.0 cm; p < 0.0167) and higher prevalence of obesity (20.7 vs. 13.2%, p < 0.0005) in comparison to consumers. | Outcome not evaluated. |
| Kapantais et al. | Greece | n = 14,454 | 13–19 years | F 53.8% | Breakfast skipping or have breakfast occasionally (< 2 times/week) – Breakfast skipped* Breakfast Consumption. | 13.6% (boys) and 17.1% (girls). | Not adjusted. | Breakfast skippers had higher BMI than consumers (boys: 23.2 vs. 21.9 kg/m², p < 0.001; girls: 21.9 vs. 20.9 kg/m², p < 0.001). | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | 8 (Low). |
|------------------|--------|------------|-------------|--------|----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|----------------|---------------------------------------------------------------------------------|------------------|------------------|------------------|---------|
| Maddah and Nikooeyh | Iran | n = 2,577 | 12–17 years | F 100% | “How many times in a week do you have breakfast?” Rarely Most times a week Categorized in: Regular Not regular. | Age, birth weight, maternal education level, watching TV (hour per day), birth rate, maternal employment, place of residence, maternal overweight/obesity, paternal overweight/obesity, walking (hour/day). | Not shown. | Girls who skipped breakfast were more likely to be overweight/obese (OR = 1.4, 95%CI = 1.09; 1.93). | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | 9 (Low). |
| Thompson-McCormick et al. | Fiji | n = 517 | 15–20 years; F 100% | “How many days in a week (on average) do you skip breakfast?” With response options ranging from 0 to 7 days. | Dimensions of Western/Ethnic and Fijian cultural orientation and involvement, age, school location, relative material wealth, boarding school, parental involvement, EDE-Q global score, and age. | 68% skipping at least once/week and 41% skipping three or more times/week. | Adolescents who skipped breakfast were more likely to be overweight (OR = 1.15, 95%CI = 1.06; 1.26, p < 0.01). | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | 7 (Present). |
| Kim and So | Korea | n = 72,399 | Age mean = 15.09 ± 1.75 | M 52.7% | “Usually how many days a week did you have breakfast?” 1–2 day(s) 3–5 days 6 to 7 days No breakfast*. | Age, smoking, frequency of consumption, parental education, economic status, frequency of physical activity (vigorous and moderate), frequency of muscle strength exercises, mental stress, and sleep duration. | 54.5% | There was no association between breakfast skipping and overweight (boys: OR = 1.059, 95%CI = 0.968; 1.159; girls: OR = 1.019, 95%CI = 0.992; 1.125) and obesity (boys: OR = 0.932, 95%CI = 0.854; 1.018; girls: OR = 0.941, 95%CI = 0.824; 1.073). | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | 8 (Low). |
| Kuriyan et al. | Bangalore | n = 3,737 | 10–16 years | F 58.0% | Skip breakfast: Yes* Not. | Not adjusted. | The adolescents who skipped breakfast had increased WC (+0.31 cm). | Not shown. | | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | 7 (Present). |
| Vaezghasemi et al. | Sweden | n = 4,987 | 13–15 years | M 50.5% | Breakfast on school days: ≥ 4 times/week ≤ 3 times/week*. | Age, country of birth, parental status, self-rated health, food consumption (fruits, vegetables, sweets, and snacks), tooth brushing, sleep duration, TV watching, physical activity, smoking, stress use, alcohol use, and drug use. | Not shown. | Skipping breakfast was associated with overweight/obesity (boys: OR = 1.7, 95%CI = 1.4; 2.2; girls: OR = 1.6, 95%CI = 1.2; 2.1), after adjustment this association remained only for males (OR = 1.4, 95%CI = 1.1; 1.8, p = 0.016). | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | 5 (Present). |
| Study                          | Country     | N     | Age       | Gender | Breakfast Consumption | Breakfast Presence | Sex and Age | Frequency | Main Results                                                                 | Risk of Bias |
|-------------------------------|-------------|-------|-----------|--------|-----------------------|-------------------|-------------|----------|--------------------------------------------------------------------------------|--------------|
| Shafiee et al.41              | Iran        | 5,625 | 10–18 years | MF2    | Regular consumption: 6–7 days/week; Often: 3 to 5 days/week; Seldom: 0–2 days/week | Breakfast omits | Not shown | 7.5% of girls do not eat breakfast daily. | Those who rarely ate breakfast were more likely to have general obesity (OR = 1.47; 95%CI = 1.20; 1.82) and abdominal obesity (OR = 1.39; 95%CI = 1.04; 1.86). Rarely consuming breakfast increased the chance of having high TG (OR = 1.41; 95%CI = 1.03; 1.93). | 8 (Low).     |
| Borčić et al.42              | Serbia      | 2,139 | 10–19 years | M 50.4%| Breakfast Consumption: Every day Sometimes Never | Breakfast omits | Not shown | 29.0% | Skipping breakfast was associated with being overweight (OR = 1.43; 95%CI = 1.02; 2.01). | 8 (Low).     |
| Díez-Navarro et al.43        | Madrid      | 986   | 11–15 years | F 55.0%| Breakfast Presence No breakfast | Breakfast omits | Not adjusted | 6.2% | Skipping breakfast was associated with obesity (OR = 3.44; 95%CI = 2.08; 5.68). The mean BMI Z-score of breakfast-omitting adolescents (1.11) was higher than those who reported breakfast frequency 3–5 times/week (0.57) and 6–7 times/week (−0.42) with p = 0.001 in both cases. | 6 (Present). |
| Faizi et al.44                | India       | 1,416 | 13–15 years | M 50.3%| Breakfast was calculated based on two questions: Q1. In a normal week, how many times/week do you have your breakfast? Q2. Last week, how often did you have your breakfast? The final response was calculated as Q1 + Q2/2. Categorized in: < 2 times/week; 3–5 times/week; 6–7 times/week. | Breakfast omits | Not adjusted | 23.6% | There was no significant association between breakfast skipping and overweight (p = 0.992). | 6 (Present). |
| Garcia-Continente et al.45   | Barcelona   | 3,089 | 13–18 years | F 52%  | (1) Always have breakfast before leaving home and halfway morning. (2) Always have breakfast before leaving home or in the middle of the morning. (3) Eat breakfast sometimes, but not every day before (4) Never eat breakfast | Breakfast omits | Age, Family Affluence Scale, ownership of the school, and NSE of the neighborhood of the school | 2.0% | Skipping breakfast was associated with overweight only in females (OR = 4.07; 95%CI = 1.59; 10.44). Skipping breakfast was associated with obesity only for males (OR = 3.24; 95%CI = 1.16; 9.07). | 7 (Present). |
| Garg et al.46                 | India       | 195   | 10–16 years | M 64.1%| Skipped breakfast | Breakfast omits | Not adjusted | 23.6% | There was no significant association between breakfast skipping and overweight. (p = 0.992). | 6 (Present). |
| Study | Country | n (Gender) | Age, Sex, Household Income, and Housing | Breakfast consumption frequency | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. |
|-------|----------|------------|----------------------------------------|-------------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| Gokler et al. | Turkey | 3,918 (1:1) | 14–18 years, F 52.2% | Not having breakfast | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. |
| Talat and Shahat | Sharkia Province | 900 (1:1) | 12–15 years, F 52.0% | Brokenfast consumption frequency: Never, Sometimes, Often | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. |
| Cayres et al. | Brazil | 120 (1:1) | 11–14 years, M 51.7% | Breakfast frequency ≤ 6 days/week | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. |
| Kim et al. | Korea | 2,091 (1:1) | 10–18 years, M 52.8% | Do not eat breakfast more than 5 times a week | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. |
| Morales and Montilva | Venezuela | 800 (1:1) | 15–19 years, M 50.6% | Skipped breakfast or skipped breakfast at least once/week | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. |
| Badr et al. | Asia Occidental | 2,672 (1:1) | 12–16 years, M 50.3% | “How often do you have breakfast?” Never, Sometimes, Ever | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. | Outcome not evaluated. |

Outcome not evaluated.

Skipping breakfast was associated with obesity in adolescents living in urban areas (OR = 1.33, 95%CI = 1.04; 1.69), but not in those living in rural areas (OR = 1.21, 95%CI = 0.75; 1.93).

Skipping breakfast was associated with increased SBP (p = 0.040).

Skipping breakfast was not associated with overall obesity (PR = 0.66; 95%CI = 0.29; 1.47) or central obesity (PR = 0.92; 95%CI = 0.70; 1.22).

There was no association between skipping breakfast and CT (p = 0.740), HDL (p = 0.723), LDL (p = 0.862), and TG (p = 0.694).

Skipping breakfast was associated with increased risk of having high LDL-cholesterol in boys (OR = 5.77, 95%CI = 1.02; 33.28).

Skipping breakfast was associated with increased SBP (p = 0.040).

Outcome not evaluated.

Outcome not evaluated.

Outcome not evaluated.

8 (Low).
### Table 1. General characteristics of the studies included in the systematic review, main results, and scores in the risk of bias assessment. Continuation

| Study | Country    | Sample Size | Age Range | Gender | Study Design | Outcome Measures                        | Risk of Bias |
|-------|------------|-------------|-----------|--------|--------------|-----------------------------------------|--------------|
| Frayon et al. | New Caledonia | n = 621 | 11–16 years | 54.4%  | Breakfast skipping before you go to school? | Skipping No skipping  | NSE, age, gender, ethnicity, weight status | 15.3%        |
|        |            |             |           |        |              | Skipping breakfast was associated with overweight for boys (OR = 2.981, 95%CI = 1.460; 6.085), but not among girls (OR = 1.085, 95%CI = 0.537; 2.190). The same trend was found for obesity (boys: OR = 3.301, 95%CI = 1.388; 7.851; girls: OR = 2.291, 95%CI = 0.928; 5.656). | 8 (Low)      |
| Zalewska et al. | Poland | n = 1,999 | 18 years | 65.7%  | Breakfast Habit: Skipped, < 8 AM, ≥ 8 AM. Not adjusted. | | | 25.0% |
|        |            |             |           |        |              | There was no significant difference in breakfast skip prevalence between normal weight and overweight and obese students (p > 0.05). | 7 (Present)  |
| De Cnop et al. | Brazil | n = 1,749 | 10–19 years | 50.1%  | Breakfast consumption frequency: Regular (daily consumption) Irregular ≤ 6 times/weeka | Sex and age. Not shown. | | |
|        |            |             |           |        |              | Skipping breakfast was associated with being overweight in public (OR = 1.48, 95%CI = 1.07; 2.06) and private (OR = 1.57, 95%CI = 1.19) schoolchildren. 2.07; elevated WHR (OR = 1.50, 95%CI = 1.03; 2.19) and high fat% (OR = 1.47, 95%CI = 1.12; 1.95) only in school students private | 8 (Low)      |
| Khan et al. | Bangladesh | n = 793 | 12–17 years | 50.0%  | 5 to 7 days/week (regular breakfast) 0 to 4 days/week (skipping breakfast). Sex, age, walk to school, involvement in school sports, and family income. 11% skipping every day and 23% consumed ≤ 4 days a week. | | | |
|        |            |             |           |        |              | Skipping breakfast was associated with overweight (OR = 1.77, 95%CI = 1.11; 2.83) and obesity (OR = 2.62, 95%CI = 1.35; 5.08) after adjustment. | 7 (Present)  |
| Silva et al. | Brazil | n = 493 | 10–14 years | 52.3%  | Breakfast was considered the first meal of the day, eaten between 5:00 and 9:00 am. Have breakfast Missing Breakfastb. Physical activity, energy consumption and sex. | | | 30.0% |
|        |            |             |           |        |              | There was no significant association between breakfast skipping and BMI Z-score (p = 0.666), WC (p = 0.640) and% body fat (p = 0.777). | 8 (Low)      |
|        |            |             |           |        |              | There was no significant association between breakfast skipping and TC (p = 0.650), HDL (p = 0.766), LDL (p = 0.714) and TG (p = 0.409). | |
|        |            |             |           |        |              | There was no significant association between skipping breakfast and glucose (p = 0.427). | |
|        |            |             |           |        |              | There was no significant association between skipping breakfast and SBP (p = 0.409) and DBP (p = 0.806). | |
Table 1. General characteristics of the studies included in the systematic review, main results, and scores in the risk of bias assessment. Continuation

| Study                  | Setting                  | Sample Size | Gender | Age, Sex, education level | Outcome not evaluated | Outcome not evaluated | Outcome not evaluated | Risk of Bias |
|------------------------|--------------------------|-------------|--------|---------------------------|-----------------------|-----------------------|-----------------------|--------------|
| Tee et al.57 Malaysia  | F 3,000                  | 13–17 years | F 51.8%| Age, sex (except for gender analysis), ethnicity, father’s education level, monthly household income and physical activity scores. | Girls who skipped breakfast were 38% more likely (95% CI = 1.01; 1.9, p = 0.044) to be overweight or obese than those who ate breakfast regularly. | There was no significant association for boys (OR = 1.31, 95% CI = 0.92; 1.87, p = 0.135). | 9 (Low). |             |
| Werneck et al.58 Brazil | Brazil                   | 280         | M 70.7%| Age, sex (except for gender analysis), ethnicity, father’s education level, monthly household income and physical activity scores. | | | |             |
| Forkert et al.59 Europe and Brazil | HELENA | F 2,171     | M 72.9%| Age, sex, age, ethnicity, somatic maturation, and body adiposity (for HOMA-IR analysis). | Adolescents skipping breakfast had higher body fat (p = 0.002). | | |             |
| BRACAH                 | n = 991                  | 14–18 years | F 54.5%| Sex, chronological age, ethnicity, somatic maturation, and body adiposity (for HOMA-IR analysis). | | | |             |
| Mustafa et al.60 Malaysia | n = 795               | 13 years    | F 63.0%| Number of days any food or drink was reported for breakfast. Categorized in: daily 4 to 6 days/week 1 to 3 days/week 0 days/week. | | | |             |

**Legend:**
- **F:** female; **M:** male; **EDE-Q:** Examination Questionnaire for Eating Disorder; **BF:** body fat; **BMI:** body mass index; **CI:** confidence interval; **DBP:** diastolic blood pressure; **HbA1c:** glycosylated hemoglobin; **HDL:** high density lipoprotein; **HOMA-IR:** homeostatic model insulin resistance; **LDL:** low density lipoprotein; **NSE:** socioeconomic level; **OR:** odds ratio; **PR:** prevalence ratio; **SBP:** systolic blood pressure; **SD:** standard deviation; **REC:** ready to eat cereals; **RR:** relative risk; **TC:** total cholesterol; **TG:** triglycerides; **WC:** waist circumference; **WHR:** waist:height ratio.
- **a:** Skipping breakfast.
- **1 Viswanathan e Berkman19; 2 The proportion of females and males was not reported; 3 Study follow-up period; 4 Only 2 participants of 20 years and were classified with normal weight.**
Breakfast skipping and cardiometabolic risk
Souza MR et al.

(10–19 years old, as defined by the World Health Organization)\(^8\), which have estimated the association of breakfast skipping with at least one of the cardiometabolic risk factors (markers of body adiposity, blood pressure, systemic arterial hypertension, serum lipid, and glucose levels).

The articles including adolescents with mental disorders, kidney disease, HIV, cancer, Down syndrome, and others were excluded from the review; those including other age groups, in addition to individuals aged between 10 and 19 years, and articles that did not present separate results for this age group; non-empirical records, opinions and editorials, case studies, summaries of scientific events that were not published as full papers, intervention studies and animal studies were also excluded.

**Review Process**

The articles were selected by two independent researchers and disagreements were discussed and analyzed at subsequent meetings. After the search, the Mendeley reference management tool was used to exclude duplicate records, and an initial screening was performed to reject records whose title and/or abstract information failed the inclusion criteria. If abstracts were unavailable or provided insufficient results, the article was selected for full reading. After analyzing the articles previously selected for full reading, reviewers included studies with results on the association of breakfast skipping with cardiometabolic risk factors (Figure).

![Figure. PRISMA flow diagram of study selection process.](https://doi.org/10.11606/s1518-8787.2021055003077)
The studies were presented according to the following characteristics: (1) identification data with citation of the author(s), year of publication and place of study; (2) number of individuals evaluated, age and sex of the sample studied; (3) study outcome(s); (4) breakfast skipping assessment; (5) control of confounding factors and (6) main results (prevalence of breakfast skipping, association of breakfast skipping with markers of body adiposity, serum lipid levels, glucose metabolism (insulin resistance, fasting glucose and glucose intolerance) and blood pressure). Table 1 shows this information in chronological order.

**Evaluation of Study Quality**

The studies included in this systematic review underwent independent quality and risk of bias review by two reviewers. The instrument used was the Research Triangle Institute (RTI) Item Bank on Bias Risk and Accuracy of Observational Studies proposed and validated by Viswanathan & Berkman to assess risk of bias and accuracy of observational studies.

The RTI Item Bank includes several study designs, and the authors provided instructions on which items to use depending on the studies being evaluated. Considering the authors’ recommendations and the types of study included in this review, ten items were used to evaluate cross-sectional studies (sample definition and selection, consistency of information, outcomes, comparability of analysis, analysis results, interpretation of results, and funding) and thirteen items for cohort studies (three additional questions on follow-up time and impact of losses). Thus, a cross-sectional study with three or more key items classified as negative or unclear or a cohort study with four or more negative or unclear items were classified as at risk of bias (Table 1).

**Evaluation of the Quality of Evidence**

This evaluation aims to provide greater reliability to the critical analysis of the findings. In this study, the Grading of Recommendations Assessment, Development and Evaluation (GRADE) System was used for each analyzed outcome. The following criteria were used to evaluate the studies: design (randomized clinical trial starts with high quality and observational study with low); factors responsible for reducing evidence level (methodological limitations, indirect evidence, imprecision, and publication bias) and factors that contribute to raising the evidence (large magnitude of effect, dose-response gradient, and residual confounding factors). After evaluation according to the GRADE rating, the studies were classified into four quality of evidence levels: High (A) – There is strong confidence that the true effect/association is close to that estimated; Moderate (B) – There is moderate confidence in the estimated effect/association; Low (C) – Confidence in the effect/association is limited; and, Very low (D) – Confidence in the effect/association estimate is very limited (Table 2).

**RESULTS**

In the databases searched, 4,660 records were identified and 3,910 remained after deletion of duplicates. Then, the titles and abstracts were read, and 134 articles were selected for full reading, of which 91 did not meet the inclusion criteria; therefore, a total of 43 articles were included in this systematic review (Figure).

Table 1 shows the summary of the main characteristics of the 43 studies involving 192,262 participants from 10 to 19 years old. Six studies are longitudinal (cohort) and thirty-seven are cross-sectional studies. In twenty-two articles, the population was predominantly female and four of them studied only adolescent girls. Three articles did not describe the frequency of each sex. The selected studies were conducted in 22 countries. Seventeen studies were conducted in Asian countries, twelve in European countries, twelve in countries of the American continent and two in Oceanian
Breakfast skipping and cardiometabolic risk
Souza MR et al.

https://doi.org/10.11606/s1518-8787.2021055003077

countries. The countries with the highest number of studies were Brazil, United States, and Iran (Table 1).

Three studies evaluated markers of body adiposity, blood pressure, and glycemic and lipid profile; one evaluated markers of body adiposity, lipid profile, and blood pressure; two assessed markers of body adiposity and glycemic profile; one article evaluated only lipid profile; one only blood pressure; and thirty-five articles evaluated only markers of body adiposity (body mass index (BMI), waist circumference (WC), body fat %, and waist-height ratio (WHR)).

The definition of breakfast skipping presented many variations; twenty-three articles assessed skipping by frequency of breakfast consumption; twelve studies considered the number of days per week (0 days/week, 0–2 days/week, 0–3 times/week, 0–4 days/week, 0–5 days/week, < 2 times/week, ≤ 6 times/week); one study considered breakfast skipping when frequency of consumption was reported as rarely; two considered skipping as never or almost never; and eight studies considered skipping as never before. Four articles evaluated skipping by the frequency

Table 2. Relationship between breakfast skipping and cardiometabolic risk factors with classification of the quality of evidence according to the GRADE system.

| Exposure                  | Outcome                  | Positive association | Negative association | No association | Summary of evidence (Grade) |
|---------------------------|--------------------------|----------------------|----------------------|----------------|-----------------------------|
| Breakfast skipping        | Glycemic profile         | -                    | -                    | Alexander et al. | Negative association (C)    |
|                           |                          |                      |                      | Shafiee et al.  |                            |
|                           |                          |                      |                      | Silva et al.    |                            |
|                           |                          |                      |                      | Werneck et al.  |                            |
|                           |                          |                      |                      | Mustafa et al.  |                            |
| Breakfast skipping        | Lipid profile            | Shafiee et al.       | -                    | Cayres et al.   | Positive association (C)    |
|                           |                          | Kim et al.           |                      | Silva et al.    |                            |
|                           |                          | Maddah et al.        |                      |                |                            |
| Breakfast skipping        | Blood pressure           | Kollias et al.       | -                    | Silva et al.    | Positive association (C)    |
|                           |                          | Shafiee et al.       |                      | Mustafa et al.  |                            |
| Breakfast skipping        | Markers of body adiposity| Timlin et al.        |                      | Hasssan et al.  | Positive association (C)    |
|                           |                          | Wang et al.          |                      | Hassan et al.   |                            |
|                           |                          | Cayres et al.        |                      | Mota et al.     |                            |
|                           |                          | Wu et al.            |                      | Kim and So      |                            |
|                           |                          | Harding et al.       |                      | Garg et al.     |                            |
|                           |                          | Maddah et al.        |                      | Morales and Montilva |                        |
|                           |                          | Sánchez et al.       |                      | Zalewska et al. |                            |
|                           |                          | Alexander et al.     |                      | Silva et al.    |                            |
|                           |                          | Croezen et al.       |                      |                |                            |
|                           |                          | Maddah et al.        |                      |                |                            |
|                           |                          | Sun et al.           |                      |                |                            |
|                           |                          | Deshmukh-Taskar et al.|                    |                |                            |
|                           |                          | Kaptantis et al.     |                      |                |                            |
|                           |                          | Maddah et al.        |                      |                |                            |
|                           |                          | Thompson-McCormick et al.|    |                |                            |
|                           |                          | Kuriyan et al.       |                      |                |                            |
|                           |                          | Vaezghasemi et al.   |                      |                |                            |
|                           |                          | Shafiee et al.       |                      |                |                            |
|                           |                          | Boricić et al.       |                      |                |                            |
|                           |                          | Diez-Navarro et al.  |                      |                |                            |
|                           |                          | Faizi et al.         |                      |                |                            |
|                           |                          | Garcia-Continente et al.|            |                |                            |
|                           |                          | Gökler et al.        |                      |                |                            |
|                           |                          | Talat and Shahat     |                      |                |                            |
|                           |                          | Cayres et al.        |                      |                |                            |
|                           |                          | Badr et al.          |                      |                |                            |
|                           |                          | Frayon et al.        |                      |                |                            |
|                           |                          | De Cnop et al.       |                      |                |                            |
|                           |                          | Khan et al.          |                      |                |                            |
|                           |                          | Tee et al.           |                      |                |                            |
|                           |                          | Werneck et al.       |                      |                |                            |
|                           |                          | Forkert et al.       |                      |                |                            |
|                           |                          | Mustafa et al.       |                      |                |                            |

*Quality of evidence (GRADE system): A – High; B – Moderate; C – Low; D – Very Low.*
of breakfast skipping (sometimes or always vs. rarely\textsuperscript{25}, 0 to 7 days\textsuperscript{26,37} and 5, 6, and 7 times/week\textsuperscript{30}). Seven articles used the “skip yes/no” option\textsuperscript{11,27,39,46,52,53,59} and nine defined skipping according to breakfast consumption: yes/no\textsuperscript{28,31}, regular/non-regular\textsuperscript{36,54}, presence/absence\textsuperscript{13,47,56} and whether study participants did not report food or drink consumption in the R24h\textsuperscript{29,34} (Table 1).

The prevalence of breakfast skipping ranged from 0.7\%\textsuperscript{33} to 94\%\textsuperscript{27}, according to the different definitions of breakfast skipping used in the articles. Twelve studies did not report the prevalence of skipping breakfast\textsuperscript{11,12,22,25,26,30,32,36,40,42,50,54}. Twenty-six\textsuperscript{12,16,22–26,29–36,38,41,42,49,50,52,54,56–59} (60.5\%) studies were classified with low risk of bias (Table 1).

The six longitudinal studies (cohort) evaluated only the markers of body adiposity\textsuperscript{11,16,21–24}. Four studies found significant association between breakfast skipping and markers of body adiposity\textsuperscript{11,16,21,22}, that is, adolescents who skipped breakfast showed an increase in BMI, and body and abdominal fat over time. The analyzes were adjusted for potential confounding factors related to sociodemographic, economic, lifestyle and sexual maturation characteristics (Table 1).

In relation to cross-sectional studies, breakfast skipping was associated with higher prevalence of body adiposity. Twenty-nine articles (78.4\%) found a significant association between breakfast skipping and excess adiposity\textsuperscript{25,26,28–30,32–37,39-45,47–49,51,52,54,55,57–60}. However, Alexander et al.\textsuperscript{29} found association only for Intra-Abdominal Adipose Tissue, Gokler et al.\textsuperscript{47} found association only in adolescents living in urban areas, Garcia-Continente et al.\textsuperscript{45}, Tee et al.\textsuperscript{57} found association only for female adolescents and Frayon et al.\textsuperscript{52} found association only for males.

Of these thirty articles that found breakfast skipping associated with excess adiposity, twenty-one performed adjusted analysis for potential confounders, such as: age, sex, race/ethnicity, socioeconomic status, total energy consumption, pubertal stage and physical activity\textsuperscript{25,26,29,30,33,34,36,37,41,42,45,47,49,51,52,54,55,57–60}. On the other hand, five studies found no association between breakfast skipping and body adiposity\textsuperscript{38,46,50,53,56}, of which two made no adjustments for potential confounding factors\textsuperscript{46,51}. In summary a significant positive association between the breakfast skipping and excess adiposity is evidenced with a GRADE C classification (Table 2).

Among the articles included in this review, eight evaluated the association of breakfast skipping with cardiometabolic risk factors (glucose metabolism, blood pressure, and serum lipid levels), all of which are cross-sectional\textsuperscript{12,29,31,41,49,56,60}.

Of these studies, five investigated the association between breakfast skipping and lipid profile\textsuperscript{12,41,49,56,60}, and three found a statistically significant association; therefore, adolescents who omitted breakfast had higher levels of total cholesterol (TC), low density lipoprotein (LDL) and triglyceride (TG)\textsuperscript{12,41,60}. Five of the eight articles investigated the association between breakfast skipping and glycemic profile (fasting glucose, Homeostatic Insulin Resistance Assessment Model (HOMA-IR), acute insulin response, and insulin sensitivity), but none of them found a significant association\textsuperscript{29,41,36,50,60}.

Regarding blood pressure, five articles evaluated the association between breakfast skipping and high blood pressure\textsuperscript{31,41,49,56,60}, and three found a significant association, i.e., adolescents who skipped breakfast had higher levels of systolic blood pressure (SBP)\textsuperscript{31,41,49}.

In summary a significant positive association for lipid profile and blood pressure was found, whereas for glycemic profile there was no association, all risk factors were rated GRADE C.

All studies investigating the association of breakfast skipping with cardiometabolic risk factors considered the potential confounders: age\textsuperscript{12,29,31,41,49,58}, sex\textsuperscript{29,41,49,56,58,60}, ethnicity\textsuperscript{49,58,60}, socioeconomic status\textsuperscript{41}, BMI\textsuperscript{12,31,41}, pubertal stage\textsuperscript{29,58}, energy intake\textsuperscript{12,29,56}, abdominal adiposity\textsuperscript{49}, total adiposity\textsuperscript{29,58}, physical activity\textsuperscript{56,60}, and smoking and alcoholic beverage\textsuperscript{60}. 

https://doi.org/10.11606/s1518-8787.2021055003077
DISCUSSION

This systematic review included 43 studies that evaluated the association between breakfast skipping and cardiometabolic risk factors in adolescents. The prevalence of breakfast skipping varied widely between studies. Adolescents who skipped breakfast were more likely to have cardiometabolic risk factors, e.g., excess adiposity, higher levels of total cholesterol, low density lipoprotein, triglycerides, and blood pressure. However, the association between breakfast skipping and glycemic profile is unclear, since only five studies were included, and none found a significant association. The impact of the content of macronutrients present at breakfast and adjustment for body adiposity, and quality of diet can explain those associations.

Of the studies, 78.4% found that breakfast skipping is associated with excess body fat in adolescents. Intiful and Lartey attribute this association to adolescents who omit breakfast being more likely to eat other meals, such as lunch and dinner, irregularly and to eat unhealthy food between meals, such as non-nutritious snacks and fast foods. Thus, adolescents who skip breakfast consume more fat and less fiber, vitamins, and minerals and are less physically active, leading to an imbalance between energy consumption and expenditure.

Wang et al. and Cayres et al. showed that breakfast skipping is associated with weight gain, since adolescents who skipped this meal spent a longer period fasting (night and morning), with increased ghrelin release, consequently, increased appetite, increasing the probability of hyperphagia and body fat accumulation.

A potential confounding factor in assessing the association between breakfast skipping and body adiposity is energy intake, since individuals who skip breakfast tend to consume high energy density foods, or they may consume more energy from other meals throughout the day. Four studies in this review evaluated the association of breakfast skipping with body adiposity, adjusting for total energy consumption; in three of them, the association remained even after adjustment.

Three articles found an association between breakfast skipping and abnormal lipid profile in addition to the observed propensity for excess body adiposity. The main factors that may explain this association are related to increased appetite and high energy intake after fasting. Breakfast skipping also induces insulin resistance and may play an important role in the development of dyslipidemia. Hyperinsulinemia may increase apolipoprotein B-48 secretion by stimulating chylomicrons formation in the small intestine and inducing postprandial hyperlipidemia. Next, lipoprotein lipase, which hydrolyzes the central chylomicrons triglycerides, is inhibited, leading to increased hepatic lipase activity, which hydrolyzes LDL-cholesterol and HDL-cholesterol, triggering the decrease in HDL-cholesterol and the increase of small and dense LDL-cholesterol arterial particles.

Regarding blood pressure increase in adolescents who omit breakfast, three articles in this review found a significant association. The mechanisms that explain this association are still unclear, but they seem to be related to body adiposity, which may be the result of skipping breakfast, as mentioned above. Vanderlei et al. argue that increased body fat is related to higher sympathetic activity, because adiposity is associated with increased oxidative stress, increasing stimulation in specific brain regions that control sympathetic activity. However, the associations found by Kollias et al., Shafiee et al., and Cayres et al. remained significant for SBP, even after adjustment for indicators of body adiposity.

The five articles that evaluated breakfast skipping and glucose metabolism-related variables found no significant association. Alexander et al. reported that this association was not supposed to be found by the impact of the macronutrient content in breakfast on metabolic parameters, but the study did not evaluate the type of breakfast, therefore, its influence in the results cannot be stated. According to Tolfrey
and Zakrzewski⁷⁰, breakfast with high-fiber, low-glycemic cereals is associated with increased glycemic control and satiety.

The metabolic effects of breakfast can also be explained by their impact on the circadian cycle, a period in which the environment influences the transcription of some genes, mainly by light variations and by the time of feeding, which helps synchronize this system⁷¹. When food is restricted during a period, such as breakfast skipping, i.e., the fasting period after the sleeping period increases, circadian cycles may be out of sync, causing changes in certain genes that regulate lipid and glucose metabolism¹.

The variation in the results found in the articles may have been influenced by the different ways of collecting information on breakfast consumption and the definition of skipping breakfast. The definition most used by the studies considered the frequency of breakfast consumption ("rarely", "never" and number of days/week).

Dialektakou et al.⁷² stressed that breakfast skipping is associated with BMI, but this association depends on how skipping is defined. Among Greek adolescents, the authors found that all variables corresponding to breakfast consumption on the day of data collection were associated with both BMI and overweight or obesity. However, few associations remained significant when considering breakfast consumption in the previous week; which may have been because adolescents’ recollections of omitting breakfast in the previous week were less accurate than information reported on the day of data collection.

Among Brazilian adolescents, Hassan et al.²³ also found that the results depend on how breakfast skipping defined and on how the variable was categorized; they noted that the prevalence of breakfast skipping ranged from 3.6% when the baseline was last week to 39.0% when we asked the teenagers if they had eaten any solid food in the morning of the interview.

In this systematic review, we observed that, in general, studies that considered breakfast skipping 5 or more times or every day showed a higher frequency of positive association between skipping this meal and the respective outcomes: lipid profile⁴²,⁴⁰,⁵⁹, blood pressure⁴⁰,⁴⁸ and body adiposity markers¹¹,¹²,²¹,²²,²⁶,³⁰,³²,³³,³⁵,³⁷–⁴²,⁴⁴,⁴⁵,⁴⁸,⁴⁹,⁵¹,⁵₂,⁵³,⁵⁵,⁵⁷–⁶⁰. Thus, a cutoff point of breakfast skipping almost every and every day possibly allows a better assessment of the association between this behavior and cardiometabolic risk factors, because adolescents who report breakfast skipping every day probably have this habit over months and years, resulting in metabolic and body composition changes.

In the cohort study conducted by Timlin et al.²¹ with a 5-year follow-up, they considered a cutoff point of breakfast skipping every day and observed that adolescents who omitted breakfast had a greater increase in the mean BMI. Cayres et al.²² observed similar results, which also considered the cutoff point of skipping in 5 days, follow-up was 12 months and abdominal fat and total body fat of the adolescents who skipped breakfast increased more than those who ate regularly.

Thus, the definition and standardization of the category defining breakfast skipping may influence the results and their interpretation. This systematic review found a wide variation in the definitions of breakfast skipping, hindering the comparison between the results. According to Hassan et al.²³, a standard definition of breakfast skipping in the scientific literature is essential to improve comparisons among studies and results interpretation.

The American Heart Association recently proposed definitions to improve and standardize the assessment of consumption and skipping of meals¹: breakfast as the first meal of the day that breaks the fast after the longest period of sleep, eaten within 2 to 3 hours of waking, consisting of food or drink from at least one food group and consumed in any location. Other meals were defined as consumption occasions that provide ≥ 15% of the total energy intake and snacks as consumption occasions that provide < 15% of the total energy intake¹.

https://doi.org/10.11606/s1518-8787.2021055003077
In addition, Food Guide for the Brazilian population recommends the consumption of fresh or minimally processed foods for breakfast, such as milk, coffee, eggs, fruits, and preparations based on cereals or tubers, since the nutritional composition of this meal is important and the consumption of certain foods for breakfast can have a protective effect against cardiometabolic risk factors, such as BMI, total cholesterol, and LDL.

Standardizing the definition of breakfast skipping is necessary to enable the aggregation of results and the summarization of effects, and to better evaluation and understanding of scientific evidence in the association between breakfast skipping and cardiometabolic risk factors in adolescents. This can subsidize public policies and technical advice directed to schools aiming at instructing on the effects and risks of skipping breakfast on the cardiometabolic health of adolescents and promoting the daily consumption of this meal.

The studies included in this systematic review showed a significant association with excess adiposity, lipid profile, and blood pressure. In summary, the positive association remained for these outcomes with quality, according to the GRADE rating, C – low. As for the glycemic profile, no association was observed, and the quality of evidence was also C – low. Despite the low quality of the evidence of this study’s findings, we observed that they agree with what other studies with adolescents verified, thus, breakfast skipping was associated with cardiometabolic risk factors. The low quality of the evidence from the studies was also mainly due to the observational design and inconsistency.

The conflicts of interest towards the financing of studies by the food industry is also important to point out. Some studies were financed by the food industries that manufacture breakfast cereals and despite the researchers reporting no conflict of interest, the food industry has an interest in promoting the habit of having breakfast, because the consumption of breakfast cereals generally occurs in this meal. Breakfast cereals are also classified as ultra-processed food products, that is, they contain high levels of added sugars, salt, and unhealthy fats, thus being unhealthy. Pagliai et al. systematic review and meta-analysis, which analyzed ultra-processed and chronic diseases, showed a relation between the consumption of ultra-processed products and increased risk of obesity, metabolic syndrome, and cardiovascular diseases.

The strengths of this review include the search in various databases, the selection and evaluation of articles by peers, the evaluation of the quality of the included studies and the focus only on adolescents aged 10 to 19 years old. Among the limitations is the inclusion of longitudinal studies that evaluated only the markers of body adiposity and the impossibility of performing statistical synthesis through meta-analysis, due to the different definitions of breakfast skipping and statistical analysis methodologies adopted by the studies.

CONCLUSION

The results suggest that breakfast skipping is associated with cardiometabolic risk factors in adolescents aged 10 to 19 years. However, considering the low quality of the evidence, they should be interpreted carefully. We emphasize the importance of standardizing the breakfast skipping definition for better use as an exposure factor in assessing cardiometabolic risk factors and we recommend carrying out studies with longitudinal designs to raise the level of evidence and ensure temporality and consistency of results in different confusion scenarios.

REFERENCES

1. St-Onge MP, Ard J, Baskin ML, Chiave SE, Johnson HM, Kris-Etherton P, et al. Meal timing and frequency: implications for cardiovascular disease prevention: a scientific statement from the American Heart Association. Circulation. 2017;135(9):e96-121. https://doi.org/10.1161/CIR.0000000000000476
2. O’Neil CE, Byrd-Bredbenner C, Hayes D, Jana L, Klinger SE, Stephenson-Martin S. The role of breakfast in health: definition and criteria for a quality breakfast. J Acad Nutr Diet. 2014;114(12 Suppl):S8-26. https://doi.org/10.1016/j.jand.2014.08.022

3. Monteiro LS, Souza AM, Hassan BK, Estima CCP, Sichieri R, Pereira RA. Breakfast eating among Brazilian adolescents: analysis of the National Dietary Survey 2008-2009. Rev Nutr. 2017;30(4):463-76. https://doi.org/10.1590/1678-98652017000400006

4. Timlin MT, Pereira MA. Breakfast frequency and quality in the etiology of adult obesity and chronic diseases. Nutr Rev. 2007;65(6 Pt 1):268-81. https://doi.org/10.1301/nr.2007.jun.268-281

5. Hallström L, Labayen I, Ruiz JR, Pettersson E, Vereecken CA, Breidenassel C, et al. Breakfast consumption and CVD risk factors in European adolescents: the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) Study. Public Health Nutr. 2013;16(7):1296-305. https://doi.org/10.1017/S1368980012000973

6. Sandercock GRH, Voss C, Dye L. Association between habitual school-day breakfast consumption, body mass index, physical activity, and cardiorespiratory fitness in English schoolchildren. Eur J Clin Nutr. 2010;64(10):1086-92. https://doi.org/10.1038/ejcn.2010.145

7. Hunty A, Gibson S, Ashwell M. Does regular breakfast cereal consumption help children and adolescents stay slimmer? A systematic review and meta-analysis. Obes Facts. 2013;6(1):70-85. https://doi.org/10.1159/000348878

8. Sampasa-Kanyinga H, Hamilton HA. Eating breakfast regularly is related to higher school connectedness and academic performance in Canadian middle- and high-school students. Public Health. 2017;143:120-3. https://doi.org/10.1016/j.puhe.2016.12.027

9. Potmey LT, Steger FL, Schubert MM, Lee J, Willis EA, Sullivan DK, et al. Breakfast intake and composition is associated with superior academic achievement in elementary schoolchildren. J Am Coll Nutr. 2015;34(4):326-33. https://doi.org/10.1080/07315724.2015.1048381

10. Smith KJ, Gall SL, McNaughton SA, Blizzard L, Dwyer T, Venn AJ. Skipping breakfast: longitudinal associations with cardiometabolic risk factors in the Childhood Determinants of Adult Health Study. Am J Clin Nutr. 2010;92(6):1316-25. https://doi.org/10.3945/ajcn.2010.30101

11. Wu CH, Lin CY, Hsieh YP, Strong C, Meshki C, Lin YC, et al. Dietary behaviors mediate the association between food insecurity and obesity among socioeconomically disadvantaged youth. Appetite. 2019;132:275-81. https://doi.org/10.1016/j.appet.2018.10.013

12. Kim SH, Song YH, Park S, Park MJ. Impact of lifestyle factors on trends in lipid profiles among Korean adolescents: the Korea National Health and Nutrition Examination Surveys study, 1998 and 2010. Korean J Pediatr. 2016;59(2):65-73. https://doi.org/10.3345/kjp.2016.59.2.65

13. Eckel RH, Kahn R, Robertson RM, Rizza RA. Preventing cardiovascular disease and diabetes: a call to action from the American Diabetes Association and the American Heart Association. Circulation. 2006;109(17):2233-42. https://doi.org/10.1161/CIRCULATIONAHA.105.578698

14. Moschonis G, Tsoutsoulopolou K, Efstathopoulou E, Tsirogiti L, Lambrinou CP, Georgiou A. Conceptual framework of a simplified multi-dimensional model presenting the environmental and personal determinants of cardiometabolic risk behaviors in childhood. Expert Rev Cardiovasc Ther. 2015;13(6):673-92. https://doi.org/10.1586/14779072.2015.1039992

15. Szajewska H, Ruszczysiński M. Systematic review demonstrating that breakfast consumption influences body weight outcomes in children and adolescents in Europe. Crit Rev Food Sci Nutr. 2010;50(2):113-9. https://doi.org/10.1080/10408390903467514

16. Wang S, Schwartz MB, Shebl FM, Read M, Henderson KE, Ickovics JR. School breakfast and body mass index: a longitudinal observational study of middle school students. Pediatr Obes. 2017;12(3):213-20. https://doi.org/10.1111/ijpo.12127

17. Jakubowicz D, Wainstein J, Ahren B, Landau Z, Bar-Dayan Y, Froy O. Fasting until noon triggers increased postprandial hyperglycemia and impaired insulin response after lunch and dinner in individuals with type 2 diabetes: a randomized clinical trial. Diabetes Care. 2015;38(10):1820-6. https://doi.org/10.2337/dc15-0761

18. World Health Organization. Physical status: the use of and interpretation of anthropometry: report of a WHO expert committee. Geneva (CH): WHO; 1995 [cited 2020 Aug 22]. (WHO Technical Report Series; nº 854). Available from: https://apps.who.int/iris/handle/10665/37003

19. Viswanathan M, Berkman ND. Development of the RTI item bank on risk of bias and precision of observational studies. J Clin Epidemiol 2012;65(2):163-78. https://doi.org/10.1016/j.jclinepi.2011.05.008
20. Ministério da Saúde (BR), Secretaria de Ciência, Tecnologia e Insumos Estratégicos, Departamento de Ciência e Tecnologia. Diretrizes metodológicas: Sistema GRADE – Manual de graduação da qualidade da evidência e força de recomendação para tomada de decisão em saúde. Brasília, DF; 2014 [cited 2020 Aug 22]. Available from: https://bvsms.saude.gov.br/bvs/publicacoes/diretrizes_metodologicas_sistema_grade.pdf.

21. Timlin MT, Pereira MA, Story M, Neumark-Sztainer D. Breakfast eating and weight change in a 5-year prospective analysis of adolescents: Project EAT (Eating Among Teens). Pediatrics. 2008;121(3):e38-45. https://doi.org/10.1542/peds.2007-1035

22. Cayres SU, Urban JB, Fernandes RA. Physical activity and skipping breakfast have independent effects on body fatness among adolescents. J Pediatr Gastroenterol Nutr. 2018;67(5):666-70. https://doi.org/10.1097/MPG.0000000000002081

23. Hassan BK, Cunha DB, Veiga GV, Pereira RA, Sichieri R. Changes in breakfast frequency and composition during adolescence: The Adolescent Nutritional Assessment Longitudinal Study, a cohort from Brazil. PLoS One. 2018;13(7):e0200587. https://doi.org/10.1371/journal.pone.0200587

24. Hassan BK, Cunha DB, Veiga GV, Pereira RA, Hoffman DJ, Sichieri R. Breakfast consumption, family breakfast, and adiposity trajectory in adolescence: The Adolescent Nutritional Assessment Longitudinal Cohort Study. J Acad Nutr Diet. 2019;119(6):944-56. https://doi.org/10.1016/j.jand.2018.11.014

25. Harding S, Teyhan A, Maynard MJ, Cruickshank KJ. Ethnic differences in overweight and obesity in early adolescence in the MRC DASH study: the role of adolescent and parental lifestyle. Int J Epidemiol. 2008;37(1):162-72. https://doi.org/10.1093/ije/dym252

26. Maddah M. Risk factors for overweight in urban and rural school girls in Iran: skipping breakfast and early menarche. Int J Cardiol. 2008;136(2):235-8. https://doi.org/10.1016/j.ijcard.2008.04.046

27. Mota J, Fidalgo F, Silva R, Ribeiro JC, Santos R, Carvalho J, et al. Relationships between physical activity, obesity and meal frequency in adolescents. Ann Hum Biol. 2008;35(1):1-10. https://doi.org/10.1080/03014460701779617

28. Henríquez Sánchez P, Doroeste Alonso J, Lainez Sevillano P, Estévez Gonzáles MD, Iglesias Valle M, López Martin G, et al. Prevalencia de obesidad y sobrepeso en adolescentes canarios. Relación con el desayuno y la actividad física. Med Clin (Barc). 2008;130(16):606-10. https://doi.org/10.1157/13120339

29. Kollias A, Antonodimitrakis P, Grammatikos E, Chatziantonakis N, Grammatikos EE, Stergiou GS. Trends in high blood pressure prevalence in Greek adolescents. J Hum Hypertens. 2009;23(6):385-90. https://doi.org/10.1038/jhh.2008.166

30. Maddah M, Rashidi A, Mohammadpour B, Vafa R, Karandish M. In-school Snacking, Breakfast Consumption, and Sleeping Patterns of Normal and Overweight Iranian High School Girls: a study in urban and rural areas in Guilan, Iran. J Nutr Educ Behav. 2009;41(1):27-31. https://doi.org/10.1016/j.jneb.2008.03.115

31. Sun Y, Sekine M, Sadanobu K. Lifestyle and overweight among Japanese adolescents: The Toyama Birth Cohort Study. J Epidemiol. 2009;19(6):303-10. https://doi.org/10.2188/jea.je20080095

32. Deshmukh-Taskar PR, Radcliffe JD, Liu Y, Nicklas TA. Do breakfast skipping and breakfast type affect energy intake, nutrient intake, nutrient adequacy, and diet quality in young adults? NHANES 1999-2002. J Am Coll Nutr. 2010;29(4):407-18. https://doi.org/10.1080/07315724.2010.10719858

33. Kapantais E, Chala E, Kaklamanou D, Lanaras L, Kaklamanou M, Tzotzas T. Breakfast skipping and its relation to BMI and health-compromising behaviours among Greek adolescents. Public Health Nutr. 2010;14(1):101-8. https://doi.org/10.1017/S1368980010000765

34. Maddah M, Nikooyeh B. Obesity among Iranian adolescent girls: location of residence and parental obesity. J Health Popul Nutr. 2010;28(1):61-6. https://doi.org/10.3329/jhpn.v28i1.4524
37. Thompson-McCormick JJ, Thomas JJ, Bainivualiku A, Khan AN, Becker AE. Breakfast skipping as a risk correlate of overweight and obesity in school-going ethnic Fijian adolescent girls. Asia Pac J Clin Nutr. 2010;19(3):372-82.

38. Kim JH, So WY. Association between frequency of breakfast eating and obesity in Korean adolescents. Iran J Public Health. 2012;41(6):50-7.

39. Kuriyan R, Thomas T, Sumithra S, Lokesh DP, Sheth NR, Joy R, et al. Potential factors related to waist circumference in urban South Indian children. Indian Pediatr. 2012;49(2):124-8. https://doi.org/10.1007/s13312-012-0027-3

40. Vaezghasemi M, Lindkvist M, Ivarsson A, Eurenius E. Overweight and lifestyle among 13-15 year olds: a cross-sectional study in northern Sweden. Scand J Public Health. 2012;40(3):221-8. https://doi.org/10.1177/1403494112443603

41. Shaﬁee G, Kelishadi R, Qorbani M, Motlagh ME, Taheri M, Ardalan G, et al. Association of breakfast intake with cardiometabolic risk factors. J Pediatr (Rio J). 2013;89(6):575-82. https://doi.org/10.1016/j.jped.2013.03.020

42. Boričić K, Simić S, Vasiljević N, Marinković J. Risk factors associated with overweight among adolescents in Serbia. Zdr Vršt. 2014;53(4):283-93. https://doi.org/10.2478/sjph-2014-0031

43. Díez-Navarro A, Martín-Camargo A, Solé-LLussà A, Marrodán MD, Gónzales-Montero de Espinoza M. [Influence of breakfast on overweight and obesity in child and adolescent population from Madrid]. Nutr Clin Diet Hosp. 2014;34(2):9-17. Spanish.

44. Afza N, Khan IM, Amir A, Azmi SA, Ahmad A, Khalique N. Breakfast skipping and proposed effects of breakfast on obesity: a school-based study in adolescents in Aligarh, India. Ann Trop Med Public Health. 2014;7(1):43-7.

45. García-Continente X, Allue N, Pérez-Giménez A, Ariza A, Sánchez-Martínez F, López MJ et al. [Eating habits, sedentary behaviors and overweight and obesity among adolescents in Barcelona (Spain)]. An Pediatr (Barc). 2015;83(1):3-10. Spanish. https://doi.org/10.1016/j.anpede.2015.05.017

46. Garg M, Rajesh V, Kumar P. Effect of breakfast skipping on nutritional status and school performance of 10-16 years old children of Udupi district. Health Popul Perspect Issues. 2014;37(3-4):98-117.

47. Gökler ME, Buğrul N, Metintaş S, Kalyoncu C. Adolescent obesity and associated cardiovascular risk factors of rural and urban life (Eskisehir, Turkey). Cent Eur J Public Health. 2015;23(1):20-5. https://doi.org/10.21101/cejph.a3958

48. Talat MA, El Shahat E. Prevalence of overweight and obesity among preparatory school adolescents in Urban Sharkia Governorate, Egypt. Egypt Pediatr Assoc Gaz. 2016;64(1):20-5. https://doi.org/10.1016/j.epag.2015.11.004

49. Cayres SU, Freitas Júnior IF, Barbosa MF, Christofaro DGD, Fernandes RA. Breakfast frequency, adiposity, and cardiovascular risk factors as markers in adolescents. Cardiol Young. 2016;26(2):244-9. https://doi.org/10.1017/S1047951115000050

50. Morales A, Montilla M. Hábitos alimentarios no saludables, actividad física y obesidad en adolescentes entre 15 y 19 años. An Venez Nutr. 2016;29(1):4-10.

51. Badr HE, Lakha SF, Pennefather P. Differences in physical activity, eating habits and risk of obesity among Kuwaiti adolescent boys and girls: a population-based study. Int J Adolesc Med Health. 2017;31(1):20160138. https://doi.org/10.1515/ijamh-2016-0138

52. Frayon S, Cherrier S, Cavaloc Y, Touitou A, Zongo P, Wattelez G, et al. Nutrition behaviors and sociodemographic factors associated with overweight in the multi-ethnic adolescents of New Caledonia. Ethn Health. 2019;24(2):194-210. https://doi.org/10.1080/13557858.2017.1315530

53. Zalewska M, Maciorkowska E. Selected nutritional habits of teenagers associated with overweight and obesity. PeerJ. 2017;5:e3681. https://doi.org/10.7717/peerj.3681

54. De Cnop ML, Monteiro LS, Rodrigues PRM, Estima CCP, Veiga GV, Pereira RA. Meal habits and anthropometric indicators in adolescents from public and private schools of the metropolitan region of Rio de Janeiro. Rev Nutr. 2018;31(1):35-47. https://doi.org/10.1590/1678-98652018001000004

55. Khan A, Khan SR, Burton NW. Missing breakfast is associated with overweight and obesity in Bangladeshi adolescents. Acta Paediatr. 2018;108(1):178-9. https://doi.org/10.1111/apa.14553
Breakfast skipping and cardiometabolic risk  
Souza MR et al.

56. Silva FA, Padez C, Sartorelli DS, Oliveira RMS, Netto MP, Mendes LL, et al. Cross-sectional study showed that breakfast consumption was associated with demographic, clinical and biochemical factors in children and adolescents. Acta Paediatr. 2018;107(9):1562-9. https://doi.org/10.1111/apa.14363

57. Tee ES, Nurliyana AR, Norimah AK, Mohamed HBJ, Tan SY, Appukutty M, et al. Breakfast consumption among Malaysian primary and secondary school children and relationship with body weight status: findings from the MyBreakfast Study. Asia Pac J Clin Nutr. 2018;27(2):421-32. https://doi.org/10.6133/apjcn.06217.12

58. Werneck AO, Agostinete RR, Cayres SU, Urban JB, Wigna A, Chagas LGM, et al. Association between Cluster of Lifestyle Behaviors and HOMA-IR among Adolescents: ABCD Growth Study. Medicina (Kaunas). 2018;54(6):96. https://doi.org/10.3390/medicina54060096

59. Forkert ECO, Moraes ACF, Carvalho HB, Manios Y, Whidhelm K, González-Gross M, et al. Skipping breakfast is associated with adiposity markers especially when sleep time is adequate in adolescents. Sci Rep. 2019;9:6380. https://doi.org/10.1038/s41598-019-42859-7

60. Mustafa N, Abd Majid H, Toumpakari Z, Carroll HA, Jalaludin Y, Al Sadat N, et al. The association of breakfast frequency and cardiovascular disease (CVD) risk factors among adolescents in Malaysia. Nutrients. 2019;11(5):973. https://doi.org/10.3390/nu11050973

61. Intiful FD, Larley A. Breakfast habits among school children in selected communities in the eastern region of Ghana. Ghana Med J. 2014;48(2):71-7. https://doi.org/10.4314/gmj.v48i2.3

62. Vissers PAJ, Jones AP, Corder K, Jennings A, Sluijs EMF, Welch A, et al. Breakfast consumption and daily physical activity in 9-10 year old British children. Public Health Nutr. 2013;16(7):1281-90. https://doi.org/10.1017/S1368980012002175

63. Depoortere I. Targeting the ghrelin receptor to regulate food intake. Regul Pept. 2009;156(1-3):13-23. https://doi.org/10.1016/j.regpep.2009.04.002

64. Taheri S, Lin L, Austin D, Young T, Mignot E. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. PLoS Med. 2004;1(3):e62. https://doi.org/10.1371/journal.pmed.0010062

65. Deshmukh-Taskar P, Nicklas TA, Radcliffe JD, O’Neil CE, Liu Y. The relationship of breakfast skipping and type of breakfast consumed with overweight/obesity, abdominal obesity, other cardiometabolic risk factors and the metabolic syndrome in young adults. The National Health and Nutrition Examination Survey (NHANES): 1999-2006. Public Health Nutr. 2013;16(11):1027-32. https://doi.org/10.1017/S1368980012004296

66. Ginsberg HN, Zhang YL, Hernandez-Ono A. Regulation of plasma triglycerides in insulin resistance and diabetes. Arch Med Res. 2005;36(3):232-40. https://doi.org/10.1016/j.arcmed.2005.01.005

67. Perret B, Mobile L, Martinez L, Tercé F, Barbaras R, Collet X. Hepatic lipase: structure/ function relationship, synthesis, and regulation. J Lipid Res. 2002;43(8):1163-9. https://doi.org/10.1194/jlr.R100020-JLR200

68. Vanderlei LCM, Pastre CM, Freitas Júnior IF, Godoy MF. Analysis of cardiac autonomic modulation in obese and eutrophic children. Clinics. 2010;65(8):789-92. https://doi.org/10.1590/S1807-59322010000800008

69. Hirooka Y, Sagara Y, Kishi T, Sunagawa K. Oxidative stress and central cardiovascular regulation. Pathogenesis of hypertension and therapeutic aspects. Circ J. 2010;74(5):827-35. https://doi.org/10.1253/circj.cj-10-0153

70. Tolfrey K, Zakrzewski J. Breakfast, glycaemic index and health in young people. J Sport Health Sci. 2012;1(3):149-59. https://doi.org/10.1016/j.jshs.2012.09.001

71. Oosterman JE, Kalsbeek A, La Fleur SE, Belsham DD. Impact of nutrients on circadian rhythmicity. Am J Physiol Regul Integr Comp Physiol. 2015;308(5):R337-50. https://doi.org/10.1152/ajpregu.00322.2014

72. Dialetakou KD, Vranas PBM. Breakfast skipping and body mass index among adolescents in Greece: whether an association exists depends on how breakfast skipping is defined. J Am Diet Assoc. 2008;108(9):1517-25. https://doi.org/10.1016/j.jada.2008.06.435

73. Ministério da Saúde (BR), Secretaria de Atenção à Saúde, Departamento de Atenção Básica. Guia alimentar para a população brasileira. 2. ed. Brasília, DF; 2014 [cited 2020 Aug 22]. Available from: https://bvsms.saude.gov.br/bvs/publicacoes/guia_alimentar_populacao_brasileira_2ed.pdf
74. Pagliai G, Dinu M, Madarena MP, Bonaccio M, Iacoviello L, Sofi F. Consumption of ultra-processed foods and health status: a systematic review and meta-analysis. Br J Nutr. 2021;125(3):308-18. https://doi:10.1017/S0007114520002688

**Funding:** Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Capes), Brazil, through a Master grant (MRS. and MEAN.; Finance Code 001). Pró-Reitora de Pesquisa/Pró-Reitora de Ensino de Pós-Graduação – Universidade Federal de Mato Grosso (UFMT). Capes and UFMT had no role in the design, analysis or writing of this manuscript and the authors have no conflicts of interest to be reported.

**Authors’ Contribution:** Study design and planning: MRS, MEAN, MGF, PRMR. Data collection, analysis and interpretation: MRS, MEAN, BMG, AMS, PSN. Manuscript drafting or review: BMG, AMS, PSN. Approval of the final version: MRS, MEAN, BMG, AMS, PSN, MGF, PRMR. Public responsibility for the content of the article: MRS, MEAN, BMG, AMS, PSN, MGF, PRMR.

**Conflict of Interests:** The authors declare no conflict of interest.