Accepted manuscript

Association between sleep timing and meal and snack patterns in schoolchildren in southern Brazil

Denise Miguel Teixeira Roberto[1], Emil Kupek [2], Mariana Winck Spanholi[1], Stella Lemke[1], Luciana Jeremias Pereira[1], Patricia Faria Di Pietro[1], Francilene Gracieli Kunradi Vieira[1], Patrícia de Fragas Hinnig[1]*

[1] Post-Graduation Program in Nutrition, Center of Health Sciences, Federal University of Santa Catarina, Florianópolis, Santa Catarina, 88040-900, Brazil

[2] Department of Public Health, Center for Health Sciences, Federal University of Santa Catarina, Florianópolis, Santa Catarina, 88040-900, Brazil

Short title: Sleep and meal and snack patterns in schoolchildren

***Corresponding author:** Patrícia de Fragas Hinnig, E-mail: phinnig@yahoo.com.br

Mailing address: Department of Nutrition, Center of Health Sciences, Federal University of Santa Catarina, Campus Universitário Reitor João David Ferreira Lima – Trindade, Florianopolis, SC 88040-900, Brazil

This peer-reviewed article has been accepted for publication but not yet copyedited or typeset, and so may be subject to change during the production process. The article is considered published and may be cited using its DOI

10.1017/S0007114524002617

The British Journal of Nutrition is published by Cambridge University Press on behalf of The Nutrition Society

Abstract

This study aimed to identify meal and snack patterns and assess their association with sleep timing in schoolchildren. This is a cross-sectional study carried out in 2018/2019 with 1333 schoolchildren aged 7–14 years from public and private schools in Florianópolis, Brazil. Previous-day dietary intake data for breakfast, mid-morning snack, lunch, mid-afternoon snack, dinner, and evening snack were collected using a validated online questionnaire. Sleep timing was measured by the midpoint of sleep and classified as quartiles (very early, early, late and very late). Latent Class Analysis was performed to identify meal and snack patterns, and multinomial logistic regression was used to assess associations. Students with very late sleep timing were less likely to consume the "Coffee with milk, bread and cheese" breakfast pattern compared with very early group (35.4%, 95%CI 27.2-43.6 vs. 56.0%, 95%CI 48.5-63.4). Also, the former were more likely to consume the "Mixed" breakfast pattern (healthy and unhealthy foods) compared with very early students (40.0%, 95%CI 32.4- 46.7 vs. 28.0%, 95%CI 23.8- 32.0). The latter were more likely to eat the "Brazilian traditional, processed meat, egg and fish" lunch pattern to the late students (35.4%, 95%CI 30.3- 40.5 vs. 21.5%, 95%CI 15.2- 27.8) and less likely to consume the "Pasta and cheese" lunch pattern compared to the students with later sleep timing (10.1%, 95%CI 8.4- 11.9 vs. 17.1%, 95%CI 13.0- 21.1). Students with later sleep timing were more likely to eat ultra-processed food at mid-afternoon snacks compared with early group (56.3%, 95%CI 52.4- 60.2 vs. 47.2%, 95%CI 43.5- 50.8). The study findings suggest that morning preference appears to promote healthier breakfast, lunch, and afternoon snack patterns, whereas later sleep timing may pose challenges in maintaining healthy patterns at these meals/snacks.

Keywords: Dietary pattern; breakfast; snacks; latent class analysis; children; chronotype

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

1. Introduction

Circadian rhythms are biological rhythms that modulate physiological functions within the body, including the regulation of sleep[1]. Sleep timing represents the hours of the day when sleep occurs[2] The midpoint of sleep (MSF) is a crucial marker for both sleep timing and circadian phase and is widely used in sleep research due to its association with health outcomes[3–6]. MSF has a strong correlation with Dim Light Melatonin Onset[7] and identifies circadian preferences by considering individual bedtime and wake-up times, thereby categorizing them into earlier or later preferences[4]. Usually, children have a morning preference, and in adolescence, they become progressively later until around 20 years of age. After the age of 20, there is a tendency to return to the morning chronotype with increasing age[8]. This fact is relevant to the discussion of school schedules and explains why starting school later can be beneficial for adolescents[9,10].

Evidence suggests that later sleep timing is associated with poorer health indicators as poorer emotional regulation, lower cognitive function/academic achievement, shorter sleep duration/poorer sleep quality, lower physical activity levels and more sedentary behaviours, including unhealthy dietary intake in children and adolescents[11]. Thus, cross-sectional studies found that late sleep timing correlates with unhealthy eating habits such as increased consumption of unhealthy foods[12-14], high-energy-dense foods, breakfast skipping[15,16], and lower intake of fruits and vegetables[15,17]. Some studies have identified that the impact of late sleep habits on food consumption is mainly related to the increased consumption of more caloric and ultra-processed foods due to the convenience of consuming them at night, as most of these foods are ready to eat or can be prepared quickly[12,18-22]. The multicenter study by Chaput et al. (2018)[14] conducted with 5873 children between 9 and 11 years old, investigated the association between bedtime and the consumption of sugary drinks. The authors observed a positive association between late bedtime and regular consumption of soft drinks. Similarly, Agostini et al. (2018)[21] identified that Australian students between 9 and 17 years old who went to bed later (after 9 pm) were likelier to consume fast food five or more times per week. Inadequate sleep routine, such as lack of consistency in bedtime and wake-up times, has been associated with lower consumption of fruits, vegetables, whole grains and higher intake of sugars and meats[22]. On the other hand, earlier sleep timing have been linked to healthier behaviors such as eating meals earlier and eating natural, minimally processed foods[23] and a reduced likelihood of schoolchildren being overweight[24].

Chrono-nutrition is used to describe the integration of circadian rhythms research into nutrition investigation, as the circadian system is influenced by food intake[25-27]. A study with 21020 Brazilian adults from the 2008-2009 Household Budget Survey, found that late meal intake was associated with overweight and obesity[28]. The studies of global dietary patterns (GDP) and meal and snack patterns (MP and SP) have been used to describe the combinations of food eaten in a day or in specific eating occasions, respectively[29,30]. This approach offers insights into the actual eating behaviors of a population and facilitates the acquisition of practical information for formulating nutritional recommendations[31,32] . Investigating eating occasions has emerged as an avenue for exploring associations with diseases or risk factors, aiding in the development of nutritional guidelines and enhancing dietary advice, thus providing tangible benefits to the population in terms of meal planning and preparation of different meals/snacks throughout the day[30,33]. Additionally, the use of a person-centered approach to derive MP and SP, such as Latent Class Analysis (LCA), involves classifying individuals into distinct groups or classes and estimating the probabilities for each indicator, thus facilitating interpretations and comparisons with characteristics of interest[34].

The studies investigating the relationship between GDP and sleep timing in children and adolescents have consistently shown that later bedtimes and short sleep duration are associated with unhealthy GDP[12,17,35,36], indicating that sleep habits can impact dietary intake. Despite this, limited research has examined the influence of sleep on meal and snack composition and the results suggests that late sleep timing is associated with skipping breakfast[13,21,37]. However, the impact of sleep timing on the composition of meals and snacks remains unexplored.

Considering the emerging field of research on the interplay between sleep and meal and snack patterns, particularly in children and adolescents, it is crucial to recognize this developmental stage as pivotal for the development of both sleep and dietary behaviors[38]. Therefore, the objective of this study was to identify meal patterns (MPs) and snack patterns (SPs) among students aged 7 to 14 years and assess their association with sleep timing. We hypothesized that those with later sleep timing are more likely to consume unhealthy meal/snack patterns compared to schoolchildren with early sleep timing.

2.Methods

2.1 Study design and sample

This is a cross-sectional study on overweight and obesity prevalences in schoolchildren aged 7 to 14 years in the city of Florianopolis, Southern Brazil, which is part of a larger longitudinal study entitled EPOCA. The latter has investigated time trends in these prevalences and associated factors among students enrolled in primary education in both public and private schools. The study surveys were conducted in four waves in 2002, 2007, 2012/2013, and 2018/2019. The latter was carried out between November 2018 and December 2019 and composed the sample of the present study.

The study population was made up of children and adolescents of both sexes aged between 7 and 14 who studied in public and private schools in the city of Florianópolis. The city has 82 schools (53 public and 29 private) and 34318 students enrolled (23883 in public schools and 10435 in private schools)[(39)]. More details about the sample calculation and sampling have been published in Pereira et al., (2022[) (40)].

A total of 6118 students from 30 schools (19 were public and 11 private were invited to participate in the research and received the Free and Informed Consent Form (FICF) so that their parents or guardians could authorize their participation in the study [(40)].

The inclusion criteria included being present in school on the day of data collection, delivering the signed FICF, and the student himself/herself signing the Free and Informed Assent Term at the beginning of the data collection. Body weight and height data and food consumption were collected from 1671 students, but implausible reports were excluded. The latter included reporting no food consumption whatsoever (n=188) and those who presented implausible food consumption data (n=87). the latter consisted of reporting >3 food items per day or the number of items that exceeded three times the standard deviation of the average consumption, assuming a Poisson distribution for reports on the frequency of food consumption[(41)]. Also, all students without sleep data were excluded (n=63) resulting in the analytical sample of 1333 students between 7 and 14 years old (Figure S1).

This study was conducted in accordance with the guidelines of the Code of Ethics of the World Medical Association (Declaration of Helsinki) and approved by the Human Research Ethics Committee of the Federal University of Santa Catarina (UFSC, protocol number 7539718.1.0000.0121).

2.2 Sleep data

The questions about sleep were adapted from the School Sleep Habits Survey (Bradley Hospital, 1994) and answered by the parents or guardians. The questionnaire included the following questions: "*What time does the child usually go to sleep at night on the days they go to school? What time does the child usually wake up in the morning on the days they go to school? What time does the child usually go to bed at night on weekends (days when they don't go to school)? What time does the child usually wake up in the morning on weekends (days when they don't go to school)?*". Allowed responses contained hours and minutes (local time) whereas sleep latency and the wake time during the night were not measured. Total sleep time was calculated as the difference between bedtime and wake-up time. The midpoint of sleep (MSFsc) was used as a measure of sleep timing and calculated considering the midpoint between bedtime and wake-up time on non-school days corrected by sleep debt[8,42]. More details on the MSFsc calculation are available in a previous report[24]. The MSFsc was divided into quartiles (Q1 to Q4 in ascending order), with the first quartile (Q1) representing those with lower MSFsc or very early sleep preference/timing and the fourth quartile (Q4) those with higher MSFsc or very late sleep preference. The second quartile (Q2) represents those with early preference and the third (Q3) those with late sleep preference. The median (interquartile range) cut-off points in local time were respectively 2:53am (2:30- 3:04), 3:38am (3:28- 3:47), 4:10am (4:07- 4:28) and 5:22am (5:00- 5:59).

2.3 Assessment of dietary intake, physical activity and screen use

2.3.1 Dietary intake and meal and snack definitions

Data on frequency of food consumption, physical activities and screen use from the previous day were obtained from the Food Consumption and Physical Activity for Schoolchildren (Consumo Alimentar e Atividade Física de Escolares, Portuguese acronym Web-CAAFE) questionnaire. This is a web- based, self-report questionnaire developed to monitor food consumption and physical activity in the school environment. The team of trained researchers accompanied the students as they responded to the web-CAAFE[43].

The questionnaire was considered adequate in a reproducibility test[44] and in usability tests[43]. The average application time was 14 minutes in the usability test study[47]. The Web-CAAFE food consumption section was validated in two studies with children[45] and adolescents[46], both of which used direct observation of school meals as a reference method.

Web-CAAFE is divided into three sections: registration, food consumption section, and physical activities, and sedentary behaviors section. The food consumption section is a previous-day recall of the intake on three meals (breakfast, lunch and dinner) and three

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

snacks (morning snack, afternoon snack and evening snack), presented in chronological order without specifying the time of eating events (discussed in section below). For each meal and snack, the questionnaire presents a list of 31 pre-defined icons of healthy and unhealthy food items for the student to select the items that were consumed in the respective eating event on the previous day: water, rice, vegetables, green leaves, vegetable soup, beans, manioc flour, pasta, instant pasta, French fries, beef/poultry, eggs, fish/seafood, maize/potatoes, sausage, nuggets, breakfast cereal, fruits, bread/ biscuits, cheese bread, cake without icing, porridge, cheese, coffee with milk, milk, yogurt, chocolate milk, fruit juices, cream cookies, soda, sweets (chocolate bars, ice cream, candies, cake with icing), chips and pizza/hotdog/hamburger.

On the day of data collection, students received instructions from trained researchers on how to complete the Web-CAAFE and the definitions of meals and snacks. The questionnaire includes six eating events ordered chronologically and presented sequentially on the screen (breakfast, mid-morning snack, lunch, mid-afternoon snack, dinner, and evening snack). It is not possible to include additional meals or snacks. The presence of an animated character (avatar) helped identify which meal was being questioned at that moment, placing it at the time of day in which it occurs, using quick definitions. For breakfast, the avatar explains: "*Breakfast is the first meal we have the day after waking up*". For the mid- morning snack: "*It's what you ate after breakfast and before lunch*." Lunch is considered the meal that takes place in the middle of the day. The mid-afternoon snack is explained as: "*is what you ate after lunch and before dinner*". Dinner: "*is the main meal we have at night*". The evening snack: *"is what you ate after dinner and before bed*". These sentences are repeated for each meal and snack. At the end of each eating event, the avatar explains "*Remember, if you didn't eat anything, click on the 'nothing' button*"[47]. Thus, when the student reported consuming at least one food item (except water) the meal or snack was considered as meal or snack consumed.

The Web-CAAFE is a qualitative questionnaire based on the daily frequency of consumption of food items considered healthy and unhealthy foods and does not allow identifying the exact time of meal or snack consumption or the amount of food intake[40]. Therefore, each meal or snack had its consumption frequency based on the consumption or non-consumption of each food item, assuming that each item can be selected once at each eating event. Each student answered the questionnaire once.

The Demo version of the web-CAAFE, including English subtitles, is available on http://caafe.ufsc.br/porta l/10/detalhes.

2.3.2 Physical activity

The physical activities/sedentary behaviors section is divided into morning, afternoon and evening, with 32 drawings depicting the activities they carried out on the previous day: basketball/volleyball, catch, soccer, running, martial arts, tennis, dancing, table tennis, marbles, hopscotch, rope jumping, gymnastics, swimming, cycling, rollerblading/skateboarding, surfing, kite flying, dodgeball, hide-and- seek, playing with the dog, studying/reading/drawing, board games, playing with dolls, playing with toy cars, watching TV, listening to music, using a smartphone/tablet, using a computer, playing videogames, doing the dishes, sweeping the floor.

The physical activity score (PAS) was calculated considering the frequency of 28 physical activities (except screen-based activities) and the Compendium of Energy Expenditures for Youth[48]. Metabolic equivalent values (METs) were considered for each physical activity and multiplied by the daily frequency (ranging from 0 to 3). The PAS was obtained by summing the scores across all physical activities and subsequently categorized into tertiles[49].

2.3.3 Screen use

Daily frequency of screen use was described for each period of the day based on the following activities: watching television, using a computer, using a smartphone/tablet and playing video games, in the three periods of the day and categorized into never, once a day, twice a day, and more than three times a day.

The information on duration of physical activity or screen time we not measured. Web-CAAFE was applied in the school environment and took place from Monday to Friday during both morning and afternoon shifts. Therefore, the data on food consumption, physical activities, and sedentary behavior were all obtained from Sunday to Thursday and on different days of the week.

2.4 Analysis of meal and snack patterns

Meal and snack patterns were identified using Latent Class Analysis (LCA), which groups individuals based on their probabilities of class membership [34]. In LCA, the consumption of at least one food item in the meals or snacks were considered, unless students

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

selected only water. All 31 food items were included in the LCA in each eating event, except the maize/potatoes item, which was excluded from breakfast, as no schoolchildren selected it.

The models were evaluated considering Akaike information criterion (AIC), sample size-adjusted Bayesian information criterion (SS-ABIC), entropy, the Lo-Mendell- Rubin (LMR) test and the percentage of schoolchildren allocation in classes (Supplementary Table 1). Lower AIC and SS-BIC values and higher entropy values indicate better-adjusted models[50,51].

To identify the food items belonging to each meal or snack pattern, the ratio of the average frequency of consumption of each food item (RAFC) and confidence intervals of 95% (95% CI) were calculated by dividing item class average frequency of consumption (AFC) of the item in the class and divided by the overall (all classes) average consumption (OAFC) of the meal/snack. A RAFC value whose 95% CI does not include the value of one was used as the criterion for inclusion of the food item in the MP or SP[52,53].

The meal and snack patterns were named according to the food items that compose them and the recommendations of the Dietary Guidelines for the Brazilian Population[54]. Those patterns that described combinations of foods traditionally consumed in Brazil were named "traditional Brazilian." Patterns that contained more ultra-processed foods were named as "Ultra-processed." Those patterns that contained both healthy foods and unhealthy foods were named as "Mixed"[53].

2.5 Anthropometric measurements and socioeconomic data

Weight and height measurements were performed at school by trained researchers according to standardized protocols (International Society for the Advancement of Kinanthropometry ISAK)[55]. Weight was measured with a portable digital scale (Marte, model LS200P, 200 kg maximum capacity, 50 g precision). A portable stadiometer (AlturExata, 2.13 m of maximum capacity and 1 mm precision) was used for height. The body mass index (BMI) was calculated as weight (kg) divided by height squared (m). Age- and sex-specific BMI *z*-scores were calculated according to the World Health Organization criteria for children and adolescents aged 5–19 years[56]. The weight status was categorized into non-overweight (underweight and normal weight, BMI *z*-score for age $< +1$) or overweight including obesity (BMI *z*-score for age $\geq +1$).

School management provided information on the students' dates of birth, classes, school shift (morning or afternoon) and type of school (public or private). Maternal education was self-reported by parents or guardians and classified into three categories according to

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

years of study (0- 8, 9- 11 and ≥ 12 years of study), thus corresponding to primary, secondary, and university educational levels.

2.6 Statistical analysis

Sample characteristics were described as absolute and relative frequencies, 95% CI for categorical variables, and mean or median and interquartile range (p25-p75) for continuous variables. The differences in categorical variables between MSFsc quartiles were analyzed using Pearson's chi-squared test, whereas Kruskal-Wallis test was applied to investigate MSFsc differences. A statistical significance level of $p<0.05$ was used as a cut-off point for the type I error.

The association between quartiles of midpoint of sleep (main exposure variable) and Meal or Snack Patters (dependent variable) was calculated for each eating event using multinomial logistic regression analysis adjusted for the following exposure variables: sex, age group (7–10 or 11–14 years), type of school (public or private) weight status (non-overweight or overweight including obesity), physical activity score tertiles, daily frequency of screen use (never, once a day, twice a day, and more than three times a day), maternal education (0–8, 9–11 or ≥12 years of schooling), day of food intake report (weekday or weekend), and school shift (morning or afternoon). The adjustment variables were selected considering their relationship with the outcome and exposure and were therefore included in the models: physical activity(57), use of screens(58), sex and age(4), type of school and maternal education (family income proxy)(41). Also, in order to assess whether there are differences in the association according to the school shift the child/adolescent studies, the analyses were stratified by this variable.

Marginal distributions for each MP and SP were presented in terms of predicted probabilities with the corresponding 95% CI adjusted for all exposure variables (using Stata command "*margins*"). Statistically significant differences were detected by non-overlapping 95% CI of the marginal effects.

Stata® version 14.0 (StataCorp LLC, College Station, TX, USA) was used for descriptive analysis and multinomial regression, whereas Mplus® version 6.12 was used for LCA. The analyses were adjusted considering the survey design effect (using the Stata command "*svy*").

3 Results

The analytical sample consisted of 1333 children aged 7 to 14 years. For each meal or snack, only the children who reported a plausible food consumption were considered, thus resulting in different sample sizes (Supplementary Figure 1).

Table 1 presents key characteristics of the study sample. Most of children were female (53.1%), between 7 and 10 years old (57.8%), studied in the morning shift (52.4%). About a third (33.8%) of the sample were overweight (including obesity). Most reports referred to weekdays (87.6%). Lunch was the most frequent meal (97.8%) consumed, followed by dinner (92.2%), mid-afternoon snack (88.0%), breakfast (83.0%), mid-morning snack (58.7%) and evening snack (54.8%). A higher proportion of public school students shared the 4th quartile of MSFsc compared to the 1st quartile (65.8% vs. 54.3%), whereas a lower proportion of private school students were in the 4th quartile compared to the 1st quartile (34.2% vs. 45.7%). The 1st quartile of MSFsc had higher proportion of morning shift students than 4th quartile (71.8 vs 27.2%). Breakfast consumption was significantly different across MSFsc quartiles (p=0.040). Mid-morning snack was more frequently consumed by the children in the 1st quartile compared to the 4th quartile (71.3 vs. 44.6%). All sleep variables were different between quartiles, except sleep duration on weekend (Table 1). Students aged 11 to 14 years had lower median of total and weekday sleep duration (9.43, 9.00 vs. 10.00, 10.00), later bedtime on weekdays and weekend (10:15pm, 11:30pm vs. 10:00pm, 11:00pm), and earlier wake-up time on weekdays (6:50am vs. 7:30am) and later on weekend (10:00am vs. 9:10am) compared with students aged 7 to 10 years (Supplementary table 1).

The most consumed food items for breakfast were bread (50%), coffee with milk (24%) and chocolate milk (22%). During the mid-morning snack, fruits (23%), water (22%) and bread (22%) were most frequently consumed. At lunch, rice (65%), beef/poultry (55%) and beans (49%) were preferred. During mid-afternoon snack, bread (31%), cream cookies (21%) and fruits (18%) were the most popular choices, and for dinner, these were rice (40%), beef/poultry (32%) and beans (22%). During the evening snack, water (33%), fruits (21%) and sweets (11%) were the most selected items (Supplementary Table 2).

The criteria used to select the best LCA model are provided in Supplementary Table 3 and resulted in three classes for breakfast, mid-morning snack, dinner and evening snack on the one hand, and four classes for mid-afternoon snack and lunch on the other hand. The food items included in patterns in each eating occasion are described in Supplementary Tables 4,5,6,7,8 and 9, respectively.

For breakfast, the most common pattern included 45% of the sample. It was named “Coffee with milk, bread and cheese” due to the high probability of consuming these items. The second breakfast pattern, called “Mixed”, included 35% of the sample with a higher probability of consuming water, rice, vegetables, beans, instant pasta, French fries, beef/poultry, fruits, cheese bread, cream cookies, breakfast cereal, yogurt, fruit juice, soda, sweets, chips, Pizza/hot-dog/hamburger and cake. The third breakfast pattern included 20% of the students and was characterized by a higher probability of consuming chocolate milk (Supplementary Table 4).

The first mid-morning snack pattern was shared by 69% of the students and was labeled "Ultra-processed and fruits" because of a higher probability of consuming fruits, cream cookies, Pizza/hotdog/hamburger and cake. The second mid-morning SP was observed in 24% of the sample and termed "Coffee with milk, bread, cheese, and processed meat" due to a higher probability of consuming sausages, bread, cheese, coffee with milk, and chocolate milk. The third SP included 9% of the students and was labeled "Traditional Brazilian lunch with soda" due to preference for consuming rice, vegetables, green leaves, vegetable soup, beans, manioc flour, corn/maize, pasta, beef/poultry and soda (Supplementary Table 5).

The most common lunch MP termed “Brazilian traditional” was observed in 41% of students, with a higher probability of consuming rice, vegetables, green leaves, beans, manioc flour and beef/poultry. The second lunch MP included 29% of the sample and was labelled “Brazilian traditional, processed meat, egg and fish” characterized by a higher probability of consuming rice, vegetables, beans, manioc flour, sausages, eggs and fish/seafood. The third lunch pattern comprised 19% of students and was identified as “Mixed” because of mixing both healthy and unhealthy diet markers, such soup, instant pasta, sausages, breads, cheese bread, cream cookies, milk, Pizza/hotdog/hamburger and cake. The fourth lunch pattern was labeled "Pasta and cheese" due to the predominance of these items and was identified in 11% of schoolchildren (Supplementary Table 6).

Most of the students (51,6%) preferred the "Ultra-processed" mid-afternoon SP. It included cheese bread, cream cookies, soda, sweets, chips, pizza/hotdog/hamburger, and cake as the most frequent food choices. The second SP was denominated "Coffee with milk, bread, cheese, and processed meat", with 30,5% of the children allocated to it, characterized by the preference for sausages, bread, cheese, and coffee with milk. The third mid-afternoon SP was termed "Fruits", with 14,6% of the students included. The fourth SP was shared by 3%

of the students and labeled "Traditional Brazilian lunch". It was composed of rice, vegetables, green leaves, vegetable soup, beans, manioc flour, corn/maize, pasta, beef/poultry, and French fries, (Supplementary Table 7).

The most common dinner patterns labelled “Mixed” was identified in 47% of the sample and indicated a higher probability of consuming vegetable soup, pasta, instant pasta, sausages, fruits, bread, cheese bread, cream cookies, cheese, coffee with milk, chocolate milk and cake. The second pattern included 41.3% of the schoolchildren and was labeled "Traditional Brazilian, fish and water" because of a higher probability of consuming water, rice, vegetables, green vegetable leaves, soup, beans, manioc flour, corn/maize, beef/poultry and fish/seafood. The third dinner pattern denominated “Ultra-processed and sweets” was identified in 12% of the sample, who had higher probability of consuming soda, sweets and Pizza/hotdog/hamburger (Supplementary Table 8).

The most common evening SP comprised 64% of the students and was labeled "Ultra-processed, sweets, dairy and fruits" due to a higher probability of consuming fruits, cream cookies, milk, yogurt, chocolate milk, sweets and Pizza/hotdog/hamburger. The second evening snack patterns was named “Water” due to a high preference for this drink and included 27% of the sample. The third evening SP labelled “Traditional Brazilian lunch and ultra-processed foods” included 9% of students and indicated a higher probability of consuming rice, vegetables, green leaves, vegetable soup, beans, manioc flour, corn/maize, beef/poultry, fish/seafood, instant pasta, French fries, sausages and eggs (Supplementary Table 9).

The probability of belonging to the meal and snack patterns in each eating occasion across the quartiles of the midpoint of sleep (MSFsc group) is shown in Table 2 There was a statistically significant decrease in the probability of belonging to the “Coffee with milk, bread and cheese” breakfast pattern in the 4th quartile compared with the 1st quartile (35.4%, 95%CI 27.2- 43.6 vs. 56.0%, 95%CI 48.5- 63.4) as well as a significant increase in the probability of belonging to the “Mixed” breakfast pattern in the 4th quartile compared with the 1st quartile (40.0%, 95%CI 32.4- 46.7 vs. 28.0%, 95%CI 23.8- 32.0) (Table 2).

As for mid-morning snack, there was a significant increase in the probability of belonging to the “Traditional Brazilian lunch with soda” SP in the 3rd quartile compared with the 1st quartile (7.8%, 95%CI 4.6- 11.0 vs. 2.0%, 95%CI 0.2- 3.9). For Lunch, there was a decrease in the probability of belonging to the “Brazilian traditional, processed meat, egg and fish” MP in the 3rd quartile compared with the 1st quartile (21.5%, 95%CI 15.2- 27.8 vs. 35.4%, 95%CI 30.3- 40.5). Also, there was an increase of the probability of belonging to the "Pasta and cheese" MP in the 3rd quartile compared with the 1st quartile (17.1%, 95%CI 13.0- 21.1 vs. 10.1%, 95%CI 8.4- 11.9) (Table 2).

A significant increase in the probability of belonging to the "Ultra-processed" SP in the 3rd quartile compared with the 2nd quartile (56.3%, 95%CI 52.4- 60.2 vs. 47.2%, 95%CI 43.5- 50.8) was found for the mid-afternoon snack. No differences were observed at dinner and evening snack (Table 2).

After stratifying by school shift, at breakfast, we observed that afternoon shift differences were similar to total sample in "Coffee with milk, bread and cheese" and Mixed patterns. At the morning snack, the students from afternoon shift showed the same result as the total sample in "Traditional Brazilian lunch with soda". At lunch, the morning shift presented a similar result to the total sample, while in the afternoon shift was observed a decrease in the "Pasta and cheese" pattern in 4th quartile compared with 2nd quartile of MSFsc (5.3%, 95%CI 0.4-10.2 vs. 16.7%, 95%CI 10.3-23.1). At dinner, it was observed that those on the morning shift had a lower probability of belonging to the "Mixed" pattern in 4th quartile compared to 2nd quartile (34.6%, 95%28.0-41.1 vs. 50.5, 95%CI 45.1-56.0). At the evening snack, the afternoon shift showed an increase in "Ultra-processed" SP in 2nd quartile compared with 1st quartile (75.9%, 95%CI 66.9-84.8 vs. 58.6%, 95%CI 51.0-66.3) and a decrease in the "Water" pattern in 2nd quartile compared with 1st quartile (19.0%, 95%CI 10.2-27.7 vs. 37.7%, 95%CI 28.1-47.3). No differences were observed at afternoon snack (Supplementary Table 10).

We performed a sensitivity analysis using MSFsc as a continuous variable, however we only found difference at breakfast in "Mixed" (β= 0.31, p= 0.020) and "Chocolate milk" (β= 0.38, p= 0.026) pattern (data not shown).

4 Discussion

To the best of our knowledge, this is the first study to assess differences in meal and snack patterns between sleep timing groups (midpoint of sleep quartiles) in children and adolescents. Three patterns were identified for breakfast, mid-morning snack, evening snack, and dinner on the one hand, and four patterns for mid-afternoon snack, and lunch on the other hand. The results suggested a link between sleep timing and meal/snack patterns in schoolchildren. Specifically, very late and late sleep preferences were associated with a higher probability of consuming the mixed breakfast pattern (healthy and unhealthy foods), the pasta-and-cheese lunch pattern, and the ultra-processed mid-afternoon pattern. Very early and early sleep preferences were associated with an increased probability of consuming typical Brazilian foods at breakfast (coffee with milk, bread, cheese) and lunch (rice, beans, beef/poultry). To date, no studies have been identified that evaluated the association of sleep timing with meals or snacks patterns with the methods used in the present study, thus limiting a direct comparison with other global dietary patterns (GDP) studies. It is also important to note that dietary patterns derived from a posteriori inherently reflect cultural and regional variations and may be influenced by the methodology employed for their derivation[30,32,59].

Schoolchildren with very early sleep preference were more likely to consume the “Coffee with milk, bread and cheese” breakfast pattern, considered a common combination of foods usually consumed for breakfast in some regions of Brazil, as described in similar studies with schoolchildren[47,53]. The Dietary Guidelines for the Brazilian Population recognize this pattern as a healthy combination of breakfast foods, particularly when it includes fruits[54]. A study in Florianopolis, conducted between 2013 and 2015 with public school students, derived meal and snack patterns using LCA and identified the second most common breakfast pattern, labeled "Traditional Brazilian breakfast", shared by a quarter of the students, characterized by coffee with milk, bread, and cheese[53], similar to the most common BP found in the present study. Although evidence is scarce about the role of sleep timing influence on breakfast food choices, some studies focused on skipping breakfast. The results suggest that those with later sleep timing are more likely to skip breakfast[15,16,21,37,60].

In the present study, students with later sleep timing were more likely to consume the “Mixed” breakfast pattern which includes healthy food items such as fruits, vegetables, rice, and beans, but also unhealthy ones, such as ultra-processed foods, pizza/hotdog/hamburger, sweets, cream cookies, and soda. This BP suggests a less structured breakfast, with higher dietary variability of food items at a very late breakfast. This may be related to a typical mealtime upon waking up. For instance, the children who wake up close to breakfast time are more likely to consume the foods typically eaten at breakfast, while those waking up closer to lunchtime may gravitate towards lunch-type foods. Although the mixed patterns cannot be considered globally healthy or unhealthy, this BP requires monitoring due to the presence of ultra-processed foods and those rich in fat, sugar, and salt in the first meal of the day. A nationwide representative study of 7425 Brazilian children and adolescents aged 10-19 years also found frequent mixing of both healthy and unhealthy breakfast patterns[61].

Some studies found associations between later sleep timing with the consumption of unhealthy foods during the day[12,13,15,16,62]. A study carried out with 465 children between 9 to 11 years old from New Zealand, found that those with later sleep preferences had lower scores in the GDP composed by fruits and vegetables than those with earlier sleep preferences[17]. Similarly, Thellman et al., (2017)[36] conducted a study with 119 North American children aged 9 -15 years and found that later sleep timing (4th quartile of weekly midpoint of sleep) was associated with a higher probability of consuming high fat, sugar and salty foods during the day, compared to children with morning preference (1st quartile of weekly midpoint of sleep). The authors highlighted that these differences were higher in the afternoon and evening hours of the day[36], this is in line with the present study result that those with later sleep timing were more likely to consume unhealthy foods in the “Mixed” BP.

Later sleep timing is not only associated with unhealthy eating, but also with lower consumption of healthy foods such as milk[62], fruits and vegetables[16] and less physical activities[17,62] in children and adolescents. Furthermore, a study from Florianopolis, found that schoolchildren with early sleep timing were less likely of being overweight including obesity than intermediate types[24]. Likewise, Yang et al. (2023)[62] found that non-morning types (intermediate and evening chronotype) Chinese children between 10-12 years of age had a higher risk of being overweight compare with the morning types.

Late sleep timing was associated with the "Traditional Brazilian lunch with soda" at mid-morning SP when compared with very early sleep timing. The children who wake up later are more likely to skip mid-morning snack[24]. However this snack could be considered a large meal (rice, beans and beef/poultry) provide by public schools in Brazil[53,63] or eaten at home before going to school in the afternoon shift. Another possibility is that children had difficulty in reporting mid-morning snack and lunch separately, due to the short time interval between them.

The schoolchildren with very early sleep preference were more likely to consume the “Brazilian traditional, processed meat, egg and fish” lunch pattern compared with those with late sleep preference. The latter were more likely to consume the “Pasta and cheese” lunch pattern compared with those with very early preference. These results suggests that lunch also can be affected by sleep timing, whereby morning habits may contribute to a healthy lunch pattern. Although the “Brazilian traditional, processed meat, egg and fish” LP contains processed meat such as sausages, it may still be considered a healthy combination of foods for lunch due to the presence of rice, beans, and vegetables which are recommended by the Dietary Guide for the Brazilian Population(54). Also, the guide states that pasta can be part of a healthy meal if accompanied with some source of protein as chicken and vegetables(54), thus making it difficult to classify the “Pasta and cheese” LP as either healthy or unhealthy.

The students with late sleep preference were more likely to consume the “Ultra-processed” mid-afternoon snack pattern compared to those with early sleep preference. Roberto *et al.* (2022)(53) found a similar most common mid-afternoon SP labelled “Ultra-processed” composed by energy-dense foods such as cream cookies, soda, sweets and Pizza/hotdog/ hamburger. However, we did not find studies investigating the composition of afternoon snacks and sleep timing. Our results support the hypothesis that later sleep timing is associated with a higher consumption of unhealthy foods during the afternoon snack.

School shift appears to influence the relationship between MSFsc quartiles and meal/snack patterns, with schoolchildren attending the afternoon shift appearing to be more affected by changes in MSFsc quartiles, although we also observed changes in the morning shift. However, our results do not allow us to assess the impact of the school shift on the association between quartiles of MSFsc and meal/snack patterns, since some associations were observed between the 1st and 2nd quartiles of MSFsc and not between the opposite quartiles, and some associated with meal/snack patterns are a mix of foods considered healthy and unhealthy. Peng et al. (2024)(64) in a study with 305 Mexican students between 9 and 17 years old, identified that who attend to the morning shift had higher adherence to a global dietary pattern “Meat and starchy” (chips, refined grains, sugar-sweetened beverages, processed meat, and high-fat dairy, sweets, pork, Mexican foods, potatoes and fried plantains, soup, legumes, and corn tortillas) compared to students in the afternoon shift. In contrast, a Brazilian study with 635 high school students found no differences between adherence of two global dietary pattern “Processed” and “Unprocessed” among those who attend school in the morning compared to those who studied in the afternoon shift (65). Future studies may help understand how chronotype and school shifts attended can influence the composition of meals and snacks.

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

In the present study, the most common morning and evening snack patterns were characterized by the presence of ultra-processed foods and fruits, thus suggesting a combination of both healthy (e.g. fruits) and unhealthy (e.g. ultra-processed) foods in daily snacks. Similarly, a nationwide representative study entitled Brazilian Dietary Survey conducted in 2017–2018 with 8264 adolescents aged 10 to 19 years, found that morning, afternoon and evening snacks were mostly composed by sweeteners added to food and beverages, cookies/crackers, coffee/tea, fast food, fruit juices and fruits[66]. Furthermore, a study with 5264 US adolescents aged 12-19 years from the National Health and Nutrition Examination Survey (NHANES), identified the most frequent sources of snacks came from fruits, refined grains, oils, solid fats and added sugars[67]. On the other hand, fruits did not compose any most common snack patterns in the study caried out with students from public schools in Florianópolis, Brazil, between 2013-2015[53]. Socioeconomic differences between public and private students may explain these results, as attending a private school in Brazil requires higher income, also associated with higher fruit and vegetable intake in Florianopolis[68,69].

It is important to highlight that consuming food late at night has been associated with disruption in circadian rhythms. In our study, we highlighted that most children are consuming ultra-processed foods, rich in fat, sugar, and salt as an evening snack, possibly close to bedtime, which can cause changes in circadian cycles responsible for hormonal and metabolic oscillations related to overweight and obesity[70].

The strengths of the present study include a large representative sample of both private and public school students- a proxy of socioeconomic status. The use of the midpoint of sleep to measure sleep timing is a new approach in sleep research [11] that considers the dimension of the time of day that sleep occurs, while traditional research focus in sleep duration. Moreover, some authors consider LCA less subjective than factor analyses to derive the meal and snack patterns[30,59]. The former is also described as person-centered analysis which facilitates data interpretation and may be adjusted for the covariates known to influence both sleep and dietary intake[4]. The approach based on time-tagged eating events - a relatively new field of dietary patterns research - has been growing fast, producing important practical applications based on time-of-the-day food intake. Also, nutritional recommendations based on specific eating occasions may be easier to follow[30].

The present study's limitations include a cross-sectional design centered on the analysis of associations that do not always imply a causal relationship. Sleep data were provided subjectively by parents or guardians, who may be prone to recall errors. However, this methodology is commonly used in epidemiological studies[71]. Screen use frequency, physical activities, and dietary intake were all self-reported by schoolchildren, and therefore depend on their attention, memory, and perceived social desirability[43]. Although Web-CAAFE was verified for usability, reproducibility, and external validity, we cannot exclude the possibility of errors in the allocation of specific foods across eating occasions[53]. The dietary data from a single day may not fully represent individuals' habitual consumption[72]. Nevertheless, this method is still widely applied for population-level assessment[52]. Furthermore, to mitigate potential bias, data collection was conducted across different days of the week, encompassing both weekdays and weekends. Lastly, Web-CAAFE does not provide the exact timing of eating events or the amount of food intake, thus limiting the possibility of investigating associations between energy intake and meal/snack timing.

5 Conclusion

The study findings suggest that schoolchildren with very late sleep timing are more likely to consume the "Mixed" pattern and less likely to consume the "Coffee with milk, bread, and cheese" pattern at breakfast when contrasted with those with very early sleep timing. Also, later sleep preferences are associated with a lower intake of the "Brazilian traditional, processed meat, egg, and fish" lunch pattern and a higher intake of the "Pasta and cheese" pattern. Later sleep timing was also associated with higher consumption of ultra-processed food at mid-afternoon snacks compared to students with earlier sleep timing.

For breakfast, a morning preference for sleep timing was associated with a healthier breakfast pattern, while later preferences seem to have an inverse association. Similarly, a morning preference appears to be advantageous for promoting healthy lunch and afternoon snack patterns. Future longitudinal studies are needed to clarify the causal nature of these associations and those between sleep timing and energy intake on different eating occasions.

The present study findings provide a basis for practical dietary recommendations, focused on specific eating events, bedtime, and wake-up time. With a growing expert agreement on the importance of sleep timing in a healthy diet, school intervention projects should give more weight to early sleep routines to improve healthy meal/snack patterns in children and adolescents.

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Acknowledgements

The authors thank the schoolchildren, their parents/guardians, the collection team of volunteers and the school authorities for their participation in this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Funding: This research was supported by the Conselho Nacional de Desenvolvimento Científico e Tecnológico [Grant/Award Number: 402322/2005-3 and 483955/2011-6]; Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina, [Grant/Award Number: 2017TR1759]. D.M.T.R. received a fellowship from the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES). The funding agencies had no participation in the design, analysis, and writing of this paper.

Author Contributions: Conceptualization, D.M.T.R and P.d.F.H.; methodology, D.M.T.R, E.K and P.d.F.H.; data curation, D.M.T.R and P.d.F.H.; writing—original draft preparation, D.M.T.R, E.K, P.d.F.H, L.J.P, M.W.S, S.L, P.F.D.P and F.G.K.V.; writing—review and editing, P.d.F.H.; Project Administration, P.d.F.H.; Funding Acquisition, P.d.F.H. All authors have read and agreed to the published version of the manuscript.

Table 1. Description of the sample of 7–14-year-old schoolchildren according to midpoint of sleep quartiles (MSFsc group). Florianopolis. Brazil. 2018/2019.

Characteristics	**Total (n= 1333)**		**Midpoint of sleep quartile (MSFsc group)** Q1 Very early (n= 339)		**Q2 Early (n= 339)**		**Q3 Late (n= 330)**		**Q4 Very Late (n= 325)**		***p*** **‡**
	n	**% (95% CI)**	**N**	**% (95% CI)**	**n**	**% (95% CI)**	**n**	**% (95% CI)**	**n**	**% (95% CI)**	
Sex (n=1333)											
Female	756	53.1 (49.2-57.0)	197	52.9 (44.0-61.6)	186	54.9 (49.5-60.1)	185	54.2 (49.5-58.9)	188	56.1 (50.0-61.9)	0.809
Male	577	46.9 (42.9-50.8)	142	47.1 (38.4-56.1)	153	45.1 (39.9-50.5)	145	45.7 (41.1-50.5)	137	43.9 (38.1-50.0)	
Age (n=1333)											
7-10 years	782	57.8 (49.7-65.6)	225	60.9 (50.0-71.0)	186	52.1 (32.0- 71.4)	196	61.6 (53.4- 69.3)	170	57.0 (50.0- 63.6)	**0.001**
11-14 years	551	42.2 (34.4-50.3)	114	39.1 (29.1-50.1)	153	47.9 (28.6- 68.0)	134	38.4 (30.7- 46.6)	155	43.1 (36.4- 50.0)	
Weight status† (n=1316)											
Non-overweight	876	66.2 (63.0-69.4)	231	68.1 (63.5-72.3)	220	62.1(59.1-65.1)	215	69.6 (64.6-74.1)	210	65.7 (56.9-73.5)	0.767
Overweight including obesity	440	33.8 (30.6-37.1)	105	31.9 (27.7-36.5)	114	37.9 (34.9- 40.9)	108	30.4 (25.9- 35.4)	113	34.3 (26.5- 43.1)	
Type of school											

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

(1333)											
Public	783	58.7 (56.1-61.4)	184	54.3 (49.0-59.5)	194	57.2 (51.9-62.4)	191	57.9 (52.5-63.1)	214	65.8 (60.5-70.8)	**0.019**
Private	550	41.3 (38.6-43.9)	155	45.7 (40.5-51.1)	145	42.8 (37.6-48.1)	139	42.1 (36.9-47.5)	111	34.2 (29.2-39.5)	
School shift (1328)											
Morning	746	52.4 (44.9-59.8)	252	71.8 (61.8-80.1)	234	68.7 (60.5 -76.0)	162	40.3 (27.1- 55.1)	98	27.2 (18.3-38.3)	**<0.001**
Afternoon	582	47.6 (40.2-55.1)	84	28.2 (20.0-38.2)	104	31.3 (24.1 -40.0)	167	59.7 (44.9- 73.0)	227	72.8 (61.7-81.7)	
Physical activity score (tertile) (n=1333)											
Lowest	438	33.3 (30.8-35.9)	117	34.8 (29,9-40.0)	100	30.0 (25.2- 35.1)	108	33.4 (28.5- 38.8)	113	35.0 (30.0- 40.4)	0.610
Middle	458	34.8 (32.3-37.4)	116	34.5 (30.0-39.8)	113	33.8 (29.0- 39.1)	116	35.9 (30.8- 41.3)	113	35.0 (30.0- 40.4)	
Highest	420	31.9 (29.4-34.5)	103	30.7 (26.0-35.8)	121	36.2 (31.1- 41.6)	99	30.7 (25.8- 36.0)	97	30.0 (25.3- 35.3)	
Daily frequency of screen use (n=1333)											
never	319	21.1 (15.7-27.8)	83	20.3 (13.9-28.7)	81	25.4 (18.2- 34.2)	79	18.5 (9.5-32.9)	76	19.8 (12.8-29.3)	0.632
once	332	26.5 (24.2-29.0)	75	23.0 (19.5-26.8)	76	23.1 (17.4- 30.0)	90	31.0 (25.1-37.6)	91	29.6 (25.0-34.7)	
twice	246	17.3 (15.1-19.7)	70	19.5 (14.3-26.0)	67	17.2 (11.6- 24.9)	52	15.1 (10.7-20.8)	57	17.2 (13.1-22.1)	

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

three times or more	436	35.1 (31.1-39.2)	111	37.3 (28.4-47.1)	115	34.3 (29.3- 39.7)	109	35.4 (28.7-42.7)	101	33.4 (26.5-41.1)	
Maternal education. years of schooling (n=1288)											
0-8	244	9.1 (2.4-28.5)	59	9.4 (2.6- 28.2)	57	7.7 (2.0-26.3)	62	9.0 (2.3-29.3)	66	10.3 (2.7-32.5)	0.368
9-11	386	22.2 (12.4-36.4)	89	17.0 (7.0- 35.6)	99	21.5 (11.8-35.8)	93	23.9 (15.0-35.8)	105	26.8 (14.5- 44.0)	
≥12	658	68.7 (43.0-86.5)	178	73.7 (43.3-91.1)	173	70.8 (45.5-87.6)	165	67.2 (44.3-84.0)	142	63.0 (35.6- 83.9)	
Meals and snacks consumed											
Breakfast	1114	83.0 (80.4-85.4)	289	83.6 (78.7-87.5)	287	84.2 (80.2-87.6)	283	87.0 (76.1-93.3)	255	77.5 (69.7- 83.7)	**0.040**
Mid-morning snack	753	58.7 (53.4-63.8)	224	71.3 (55.1-83.4)	211	63.9 (60.0- 67.7)	170	54.3 (46.5-61.9)	148	44.6 (36.3-53.3)	**<0.001**
Lunch	1293	97.8 (96.6-98.6)	328	97.8 (94.2-99.2)	329	97.4 (96.0- 98.4)	322	97.4 (95.9- 98.4)	314	98.5 (94.4-99.6)	0.893
Mid-afternoon snack	1115	88.0 (82.2-87.3)	277	82.3 (79.3-84.9)	286	86.4 (82.4-89.5)	279	86.5 (80.0-91.2)	273	84.6 (80.6-87.9)	0.734
Dinner	1218	92.2 (89.3-94.4)	309	92.0 (89.5-94.0)	308	92.9 (88.0-96.0)	304	92.5 (85.4-96.3)	297	91.4 (89.3-93.1)	0.946
Evening snack	738	54.8 (50.8-58.8)	176	48.2 (42.4-54.0)	186	52.1 (44.6- 59.5)	181	55.2 (51.2-59.1)	195	64.2 (52.3-71.3)	0.210
Day of food intake report (n=1333)											
Weekday	1067	87.6 (70.0-	266	86.2 (66.7-95.1)	263	87.0 (66.2-95.7)	280	90.1 (75.7-96.3)	258	87.3 (68.1-95.7)	0.083

		95.6)									
Weekend	266	12.4 (4.4-30.5)	73	13.8 (4.9-33.3)	76	13.1 (4.3-33.8)	50	10.0 (3.7-24.3)	67	12.7 (4.3-31.9)	
	Median (p25- p75)		**Median (p25- p75)**		**Median (p25- p75)**		**Median (p25- p75)**		**Median (p25- p75)**		***p*** §
Sleep duration (h) (n=1333)											
Total	9.79 (9.14- 10.54)		9.69 (9.14- 10.24) [a]		9.57 (8.93- 10.29) [b, c]		10.00 (9.14- 10.64) [b, d]		10.14 (9.43- 11.00) [a, c, d]		<**0.001**
Weekday	9.50 (8.33- 10.50)		9.50 (8.83- 10.00) [a]		9.17 (8.50- 10.00) [b, c]		10.00 (8.75- 10.50) [b, d]		10.00 (9.17- 11.00) [a, c, d]		<**0.001**
Weekend	10.50 (9.50- 11.00)		10.00 (9.50- 11.00)		10.50 (9.50- 11.00)		10.50 (10.00- 11.00)		10.33 (9.50- 11.00)		0.300
Bedtime (h:mm) (n=1333)											
Weekday	22:00 (21:30- 23:00)		21:30 (21:00-22:00) [e]		22:00 (21:30- 22:30) [e]		22:30 (22:00-23:00) [e]		23:00 (22:30- 23:30) [e]		<**0.001**
Weekend	23:00 (22:30- 0:00)		22:00 (21:30- 22:30)		23:00 (22:30- 23:00) [e]		23:30 (23:00- 0:00) [e]		0:30 (24:00- 1:00) [e]		<**0.001**
Wake up time (h:mm) (n=1333)											
Weekday	7:00 (6:30- 8:30)		6:40 (6:20- 7:00) [e]		7:00 (6:30- 7:30) [e]		7:20 (6:50- 9:00) [e]		9:00 (7:09- 10:00) [e]		<**0.001**
Weekend	9:30 (8:30- 10:30)		8:00 (7:30- 9:00) [e]		9:00 (8:30- 10:00) [e]		10:00 (9:00- 10:20) [e]		10:40 (10:00- 11:30) [e]		<**0.001**
MSFsc (n=1333)	3:58 (3:15- 4:38)		2:53 (2:30- 3:04) [e]		3:38 (3:28- 3:47) [e]		4:10 (4:07- 4:28) [e]		5:22 (5:00- 5:59) [e]		<**0.001**

Abbreviations: Q: quartile; 95% CI: confidence interval 95%; p25; p75: interquartile range; MSFsc: midpoint of sleep on free days corrected.

† Classified according to WHO (2006). ‡ Pearson's chi-squared test. § Kruskall wallis test. Bold values denote statistical significance at the $p < 0.05$ level.

[a] The contrast between the first and fourth quartile is significantly different at 5% level, [b] the contrast between the second and third quartile is significantly different at 5% level, [c] the contrast between the second and fourth quartiles is significantly different at 5% level, [d] the contrast between the third and fourth quartiles is significantly different at 5% level. [e] all quartiles are significantly different from each other at a 5% level.

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

Table 2. Probability (%) of belonging to a latent class at different meals/snacks in schoolchildren by midpoint of sleep quartiles (MSFsc group). Florianópolis. Brazil 2018/2019 (*n* = 1333).

Meal/snack pattern	Midpoint of sleep quartiles (MSFsc group)							
	Q1 (Very early)		**Q2 (Early)**		**Q3 (Late)**		**Q4 (Very late)**	
	% †	**95% CI**	**% †**	**95% CI**	**% †**	**95% CI**	**% †**	**95% CI**
Breakfast								
Coffee with milk, bread and cheese	**56.0**	**(48.5- 63.4)**	45.1	(36.5- 53.6)	43.0	(36.2- 49.8)	**35.4**	**(27.2- 43.6)**
Mixed	**28.0**	**(23.8- 32.0)**	38.4	(30.2- 46.6)	31.0	(25.5- 36.4)	**40.0**	**(32.4- 46.7)**
Chocolate milk	16.1	(9.0- 23.3)	16.5	(13.9- 19.1)	26.0	(18.7- 33.3)	25.0	(20.3- 30.0)
Mid-morning snack								
Ultra-processed and frui	73.8	(66.0- 81.5)	75.6	(70.1- 81.1)	72.6	(62.6- 82.5)	71.9	(56.3- 87.4)
Coffee with milk, bread, cheese and processed meat	24.2	(17.2- 31.2)	21.0	(16.9- 25.1)	19.6	(12.0- 27.3)	22.0	(9.8- 34.1)
Traditional Brazilian lunch with soda	**2.0**	**(0.2- 3.9)**	3.4	(0.4- 6.4)	**7.8**	**(4.6- 11.0)**	6.2	(1.6- 10.8)
Lunch								
Brazilian traditional	44.9	(39.0- 51.0)	45.0	(39.0- 50.8)	44.1	(37.3- 51.0)	41.1	(36.4- 45.7)
Brazilian traditional, processed meat, egg and fish	**35.4**	**(30.3- 40.5)**	25.4	(20.7- 30.0)	**21.5**	**(15.2- 27.8)**	28.1	(22.2- 34.0)
Ultra-processed, milk and bread	9.6	(3.9- 15.4)	15.4	(7.9- 22.9)	17.3	(14.9- 19.6)	18.7	(15.2- 22.1)
Pasta and cheese	**10.1**	**(8.4- 11.9)**	14.3	(11.4 - 17.2)	**17.1**	**(13.0- 21.1)**	12.2	(6.1- 18.2)

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

Mid-afternoon snack								
Ultra-processed	55.0	(50.2-59.6)	**47.2**	(**43.5-50.8**)	**56.3**	(**52.4-60.2**)	56.6	(45.6-67.7)
Coffee with milk, bread, cheese, and processed meat	26.3	(21.7-31.0)	36.9	(30.9-42.8)	28.2	(22.8-33.5)	31.8	(23.6-40.1)
Fruits	15.5	(12.7-18.3)	13.6	(9.5- 17.6)	12.8	(7.5- 18.0)	10.2	(5.6- 14.8)
Traditional Brazilian lunch	3.3	(1.3- 5.2)	2.4	(0.07- 4.8)	2.8	(0.5- 5.1)	1.3	(0.5- 2.1)
Dinner								
Mixed	49.4	(43.4-55.4)	48.9	(41.8-56.0)	46.9	(40.5-53.2)	41.2	(37.5-44.8)
Traditional Brazilian, water and fish	38.7	(33.8-43.7)	37.7	(30.3-45.1)	40.9	(34.1-47.6)	43.4	(35.3-51.4)
Ultra-processed and sweets	11.9	(8.4- 15.4)	13.5	(9.5- 17.4)	12.3	(9.3- 15.3)	15.5	(10.3-20.6)
Evening snack								
Ultra-processed, sweets, dairy and fruits	54.7	(45.4-63.9)	63.2	(54.8-71.7)	61.0	(51.8-70.2)	63.9	(55.2-72.5)
Water	37.9	(28.7-47.1)	33.9	(28.0-39.9)	30.4	(23.5-37.3)	30.0	(22.1-37.7)
Traditional Brazilian lunch and ultra-processed foods	7.4	(4.0- 10.9)	2.8	(-0.7- 6.4)	8.6	(4.5- 12.6)	6.2	(4.3- 8.2)

Abbreviation: CI. confidence interval. Q: quartile

† Adjusted for sex. age. screen use. type of school, maternal education, weight status, school shift, physical activity and day of food intake report

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

References

1. Vetter C. Circadian disruption: What do we actually mean? European Journal of Neuroscience [Internet]. 2020 Jan 1 [cited 2024 Sep 11];51(1):531–50. Available from: https://doi.org/10.1111/ejn.14255

2. Buysse DJ, St H. Sleep Health: Can We Define It? Does It Matter? Sleep [Internet]. 2014 Jan 1 [cited 2024 Sep 11];37(1):9–17. Available from: https://doi.org/10.5665/sleep.3298

3. Kramer A, Lange T, Spies C, Finger AM, Berg D, Oster H. Foundations of circadian medicine. PLoS Biol [Internet]. 2022 Mar 1 [cited 2022 Sep 12];20(3). Available from: https://doi.org/10.1371/journal.pbio.3001567

4. Roenneberg T, Kuehnle T, Juda M, Kantermann T, Allebrandt K, Gordijn M, et al. Epidemiology of the human circadian clock. Sleep Med Rev [Internet]. 2007 Dec 1 [cited 2024 Sep 11];11(6):429–38. Available from: https://doi.org/10.1016/j.smrv.2007.07.005

5. Roenneberg T, Allebrandt K V., Merrow M, Vetter C. Social Jetlag and Obesity. Current Biology [Internet]. 2012 May 22 [cited 2024 Sep 11];22(10):939–43. Available from: https://doi.org/10.1016/j.cub.2012.03.038

6. Roenneberg T, Daan S, Merrow M. The art of entrainment. J Biol Rhythms [Internet]. 2003 Jun 1 [cited 2023 Feb 9];18(3):183–94. Available from: https://pubmed.ncbi.nlm.nih.gov/12828276/

7. Terman JS, Terman M, Lo ES, Cooper TB. Circadian Time of Morning Light Administration and Therapeutic Response in Winter Depression. Arch Gen Psychiatry [Internet]. 2001 Jan 1 [cited 2024 Sep 11];58(1):69–75. Available from: https://doi.org/10.1001/archpsyc.58.1.69

8. Roenneberg T, Kuehnle T, Pramstaller PP, Ricken J, Havel M, Guth A, et al. A marker for the end of adolescence. Current Biology [Internet]. 2004 Dec 29 [cited 2021 Oct 3];14(24):R1038–9. Available from: https://doi.org/10.1016/j.cub.2004.11.039

9. Au R, Carskadon M, Millman R, Wolfson A, Braverman PK, Adelman WP, et al. School Start Times for Adolescents. Pediatrics [Internet]. 2014 Sep 1 [cited 2024 Sep 11];134(3):642–9. Available from: https://doi.org/10.1542/peds.2014-1697

10. Paruthi S, Brooks LJ, D'Ambrosio C, Hall WA, Kotagal S, Lloyd RM, et al. Consensus Statement of the American Academy of Sleep Medicine on the Recommended Amount of

Sleep for Healthy Children: Methodology and Discussion. Journal of Clinical Sleep Medicine [Internet]. 2016 Nov 15 [cited 2024 Sep 11];12(11):1549–61. Available from: https://doi.org/10.5664/jcsm.6288

11. Dutil C, Podinic I, Sadler CM, da Costa BG, Janssen I, Ross-White A, et al. Sleep timing and health indicators in children and adolescents: a systematic review. Health Promotion and Chronic Disease Prevention in Canada [Internet]. 2022 Apr 25 [cited 2022 Aug 28];42(4):150–69. Available from: https://doi.org/10.24095/hpcdp.42.4.04

12. Chaput JP, Katzmarzyk PT, LeBlanc AG, Tremblay MS, Barreira T V, Broyles ST, et al. Associations between sleep patterns and lifestyle behaviors in children: an international comparison. 2015 Dec 8 [cited 2021 Aug 8];5:S59–65. Available from: https://doi.org/10.1038/ijosup.2015.21

13. Thivel D, Isacco L, Aucouturier J, Pereira B, Lazaar N, Ratel S, et al. Bedtime and Sleep Timing but not Sleep Duration Are Associated With Eating Habits in Primary School Children. Journal of Developmental & Behavioral Pediatrics [Internet]. 2015 Apr [cited 2024 Sep 13];36(3):158–65. Available from: https://doi.org/10.1097/DBP.0000000000000131

14. Chaput JP, Tremblay MS, Katzmarzyk PT, Fogelholm M, Hu G, Maher C, et al. Sleep patterns and sugar-sweetened beverage consumption among children from around the world. Public Health Nutr [Internet]. 2018 Sep 1 [cited 2024 Sep 14];21(13):2385–93. Available from: https://doi.org/10.1017/S1368980018000976

15. Arora T, Taheri S. Associations among late chronotype, body mass index and dietary behaviors in young adolescents. Int J Obes [Internet]. 2015 Jan 10 [cited 2022 May 29];39(1):39–44. Available from: https://doi.org/10.1038/ijo.2014.157

16. Golley RK, Maher CA, Matricciani L, Olds TS. Sleep duration or bedtime? Exploring the association between sleep timing behaviour, diet and BMI in children and adolescents. International Journal of Obesity 2013 37:4 [Internet]. 2013 Jan 8 [cited 2021 Sep 7];37(4):546–51. Available from: https://doi.org/10.1038/ijo.2012.212

17. Harrex HAL, Skeaff SA, Black KE, Davison BK, Haszard JJ, Meredith-Jones K, et al. Sleep timing is associated with diet and physical activity levels in 9-11-year-old children from Dunedin, New Zealand: the PEDALS study. J Sleep Res [Internet]. 2018 Aug 1 [cited 2022 May 16];27(4). Available from: https://doi.org/10.1111/jsr.12634

18. Chaput JP. Sleep patterns, diet quality and energy balance. Physiol Behav [Internet]. 2014 Jul 1 [cited 2024 Sep 12];134(C):86–91. Available from: https://doi.org/10.1016/j.physbeh.2013.09.006

19. Baron KG, Reid KJ, Kern AS, Zee PC. Role of Sleep Timing in Caloric Intake and BMI. Obesity [Internet]. 2011 Jul 1 [cited 2024 Sep 12];19(7):1374–81. Available from: https://doi.org/10.1038/oby.2011.100

20. Grummon AH, Sokol RL, Lytle LA. Is late bedtime an overlooked sleep behaviour? Investigating associations between sleep timing, sleep duration and eating behaviours in adolescence and adulthood. Public Health Nutr [Internet]. 2021 May 1 [cited 2024 Sep 12];24(7):1671–7. Available from: https://doi.org/10.1017/S1368980020002050

21. Agostini A, Lushington K, Kohler M, Dorrian J. Associations between self-reported sleep measures and dietary behaviours in a large sample of Australian school students (n = 28,010). J Sleep Res [Internet]. 2018 Oct 1 [cited 2022 Jun 2];27(5):e12682. Available from: https://doi.org/10.1111/jsr.12682

22. Rusu A, Ciobanu DM, Inceu G, Craciun AE, Fodor A, Roman G, et al. Variability in Sleep Timing and Dietary Intake: A Scoping Review of the Literature. Nutrients 2022, Vol 14, Page 5248 [Internet]. 2022 Dec 9 [cited 2024 Sep 12];14(24):5248. Available from: https://doi.org/10.3390/nu14245248

23. Teixeira GP, Guimarães KC, Soares AGNS, Marqueze EC, Moreno CRC, Mota MC, et al. Role of chronotype in dietary intake, meal timing, and obesity: a systematic review. Nutr Rev [Internet]. 2022 Dec 6 [cited 2024 Sep 12];81(1):75–90. Available from: https://doi.org/10.1093/nutrit/nuac044

24. Roberto DMT, Pereira LJ, Vieira FGK, Di Pietro PF, de Assis MAA, Hinnig P de F. Association between Sleep Timing, Being Overweight and Meal and Snack Consumption in Children and Adolescents in Southern Brazil. Int J Environ Res Public Health [Internet]. 2023 Sep 21 [cited 2023 Oct 31];20(18):6791. Available from: https://doi.org/10.3390/ijerph20186791

25. Pot GK. Chrono-nutrition – an emerging, modifiable risk factor for chronic disease? Nutr Bull [Internet]. 2021 Jun 29 [cited 2021 Jun 7];46(2):114–9. Available from: https://doi.org/10.1111/nbu.12498

26. St-Onge MP, Ard J, Baskin ML, Chiuve 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 [Internet]. 2017;135(9):e96–121. Available from: http://dx.doi.org/10.1161/cir.0000000000000476

27. Tahara Y, Shibata S. Chronobiology and nutrition. Neuroscience [Internet]. 2013;253:78–88. Available from: http://dx.doi.org/10.1016/j.neuroscience.2013.08.049

28. Crispim CA, Rinaldi AEM, Azeredo CM, Skene DJ, Moreno CRC. Is time of eating associated with BMI and obesity? A population-based study. Eur J Nutr [Internet]. 2024 Mar 1 [cited 2024 Sep 11];63(2):527–37. Available from: https://doi.org/10.1007/s00394-023-03282-x

29. Leech RM, Worsley A, Timperio A, McNaughton SA. Understanding meal patterns: definitions, methodology and impact on nutrient intake and diet quality. Nutr Res Rev [Internet]. 2015 Mar 19 [cited 2023 Feb 23];28(1):1–21. Available from: http://dx.doi.org/10.1017/s0954422414000262

30. O'Hara C, Gibney ER. Meal Pattern Analysis in Nutritional Science: Recent Methods and Findings. 2021 Jul [cited 2021 Oct 25];12(4):1365–78. Available from: https://doi.org/10.1093/advances/nmaa175

31. Kant AK. Dietary patterns and health outcomes. J Am Diet Assoc [Internet]. 2004 Apr 1 [cited 2024 Sep 12];104(4):615–35. Available from: https://doi.org/10.1016/j.jada.2004.01.010

32. Olinto MTA. Padrões alimentares: análise de componentes principais. In: Epidemiologia Nutricional. Rio de Janeiro: Editora Fiocruz/Atheneu; 2007

33. Leech RM, Worsley A, Timperio A, McNaughton SA. Characterizing eating patterns: a comparison of eating occasion definitions. Am J Clin Nutr [Internet]. 2015;102(5):1229–37. Available from: http://dx.doi.org/10.3945/ajcn.115.114660

34. Oberski D. Mixture models: Latent profile and latent class analysis. In: Modern statistical methods for HCI. Cham: Springer; 2016. p. 275–87.

35. de Oliveira MT, Lobo AS, Kupek E, Assis MAA de, Cezimbra VG, Pereira LJ, et al. Association between sleep period time and dietary patterns in Brazilian schoolchildren aged

7–13 years. Sleep Med [Internet]. 2020 Oct 1 [cited 2024 Sep 12];74:179–88. Available from: https://doi.org/10.1016/j.sleep.2020.07.016

36. Thellman KE, Dmitrieva J, Miller A, Harsh JR, LeBourgeois MK. Sleep timing is associated with self-reported dietary patterns in 9- to 15-year-olds. Sleep Health [Internet]. 2017 Aug 1 [cited 2024 Sep 12];3(4):269–75. Available from: https://doi.org/10.1016/j.sleh.2017.05.005

37. Yu BYM, Yeung WF, Ho YS, Ho FYY, Chung KF, Lee RLT, et al. Associations between the Chronotypes and Eating Habits of Hong Kong School-Aged Children. Int J Environ Res Public Health [Internet]. 2020 Apr 9 [cited 2024 Sep 13];17(7):2583. Available from: https://doi.org/10.3390/ijerph17072583

38. Matricciani L, Bin YS, Lallukka T, Kronholm E, Dumuid D, Paquet C, et al. Past, present, and future: trends in sleep duration and implications for public health. Sleep Health [Internet]. 2017 Oct 1 [cited 2023 Feb 7];3(5):317–23. Available from: https://doi.org/10.1016/j.sleh.2017.07.006

39. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP). CENSO ESCOLAR [Internet]. Brasília: Ministério da educação; 2017. Available from: https://www.gov.br/inep/pt-br/areas-de-atuacao/pesquisas-estatisticas-e-indicadores/censo-escolar/resultados

40. Pereira LJ, Vieira FGK, Belchor ALL, Cezimbra VG, Junior CASA, Matsuo LH, et al. Methodological aspects and characteristics of participants in the Study on the Prevalence of Obesity in Children and Adolescents in Florianópolis, Southern Brazil, 2018–2019: EPOCA study. Ann Epidemiol [Internet]. 2022 Nov 4 [cited 2022 Nov 7]; Available from: https://doi.org/10.1016/j.annepidem.2022.10.017

41. Leal DB, de Assis MAA, Hinnig P de F, Schmitt J, Lobo AS, Bellisle F, et al. Changes in Dietary Patterns from Childhood to Adolescence and Associated Body Adiposity Status. Nutrients [Internet]. 2017 Oct 6 [cited 2024 Sep 12];9(10):1098. Available from: https://doi.org/10.3390/nu9101098

42. Roenneberg T, Wirz-Justice A, Merrow M. Life between clocks: daily temporal patterns of human chronotypes. J Biol Rhythms [Internet]. 2003 Feb 1 [cited 2021 Sep 7];18(1):80–90. Available from: http://dx.doi.org/10.1177/0748730402239679

43. da Costa FF, Schmoelz CP, Davies VF, Di Pietro PF, Kupek E, de Assis MA. Assessment of diet and physical activity of brazilian schoolchildren: usability testing of a web-based questionnaire. JMIR Res Protoc [Internet]. 2013;2(2):e31. Available from: http://dx.doi.org/10.2196/resprot.2646

44. Perazi FM, Kupek E, de Assis MAA, Pereira LJ, Cezimbra VG, de Oliveira MT, et al. Efeito do dia e do número de dias de aplicação na reprodutibilidade de um questionário de avaliação do consumo alimentar de escolares. Revista Brasileira de Epidemiologia [Internet]. 2020 Jul 17 [cited 2024 Sep 12];23:e200084. Available from: https://doi.org/10.1590/1980-549720200084

45. Davies VF, Kupek E, de Assis MA, Engel R, da Costa FF, Di Pietro PF, et al. Qualitative analysis of the contributions of nutritionists to the development of an online instrument for monitoring the food intake of schoolchildren. J Hum Nutr Diet [Internet]. 2015;28 Suppl 1:65–72. Available from: http://dx.doi.org/10.1111/jhn.12209

46. Jesus GM, Assis MAA, Kupek E. Validity and reproducibility of an Internet-based questionnaire (Web-CAAFE) to evaluate the food consumption of students aged 7 to 15 years. Cad Saude Publica [Internet]. 2017;33(5):e00163016. Available from: http://dx.doi.org/10.1590/0102-311x00163016

47. Cezimbra VG, Assis MAA De, De Oliveira MT, Pereira LJ, Vieira FGK, Di Pietro PF, et al. Meal and snack patterns of 7-13-year-old schoolchildren in southern Brazil. Public Health Nutr [Internet]. 2021 Jun 1 [cited 2023 Feb 23];24(9):2542–53. Available from: https://doi.org/10.1017/S1368980020003808

48. Butte NF, Watson KB, Ridley K, Zakeri IF, McMurray RG, Pfeiffer KA, et al. A Youth Compendium of Physical Activities: Activity Codes and Metabolic Intensities. Med Sci Sports Exerc [Internet]. 2018 [cited 2023 Oct 31];50(2):246–56. Available from: https://doi.org/10.1249/MSS.0000000000001430

49. Jesus G, Assis MA, Kupek E, Dias L. Avaliação da atividade física de escolares com um questionário via internet. Revista Brasileira de Medicina do Esporte [Internet]. 2016 [cited 2024 Sep 13];22:261–6. Available from: https://doi.org/10.1590/1517-869220162204157067

50. Emiliano P, Vivanco M, Menezes F. Information criteria: How do they behave in different models? Comput Stat Data Anal [Internet]. 2014 [cited 2024 Sep 13];69:141–53. Available from: https://doi.org/10.1016/j.csda.2013.07.032

51. Weller BE, Bowen NK, Faubert SJ. Latent Class Analysis: A Guide to Best Practice. Journal of Black Psychology [Internet]. 2020 May 1 [cited 2023 Oct 31];46(4):287–311. Available from: https://doi.org/10.1177/0095798420930932

52. Lobo AS, de Assis MAA, Leal DB, Borgatto AF, Vieira FK, Di Pietro PF, et al. Empirically derived dietary patterns through latent profile analysis among Brazilian children and adolescents from Southern Brazil, 2013-2015. PLoS One [Internet]. 2019;14(1):e0210425. Available from: http://dx.doi.org/10.1371/journal.pone.0210425

53. Roberto DMT, Kupek E, de Assis MAA, Lobo AS, Belchor ALL, Spanholi MW, et al. Most meal and snack patterns are stable over a 3-year period in schoolchildren in southern Brazil. Nutr Bull [Internet]. 2022 Mar 1 [cited 2024 Sep 12];47(1):79–92. Available from: https://doi.org/10.1111/nbu.12541

54. Brazil M of H of BrazilS of HCarePHCDepartment. Dietary Guidelines for the Brazilian population [Internet]. 2014. 152 p. Available from: http://bvsms.saude.gov.br/bvs/publicacoes/dietary_guidelines_brazilian_population.pdf

55. Stewart A, Marfell-Jones M, Olds T, Ridder H de. International Standards for Anthropometric Assesment. International Society for the Advancement of Kinanthropometry - ISAK; 2011.

56. World Health Organization. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for- height and body mass index-for-age: methods and development. 2006.

57. Kline CE, Hillman CH, Bloodgood Sheppard B, Tennant B, Conroy DE, Macko RF, et al. Physical activity and sleep: An updated umbrella review of the 2018 Physical Activity Guidelines Advisory Committee report. Sleep Med Rev [Internet]. 2021 Aug 1 [cited 2024 Sep 14];58:101489. Available from: https://doi.org/10.1016/j.smrv.2021.101489

58. Lund L, Sølvhøj IN, Danielsen D, Andersen S. Electronic media use and sleep in children and adolescents in western countries: a systematic review. BMC Public Health [Internet].

2021 Dec 1 [cited 2024 Sep 12];21(1):1–14. Available from: https://doi.org/10.1186/s12889-021-11640-9

59. Carvalho CA de, Fonsêca PC de A, Nobre LN, Priore SE, Franceschini S do CC, Fonseca PC, et al. [Methods of a posteriori identification of food patterns in Brazilian children: a systematic review]. Cien Saude Colet [Internet]. 2016 Jan 1 [cited 2023 Feb 22];21(1):143–54. Available from: http://dx.doi.org/10.1590/1413-81232015211.18962014

60. Roßbach S, Diederichs T, Nöthlings U, Buyken AE, Alexy U, Rossbach S, et al. Relevance of chronotype for eating patterns in adolescents. Chronobiol Int [Internet]. 2018 Mar 4 [cited 2021 Apr 25];35(3):336–47. Available from: http://dx.doi.org/10.1080/07420528.2017.1406493

61. Hassan BK, Cunha DB, Santos RDO, Baltar VT. Breakfast patterns and weight status among adolescents: a study on the Brazilian National Dietary Survey 2008–2009. British Journal of Nutrition [Internet]. 2022 May 28 [cited 2024 Jan 30];127(10):1549–56. Available from: https://doi.org/10.1017/S0007114521002403

62. Yang Y, Li SX, Zhang Y, Wang F, Jiang DJ, Wang SJ, et al. Chronotype is associated with eating behaviors, physical activity and overweight in school-aged children. Nutr J [Internet]. 2023 Dec 1 [cited 2024 Sep 12];22(1):1–9. Available from: https://doi.org/10.1186/s12937-023-00875-4

63. Kupek E, Lobo AS, Leal DB, Bellisle F, de Assis MA. Dietary patterns associated with overweight and obesity among Brazilian schoolchildren: an approach based on the time-of-day of eating events. Br J Nutr [Internet]. 2016;116(11):1954–65. Available from: http://dx.doi.org/10.1017/s0007114516004128

64. Peng Y, Arboleda-Merino L, Arrona-Palacios A, Cantoral A, Tellez Rojo MM, Peterson KE, et al. The Impact of the Double School Shift System on Lifestyle Behaviors Among Mexican Adolescents. Journal of Adolescent Health [Internet]. 2024 Jun 1 [cited 2024 Sep 13];74(6):1164–74. Available from: https://doi.org/10.1016/j.jadohealth.2024.01.026

65. Malheiros LEA, da Costa BGG, Lopes MVV, Silva KS. School schedule affects sleep, but not physical activity, screen time and diet behaviors. Sleep Med [Internet]. 2021 Sep 1 [cited 2024 Sep 8];85:54–9. Available from: https://pubmed.ncbi.nlm.nih.gov/34274812/

https://doi.org/10.1017/S0007114524002617 Published online by Cambridge University Press

66. Monteiro LS, Rodrigues PRM, de Vasconcelos TM, Sperandio N, Yokoo EM, Sichieri R, et al. Snacking habits of Brazilian adolescents: Brazilian National Dietary Survey, 2017–2018. Nutr Bull [Internet]. 2022 Dec 1 [cited 2023 Nov 2];47(4):449–60. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/nbu.12586

67. Croce CM, Fisher JO, Coffman DL, Bailey RL, Davey A, Tripicchio GL. Association of weight status with the types of foods consumed at snacking occasions among US adolescents. Obesity [Internet]. 2022 Dec 1 [cited 2024 Sep 13];30(12):2459–67. Available from: https://doi.org/10.1002/oby.23571

68. da Costa FF, de Assis MAA, Leal DB, Campos VC, Kupek E, Conde WL. Mudanças no consumo alimentar e atividade física de escolares de Florianópolis, SC, 2002 - 2007. Rev Saude Publica [Internet]. 2012 Dec [cited 2024 Sep 13];46(SUPPL.1):117–25. Available from: https://doi.org/10.1590/S0034-89102012005000058

69. Galego CR, D'Avila GL, de Vasconcelos F de AG. Factors associated with the consumption of fruits and vegetables in schoolchildren aged 7 to 14 years of Florianópolis, South of Brazil. Revista de Nutrição [Internet]. 2014 [cited 2024 Sep 13];27(4):413–22. Available from: https://doi.org/10.1590/1415-52732014000400003

70. Vilela S, Oliveira A, Severo M, Lopes C. Chrono-Nutrition: The Relationship between Time-of-Day Energy and Macronutrient Intake and Children's Body Weight Status. J Biol Rhythms [Internet]. 2019 Jun 1 [cited 2024 Sep 13];34(3):332–42. Available from: https://doi.org/10.1177/0748730419838908

71. Pot GK. Sleep and dietary habits in the urban environment: the role of chrono-nutrition. Proceedings of the Nutrition Society [Internet]. 2018 Aug 25 [cited 2024 Sep 13];77(3):189–98. Available from: https://doi.org/10.1016/j.jadohealth.2024.01.026

72. Patterson E, Warnberg J, Kearney J, Sjostrom M. The tracking of dietary intakes of children and adolescents in Sweden over six years: the European Youth Heart Study. Int J Behav Nutr Phys Act [Internet]. 2009;6:91. Available from: http://dx.doi.org/10.1186/1479-5868-6-91