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# Association between Processed Food Consumption and Sleep Quality in Children: A Cross-Sectional Study in Schools

# *Associação entre o Consumo de Alimentos Processados e a Qualidade do Sono em Crianças: Estudo Transversal em Escolas*

Matilde de Albergaria Sousa Gomes

**ORIENTADO POR: DRA. ARIANA COSTA**
**COORIENTADO POR: MESTRE JULIANA MARTINS**

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**Abstract and Keywords**

This cross-sectional study aimed to investigate the relationship between processed food consumption and sleep quality among school-aged children. Our sample consisted of 137 children, with 52.6% being girls and having a mean age of 7.9 ± 1.2 years. Moreover, 40.2% of children had overweight and 35.9% had experienced sleep problems.

Dietary intake was evaluated using two non-consecutive 24-hour recalls, and foods were categorized according to the NOVA classification system. The amount of sweet snacks consumed, in grams, was also recorded for each meal and throughout the day. Sleep quality was assessed using the Portuguese Children's Sleep Habits Questionnaire (CSHQ-PT).

The study found a significant and positive association between the sleep habits score and daily sweet snack consumption (0.035; 95% CI: 0.011, 0.059). Additionally, a significative positive association was observed between problem sleepers and the percentage of total energy intake from ultra-processed foods (OR: 1.043; 95% CI: 1.004, 1.084), as well as the total daily consumption of sweet snacks (OR: 1.016; 95% CI: 1.006, 1.026), and particularly during morning and afternoon snack times (OR: 1.018; 95% CI: 1.002, 1.033).

These findings underscore the importance of addressing dietary patterns on children's sleep quality. Future interventions should account for reducing NOVA 4 and sweet snacks consumption in order to improve sleep quality.

**Keywords:** Processed food consumption, NOVA classification, Dietary patterns, Sleep quality, Children's health

**Resumo e palavras-chave**

Este estudo transversal teve como objetivo investigar a relação entre o consumo de alimentos processados e a qualidade do sono de crianças em idade escolar. A amostra foi constituída por 137 crianças, sendo 52,6% do sexo feminino, com uma média de idades de 7,9 ± 1,2 anos. Além disso, 40,2% destas crianças encontravam-se com excesso de peso e 35,9% apresentavam problemas de sono. A ingestão alimentar foi avaliada através de questionários de 24 horas anteriores em dois dias não consecutivos. A categorização dos alimentos foi feita segundo a classificação NOVA. A quantidade de *snacks* açucarados consumidos, em gramas, foi analisada para cada refeição e ao longo do dia. A qualidade do sono foi reportada pelos pais utilizando o Questionário Português de Hábitos de Sono Infantil (CSHQ-PT). Verificou-se uma associação significativa e positiva entre o *score* de hábitos de sono e o consumo diário de *snacks* açucarados (0,035; 95% IC: 0,011; 0,059). Além disso, observaram-se associações positivas e estatisticamente significativas entre crianças com pior qualidade de sono e a percentagem de ingestão energética total de ultra-processados (OR: 1,043; 95% IC: 1,004, 1,084), bem como o consumo diário total de *snacks* açucarados (OR: 1,016; 95% IC: 1,006, 1,026), e particularmente durante os lanches da manhã e da tarde (OR: 1,018; 95% IC: 1,002, 1,033). Estes resultados sublinham a importância de abordar os padrões alimentares e realizar futuras intervenções, incentivando a redução do consumo de NOVA 4 e snacks açucarados, com o intuito de melhorar a qualidade do sono das crianças.

**Palavras-chave:** Consumo de Alimentos Processados, Classificação NOVA, Padrões Alimentares, Qualidade de Sono, Saúde Infantil

**List of abbreviations, acronyms, and initials**

**CI** – Confidence Interval

**CSHQ-PT -** Children's Sleep Habits Questionnaire – Portuguese Version

**NOVA -** A classification system for food processing levels

**OR -** Odds Ratio

**SD -** Standard Deviation

**TEI -** Total Energy Intake

**UPFs -** Ultra-Processed Foods

**Summary**

## Introduction

Obesity is a pressing public health concern with a complex set of causes, including genetic, environmental, behavioral, and socioeconomic factors. Poor dietary choices, insufficient physical activity, and socioeconomic status all play a role in the prevalence of obesity [1].

The World Health Organization states that 29% of children in Europe are living with overweight, including both overweight and obesity [1]. According to recent data from the 2022 Child Nutrition Surveillance System (COSI Portugal) 31.9% of Portuguese children aged 6 to 8 are, as well, living with overweight. The results also indicate that the prevalence is higher among boys (31%) than girls (28%) in the age interval considered [2].

Research shows that many Portuguese children do not meet the recommended levels of daily physical activity, and families with lower incomes face challenges in maintaining healthy eating habits due to financial limitations and limited access to nutritious foods [3, 4].

Changes in lifestyles in the past few decades have altered dietary patterns, resulting in increased consumption of highly processed foods and a decrease in the intake of fresh and minimally processed foods. In this context, epidemiologists developed the NOVA classification after observing that the rise in obesity and type II diabetes was linked to higher consumption of ultra-processed foods (UPFs). This classification categorizes foods based on their level of processing into four groups: fresh and minimally processed, processed culinary ingredients, processed foods, and UPFs [5].

Studies from Generation XXI cohort have revealed that UPFs account for 30% of total energy in school-age children [4].

As noted earlier, poor dietary habits appear to be directly linked to the development of obesity, and there is increasing concern in Portugal about children's inadequate diets.

On the other hand, recent research has started to reveal their potential impact on another crucial aspect of health: sleep, especially in children [6, 7].

Sleep plays a crucial role in growth, cognitive development, and overall well-being [8]. Inadequate or poor-quality sleep can result in various adverse outcomes, including impaired learning and memory, heightened risk of obesity, and emotional issues. Parents report that 10-75% of children globally experience sleep difficulties, which can range from temporary benign behavioral problems to more chronic and severe conditions like sleep apnea syndromes [9-11].

Given the paramount significance of sleep for children, comprehending the potential disruptors is important [12].

The link between dietary patterns and sleep has been explored, and evidence has revealed that high consumption of UPFs is associated with poor sleep outcomes [13]. Notably, the high glycemic load and vitamin deficiency common in many UPFs may contribute to increased wakefulness and decreased sleep efficiency in children [14, 15].

Therefore, eating habits and sleep are important factors to consider concerning children’s health, so it is essential to evaluate the relationship between these two parameters.

**Objective**

This study aimed to estimate the association between processed food consumption and sleep quality in children.

## Methods

### Study Design

This is a cross-sectional study that used a sub-sample of the BeE-school project, which involved primary schools situated in regions facing economic and social challenges, including poverty and social exclusion, making them particularly vulnerable.

### Ethics

The study received approval from the schools where it was conducted and from the Ethics Committee for Research in Life and Health Sciences at the University of Minho - CEICVS 009/2022. Before participating in data collection, parents provided informed consent following the ethical standards outlined in the Declaration of Helsinki, and children provided oral assent.

### Dietary Assessment

The dietary intake information was collected by trained researchers through two non-consecutive 24-hour recalls and did not include non-typical days, such as weekends. Children provided detailed descriptions of their eating occasions, including the time and place of consumption, a detailed description of the food or beverages, the quantity consumed, and the brand of manufactured foods.

A picture booklet was used to identify portion sizes, and when that was not possible, the Weights and Portions Manual [16] was used to estimate them. Energy and nutrient intake were estimated using the Food Processor Software. If nutritional information was not available, it was obtained from food labels on supermarket sites.

To address missreporters we exclude those with daily energy intake under 500 and upper 3500 kcal [17] and those who did not report lunch or dinner.

Food and beverage items were categorized into groups based on the NOVA food classification system, considering the nature, extent, and purpose of industrial processing [18, 19]. This classification system offers a comprehensive framework by classifying food items into four main groups according to the level and intention of their industrial processing rather than their nutritional value. (1) Unprocessed or minimally processed foods: This group includes natural foods that have undergone minimal processing such as cleaning, chilling, and pasteurization (e.g. fresh fruits, vegetables, nuts, and meats); (2) Processed culinary ingredients: These are derived from unprocessed or minimally processed foods through processes like pressing or refining and are used for food preparation (e.g. oils, fats, sugar, and salt); (3) Processed foods: This category encompasses foods that have been modified through methods such as adding salt, sugar, or oil to enhance their shelf life or taste while retaining the basic identity and nutritional properties of the original food (e.g. canned vegetables, fruits in syrup, cheeses, and freshly made bread); (4) Ultra-processed foods (UPFs): UPFs result from extensive industrial processes, often containing additives and preservatives and little to no whole foods (e.g. soft drinks, packaged snacks, reconstituted meat products, and pre-prepared frozen meals).

According to the NOVA classification system, we have identified 498 foods, 149 in NOVA 1, 14 in NOVA 2, 90 in NOVA 3, and 245 in NOVA 4. To calculate the percentage of energy from each NOVA group, we divided the energy content of each group by the total energy intake.

A sweet snacks group was created with all identified foods that contained: Added sugar; Honey, molasses and syrup; Fruit jams, jams and marmalade; Candies and gummies; Chocolates and chocolate snacks; Ice creams; Sweet desserts; Cakes (cakes, pies, croissants, etc.); Commercial biscuits and biscuits.

Three variables were also created to describe their consumption per meal (breakfast, morning and afternoon snack, dinner and evening snack) for a more detailed analysis.

**Sleep Quality Assessment**

To assess the sleep habits of the children participating in our study, we utilized the Portuguese Children's Sleep Habits Questionnaire (CSHQ-PT). The CSHQ-PT is a validated parent-reported instrument specifically adapted for Portuguese-speaking populations. It is designed to evaluate various dimensions of sleep habits in children aged 4 to 10 years, providing a comprehensive overview of sleep-related issues. The score of the questionnaire (sleep habits score) was calculated by summing the 33 items. Higher scores indicate a higher frequency of sleep problems [(20)]. The cutoff point of 48 or higher was defined to identify problem sleepers and non-problem sleepers (< 48) [(21)].

**Anthropometric Measurements**

At their schools, participants' height and weight were measured by trained researchers using standardized methods. The measurements were taken with the participants barefoot and dressed in light clothing. Weight was measured with a pediatric scale (SECA 799) and noted to the nearest 100 grams. Body Mass Index

was calculated and then converted into standard deviation (SD) scores, adjusted for age and sex, using the World Health Organization growth reference [22].

**Sociodemographic Characteristics**

Sociodemographic data were collected, including the child's sex and birth date. The parent's highest level of education was self-reported and categorized into three groups: elementary (≤9 years), high school (10-12 years), and higher education (>12 years). Additionally, household income was evaluated and divided into four categories: less than 1000, 1001-1500, 1501-2000 and over 2001 euros per month.

**Statistical analysis**

The participants' characteristics are presented for the whole sample and by sex as absolute and relative frequencies for categorical variables and as mean ± standard deviation for normal-distributed continuous variables. Skewness and kurtosis coefficients were used to check the normality of continuous variables.

Differences between groups were assessed using the student's t-test for independent and continuous normally distributed variables and the Chi-squared test for categorical variables.

Generalized linear models were performed to investigate the association between the proportion of total energy intake, according to processing group (unprocessed or minimally processed; culinary ingredients; processed foods; ultra-processed foods), sweet snacks consumption (total and per meal) and sleep habits score.

Binary logistic regression models were employed to estimate the associations between sleep habits (outcome), the total energy intake of NOVA groups, and sweet snacks consumption (predictors).

For all analyses, a crude univariate and multivariate model adjusted for age, sex, household income, and the highest parent's education level was conducted.

The data are expressed as regression coefficients (B) in generalized linear model and odds ratio (OR) in binary logistic, with their respective 95% confidence intervals (CI 95%) and p-values. All analyses were performed using the Statistical Package for the Social Sciences (SPSS, Inc. Chicago, IL, USA, version 29.0), with a significance level of $p < 0.05$.

**Results**

The main characteristics of participants (n = 137) are presented in Table 1. The mean age of children was 7.9 ± 1.2 years, and 52.6% (n = 72) were girls. As can be seen, 40.2% of the children presented weight above the normal, 26.3% had overweight and 13.9% had obesity, with a higher prevalence in boys (18.5%).

The mean total energy intake (TEI) per day was 1967.1 ± 530.8, with higher values observed in boys (2050.2 ± 539.7) than in girls (1892.1 ± 515.0).

In addition, the mean intake from children's diet for unprocessed or minimally processed foods (NOVA 1) was 49.6%, culinary ingredients (NOVA 2) was 2.2%, processed foods (NOVA 3) was 21.5% and ultra-processed foods (NOVA 4) was 26.7%. No significant differences were found among girls and boys for the contribution of each NOVA group.

**Table 1.** Summary of participants' characteristics by sex

| Variables | Total | Girls | Boys | *p*-Value |
|---|---|---|---|---|
| **Age, mean ± SD** | 7.9 ± 1.2 | 7.9 ± 1.2 | 7.8 ± 1.1 | 0.726 [1] |
| **Weight status, n (%)** | | | | |
| Underweight | 1 (0.7) | 1 (1.4) | 0 (0) | |
| Healthy weight | 81 (59.1) | 40 (55.6) | 41 (63.1) | |
| Overweight | 36 (26.3) | 24 (33.3) | 12 (18.5) | 0.112 [2] |
| Obesity | 19 (13.9) | 7 (9.7) | 12 (18.5) | |
| **TEI (kcal/day), mean ± SD** | 1967.1±530.8 | 1892.1±515.0 | 2050.2±539.7 | 0.082 [1] |
| **Sweet snacks (grams), mean ± SD** | 76.3±65.0 | 78.7±70.7 | 73.7±58.5 | 0.651 [1] |
| **NOVA Groups (% TEI), mean ± SD** | | | | |
| NOVA 1 | 49.6±14.7 | 49.3±15.2 | 49.9±14.2 | 0.817 [1] |
| NOVA 2 | 2.2±2.6 | 2.2±2.6 | 2.1±2.5 | 0.926 [1] |
| NOVA 3 | 21.5±11.6 | 20.7±11.0 | 22.4±12.3 | 0.403 [1] |
| NOVA 4 | 26.7±14.4 | 27.8±15.4 | 25.6±12.4 | 0.363 [1] |
| **Sleep habits score, mean ± SD** | 46.0±6.8 | 45.6±6.5 | 45.4±7.2 | 0.458 [1] |
| Missings | 59 | 30 | 29 | |
| **Sleep habits, n (%)** | | | | |
| Non-problem sleepers | 50 (64.1) | 25 (59.5) | 25 (69.4) | |
| Problem sleepers | 28 (35.9) | 17 (40.5) | 11 (30.6) | 0.363 [2] |
| Missings | 59 | 30 | 29 | |
| **Parent's education level, n (%)** | | | | |
| Elementary | 15 (13.6) | 8 (13.8) | 7 (13.5) | |
| High School | 43 (39.1) | 22 (37.9) | 21 (40.4) | 0.965 [2] |
| Bachelor's degree or higher | 52 (47.3) | 28 (48.3) | 24 (46.2) | |
| Missings | 27 | 14 | 13 | |
| **Household income, n (%)** | | | | |
| <1000 | 22 (22.0) | 12 (54.5) | 10 (45.5) | |
| 1001-1500 | 35 (35.0) | 17 (48.6) | 18 (51.4) | 0.408 [2] |
| 1501-2000 | 26 (26.0) | 12 (46.2) | 14 (53.8) | |
| >2001 | 17 (17.0) | 12 (70.6) | 5 (29.4) | |
| Missings | 37 | 19 | 18 | |

[1] Independent sample t-test was used for continuous normally distributed variables; [2] $X^2$-square test was used for categorical variables; Notes: % percentage.

In terms of sweet snacks, our population consumed around 76.3 ± 65.0 grams per day, with higher consumption in the girl's group (78.7 ± 70.7 grams).

The mean sleep habits score was 45.6 ± 6.5 and 45.4 ± 7.2 for girls and boys, respectively and 35.9% of children were classified as problem sleepers, with no significant differences found between boys and girls.

Additionally, parent's education level and household income were also inquired, with most having completed high school (39.1%) or a higher degree (47.3%), and 35% having an income of 1001-1500€.

Table 2 presents the association between energetic contribution to total energy intake of NOVA groups, sweet snacks consumption and sleep habits score.

**Table 2.** Association between energetic contribution to total energy intake of NOVA groups, sweet snacks consumption and sleep habits score.

| Variables | Unadjusted Analysis | | Adjusted Analysis * | |
|---|---|---|---|---|
| | B (95% CI) | *p*-Value | B (95% CI) | *p*-Value |
| **NOVA Groups (% TEI)** | | | | |
| NOVA 1 | -0.082 (-0.190;0.025) | 0.132 | -0.094 (-0.198;0.011) | 0.080 |
| NOVA 2 | -0.266 (-0.817;0.286) | 0.345 | -0.157 (-0.711;0.396) | 0.577 |
| NOVA 3 | -0.030 (-0.170;0.109) | 0.670 | 0.002 (0.136;0.140) | 0.979 |
| NOVA 4 | **0.115 (0.007;0.224)** | **0.036** | 0.106 (-0.002;0.140) | 0.055 |
| **Sweet snacks (g)** | | | | |
| Total | **0.034 (0.010;0.058)** | **0.006** | **0.035 (0.011;0.059)** | **0.005** |
| Breakfast | 0.033 (-0.302;0.098) | 0.322 | 0.051 (-0.015;0.117) | 0.127 |
| Morning and Afternoon snack | 0.033 (-0.008;0.740) | 0.114 | 0.035 (-0.007;0.076) | 0.100 |
| Dinner and Evening snack | 0.023 (-0.025;0.700) | 0.347 | 0.025 (-0.023;0.073) | 0.306 |

Generalized linear models were employed to estimate the associations between sleep habits score, the total energy intake of NOVA groups and sweet snacks consumption. Notes: %—percentage; B —coefficient.
*Adjusted for sex, age, highest parent's education level and household income.

For each increase of 1 % of TEI in the consumption of foods from the NOVA 4 group, there was an increase of 0.115 (95% CI: 0.007; 0.224) in the sleep habits score, only in the non-adjusted model. Regarding sweet snacks consumption and sleep

habits score, the unadjusted and adjusted results, also in Table 2, revealed that for each increase of 1 g in the total daily consumption, the sleep habits score increased by 0.034 (95% CI: 0.010; 0.058). However, no significant associations were found between sweet snacks consumption per meal and sleep habits score. Finally, when the model was adjusted, the association remained significant (0.035; 95% CI: 0.011; 0.059).

The association between energetic contribution to the total energy intake of NOVA groups and sweet snacks consumption and children's sleep quality is presented in Table 3. Children with a higher energy contribution of ultra-processed foods (NOVA 4) had higher odds of achieving poor sleep quality (OR: 1.042; 95% CI: 1.004; 1.081). After adjustment for sex, age, parent's education level and household income, the same significant association was observed (OR: 1.043; 95% CI: 1.004; 1.084).

**Table 3.** Association between energetic contribution to total energy intake of NOVA groups, sweet snacks consumption and sleep habits.

| Variables | Unadjusted Analysis | | Adjusted Analysis * | |
|---|---|---|---|---|
| | Problem sleepers OR (95% CI) | *p*-Value | Problem sleepers OR (95% CI) | *p*-Value |
| **NOVA Groups (%TEI)** | | | | |
| NOVA 1 | 0.970 (0.937;1.005) | 0.096 | 0.968 (0.933;1.004) | 0.078 |
| NOVA 2 | 0.893 (0.735;1.085) | 0.254 | 0.882 (0.720;1.082) | 0.229 |
| NOVA 3 | 0.992 (0.950;1.036) | 0.728 | 0.996 (0.953;1.042) | 0.871 |
| NOVA 4 | **1.042 (1.004;1.081)** | **0.031** | **1.043 (1.004;1.084)** | **0.032** |
| **Sweet snacks (g)** | | | | |
| Total | **1.015 (1.005;1.025)** | **0.002** | **1.016 (1.006;1.026)** | **0.003** |
| Breakfast | 1.011 (0.992;1.032) | 0.262 | 1.013 (0.992;1.034) | 0.224 |
| Morning and Afternoon snack | **1.017 (1.002;1.031)** | **0.023** | **1.018 (1.002;1.033)** | **0.022** |
| Dinner and Evening snack | 1.013 (0.997;1.029) | 0.102 | 1.012 (0.997;1.028) | 0.118 |

Binary logistic regression models were employed to estimate the associations between sleep habits, the total energy intake of NOVA groups and sweet snacks consumption. Notes: %—percentage.
*Adjusted for sex, age, parent's education level and household income.

As shown in Table 3, an increased total daily consumption of sweet snacks, especially in the morning and afternoon snack, is associated with a higher likelihood of having a lower sleep quality (OR: 1.015; 95% CI: 1.005; 1.025) and (OR: 1.017; 95% CI: 1.002; 1.031), respectively. These results remained after adjustment for all the confounders previously mentioned (OR: 1.016; 95% CI: 1.006; 1.026) and (OR: 1.018; 95% CI: 1.002; 1.033).

**Discussion**

The study identified a positive association between the sleep habits score and daily sweet snack consumption. Additionally, a positive link was observed between problem sleepers and the percentage of total energy intake from ultra-processed foods, as well as the total daily consumption of sweet snacks, particularly during morning and afternoon snack times. As far as we know, very few studies have reported whether these two dietary factors are associated with the sleep quality of children aged 5 to 11. In accordance with our findings, and despite the differences in population for outcome assessment, other studies have suggested the adverse impact of a diet high in ultra-processed and sugary foods on sleep quality [23, 24].

A systematic review conducted to evaluate the association between dietary patterns and sleep among children and adolescents verified that long sleep duration and better sleep quality were consistently associated with healthy dietary patterns [25]. A previous study found that children who reported difficulty waking up in the morning tended to consume energy-rich foods more frequently and nutrient-dense foods less frequently [26]. This study also showed that children who consumed energy-rich foods were more likely to report feeling tired during

the day. Chaput et al. [27] analyzed the association between sleep efficiency and dietary pattern score in children aged 9 to 11 and found that shorter sleep duration and poorer sleep efficiency were associated with unhealthy eating patterns. Moreira et al. [28] identified 8 patterns from an 86-item FFQ in children aged 5-10 and established a link with sleep duration, being negatively associated with fast food, sugar-sweetened beverages, and pastry.

Despite the fact that none of the studies mentioned specifically refer to “ultra-processed” or “NOVA 4,” given that these food groups are products of extensive industrial processes and contain minimal to no whole foods, it is plausible to suggest that they could be classified as such [29].

Our analysis revealed that 26.7% of the children's dietary energy came from NOVA 4, which is lower than in other populations. In a Brazilian sample, UPFs contribute approximately 48% of the total energy intake at age 8 [30], while in Belgian children aged 3 to 9, UPFs contribute around 33% [31]. A previous study, with subjects who were the same age or younger as ours, followed the same classification for food and used data from the Generation XXI cohort, found a high energy contribution from NOVA 1 + NOVA 2 (59.8%), followed by NOVA 4 (29.3%) and NOVA 3 (10.9%). In comparison, our results showed a similar energy contribution from NOVA 1 + NOVA 2 and UPF (51.8 and 26.7%, respectively) [4].

Due to advances in food production systems and changes in lifestyle trends, the consumption of ultra-processed foods, including sugary products, has been increasing in Portugal. This has led to a high prevalence of inadequate sugar intake among children [32]. About 72,4% of Portuguese children consume sweet snacks such as candies, chocolates, chewing gums, chocolates, or lollipops up to three times a week [2]. In our research, the average daily intake of this food group was

76.3 grams, identical to the average reported by the National Food, Nutrition and Physical Activity Survey 2015-2016, which also recorded 76.3 grams and included sweets, candies, cakes, and breakfast cereals [33]. Although our sample may not fully represent the broader population, these findings indicate a consistent trend in sugar consumption within this age group.

When analyzing the sleep habits of the evaluated children, we found that 35.9% had poor sleep quality, with a mean score of 46.0. This finding is similar to Silva et al., whose mean score was 45.1 [20].

In our study, those with a higher energy contribution from NOVA 4 and higher consumption of sweet snacks had poor sleep quality. Similar patterns were noted for the sleep habits score, where an increased daily intake of sugary products, particularly during morning and afternoon snacks, was linked to a higher likelihood of a higher score, indicating poorer quality. According to this, other studies found that fast food, sugary drinks, and baked goods were negatively associated with sleep duration and sleep efficiency [27, 28].

The relationship between these dietary factors and the quality of children's sleep may be clarified by several mechanisms. Foods containing high amounts of sugar can cause rapid fluctuations in blood sugar levels, increasing wakefulness and reducing sleep efficiency in children [14]. Moreover, having a diet high in UPFs can lead to nutritional deficiencies that may affect sleep. UPFs are generally low in essential nutrients such as magnesium, vitamin B6, and vitamin D, which have been associated with sleep issues, and a diet lacking these nutrients can disrupt the body's production of melatonin, a hormone that regulates sleep [15]. Also, increased consumption of UPFs is associated with heightened inflammatory responses due to chemical additives and the nutritional composition of these

foods. Elevated levels of inflammatory markers such as C-reactive Protein (CRP) and interleukin-6 (IL-6) have been linked to sleep disturbances [34].

These findings are significant because sleep deprivation has been related to higher rates of overweight and obesity, increased body fat, and elevated hunger and appetite levels [35].

To our knowledge, this is the first report addressing the associations between processed food consumption and sleep quality in vulnerable contexts. Nevertheless, it's important to recognize the study's limitations. Some children provided only one 24-hour recall, yet the average total energy intake did not significantly differ from those who provided two recalls. Additionally, there were missing responses to the sleep habits questionnaire, as well as information on parent's education and household income, resulting in some missing data in our study.

Despite controlling for sex, age, parent's education level, and household income in our analyses, the relatively small sample size restricts our ability to include a wider range of socioeconomic factors and other variables. We believe that this study represents an important effort within these age groups. A significant strength of our research is the application of food groups based on NOVA classification to delineate dietary patterns. This methodology enables the identification of dietary patterns according to both the types of food and their degree of processing. Additionally, we used the Children's Sleep Habits Questionnaire, which has been validated for Portugal and possesses suitable psychometric characteristics for screening sleep problems in children from 2 to 10 years old [20]. Finally, we assessed not only the overall daily intake of sweet snacks but also their consumption at individual meals, which led us to find a positive

association with poor sleep quality. Such an approach can contribute to the development of other studies that assess causality between food consumption according to the degree of processing and sleep quality.

## Conclusion

The results indicate that a higher intake of ultra-processed foods and sugary products, particularly during morning and afternoon snacks, is linked to poorer sleep quality. To enhance children's sleep health and overall well-being, it is essential to address their dietary habits. Future research should further examine these associations to formulate effective dietary guidelines and public health strategies aimed at reducing the consumption of ultra-processed foods and promoting healthier sleep patterns among children.

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**References**


1. World Health Organization. Obesity and overweight. 2020.
2. WHO Regional Office for Europe. Report on the fifth round of data collection, 2018–2020: WHO European Childhood Obesity Surveillance Initiative (COSI). Copenhagen; 2022.
3. Gomes TN, Katzmarzyk PT, dos Santos FK, Souza M, Pereira S, Maia JA. Overweight and obesity in Portuguese children: prevalence and correlates. Int J Environ Res Public Health. 2014; 11(11):11398-417.
4. Vedovato GM, Vilela S, Severo M, Rodrigues S, Lopes C, Oliveira A. Ultra-processed food consumption, appetitive traits and BMI in children: a prospective study. Br J Nutr. 2021; 125(12):1427-36.
5. Fardet A. Chapter Three - Characterization of the Degree of Food Processing in Relation With Its Health Potential and Effects. In: Toldrá F, editor. Advances in Food and Nutrition Research. Academic Press; 2018. 85, p. 79-129.
6. Owens J. Insufficient sleep in adolescents and young adults: an update on causes and consequences. Pediatrics. 2014; 134(3):e921-32.
7. Shochat T, Cohen-Zion M, Tzischinsky O. Functional consequences of inadequate sleep in adolescents: a systematic review. Sleep Med Rev. 2014; 18(1):75-87.
8. Gruber R, Cassoff J. The interplay between sleep and emotion regulation: conceptual framework empirical evidence and future directions. Curr Psychiatry Rep. 2014; 16(11):500.
9. Petry C, Pereira MU, Pitrez PM, Jones MH, Stein RT. The prevalence of symptoms of sleep-disordered breathing in Brazilian schoolchildren. J Pediatr (Rio J). 2008; 84(2):123-9.
10. Mindell JA, Owens J, Alves R, Bruni O, Goh DY, Hiscock H, et al. Give children and adolescents the gift of a good night's sleep: a call to action. Sleep Med. 2011; 12(3):203-4.
11. Moore M, Allison D, Rosen CL. A review of pediatric nonrespiratory sleep disorders. Chest. 2006; 130(4):1252-62.
12. Touchette E, Petit D, Séguin JR, Boivin M, Tremblay RE, Montplaisir JY. Associations between sleep duration patterns and behavioral/cognitive functioning at school entry. Sleep. 2007; 30(9):1213-9.
13. Naveed S, Lakka TA, Haapala E. An Overview on the Associations between Health Behaviors and Brain Health in Children and Adolescents with Special Reference to Diet Quality. International Journal of Environmental Research and Public Health. 2020; 17:953.
14. Chaput JP, Gray CE, Poitras VJ, Carson V, Gruber R, Olds T, et al. Systematic review of the relationships between sleep duration and health indicators in school-aged children and youth. Appl Physiol Nutr Metab. 2016; 41(6 Suppl 3):S266-82.
15. Grandner MA. Sleep, Health, and Society. Sleep Med Clin. 2017; 12(1):1-22.
16. Goios A, Oliveira A, Afonso C, Amaral T. Pesos e Porções de Alimentos. 3rd ed.: U. Porto Press; 2021.
17. Willett W. Nutritional Epidemiology (Monographs in Epidemiology and Biostatistics). Oxford University Press; 2013.
18. Monteiro CA, Cannon G, Levy RB, Moubarac JC, Louzada ML, Rauber F, et al. Ultra-processed foods: what they are and how to identify them. Public Health Nutr. 2019; 22(5):936-41.

19. Monteiro CA, Cannon G, Moubarac JC, Levy RB, Louzada MLC, Jaime PC. The UN Decade of Nutrition, the NOVA food classification and the trouble with ultra-processing. Public Health Nutr. 2018; 21(1):5-17.
20. Silva FG, Silva CR, Braga LB, Neto AS. Portuguese Children's Sleep Habits Questionnaire - validation and cross-cultural comparison. J Pediatr (Rio J). 2014; 90(1):78-84.
21. Parreira AF, Ribeiro F, Silva FG. Validação Clínica da Versão Portuguesa do Questionário de Hábitos de Sono das Crianças (CSHQ-PT) em Crianças com Perturbações do Sono e PHDA [Clinical Validation of The Portuguese Version of the Children's Sleep Habits Questionnaire (CSHQ-PT) in Children with Sleep Disorder and ADHD]. Acta Med Port. 2019 Mar 29
22. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ. 2007; 85(9):660-7.
23. Katagiri R, Asakura K, Kobayashi S, Suga H, Sasaki S. Low intake of vegetables, high intake of confectionary, and unhealthy eating habits are associated with poor sleep quality among middle-aged female Japanese workers. J Occup Health. 2014; 56(5):359-68.
24. Sousa RDS, Bragança M, Oliveira BR, Coelho C, Silva A. Association between the Degree of Processing of Consumed Foods and Sleep Quality in Adolescents. Nutrients. 2020; 12(2)
25. Alibabaei Z, Jazayeri S, Vafa M, Feizy Z, Sajadi Hezaveh Z. The association between dietary patterns and quality and duration of sleep in children and adolescents: A systematic review. Clinical Nutrition ESPEN. 2021; 45:102-10.
26. Westerlund L, Ray C, Roos E. Associations between sleeping habits and food consumption patterns among 1011-year-old children in Finland [Article]. British Journal of Nutrition. 2009; 102(10):1531-37.
27. Chaput JP, Katzmarzyk PT, LeBlanc AG, Tremblay MS, Barreira TV, Broyles ST, et al. Associations between sleep patterns and lifestyle behaviors in children: an international comparison. International Journal of Obesity Supplements. 2015; 5(2):S59-S65.
28. Moreira P, Santos S, Padrão P, Cordeiro T, Bessa M, Valente H, et al. Food Patterns According to Sociodemographics, Physical Activity, Sleeping and Obesity in Portuguese Children. International Journal of Environmental Research and Public Health. 2010; 7(3):1121-38.
29. Monteiro CA, Cannon G, Levy RB, Moubarac J-C, Louzada MLC, Rauber F, et al. Ultra-processed foods: what they are and how to identify them. Public Health Nutrition. 2019; 22(5):936-41.
30. Costa CS, Del-Ponte B, Assunção MCF, Santos IS. Consumption of ultra-processed foods and body fat during childhood and adolescence: a systematic review. Public Health Nutr. 2018; 21(1):148-59.
31. Vandevijvere S, De Ridder K, Fiolet T, Bel S, Tafforeau J. Consumption of ultra-processed food products and diet quality among children, adolescents and adults in Belgium. Eur J Nutr. 2019; 58(8):3267-78.
32. Bento A, Gonçalves C, Cordeiro T, Vaz de Almeida MD. Portugal nutritional transition during the last 4 decades: 1974–2011. Porto Biomedical Journal. 2018; 3(3):e25.
33. Lopes C, Torres D, Oliveira A, Severo M, Alarcão V, Guiomar S, Mota, Teixeira P, Rodrigues S, Lobato L, Magalhães V, Correia D, Carvalho C, Pizarro A, Marques A, Vilela S, Oliveira L, Nicola P, Soares S, Ramos E. . Inquérito Alimentar

Nacional e de Atividade Física, IAN-AF 2015-2016: Relatório de resultados. Universidade do Porto; 2017.
34. St-Onge MP, Wolfe S, Sy M, Shechter A, Hirsch J. Sleep restriction increases the neuronal response to unhealthy food in normal-weight individuals. International Journal of Obesity. 2014; 38(3):411-16.
35. Spiegel K, Tasali E, Leproult R, Van Cauter E. Effects of poor and short sleep on glucose metabolism and obesity risk. Nature Reviews Endocrinology. 2009; 5(5):253-61.