Addictive Behaviors Reports 19 (2024) 100531

Contents lists available at ScienceDirect

Addictive Behaviors Reports

journal homepage: www.elsevier.com/locate/abrep

Review

Dietary intake in children and adolescents with food addiction: A systematic review

Gabriela Carvalho Jurema Santos [a], Matheus Santos de Sousa Fernandes [b], Pacheco Gabriela Carniel [c], Anderson da Silva Garcêz [d], Carol Góis Leandro [a], Raquel Canuto [a,c,*]

[a] Postgraduate Program in Nutrition, Universidade Federal de Pernambuco, Recife, Pernambuco, Brazil
[b] Keizo Asami Institute, Universidade de Federal de Pernambuco, Recife, Pernambuco, Brazil
[c] Postgraduate Program in Food, Nutrition and Health, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil
[d] Postgraduate Program in Nutrition Science, Universidade Federal de Ciências da Saúde de Porto Alegre, Rio Grande do Sul, Brazil

ARTICLE INFO

Keywords:
Childhood obesity
NOVA classification
Ultra-processed food
YFAS-C
Food Addiction

ABSTRACT

Food addiction (FA) is characterized by behavioral changes related to the consumption of palatable foods, marked by dependence, impulsivity, and compulsion. Children and adolescents are more vulnerable to FA owing to their significant consumption of ultra-processed foods. This review aims to investigate the differences in dietary intake in pediatric populations with and without FA. We conducted a systematic literature review. PubMed, ScienceDirect, and PsycINFO databases were searched up to July 2023. Potentially eligible studies were independently checked by two researchers. The methodological quality of the included studies was assessed using the Joanna Briggs Institute Critical Appraisal Checklist for analytical cross-sectional studies. Of the 4868 articles identified, six studies were included. All the included studies had high methodological quality. High consumption of calories and fat was observed in children and adolescents with FA. A diet quality analysis showed that the consumption of ultra-processed foods, such as sugary drinks, sweets, and chips, was related to FA. Given these findings, we concluded that FA in childhood may be associated with higher energy consumption and, consequently, higher intake of macronutrients. Few studies have examined the relationship between FA and food intake in childhood, and more studies are required.

1. Introduction

The concept of food addiction (FA) considers that addictive behavior patterns can occur through exposure to potentially addictive foods in individuals with a predisposition (Hauck et al., 2020; Kalon et al., 2016). Thus, FA involves eating behaviors based on supraphysiological consumption of high-energy and palatable foods (Vasiliu, 2022). Furthermore, the concept of FA encompasses clinical components observed in eating disorders, such as a lack of control and tolerance (Hauck et al., 2020). Nevertheless, distinctions arise in comparison to eating disorders, primarily attributed to the chemical additive component associated with substance use (Schulte et al., 2017).

The Yale FA Scale for Children (YFAS-C) was proposed to identify FA in children and adolescents and was developed as a tool to identify eating patterns like behaviors observed in addiction (Gearhardt et al., 2013). This scale is based on the diagnostic criteria for substance dependence according to the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (Bell, 1994). Studies using the YFAS-C have reported different prevalence rates of FA depending on the evaluated population, ranging from 2.6 % (adolescents) to 71 % (children with overweight and obesity) (Keser et al., 2015; Mies et al., 2017).

Given that children and adolescents are highly exposed to an obesogenic food environment, they could represent a group at increased risk of developing FA (Crane et al., 2023; de Almeida et al., 2021; Schulte & Jacques-Tiura, 2018; Yekaninejad et al., 2021). Population surveys have shown that children's food intake is largely based on ultra-processed foods (UPFs) (Gyimah et al., 2023; Heerman et al., 2023; Oliveira et al., 2020; Parnham et al., 2022; Tucker et al., 2023). UPFs are

Abbreviations: FA, Food addiction; YFAS-C, Yale Food Addiction Scale for Children; UPF, ultra-processed foods.

* Corresponding author at: Postgraduate Program in Food, Nutrition and Health, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil.

E-mail addresses: gabriela.cjsantos@ufpe.br (G.C. Jurema Santos), matheus.sfernandes@ufpe.br (M.S. de Sousa Fernandes), carol.leandro@ufpe.br (C. Góis Leandro), raquel.canuto@ufrgs.br (R. Canuto).

https://doi.org/10.1016/j.abrep.2024.100531
Received 23 October 2023; Received in revised form 20 December 2023; Accepted 22 January 2024
Available online 23 January 2024

industrial formulations that comprise high amounts of substances from foods, including sugar and fats, or synthesized in the laboratory, such as additives and hydrogenated fats (Monteiro et al., 2019). UPFs can represent up to 65.4 % of a child's energy intake (Onita et al., 2021). High consumption of UPFs has been recognized to increase the risk of developing chronic diseases (Lukomskyj et al., 2021; Ribeiro et al., 2022; Sultana et al., 2021; Touvier et al., 2023).

An explanation for these findings lies in the excessive consumption of sugar, fat, and sodium present in UPFs, which can act as a reward system (Bijoch et al., 2023; Edwin Thanarajah et al., 2023). Preclinical studies have shown reduced concentrations and changes in dopamine signaling in the reward system areas (Hamelin et al., 2022). These changes can increase in the search for palatable foods, promoting a deregulation in the control of food intake (Wallace & Fordahl, 2022).

Two systematic reviews presented the differences and association between FA and food consumption in the adult population (Pursey et al., 2021; Reche-García et al., 2022). Their association in the pediatric population has not been systematically summarized. Food intake in this population has particularities that warrant investigation. Thus, this systematic review aims to investigate qualitative and quantitative food intake in the pediatric population with and without FA.

2. Methods

This study was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses and was developed in accordance with the Cochrane guidelines (Higgins & Green, 2008; Page et al., 2021). The protocol for this systematic review was registered in the International Prospective Register of SR-PROSPERO (registration number: CRD42023439440).

2.1. Information sources and search strategy

We conducted a systematic literature search using the PubMed, PsycINFO, and ScienceDirect databases to screen studies published until July 2023. Studies describing the association between FA and food intake in children and adolescents were selected using appropriate search terms considering the Medical Subject Headings (MeSH terms) for databases. In the PubMed database, the search strategy used the following search terms: (((((food addiction) OR (compulsive eating)) OR (eating addiction)) OR (YFAS)) OR (YFAS-C)) AND ((((((((((food intake) OR (dietary intake)) OR (nutrient intake)) OR (ultra-processed food)) OR (diet assessment)) OR (fast food)) OR (food frequency questionnaire)) OR (diet recall)) OR (High Fat Diet)) OR (Energy Intake)). The ages of the children were classified as follows: preschool child: 2–5 years, child: 6–12 years, and adolescent: 13–18 years. Appropriate modifications were made for searches in the ScienceDirect and PsycINFO databases.

2.2. Selection and data collection

Articles were selected in two stages. First, two authors (GCJS and MSSF) independently evaluated the titles and abstracts of the articles. If the abstract contained the necessary information for the inclusion and exclusion criteria, the full text was evaluated for the presence or absence of eligibility criteria. Gray literature was searched on Google search engines using the systematic review search terms, but no studies were added to the manuscript. Duplicates were automatically removed by creating an EndNote® library version 20, Clarivate Analytics, Philadelphia, PA. Discrepancies between evaluators were resolved by consensus.

2.3. Eligibility criteria

Studies that met the eligibility criteria for the Population, Exposure, Comparison, Outcomes, and Study design were included in the study: (1) population: children and adolescents; (2) exposure: FA measured using different versions of the YFAS; (3) comparisons: participants without FA; (4) outcomes: food intake evaluated using the 24-h food recall or food frequency questionnaire; and (5) study design: observational studies. Articles were excluded if (1) they did not use the YFAS; (2) specific samples with associated diseases or interventions were included; and (3) they were opinions, letters, reviews, animal, or experimental studies.

2.4. Data items

A data extraction template was created using Microsoft Excel (version 2021). The two reviewers independently extracted the following information from the selected studies: study characteristics (the first author/year of publication, country of study, study design, and sample size), demographic participant characteristics (age and sex), nutritional status, YFAS version and psychometric properties, prevalence of FA, and the assessment of the quantitative and qualitative food intake.

2.5. Methodological quality assessment

The Joanna Briggs Institute Critical Appraisal Checklist for analytical cross-sectional studies was used to assess the methodological quality of the included studies. This tool consists of eight questions that evaluate methodological criteria: participant selection, confounding factors, and the validity and reliability of the results. The questions were answered with options of "yes, no, or not clear." When the answer was "yes," a score was provided, whereas when the answer was "no" or "not clear," no score was provided. The overall scores for each study were calculated as percentages, and the quality of each study was rated as high (80–100 %), regular (50–79 %), or low (<50 %) (Munn et al., 2017). Two reviewers independently reviewed all the selected studies. Discrepancies between evaluators were resolved by consensus. The materials and analysis codes for this study are available from the corresponding author upon request.

3. Results

3.1. Study selection, study characteristics, and methodological quality within studies

A total of 4868 reports were identified in the PubMed (n = 1449), ScienceDirect (n = 2311), and PsycINFO (n = 1108) databases. Subsequently, 36 reports were removed for duplicates. After reading the titles and/or abstracts, 4650 reports were excluded, leaving 181 articles for further screening. Finally, five studies and six articles were included (Fig. 1).

All studies were cross-sectional. The articles were published between 2015 and 2021. Most studies were conducted in North America (n = 2) and South America (n = 2). The two studies conducted in South America utilized the same sample. The sample size ranged from 70 to 2653 participants. The studies included children and adolescents aged 4–21 years. All articles included both sexes in the analysis. Four studies included only participants with overweight and obesity in their sample (Table 2).

The most used version of the YFAS was the YFAS-C (n = 5). Psychometric properties were assessed using the Cronbach alpha coefficient with a range of 0.59–0.93. The prevalence of FA reported in all articles varied between 2.6 % and 71 % (Table 2).

The methodological quality of the included studies was high (score ≥ 80 %). Most studies presented inclusion criteria, such as sex, age, and filling in questionnaires, and all presented the context of the studies. FA was reliably assessed using valid instruments by trained evaluators. The objectives of this study followed a methodological framework. Most studies used strategies to identify and eliminate confounding factors. The results were reliably validated using appropriate statistics (Table 1).

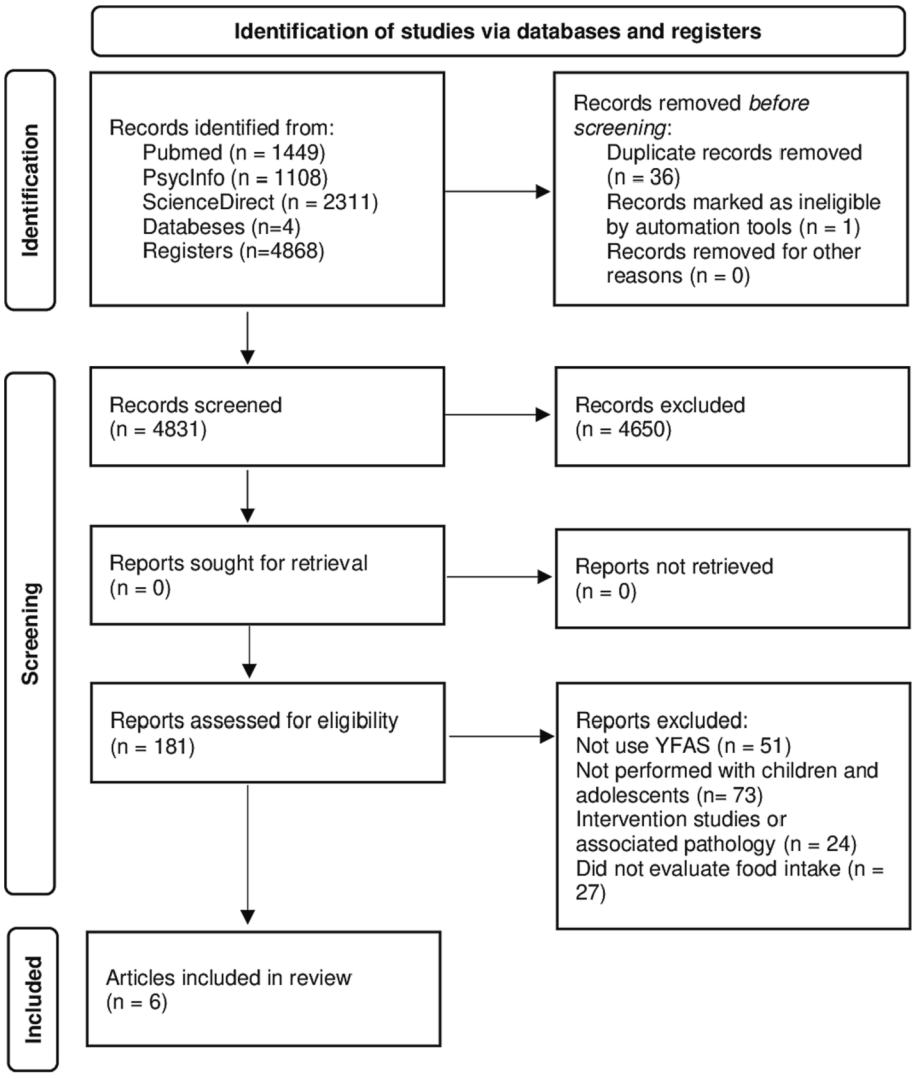

Fig. 1. PRISMA (Preferred Reporting Items for System,atic Reviews and MetaAnalysis) flow chart.

Table 1
Critical appraisal results for included articles using the Joanna Briggs Institute.

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
De Almeida et al., 2021	Y	Y	Y	Y	Y	Y	Y	Y
Filgueiras et al., 2019	Y	Y	Y	Y	Y	Y	Y	Y
Keser et al., 2015	Y	Y	Y	Y	Y	Y	N	Y
Mies et al., 2017	Y	Y	Y	Y	Y	U	N	Y
Richmond et al., 2017	N	Y	Y	Y	Y	U	N	Y
Schulte et al., 2017	Y	Y	Y	Y	Y	N	Y	Y

Y - Yes, N - No, U – Unclear. Q1: Have the criteria for inclusion in the sample been clearly defined?; Q2: Were the study subjects and context described in detail?; Q3: Was exposure measured in a valid and reliable manner?; Q4: Were objective, standard criteria used to measure the condition?; Q5: Confounding factors have been identified?; Q6: Were strategies addressed to deal with confounding factors?; Q7: Were the results measured in a valid and reliable way?; Q8: Was appropriate statistical analysis used?

3.2. Food intake outcomes

Food intake is shown in Table 3. The food frequency questionnaire was the most frequently used instrument for assessment (n = 4). In other studies, consumption was assessed using a daily or weekly list of foods (n = 1) and 24-h food recall (n = 1). In addition, food portion photographic albums were used to quantify the servings. Food intake was evaluated over days, weeks, and months (Table 3).

Food consumption data were evaluated using means of statistical tests of the difference between the mean and median and measures of association. For non-parametric data, the Mann–Whitney *U* test was performed to analyze differences (n = 1). To assess the association between food consumption and FA, Pearson's (n = 1) and Spearman's correlation tests (n = 1), univariate logistic, multiple linear (n = 1), multivariate logistic (n = 1), binary logistic regression (n = 1), and generalized estimation equation (n = 2) were used. Multiple and univariate regression models were adjusted for sex, age, and school attended, as well as sugar, salt, and fat consumption. The generalized estimation equations were adjusted for sex, age, education, weight class, body mass index percentile, and race/ethnicity (Table 3).

Quantitative food intake was evaluated based on the consumption of calories, macronutrients (carbohydrates, proteins, and fats), and micronutrients (sodium) (n = 2). Qualitative food intake was evaluated using the consumption of sugar and UPFs, such as soft drinks, sweetened juices, condiments, desserts, sausages, instant noodles, and fries (n = 4) (Table 3).

Changes in the diets of individuals with FA were observed. The consumption of total calories was associated with FA, and its consumption was higher in children and adolescents with FA (n = 4). The consumption of carbohydrates, protein, total fat, and sodium was associated with FA, and their consumption was higher in individuals

Table 2
Description of articles included in the systematic review (n = 6).

Author, year	Country of study	Sample size (n)	Age (Years old)	Sex (F/M)	Nutritional status	YFAS version	Psychometric properties (α)	FA (%)
De Almeida et al., 2021	Brazil	120	9–11	53.4 % / 46.7 %	Mean BMI/Age Z-score = 1.96; SD 0.68	YFAS-C	0.83	33.4
Filgueiras et al., 2019	Brazil	139	9–11	46.7 % / 53.2 %	56.1 % overweight 36.6 % obese 7.3 % severely obese	YFAS-C	0.83	24
Keser et al., 2015	Turkey	100	10–18	63 % / 37 %	20 % overweight 80 % obese	YFAS	0.93	71
Mies et al., 2017	Holand	2653	14–21	61.3 % / 38.7 %	10.3 % underweight 77 % normal weight 12.7 % overweight	YFAS-C	0.59	2.6
Richmond et al., 2017	USA	70	4–16	42.9 % / 57.1 %	Not informed	YFAS-C	0.84	7.2
Schulte et al., 2017	USA	181	12–16	61.4 % / 38.6 %	BMI > 95th percentile	YFAS-C	0.68	10.1

BMI, Body mass index; FA, food addiction; SD, Standard deviation;YFAS-C, Yale Food Addiction for Childrens; α, Cronbach's alpha test coefficient.

with FA (n = 3), as was sugar consumption (n = 4) when compared to the group without FA.

In relation to diet quality, individuals with FA had a higher consumption of soft drinks, sweetened juices, sauces and condiments, sweetened milk drinks, desserts, cookies, savory biscuits, sausages, corn chips, instant noodles, French fries, and hamburgers (n = 2). Moreover, an association was observed between the consumption of junk food and FA (n = 2). The consumption of calories from UPFs was associated with FA and was higher when comparing the FA and NFA groups (n = 1). No differences were observed in the consumption of minimally processed foods (n = 1). In addition, higher dinner calorie consumption was observed in the FA group (n = 1).

4. Discussion

This systematic review aims to assess food intake in children and adolescents with FA. The main results showed that children and adolescents with FA had a high consumption of foods rich in sugar, fat, and calories. Similarly, when assessing the quality of the diet, we found that FA was associated with higher consumption of UPFs owing to excess calories, sugar, sodium, and fat, giving these foods a high level of palatability (Filgueiras et al., 2019; Monteiro et al., 2019).

The findings of the present systematic review are in line with recent evidence in adults. A *meta*-analysis of six studies identified that adult patients with FA and different nutritional status present higher energy intake and consumption of fat and carbohydrates (including sugars) (Reche-García et al., 2022). In another study that evaluated individuals aged 18–65 years, UPF consumption was a predictive factor for FA, as UPFs are potentially addictive owing to their high sugar content (Freeman et al., 2018; Schulte et al., 2015).

Supraphysiological doses of sugar present in UPFs can promote uncontrolled and unconscious use (Fazzino & Kong, 2023). A preclinical study revealed that the intake of a high concentration of sucrose solution for 1 h on 12 consecutive days causes decreased the density of dopamine D2/D3 receptors in the striatum, nucleus accumbens, thalamus, amygdala, cingulate cortex, and prefrontal cortex (Winterdahl et al., 2019). These neural regions correspond to the reward system. The release of neurotransmitters, including dopamine, in these systems can produce feelings of pleasure and euphoria (Leigh & Morris, 2018).

The lower availability and response of dopaminergic receptors may explain the addictive potential associated with sucrose ingestion, thus increasing tolerance to achieve pleasure or satiety (Winterdahl et al., 2019). In addition, the reward system is stimulated by food intake via anticipatory mechanisms and satiety pathways, and pleasure is an adaptive function that occurs in response to a reward (A. L. Kelly et al., 2022). However, the abundance of pleasure can generate uncompensated responses, promoting changes in food intake (Calcaterra et al., 2023).

In addition to sugar, prolonged consumption of high fat concentrations can increase dopamine levels in the nucleus accumbens, amygdala, and prefrontal cortex, resulting in a high sensation of reward-seeking (Jacques et al., 2019; Lennerz & Lennerz, 2018). An experimental study carried out in young male Sprague–Dawley rats investigated the effect of exposure to a high-fat diet (60 % lipids) for 62 days on dopaminergic modulation in the nucleus accumbens (Plaza-Briceño et al., 2023). In this study, chronic exposure to high lipid concentrations promoted a reduction in dopamine release in the nucleus accumbens, in addition to an increase in body weight and retroperitoneal fat (Plaza-Briceño et al., 2023).

The associated and prolonged consumption of high concentrations of sugar and fat is a nutritional profile observed in UPFs. Several studies have observed that the convergence of peripheral signals from the mutual ingestion of high concentrations of fat and sugar is a possible target of dopaminergic activation (A. G. DiFeliceantonio et al., 2018; Perszyk et al., 2021). A study carried out in 56 eutrophic adult participants reported greater responses in the reward system (the caudate nucleus and putamen) when an association between lipids and fat existed through functional magnetic resonance (Alexandra G DiFeliceantonio et al., 2018). However, these mechanisms have remained unclear (Amber L Kelly et al., 2022).

In contrast to natural foods that are essential for the maintenance of life and do not promote dependence, UPFs are industrial formulations that can aid neural changes, such as drug addiction (Brown et al., 2022; Zawertailo et al., 2020) (Fig. 2). Drugs are substances synthesized in laboratories that result in rewarding responses above their natural mechanisms (Bourdy & Befort, 2023). Similarities in routes of administration, dose, and rate of absorption between drugs and UPFs can generate neuroplastic responses in the nervous system (Amber L Kelly et al., 2022). In childhood, these alterations can promote repercussions, causing changes in food consumption throughout life (Speranza et al., 2021).

This systematic review is the first to summarize the main recent findings on FA and its relationship with food intake in children and adolescents. The obtained results demonstrate the clinical relevance of assessing factors related to addictive behaviors during childhood. Excessive consumption of UPF can have consequences on public health owing to excessive caloric consumption and its consequence on an increase in cases of obesity and metabolic diseases. In addition, the current obesogenic environment associated with the growth and development phases may contribute to the early development of this phenotype.

This review has several limitations. First, the included studies used different assessment methods of food intake. However, the FFQ, the

Table 3
Assessment methods and main results between food addiction and food intake of the articles included in the systematic review.

Author, year	Assessment of food intake	Statistical analysis	Food Intake
De Almeida et al., 2021	Semi-quantitative FFQ and food portion photographic album. Ultra-processed foods were identified according to the NOVA system	Multiple linear regression. The models were adjusted for sex, age, and which school the participant attended.	Total energy: FA β = 145.95, **p = 0.02** Carbohydrates (g/day): FA β = 21.15, **p = 0.02** Protein (g/day): FA β = 3.49, **p = 0.01** Total Fat (g/day): FA β = 5.33, p = 0.08 Total Sugar (g/day): FA β = 14.63, **p = 0.009** Sodium (mg/day): FA β = 196.82, **p = 0.02**
Filgueiras et al., 2019	Semi-quantitative FFQ with 88 food items which evaluated the daily, weekly, and monthly consumption. Food portion photographic album was utilized for the quantification of portions. The FFQ was applied to the child only once. Ultra-processed foods were identified according to the NOVA system.	Univariate logistic and multivariate logistic regression analysis. The models were adjusted for the consumption of sugar, salt, and fat.	Total diet (OD 0.99, 95 % CI 0.94 – 1.03, p = 0.05*) Unprocessed/ minimally processed foods (OD 0.89, 95 % CI 0.73 – 1.09, **p = 0.03***): Ultra-processed food (OD 1.15, 95 % CI 1.01 – 1.31, **p = 0.01***) Soft drinks (kJ/day) UL: OD 1.39, 95 % CI 1.00 – 1.92, **p = 0.03*;** ML: OD 1.26, 95 % CI 0.83 – 1.92, p = 0.05* Sweetened Juices (kJ/day) UL: OD 1.24, 95 % CI 0.08 – 1.97, **p = 0.01*** Sauces and condiments (kJ/day) UL: OD 2.77, 95 % CI 0.34 – 4.83, p = 0.05* Sweetened milk drinks (kJ/day) UL: OD 0.98, 95 % CI 0.35 – 2.75, **p = 0.006*** Desserts (kJ/day) UL: OD 1.16, 95 % CI 0.35 – 2.75, **p = 0.01*** Cookies and savory biscuits (kJ/day) UL: OD 3.43, 95 % CI 1.46 – 8.06, **p = 0.03*;** ML: OD 4.04, 95 % CI 1.27 – 12.85, **p = 0.01*** Sausages (kJ/day) UL: OD 5.90, 95 % CI 0.93 – 37.34, **p = 0.03*;** ML: OD 11.01, 95 % CI 1.22 – 99.01, **p = 0.03*** Corn Chips (kJ/day) UL: OD 0.71, 95 % CI 0.14 – 3.48, **p = 0.02*** Instant noodles (kJ/day) UL: OD 2.01, 95 % CI 0.06 – 63.90, **p = 0.02*.**
Keser et al., 2015	FFQ which evaluated the daily, weekly, and monthly consumption of food groups	Binary logistic regression.	Consumption of French fries ≥ 1–2 times a week: B coefficient = 0.828, **p = 0.007**. Consumption of hamburger ≥ 1–2 times a week: B coefficient = 0.423, p = 0.106.
Mies et al., 2017	Food list based on daily or weekly consumption of sugar consumption through beverages.	Generalized Estimation Equation. The models were adjusted for gender, age, educational level, and weight class.	Sugar through drinks per day: B coefficient = 0.002, **p < 0.0001**, R^2 5 %.
Richmond et al., 2017	R24h using the multiple-pass method and a photo album. Younger children have their food consumption answered by their parents, while older children have answered themselves.	Pearson's correlations. Generalized Estimation Equation. The models were adjusted for BMI percentile, race/ ethnicity, sex, and age.	Total Calories Ordered: r = 0.15; p > 0.05; β = 0.17, p > 0.05. Total Dinner Calories Consumed: r = 0.25; **p < 0.05**; β = 0.25, **p < 0.05**. Total Calories Consumed Post Dinner: r = 0.03, p > 0.05; β = 0.03, p > 0.05. Total Dinner Plus Post-Dinner Calories Consumed: r = 0.23, p > 0.05; β = 0.23, **p < 0.05**.
Schulte et al., 2017	FFQ was to measure foods consumed (65 types of foods and 10 categories of drinks) by participants in the past week.	Mann-Whitney *U* test. Spearman's correlations.	Total calories: U = 794.00, **p = 0.002**; r = 0.23, **p = 0.003**. Total grams of fat: U = 807.00, **p = 0.002**; r = 0.26, **p < 0.001**. Saturated fat grams: U = 826.00, **p = 0.003**; r = 0.25, **p = 0.001**. Trans fat grams: U = 839.00, **p = 0.003**; r = 0.31, **p < 0.001**. Total grams of carbohydrate: U = 783.00, **p = 0.001**; r = 0.20, **p = 0.008**. Total grams of sugar: U = 828.00, **p = 0.003**; r = 0.16, **p = 0.03**. Added teaspoons of sugar: U = 764.50, **p = 0.001**; r = 0.18, **p = 0.01**.

FFQ, food frequency questionnaire; FA, food addiction; NFA, non-food addiction; p*, critical p-value corrected for multiplicity; OR, odds ratio; CI, confidence interval; β, regression coefficient; YFAS-C, yale food addiction scale for children's; R24h, 24-hour food recall; g, grams; KJ, kilojoules; U, U of Mann Whitney; ML, Multivariate logistic regression; UL, Univariate logistic regression.

most used method, proposes to describe the usual diet and is best suited to evaluate general food intake in nutritional epidemiological studies (Cui et al., 2023). Therefore, a coherence between the findings on food consumption can be highlighted between the studies, demonstrating that there is a relationship between the consumption of palatable foods

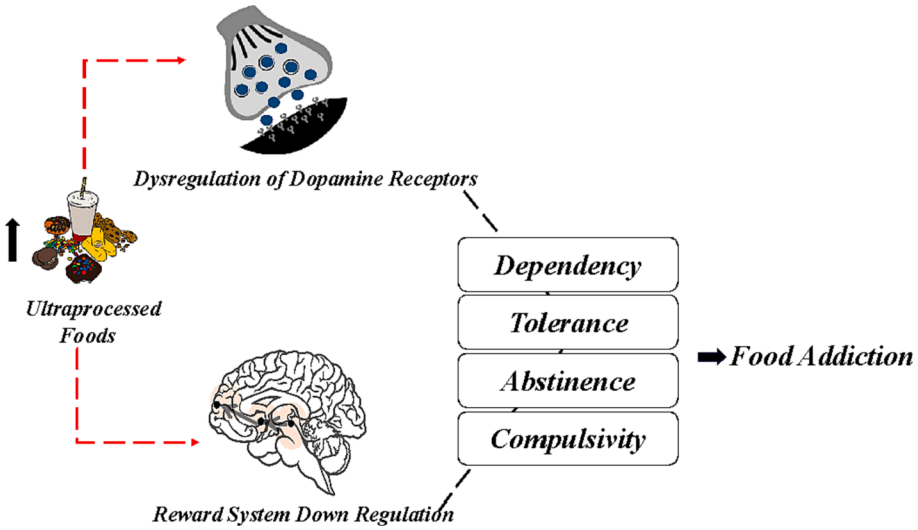

Fig. 2. Physiological mechanisms involved between the consumption of ultra-processed foods and food addiction. Excessive and prolonged consumption of ultra-processed foods is responsible for causing dysregulation in dopamine receptors, through a reduction in their density. In addition, a minor activation of the reward system occurs. With a lower responsiveness of this system, the appearance of symptoms of food addiction is observed.

and FA. Second, subjective methods of assessing food intake were performed in the child population, and few academic studies have investigated this topic. Third, all studies included in this review were cross-sectional. Longitudinal studies are well-known to have good study designs to investigate the temporal relationship between exposure and change in outcome status. The issue of reverse causality is critical because evaluating possible bidirectional associations is important.

Some methodological heterogeneities were observed in the studies, including the utilization of the Yale Food Addiction Scale (YFAS) in child populations and variations in prevalence estimates attributed to the use of clinical samples (de Almeida et al., 2021; Keser et al., 2015). The elevated prevalence of FA observed in the study by Keser et al., which may be attributed to the use of the Yale Food Addiction Scale (YFAS) in child populations, could have biased the results of the association between FA and food consumption (Gearhardt et al., 2009). YFAS-C differs from the adult version due to its use of clear and accessible language designed for children and adolescents, despite assessing the same symptoms and featuring the same number of questions (25 items) (Gearhardt et al., 2013). Additionally, a new updated version of the YFAS-C was developed based on the new DSM-5 diagnostic criteria. However, none of the studies included in this review utilized the new version of the YFAS-C (Horsager et al., 2023).

Finally, the FA encompasses different concepts related to dependence on sugar, fat, and ultra-processed foods (Avena et al., 2008; Sarkar et al., 2019; Wiss, 2022). However, it is an emerging theme, its conceptualization is currently under construction, and there is a necessity for more extensive discussion and a deeper exploration of the theoretical framework of FA.

5. Conclusion

The present systematic review showed that children and adolescents with FA present changes in food consumption, such as high UPF intake, resulting in high consumption of calories, fats, and sugar. This problem could develop in the early stages of life, such as childhood. Thus, this study emphasized the development of addictive behaviors and their repercussions in early life, as well as the need for new perspectives for intervention and changing environments, even in the early stages of life. Further longitudinal studies are warranted to elucidate the relationship between food intake and FA, particularly in children and adolescents. Furthermore, the use of the updated version of YFAS-C could assist in the diagnosis of FA.

Grants and Funding

National Council for Scientific and Technological Development [CNPq: 312079/2018–4 and 306656/2022–1], Coordination for the Improvement of Higher Level or Education Personnel [CAPES: 977/20], the State of Pernambuco Science and Technology Support Foundation [FACEPE, APQ: 0797–4.05/14] and State of Rio Grande do Sul Science and Technology Support Foundation [FAPERGS: 21/2551–0000520-3].

CRediT authorship contribution statement

Gabriela Carvalho Jurema Santos: Methodology, Investigation, Formal analysis. **Matheus Santos de Sousa Fernandes:** . **Pacheco Gabriela Carniel:** Methodology, Investigation, Formal analysis. **Anderson da Silva Garcêz:** Validation, Software, Resources. **Carol Góis Leandro:** Writing – original draft, Supervision, Investigation, Funding acquisition. **Raquel Canuto:** .

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

References

Avena, N. M., Rada, P., & Hoebel, B. G. (2008). Evidence for sugar addiction: Behavioral and neurochemical effects of intermittent, excessive sugar intake. *Neuroscience & Biobehavioral Reviews, 32*(1), 20–39.

Bell, C. C. (1994). DSM-IV: Diagnostic and Statistical Manual of Mental Disorders. *Journal of the American Medical Association, 272*(10), 828–829. https://doi.org/10.1001/jama.1994.03520100096046 %J JAMA

Bijoch, Ł., Klos, J., Pawłowska, M., Wiśniewska, J., Legutko, D., Szachowicz, U., … Beroun, A. (2023). Whole-brain tracking of cocaine and sugar rewards processing. *Translational Psychiatry, 13*(1), 20. https://doi.org/10.1038/s41398-023-02318-4

Bourdy, R., & Befort, K. (2023). The Role of the Endocannabinoid System in Binge Eating Disorder. *International Journal of Molecular Sciences, 24*(11). https://doi.org/10.3390/ijms24119574

Brown, R. M., Dayas, C. V., James, M. H., & Smith, R. J. (2022). New directions in modelling dysregulated reward seeking for food and drugs. *Neuroscience and Biobehavioral Reviews, 132*, 1037–1048. https://doi.org/10.1016/j.neubiorev.2021.10.043

Calcaterra, V., Cena, H., Rossi, V., Santero, S., Bianchi, A., & Zuccotti, G. (2023). Ultra-Processed Food, Reward System and Childhood Obesity. *Children (Basel), 10*(5). https://doi.org/10.3390/children10050804

Crane, N. T., Butryn, M. L., Gorin, A. A., Lowe, M. R., & LaFata, E. M. (2023). Overlapping and distinct relationships between hedonic hunger, uncontrolled eating, food craving, and the obesogenic home food environment during and after a 12-month behavioral weight loss program. *Appetite, 185*, Article 106543. https://doi.org/10.1016/j.appet.2023.106543

Cui, Q., Xia, Y., Wu, Q., Chang, Q., Niu, K., & Zhao, Y. (2023). Validity of the food frequency questionnaire for adults in nutritional epidemiological studies: A systematic review and meta-analysis. *Critical Reviews in Food Science and Nutrition, 63*(12), 1670–1688. https://doi.org/10.1080/10408398.2021.1966737

de Almeida, V. B. P., Filgueiras, A. R., Nogueira, P. C. K., Sesso, R. C., Sawaya, A. L., & Domene, S. (2021). The impact of food addiction behaviours on the treatment of overweight students. *The British Journal of Nutrition, 1–8*. https://doi.org/10.1017/s0007114521004189

DiFeliceantonio, A. G., Coppin, G., Rigoux, L., Edwin Thanarajah, S., Dagher, A., Tittgemeyer, M., & Small, D. M. (2018). Supra-Additive Effects of Combining Fat and Carbohydrate on Food Reward. *Cell Metab*, *28*(1), 33-44.e33. https://doi.org/10.1016/j.cmet.2018.05.018.

DiFeliceantonio, A. G., Coppin, G., Rigoux, L., Thanarajah, S. E., Dagher, A., Tittgemeyer, M., & Small, D. M. J. C. m. (2018). Supra-additive effects of combining fat and carbohydrate on food reward. *28*(1), 33-44. e33.

Edwin Thanarajah, S., DiFeliceantonio, A. G., Albus, K., Kuzmanovic, B., Rigoux, L., Iglesias, S., … Small, D. M. (2023). Habitual daily intake of a sweet and fatty snack modulates reward processing in humans. *Cell Metabolism, 35*(4), 571–584.e576. https://doi.org/10.1016/j.cmet.2023.02.015

Fazzino, T. L., & Kong, K. L. (2023). A new paradigm for investigating the etiology of obesity in early childhood: Exposure to added sugars and hyper-palatable foods in infancy and dysregulation of food reinforcement processes. *Obesity Reviews, 24*(2), e13526.

Filgueiras, A. R., Pires de Almeida, V. B., Koch Nogueira, P. C., Alvares Domene, S. M., Eduardo da Silva, C., Sesso, R., & Sawaya, A. L. (2019). Exploring the consumption of ultra-processed foods and its association with food addiction in overweight children. *Appetite, 135*, 137–145. https://doi.org/10.1016/j.appet.2018.11.005

Freeman, C. R., Zehra, A., Ramirez, V., Wiers, C. E., Volkow, N. D., & Wang, G.-J. (2018). Impact of sugar on the body, brain, and behavior. *Frontiers in bioscience (Landmark edition)*, *23*(12), 2255-2266. Retrieved 2018/06//, from http://europepmc.org/abstract/MED/29772560https://doi.org/10.2741/4704.

Gearhardt, A. N., Corbin, W. R., & Brownell, K. D. (2009). Preliminary validation of the Yale Food Addiction Scale. *Appetite, 52*(2), 430–436. https://doi.org/10.1016/j.appet.2008.12.003

Gearhardt, A. N., Roberto, C. A., Seamans, M. J., Corbin, W. R., & Brownell, K. D. (2013). Preliminary validation of the Yale Food Addiction Scale for children. *Eating Behaviors, 14*(4), 508–512. https://doi.org/10.1016/j.eatbeh.2013.07.002

Gyimah, E. A., Nicholas, J. L., Waters, W. F., Gallegos-Riofrío, C. A., Chapnick, M., Blackmore, I., … Iannotti, L. L. (2023). Ultra-processed foods in a rural Ecuadorian community: Associations with child anthropometry and bone maturation. *The British Journal of Nutrition, 1–46*. https://doi.org/10.1017/s0007114523000624

Hamelin, H., Poizat, G., Florian, C., Kursa, M. B., Pittaras, E., Callebert, J., … Granon, S. (2022). Prolonged Consumption of Sweetened Beverages Lastingly Deteriorates Cognitive Functions and Reward Processing in Mice. *Cerebral Cortex, 32*(7), 1365–1378. https://doi.org/10.1093/cercor/bhab274

Hauck, C., Cook, B., & Ellrott, T. (2020). Food addiction, eating addiction and eating disorders. *The Proceedings of the Nutrition Society, 79*(1), 103–112. https://doi.org/10.1017/s0029665119001162

Heerman, W. J., Sneed, N. M., Sommer, E. C., Truesdale, K. P., Matheson, D., Noerper, T. E., … Barkin, S. L. (2023). Ultra-processed food consumption and BMI-Z among children at risk for obesity from low-income households. *Pediatric Obesity, e13037*. https://doi.org/10.1111/ijpo.13037

Higgins, J. P., & Green, S. (2008). Cochrane handbook for systematic reviews of interventions.

Horsager, C., LaFata, E. M., Faerk, E., Lauritsen, M. B., Østergaard, S. D., & Gearhardt, A. N. (2023). Psychometric validation of the full Yale food addiction scale for children 2.0 among adolescents from the general population and adolescents with a history of mental disorder. *European Eating Disorders Review, 31*(4), 474–488. https://doi.org/10.1002/erv.2974

Jacques, A., Chaaya, N., Beecher, K., Ali, S. A., Belmer, A., & Bartlett, S. (2019). The impact of sugar consumption on stress driven, emotional and addictive behaviors. *Neuroscience and Biobehavioral Reviews, 103*, 178–199. https://doi.org/10.1016/j.neubiorev.2019.05.021

Kalon, E., Hong, J. Y., Tobin, C., & Schulte, T. (2016). Psychological and Neurobiological Correlates of Food Addiction. *International Review of Neurobiology, 129*, 85–110. https://doi.org/10.1016/bs.irn.2016.06.003

Kelly, A. L., Baugh, M. E., Oster, M. E., & DiFeliceantonio, A. G. (2022). The impact of caloric availability on eating behavior and ultra-processed food reward. *Appetite, 178*, Article 106274. https://doi.org/10.1016/j.appet.2022.106274

Kelly, A. L., Baugh, M. E., Oster, M. E., & DiFeliceantonio, A. G. J. A. (2022). *The impact of caloric availability on eating behavior and ultra-processed food reward., 178*, Article 106274.

Keser, A., Yüksel, A., Yeşiltepe-Mutlu, G., Bayhan, A., Özsu, E., & Hatun, Ş. (2015). A new insight into food addiction in childhood obesity. *The Turkish Journal of Pediatrics, 57*(3), 219–224.

Leigh, S. J., & Morris, M. J. (2018). The role of reward circuitry and food addiction in the obesity epidemic: An update. *Biological Psychology, 131*, 31–42. https://doi.org/10.1016/j.biopsycho.2016.12.013

Lennerz, B., & Lennerz, J. K. (2018). Food Addiction, High-Glycemic-Index Carbohydrates, and Obesity. *Clinical Chemistry, 64*(1), 64–71. https://doi.org/10.1373/clinchem.2017.273532

Lukomskyj, N., Allman-Farinelli, M., Shi, Y., & Rangan, A. (2021). Dietary exposures in childhood and adulthood and cardiometabolic outcomes: A systematic scoping review. *Journal of Human Nutrition and Dietetics, 34*(3), 511–523. https://doi.org/10.1111/jhn.12841

Mies, G. W., Treur, J. L., Larsen, J. K., Halberstadt, J., Pasman, J. A., & Vink, J. M. (2017). The prevalence of food addiction in a large sample of adolescents and its association with addictive substances. *Appetite, 118*, 97–105.

Monteiro, C. A., Cannon, G., Levy, R. B., Moubarac, J.-C., Louzada, M. L., Rauber, F., Khandpur, N., Cediel, G., Neri, D., & Martinez-Steele, E. J. P. h. n. (2019). Ultra-processed foods: what they are and how to identify them. *22*(5), 936-941.

Munn, Z., Moola, S., Lisy, K., Riitano, D., & Tufanaru, C. (2017). *Systematic reviews of prevalence and incidence. Joanna Briggs Institute reviewer's manual* (p. 5.1-5.5.). Adelaide, South Australia: The Joanna Briggs Institute.

Oliveira, T., Ribeiro, I., Jurema-Santos, G., Nobre, I., Santos, R., Rodrigues, C., … Araújo, A. (2020). Can the Consumption of Ultra-Processed Food Be Associated with Anthropometric Indicators of Obesity and Blood Pressure in Children 7 to 10 Years Old? *Foods, 9*(11). https://doi.org/10.3390/foods9111567

Onita, B. M., Azeredo, C. M., Jaime, P. C., Levy, R. B., & Rauber, F. (2021). Eating context and its association with ultra-processed food consumption by British children. *Appetite, 157*, Article 105007. https://doi.org/10.1016/j.appet.2020.105007

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, Article n71. https://doi.org/10.1136/bmj.n71

Parnham, J. C., Chang, K., Rauber, F., Levy, R. B., von Hinke, S., Laverty, A. A., … Vamos, E. P. (2022). The ultra-processed food content of school meals and packed lunches in the UK, 2008–17: A pooled cross-sectional study. *Lancet, 400*(Suppl 1), S12. https://doi.org/10.1016/s0140-6736(22)02222-x

Perszyk, E. E., Hutelin, Z., Trinh, J., Kanyamibwa, A., Fromm, S., Davis, X. S., … Small, D. M. J. N. (2021). *Fat and carbohydrate interact to potentiate food reward in healthy weight but not in overweight or obesity., 13*(4), 1203.

Plaza-Briceño, W., Velásquez, V. B., Silva-Olivares, F., Ceballo, K., Céspedes, R., Jorquera, G., … Sotomayor-Zárate, R. (2023). Chronic Exposure to High Fat Diet Affects the Synaptic Transmission That Regulates the Dopamine Release in the Nucleus Accumbens of Adolescent Male Rats. *International Journal of Molecular Sciences, 24*(5). https://doi.org/10.3390/ijms24054703

Pursey, K. M., Collins, R., Skinner, J., & Burrows, T. L. (2021). Characteristics of individuals seeking addictive eating treatment. *Eating and Weight Disorders, 26*(8), 2779–2786. https://doi.org/10.1007/s40519-021-01147-y

Reche-García, C., Piernas, C., Martínez-Rodríguez, A., Sánchez-Guerrero, A., & Hernández-Morante, J. J. (2022). Dietary intakes among people with vs without food addiction: A systematic review and meta-analysis. *Clinical Nutrition, 41*(8), 1770–1780. https://doi.org/10.1016/j.clnu.2022.06.033

Ribeiro, I. D. C., de Almeida, S., Oliveira, T. L. P., Santos, G. C. J., Nobre, I. G., Dos Santos, R. M., … Leandro, C. G. (2022). Daily consumption of ultra-processed foods and cardiometabolic risk factors in children aged 7 to 10 years in Northeast Brazil. *Nutrition and Health, 2601060221084816*. https://doi.org/10.1177/02601060221084816

Richmond, R. L., Roberto, C. A., & Gearhardt, A. N. (2017). The association of addictive-like eating with food intake in children. *Appetite, 117*, 82–90.

Sarkar, S., Kochhar, K. P., & Khan, N. A. (2019). Fat addiction: Psychological and physiological trajectory. *Nutrients, 11*(11), 2785.

Schulte, E. M., Avena, N. M., & Gearhardt, A. N. (2015). Which foods may be addictive? The roles of processing, fat content, and glycemic load. *PLoS One1, 10*(2), e0117959.

Schulte, E. M., & Jacques-Tiura, A. J. (2018). *Food addiction prevalence and concurrent validity in African American adolescents with obesity., 32*(2), 187–196. https://doi.org/10.1037/adb0000325

Schulte, E. M., Potenza, M. N., & Gearhardt, A. N. (2017). A commentary on the "eating addiction" versus "food addiction" perspectives on addictive-like food consumption. *Appetite, 115*, 9–15. https://doi.org/10.1016/j.appet.2016.10.033

Speranza, L., di Porzio, U., Viggiano, D., de Donato, A., & Volpicelli, F. (2021). Dopamine: The Neuromodulator of Long-Term Synaptic Plasticity. *Reward and Movement Control. Cells, 10*(4). https://doi.org/10.3390/cells10040735

Sultana, S., Rahman, M. M., Sigel, B., & Hashizume, M. (2021). Associations of lifestyle risk factors with overweight or obesity among adolescents: A multicountry analysis. *The American Journal of Clinical Nutrition, 113*(3), 742–750. https://doi.org/10.1093/ajcn/nqaa337

Touvier, M., da Costa Louzada, M. L., Mozaffarian, D., Baker, P., Juul, F., & Srour, B. (2023). Ultra-processed foods and cardiometabolic health: Public health policies to reduce consumption cannot wait. *BMJ, 383*.

Tucker, A. C., Martinez-Steele, E., Leung, C. W., & Wolfson, J. A. (2023). Associations Between Household Frequency of Cooking Dinner and Ultraprocessed Food Consumption and Dietary Quality Among US Children and Adolescents. *Childhood Obesity*. https://doi.org/10.1089/chi.2022.0200

Vasiliu, O. (2022). Current status of evidence for a new diagnosis: Food addiction-a literature review. *Frontiers in Psychiatry, 12*, 2545.

Wallace, C. W., & Fordahl, S. C. (2022). Obesity and dietary fat influence dopamine neurotransmission: Exploring the convergence of metabolic state, physiological stress, and inflammation on dopaminergic control of food intake. *Nutrition Research Reviews, 35*(2), 236–251. https://doi.org/10.1017/s0954422421000196

Winterdahl, M., Noer, O., Orlowski, D., Schacht, A. C., Jakobsen, S., Alstrup, A. K. O., … Landau, A. M. (2019). Sucrose intake lowers μ-opioid and dopamine D2/3 receptor

availability in porcine brain. *Scientific Reports, 9*(1), 16918. https://doi.org/10.1038/s41598-019-53430-9

Wiss, D. (2022). Clinical considerations of ultra-processed food addiction across weight classes: An eating disorder treatment and care perspective. *Current Addiction Reports, 9*(4), 255–267.

Yekaninejad, M. S., Badrooj, N., Vosoughi, F., Lin, C. Y., Potenza, M. N., & Pakpour, A. H. (2021). Prevalence of food addiction in children and adolescents: A systematic review and meta-analysis. *Obesity Reviews*. https://doi.org/10.1111/obr.13183

Zawertailo, L., Attwells, S., deRuiter, W. K., Le, T. L., Dawson, D., & Selby, P. (2020). Food Addiction and Tobacco Use Disorder: Common Liability and Shared Mechanisms. *Nutrients, 12*(12). https://doi.org/10.3390/nu12123834