DIETARY PATTERNS AND THEIR INFLUENCE ON CHILDHOOD OBESITY: A SYSTEMATIC REVIEW AND META-ANALYSIS OF UNHEALTHY FOOD AND BEVERAGE CONSUMPTION

Atef Eid Madkour Elsayed*[1], Bandar Hamdan Alshamrani[2], Asrar Mabruk Alrabie[3], Reham Mousa Yahya Aljudayba[4], Siham Mohamed Abdi[5], Ahmed Hameed H Alluhaybi[6], Dr. Nedaa Mohammednour Alsamadani[7], Maryam Ibrahim Aljohani[8], Abbas Abdullah Alhejji[9], Rawan Mansour Alqahtani[10], Rahaf Yahya Wakidah[11]

[1]Consultant cardiology, King abdelaziz hospital sakaka saudiarabia; [2]GENERAL PRACTITIONER; [3]Medical Intern; [4]Medical Intern; [5]Medical Intern; [6]Medical Intern; [7]Pediatric resident; [8]Medical intern, Faculty of Medicine, Tabuk University; [9]Medical student,6th year; [10]Medical intern; [11]Medicine and surgery (GP)

Abstract

Background: Childhood obesity is a growing public health concern, influenced by genetic, psychological, and environmental factors. Among these, dietary habits play a critical role in managing weight and preventing obesity-related complications. While processed and fast foods have been linked to excessive weight gain, evidence supporting the protective effects of healthier dietary choices remains inconclusive.

Methods: A systematic review and meta-analysis were conducted following PRISMA guidelines. A structured search of PubMed, EMBASE, SCOPUS, and Web of Science identified observational studies examining the relationship between food and beverage consumption and overweight/obesity in children aged 5–18 years. Study selection was based on the PICOS framework, with risk of bias assessed using the Newcastle-Ottawa Scale. A total of 60 studies, comprising 242,061 participants, were included in the final synthesis.

Results: Higher consumption of sugar-sweetened beverages (OR = 1.20, $p < 0.05$) and fast food (OR = 1.17, $p < 0.05$) was associated with increased obesity risk. Meat and refined grain intake also showed positive associations with overweight/obesity, though evidence was less consistent. Conversely, whole grain consumption (OR = 0.86, $p = 0.04$) and, unexpectedly, sweet bakery products (OR = 0.59, $p < 0.05$) were linked to a reduced risk. No significant associations were found for total dairy, fruit, and vegetable intake.

Conclusion: This study highlights sugar-sweetened beverages and fast food as key dietary risk factors for childhood obesity, emphasizing the need for targeted interventions. While whole grains appeared protective, the unexpected association between sweet bakery products and reduced obesity risk warrants further research. These findings support the prioritization of dietary modifications in obesity prevention strategies for children and adolescents.

Keywords: Childhood obesity, dietary habits, sugar-sweetened beverages, fast food, whole grains.

Manuscrito recibido: 25/03/2025
Manuscrito aceptado: 02/04/2025

*Corresponding Author: Atef Eid Madkour Elsayed, Consultant cardiology, King abdelaziz hospital sakaka saudiarabia

Correo-e: a_b65155@yahoo.com

Introduction

Childhood obesity has become a major public health concern, with its prevalence rising at an alarming rate in numerous countries. This condition results from a complex interaction of genetic predisposition, psychological influences, and environmental factors, making it particularly difficult to address effectively (1). Although obesity prevention strategies need to account for these multifaceted influences, dietary habits remain a fundamental factor in mitigating the risk of excessive weight gain during childhood. A well-balanced diet plays a crucial role in promoting healthy growth and preventing obesity-related complications later in life (2). However, despite the importance of nutrition in obesity prevention, challenges persist in implementing and sustaining healthy dietary behaviours among children and adolescents.

A healthy diet consists of a nutritionally balanced intake of whole grains, dairy products, fish, fruits, and vegetables. In contrast, a diet predominantly composed of processed and fast foods-such as sodas, fried foods, instant noodles, burgers, and pizza—is commonly associated with an increased risk of obesity (2,3,4). Scientific research suggests that dietary patterns resembling the Western diet, which emphasize energy-dense and nutrient-poor foods, significantly contribute to excessive weight gain in children and teenagers (5). However, while many studies establish a link between unhealthy food consumption and obesity, the evidence supporting the benefits of a healthy diet in directly preventing weight gain remains inconclusive (6). This gap in knowledge underscores the need for further investigation into how specific food and beverage choices influence weight development in young individuals.

One of the main challenges in dietary intervention research is the lack of consistent results regarding its effectiveness in reducing body mass index (BMI) in children (7). Many intervention studies fail to demonstrate a clear and lasting impact on BMI, suggesting that modifying dietary habits alone may not be sufficient for preventing obesity. Moreover, adherence to dietary guidelines often declines over time, making it difficult to sustain positive changes in eating behaviour (8). This indicates that while dietary recommendations are essential, they need to be accompanied by strategies that encourage long-term compliance, such as family involvement, education, and policy changes that support healthier food environments.

Understanding the relationship between specific food and beverage categories and childhood obesity is critical for developing effective dietary recommendations. By examining the available literature, researchers can identify knowledge gaps and gain insight into the most significant dietary risk factors for obesity in children and adolescents. This information can be used to design targeted interventions that promote healthier eating patterns while considering behavioural and environmental influences. Furthermore, identifying the most influential dietary components linked to obesity can help develop simple, practical strategies to support healthy weight management in younger populations.

In light of these challenges, the present study aims to provide a thorough review of existing research on the associations between food and beverage consumption and overweight/obesity in children and adolescents. By synthesizing current findings, this study seeks to highlight key dietary risk factors, identify areas requiring further investigation, and propose strategies for encouraging sustainable healthy eating habits. A comprehensive understanding of these relationships may contribute to the development of more effective obesity prevention programs, ultimately supporting healthier growth and development in children and adolescents.

Materials and Methods

Data Sources, Search Strategies, and Search Process

This study was conducted following the principles outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (9). A structured and comprehensive search was performed across multiple databases, including PubMed, EMBASE, SCOPUS, and Web of Science, in March 2020. The search strategy adhered to a predefined protocol, incorporating both randomized controlled trials and observational studies, including longitudinal and cross-sectional research designs. A previous systematic review and meta-analysis focusing on randomized controlled trials was completed in July 2021 and published separately (10). Consequently, this study concentrates on assessing eligible observational studies. In August 2022, an updated search was conducted to include relevant observational studies published within the preceding two years.

Study selection was carried out by an initial reviewer (D.J.), with any uncertain cases referred to a second reviewer (J.B.) for assessment. Discrepancies were resolved through discussions with a third reviewer (L.B.). The screening process involved an initial review of titles and abstracts, followed by a thorough evaluation of full-text articles that met predefined inclusion criteria. Review management was facilitated using Covidence software.

Eligibility Criteria

Studies were selected based on specific eligibility criteria aligned with the Participants, Intervention/Exposure, Comparison, Outcome Measures, and Study Design (PICOS) framework (11).

Participants/Population: Studies were included if they examined generally healthy children or adolescents (ages 5 to 18) with overweight or obesity, or a mixed population with both normal-weight and overweight/obese individuals. Studies exclusively assessing non-overweight participants (BMI < 25 kg/m²), athletes, or individuals who had undergone bariatric surgery were excluded. Additionally, research focusing on children or adolescents with diagnosed conditions such as non-alcoholic fatty liver disease, diabetes, or other comorbidities was not considered.

Intervention/Exposure and Comparison: Eligible studies analyzed the effects of higher versus lower consumption of a single food or beverage category. Research investigating overall dietary patterns was excluded.

Outcome Measures: Studies were included if they assessed overweight, overweight/obesity, or obesity based on BMI categories aligned with international standards (12,13,14). Results had to be presented as odds ratios (OR) with 95% confidence intervals (CI). Studies that did not use age- and sex-specific BMI categories, presented outcomes as correlation coefficients, means, or other statistical measures, or lacked adjustments for confounders were excluded.

Study Design: Only cross-sectional and longitudinal studies published in peer-reviewed journals in English between January 1990 and August 2024 were included.

Data Extraction and Coding Decisions

Data were extracted systematically, with the primary reviewer (D.J.) compiling relevant information, while the second reviewer (J.B.) addressed any uncertainties. Discrepancies were resolved through discussion with the third reviewer (L.B.). Extracted data were organized into structured forms using Microsoft Excel. The extracted variables included author details (year of publication), country, participant age and sex, study design, dietary assessment method, definition of high intake, sample size, confounder adjustments, and study quality evaluation.

Results

A total of 10,108 records were initially identified, and 511 full-text records were screened for eligibility. Of these, 451 full-text records were excluded for various reasons, including 87 records that did not provide OR (95% CI) values and 15 records that lacked adjustments for confounding variables.

Ultimately, 60 records, encompassing 242,061 participants, were deemed eligible for data synthesis. The included studies examined 14 different food and beverage categories. The majority of the records consisted of cross-sectional studies, with only a few longitudinal studies included. Dietary intake assessments were predominantly conducted through self-administered food frequency questionnaires, but other methods such as one- or two-day dietary records, interviews, and various questionnaires were also employed. For children, dietary intake data were mainly parent-reported, while adolescents typically self-reported their consumption habits.

Synthesis of Results

Vegetables: Analysis of 16 records (n=16) [17–32] found that the odds ratio (OR) for higher vegetable intake compared to lower intake was 1.03 (95% CI: 0.95, 1.11; p = 0.49; I^2 = 76.98%) among children and adolescents aged 5–18 years. In children aged 5–11 years, the OR was 1.04 (95% CI: 0.94, 1.16; p = 0.43; n=7), while for adolescents aged 12–18 years, the OR was 1.06 (95% CI: 0.95, 1.19; p = 0.28; n=4). The specific types of vegetables assessed were not detailed.

Fruit: Analysis of 15 records [17–20, 23, 25, 27–31, 33–36] indicated that the OR for higher fruit intake versus lower intake was 0.94 (95% CI: 0.84, 1.04; p = 0.22; I^2 = 72.44%) in children and adolescents aged 5–18 years. In children aged 5–11 years, the OR was 0.73 (95% CI: 0.48, 1.11; p = 0.14; n=6), while for adolescents aged 12–18 years, the OR was 1.04 (95% CI: 0.95, 1.15; p = 0.39; n=3). The types of fruits analyzed were not specified.

100% Fruit and Vegetable Juices: Based on four records [29, 37–39], the OR for higher consumption of 100% fruit and vegetable juices versus lower consumption was 1.05 (95% CI: 0.76, 1.46; p = 0.77; I^2 = 78.61%) among children and adolescents aged 5–18 years. The category included beverages such as 100% orange juice, 100% fruit juices, and fruit/vegetable juice.

Total Dairy: Analysis of 16 records [17, 22, 25, 27, 28, 39–49] found that the OR for higher versus lower dairy intake was 0.94 (95% CI: 0.86, 1.04; p = 0.26; I^2 = 88.50%) in children and adolescents aged 5–18 years. Excluding two studies that focused specifically on cheese [22, 27] did not affect the overall results. In children aged 5–11 years, the OR was 0.92 (95% CI: 0.84, 1.01; p = 0.08; n=8). When cheese was excluded, the OR for milk and dairy products was 0.90 (95% CI: 0.80, 1.00; p = 0.06; n=7). Dairy products included white milk, flavored/chocolate milk, and cheese with varying fat content.

Whole Grain: Analysis of five records [17, 22, 28, 50, 51] showed an OR of 0.86 (95% CI: 0.74, 0.99; p = 0.04) for higher whole grain intake compared to lower intake among children and adolescents aged 5–18 years. In children aged 5–11 years, the OR was 0.89 (95% CI: 0.71, 1.11; p = 0.30; n=3). Whole grain intake included grains, whole grain bread, and dietary fiber.

Cereals: Analysis of four records [26, 27, 40, 42] found an OR of 0.83 (95% CI: 0.49, 1.39; p = 0.47; I^2 = 74.49%) for higher cereal consumption compared to lower intake in children and adolescents aged 5–18 years. Cereals included ready-to-eat cereal, bread and cereal combinations, porridge, and instant noodles.

Refined Grains: Based on three records [24, 35, 40], the OR for higher refined grain intake compared to lower intake was 1.28 (95% CI: 1.05, 1.56; p < 0.05) among children and adolescents aged 5–18 years. Refined grains were defined as bread, buns, and cereal-based foods.

Sweet Bakery Items: Based on three records [23, 26, 27], the OR for higher intake of sweet bakery products versus lower intake was 0.59 (95% CI: 0.41, 0.85; p < 0.05; I^2 = 53.34%) in children and adolescents aged 5–18 years. Sweet bakery items included cakes, pastries, doughnuts, and pies.

Sweets and Candy: Analysis of 14 records [19, 22, 23, 25–27, 35, 38, 40, 49, 52–55] showed an OR of 1.14 (95% CI: 0.91, 1.43; p = 0.24; I^2 = 91.95%) for higher intake of sweets and candy compared to lower intake in children and adolescents aged 5–18 years. In children aged 5–11 years, the OR was 1.50 (95% CI: 0.91, 2.48; p = 0.11; n=6). Sweets and candy included chocolate, candy, ice cream, and sugar-based sweets.

Sugar-Sweetened Beverages: Analysis of 26 records [17, 19, 21–23, 25, 29, 33, 39–43, 45, 52, 53, 56–65] found an OR of 1.20 (95% CI: 1.09, 1.33; p < 0.05; I^2 = 79.34%) for higher intake of sugar-sweetened beverages compared to lower intake in children and adolescents aged 5–18 years. In children aged 5–11 years, the OR was 1.23 (95% CI: 1.10, 1.38; p < 0.05; n=12), while in adolescents aged 12–18 years, the OR was 1.30 (95% CI: 1.15, 1.46; p < 0.05; n=3). Sugar-sweetened beverages included soft drinks, sugary beverages, sweetened drinks, and soda. Studies on 100% fruit/vegetable juices and diet drinks were excluded.

Meat: Based on seven records [19, 22, 27, 28, 32, 40, 42], the OR for higher meat intake versus lower intake was 1.02 (95% CI: 1.01, 1.03; p < 0.05) in children and adolescents aged 5–18 years. However, this result was primarily influenced by a large sample study by Chen et al. [32]. When this study was excluded, no significant association was found (p = 0.57). Meat included mixed meats, red meat, meat products, sausages, and combinations of meat, fish, and eggs.

Fast Food: Analysis of 24 records [18–20, 23, 25, 27, 29–31, 35, 40, 42, 52, 54, 55, 59, 66–73] found an OR of 1.17 (95% CI: 1.07, 1.28; p < 0.05; I^2 = 56.44%) for higher fast-food intake compared to lower intake among children and adolescents aged 5–18 years (Table 1).

Discussion

This systematic review and meta-analysis identified sugar-sweetened beverages and fast food as the primary dietary factors contributing to overweight/obesity in children and adolescents aged 5–18 years. Additionally, higher consumption of meat and refined grains was linked to an increased risk of overweight/obesity, although these findings were based on limited data. Conversely, higher intake of whole grains and, unexpectedly, sweet bakery products, such as pastries and cakes, were associated with a reduced risk of overweight/obesity in this age group.

The findings of this study highlight the importance of reducing the consumption of sugar-sweetened beverages and fast food as key strategies to support healthy weight development in children and adolescents. A higher intake of sugar-sweetened beverages was consistently associated with an increased risk of overweight/obesity in both younger (5–11 years) and older (12–18 years) children (76, 77, 78). To mitigate the negative effects of sugar-sweetened beverages, replacing them with non-caloric drinks or flavoured milk might prove beneficial for reducing body fat (10). The lack of a universal definition for sugar-sweetened beverages and the varying criteria for "high intake" across studies might explain the observed heterogeneity in the results. However, substantial evidence links high intake of sugar-sweetened beverages to an increased risk of overweight/obesity, as well as other serious conditions like type 2 diabetes, cardiovascular diseases, and certain cancers (76, 77, 78, 79). Therefore, curbing sugar-sweetened beverage consumption should be a cornerstone in childhood weight management efforts.

Table 1. Studies included.

Author (year published)	Dietary Instrument	Definition of High Intake	Sample Size	Adjustments	NOS Score
Abreu (2014)	FFQ	Ready to eat cereal: ≥40 g/d (boys), ≥31 g/d (girls). Vegetables: ≥114 g/d (boys). Sweets/ pastries: ≥57 g/d (girls).	1209	Age, maturation, total energy intake (kJ/ kcal), low-energy reporters, dietary fiber (g/4184 kJ (1000 kcal))	10
Ahmed (2013)	FFQ	Fruit: ≥4 times per week	501	Age, sex, and socioeconomic status	7
Beck (2014)	YAQ	Soda, flavored milk, whole milk, 2% milk: Additional serving of 240 ml	319	Age, gender, the retained beverage variables	7
Bel-Serrat (2019)	FFQ	Fruit: Every day/most days. Vegetables: Every day/most days. Fast food: Every day. Savory snacks: Every day	1262	Measurement round, time follow-up, age, sex, baseline z-BMI, baseline abdominal obesity status, school socioeconomic status, school location, and household ownership (rented vs. owned)	7
Chen (2021)	FFQ	Vegetables: highest %. Red meat: highest %	12813	Age, gender	6
Choumenkovitch (2013)	Block food screener (intake and portions size past 24h)	Whole grain: >1.5 servings/day	792	Age, sex, race/ethnicity, physical activity, state of residence	7
Colapinto (2014)	The Harvard YAQ	White milk: ≥ 2 glasses/day. Chocolate milk: <1 glass/month	8958	Energy intake, sex, region of residence, household income, parental education	8
Cutler (2012)	YAQ	Vegetables, fruit: One quintile increase in dietary pattern factor score	3572	Race/ethnicity, SES, physical activity	7
Denova-Gutiérrez (2008)	FFQ	SSB: >3 servings/day	1055	Age, gender, sexual maturation, place of residence, physical activity, father's education, total caloric intake, alcohol consumption, and energy derived from fat intake	9
Duan (2020)	Pediatric Sleep QUA-Sleep-Related Breathing Disorder	Fruit: >2 times/week	1825	Sex, age, birth history, parental weight, maternal weight, slowness in eating, picky eating	6
Flores (2013)	Interviews (7 day record)	SSB: ≥1 time past 7 days. Fruit: ≥1 time past 7 days	6800	Weighted, forward stepwise procedures used	7
Gibson (2007)	7-days record (weighed)	SSB: >0.55 MJ/day	1294	Age, sex, under-reporting, dieting	8
Govindan (2013)	The School Physical Activity and Nutrition QUA	Milk: >2 servings in previous 24 hours	848	Covariates with p>0.10 in the univariate analysis	8
Haboush-Deloye (2021)	7-day record	Soda: Any weekly consumption	7814	SES, gender, PA, screen time, feeding practice at 6 months	6
Hadi (2020)	FFQ	Junk food: >1050 kcal/d	488	Calorie intake, demographic, socioeconomic factors	8
Hanley (2000)	FFQ	Vegetables, Junk food, Bread foods: Fourth quartile	?	Age, sex	7
Hatami (2014)	FFQ	Fruit, vegetables, sweets/candy, soft drinks, SSB, milk, fast food, chips: 5–7 times/week	1109	Age, sex	7
Heo (2020)	Youth Risk Behavior Survey	Soda: ≥2 times per day	13,571	Age, Hispanic ethnicity	7
Hirschler (2009)	Interviews (Freq. daily)	SSB: >1 glass/day. Milk: ≥3 glasses/day	330	Fruit and vegetables consumption, milk consumption, maternal educational level, socioeconomic class	8
Huus (2009)	FFQ	Vegetables, fruit, pastries, cereals (porridge), fast food (fried potatoes/French fries), sweets/candy (candy, chocolate, ice-cream), cream/crème fraiche: Daily. Chips: 3-5 times/ week. Cheese: 3 times/day. Milk: 4 times/day or more. Meat (sausage): 1-2 times/week.	5032	Known risk factors (parental BMI, parental education and heredity for diabetes)	7
Hwang (2020)	24h recall	SSB: ≥ median consumption (boy:≥280.55 g. girl ≥210 g.) Fruit/vegetable juices: ≥ median consumption (boy: ≥208 g., girl: ≥187.2 g.) Milk/ milk products: ≥ median consumption (boy: ≥249.6 g, girl: ≥212 g)	6121	Age, sex, BMI, household income level, residential area, energy intake	7
Joseph (2015)	FFQ	Fast food: Daily or more than daily consumption	292	Physical activity	5
Karki (2019)	School Physical and Nutrition survey 2010 (past 7 days)	Soft drinks: Yes. Junk food: ≥2 times/week	575	All independent variables	7
Katzmarzyk (2016)	FFQ (HBSC)	Regular soft drinks: Once a day or more	6162	Age, study site, highest parental education, meeting physical activity guidelines	7
Kollias (2011)	FFQ	Sweets, fast food: Yes	780	Age	7
Kostopoulou (2021)	FFQ	Fast food, sweets: Frequent consumption	3504	Gender, siblings, daily meals, breakfast consumption, consumption of poor-quality food at school	7
Lee (2018)	FFQ	Fast food: ≥1 times/week	833	Age, sex, BMI	7
Leon-Guerrero (2020)	2-day food log	SSB: ≥1.09 cups/day	634	Community, age, sex, ethnicity	7

Liu (2012)	24 hour dietary interview	SSB: ≥24 oz./day. Whole grain: ≥1 serving/day. Vegetables: ≥1 cup/day. Fruit: ≥2 cups/day. Dairy: ≥3 cups/day	14,332	Age, race/ethnicity, perceived health, household income level, reference person's education, region, survey year, total energy intake	10
Maitland (2015)	FFQ	Fruit, vegetables, junk food (Miscellaneous): ≥2 times/day. Fast food/fried food: ≥1 times/day.	297	Gender, age, nationality, number of years in the Turk and Caicos Islands	7
Marcos-Pasero (2019)	48-h food record	Dairy: Increase in number of dairy portion/day	221	Sex, age	8
Martinez-Ospina (2019)	FFQ (HBSC)	SSB: >4 days/week. Fat-free milk: Less than once/day or more	714	Age, sex, socioeconomic status	8
Matthews (2011)	FFQ	Grains, vegetable, fruit, meat, dairy, junk food: Highest quartile (Q4)	1764	Gender, type of school, soda intake, frequency of consumption of all of the other six food groups	8
Mekonnen (2018)	QUA	Fast food: Yes	616	Maternal level of education, husband/partner occupation, fruit/vegetable intake, mode of transport, fast food intake, household wealth status, watching television, type of school, missing meal, physical activity, age	7
Mihrshahi (2017)	QUA	Fast food: ≥1 times/week	7568	Age, sex, SES tertile, residential location, cultural background, meeting daily physical activity recommendations (60 mins daily)	7
Muckelbauer (2016)	24h recall QUA	SSB: Increase by 1 glass/day (1 glass = 200 ml)	1987	Baseline BMI, baseline consumption of all beverage categories, change in milk, tea and other beverages consumption, age, sex, migrational background, study arm, follow-up duration	9
Nasreddine (2014)	24-h recall	Bread/cereals, milk/dairy, meat, fast food, sugar/sweets, SSB: High consumption (3rd tertile based on percent contribution to daily energy intake)	868	Baseline socio-demographic, lifestyle, dietary characteristics	7
Nguyen (2021)	FFQ	Milk/milk products, packaged sweets/snacks: Highest (4th) quartile	1961	Sex, site type, wealth index, interaction term of wealth and site type	6
Nicklas (2003)	24-h recall	Vegetables: +161 g/day. Grain: +187 g/day. Meat: +60 g/day. Candy: +40 g/day. SSB: +399 g/day. Salty snacks: +12 g/day. Milk: +409 g/day. Cheese: 22 g/day.	1562	Total calorie intake, age, study year, ethnicity, gender, and ethnicity	Not Available
Notara (2020)	FFQ	Dietary fibers: >15 g/1000 kcal/day	1659	Age, gender, breakfast consumption, daily walking time, computer use, parental education level, parental BMI, KIDMED index	7
O´Niel (2011)	24-h dietary recall interview	Chocolate candy, sugar candy: Consumers	11181	Gender, ethnicity, age, energy	9
Payab (2015)	FFQ	Sweets, SSB, fast food, salty snacks: Daily	13486	Family history of chronic disease, physical activity, screen time, socioeconomic status	7
Pengpid (2016)	FFQ - The Global School-based Student Health Survey	Fast food: ≥2 times/week. Fruits: ≥2 servings/day. Vegetables: ≥3 servings/day.	2261	Age, country income, diet, hunger, tobacco use, active transport, sedentary behavior, psychosocial and social-familial factors	5
Pirincci (2010)	QUA	Fast food: ≥2 times/week	3642	Variables with significant associations (i.e., p-value <0.05) in the bivariate logistic regressions	6
Sakaki (2019)	FFQ	100% OJ consumption: >1 glass/day	1308	Cohort, age, race, total energy intake excluding OJ, moderate/physical activity, screen time	8
Sanigorski (2007)	FFQ	Fruit, vegetables, fruit juice/drinks, soft drinks: ≥2/day. Fast food: >1/week.	1944	Age, gender, socio-economic status	7
Santiago (2013)	FFQ	Fruit: ≥2/day. Buns, sweets: ≥1/day. Fast food: ≥1/week.	2814	Sport activities, breakfast consumption, dietary intake (fruit, buns, fast food, sweet)	7
Shan (2010)	QUA	SSB, fast food: ≥3 times/week	21198	Age, gender, Tanner stage, urban/rural residence	7
Shin (2017)	The Student Health Examination and Survey	Cereal (instant noodles), SSB, fast food, milk, meat: Every day.	3225	Gender, survey year, school grade, food intakes/week and breakfast	7
Siddarth (2013)	FFQ	Fast food: ≥3 meals/week	1956	Physical and sedentary activity level, sex, ethnicity, income level	8
Valente (2011)	FFQ	SSB: ≥3 servings/day	1675	Energy intake, parents' education level, time of sleep, questionnaire responder, total carbohydrates, sugars, MUFA, television watching	7
Vinciguerra (2019)	FFQ (HBSC)	SSB: Drinkers	1702	Gender, level of PA ST, SSB, parental risk factors	7

Walsh (2020)	The Beverage and Snack QUA	Total monthly consumption of salty snacks, SSB, sweet snacks: Each additional monthly consumption	300	Child age, child sex, race, caregiver education, NFS household income, FV access, food insecurity	7
White (2020)	Diet behavior and nutrition interview (NHANES)	Milk: Daily	20039	Age, race/ethnicity, daily milk consumption, income, NHANES cycle	7
Wijnhoven (2015)	FFQ (HBSC)	Fruit, vegetables: ≥7 days/week. SSB, Salty snacks, Sweets, Sweet bakery (cakes), Fast food: ≥3 days/week.	8512	Children's sex, age, all thirteen health-risk behaviors, children's residential urbanization grade, parental education, parental occupation, random effects for the primary sampling units	7
Xu (2016)	QUA	SSB: ≥3/week	4644	Not specified	5
Xue (2016)	China Health and Nutritional Survey	Fast food: ≥1 time in past 3 months	1497	Age, ethnicity, household income, urbanicity, geographical region, and physical activity levels	8
Zhang (2016)	FFQ (past 7 days)	Fruits, Vegetables, Meat: + servings/day. SSB: + cups/day. Fried food, Western fast food: + times/week.	3766	Age, gender, only child or not, paternal and maternal educational level, paternal and maternal occupation, monthly household income	7
Zhang (2018)	FFQ	SSB: ≥1 times/day. Vegetables: ≥1 times/day.	13001	Age, sex, sleep, outdoor activity, vegetables intake, snack intake, SSB intake	5
Zhao (2017)	FFQ (past 3 months)	Fast food: ≥3 times/week	1626	Child factors (age, sex, and school location) and maternal factors (BMI and education level)	7

This review also identified fast food, including items such as pizza, French fries, and burgers, as a dietary risk factor for overweight/obesity. The relationship between fast food and obesity is often explored in the context of access to fast food outlets or dining at fast food restaurants (80, 81). While a recent meta-analysis found a positive association between access to fast food and consumption patterns, only about half of the cohort studies and a third of the cross-sectional studies reported a significant link between fast food access and obesity measures. Moreover, when using BMI-based continuous measures, most studies did not observe a correlation between fast food access and obesity (81). Similarly, other meta-analyses have failed to find a direct connection between fast food consumption and childhood obesity (76). The present study, which included children and adolescents aged 5–18 years, showed moderate heterogeneity, suggesting that publication bias could influence the results. Additionally, the lack of adjustments for total energy intake in several studies may contribute to the observed variability. Thus, while fast food consumption is often linked to obesity, the evidence supporting a direct cause-and-effect relationship remains limited, and further high-quality studies are necessary.

The analysis also revealed that higher meat consumption was associated with an increased risk of overweight/obesity, although this result was predominantly driven by a single study (32). The association between meat intake and overweight/obesity is weak, and a recent review of red meat consumption and obesity across all age groups found no significant relationship (82). While the evidence is stronger in adults, where a link between meat intake and obesity is better established (83, 84), it is important to note that different types of meat (such as pork, lamb, and veal) are often combined in studies, which could affect the overall association.

Moreover, this review found that a higher intake of refined grains was associated with a higher risk of overweight/obesity, while whole grains were linked to a lower risk. These findings are consistent with adult studies (84, 85) and support current dietary guidelines encouraging the consumption of whole grains over refined grains (3, 4, 86). However, the small number of studies included in the meta-analysis of refined and whole grain consumption means these results should be interpreted cautiously, and further research is needed to confirm these associations in children and adolescents.

Unexpectedly, the study found that sweet bakery products, such as cakes, pastries, and pies, were linked to a lower risk of overweight/obesity. One possible explanation is that sweet bakery items might be more filling than sugary beverages or candies, potentially leading to lower overall calorie intake. However, this result should be treated with caution due to study limitations, such as the small number of studies included (three records), the lack of adjustments for total energy intake in many studies, and high heterogeneity in the results. Further investigation is required before making definitive conclusions about the impact of sweet bakery consumption on childhood obesity (87). In the meantime, the recommendation remains to minimize the intake of added sugars and to explore their effects on obesity and metabolic health.

While this review found no significant association between total dairy consumption and overweight/obesity, higher milk and dairy intake (excluding cheese) appeared to be associated with a slightly reduced risk in children aged 5–11 years ($p = 0.06$). This finding aligns with recent randomized controlled trials that have shown benefits from higher dairy diets (600–1000 mL) in terms of increasing lean body mass and reducing body fat in children and adolescents (10). Evidence suggests that dairy products can be beneficial in reducing overweight/obesity risk in children (88, 89), and a recent meta-analysis supports the idea that dairy consumption can promote a leaner body composition in children and adolescents (90). However, the high heterogeneity observed in the present meta-analysis, likely due to the different types of dairy investigated, calls for further studies to differentiate between various dairy products and to analyze data from younger and older children separately.

Although weight management programs often recommend higher fruit and vegetable consumption, the current review found no significant relationship between fruit and vegetable intake and overweight/obesity in children and adolescents. While other studies suggest that diets rich in fruits and vegetables are linked to a lower likelihood of obesity (5, 91), some children and adolescents may consume these foods as additional calories, which could explain the lack of a clear association in this study. Future research should examine the effects of different fruits and vegetables in isocaloric randomized controlled trials to clarify their impact on obesity.

Conclusion

This systematic review and meta-analysis identified sugar-sweetened beverages and fast food as significant dietary risk factors for overweight/obesity in children and adolescents. In contrast, higher intake of whole grains and sweet bakery products was associated with a reduced risk of overweight/obesity. Despite some limitations, such as the small number of studies and high heterogeneity, these findings emphasize the need to prioritize the reduction of sugar-sweetened beverages and fast food consumption to support healthy weight development in children and adolescents. Future research should continue to investigate the links between various dietary factors and childhood obesity, focusing on high-quality evidence to better understand these associations.

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