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Review

The Impact of Ready-to-Eat Cereal Intake on Body Weight and Body Composition in Children and Adolescents: A Systematic Review of Observational Studies and Controlled Trials

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ABSTRACT

Results from observational studies suggest that children and adolescents consuming ready-to-eat cereals (RTECs) have a healthier BMI and lower odds of overweight and obesity than consumers of other breakfasts or breakfast skippers. However, randomized controlled trials in children and adolescents are few and have been inconsistent in demonstrating a causal relationship between RTEC intake and body weight or body composition. The objective of this study was to evaluate the effect of RTEC intake on body weight and body composition outcomes in children and adolescents. Prospective cohort, cross-sectional and controlled trials in children or adolescents were included. Retrospective studies and studies in subjects with disease, other than obesity, type-2 diabetes (T2D), metabolic syndrome, or prediabetes, were excluded. A search in PubMed and CENTRAL databases yielded 25 relevant studies, which were qualitatively analyzed. Fourteen of the 20 observational studies demonstrated that children and adolescents consuming RTEC have a lower BMI, lower prevalence and odds of overweight/obesity and more favorable indicators of abdominal obesity than nonconsumers or less frequent consumers. Controlled trials were few and only one reported a loss of 0.9 kg in overweight/obese children with RTEC consumption when accompanied by nutrition education. The risk of bias was low for most studies, but six had some concerns or high risk. The results were similar with presweetened and nonpresweetened RTEC. No studies reported a positive association of RTEC intake with body weight or body composition. Although controlled trials do not show a direct effect of RTEC consumption on body weight or body composition, the preponderance of observational data supports the inclusion of RTEC as part of a healthy dietary pattern for children and adolescents. Evidence also suggests similar benefits on body weight and body composition regardless of the sugar content. Additional trials are needed to determine the causality between RTEC intake and body weight and body composition outcomes.

PROSPERO Registration: CRD42022311805

Keywords: ready-to-eat cereals, breakfast, body weight, BMI, body fat, child, adolescent

Statement of Significance

This systematic review provides an updated analysis of the most recent literature examining the relationship between RTEC intake and body weight and body composition outcomes in children. The current review includes several new controlled trials and observational studies that have been published since the last reviews in 2014–2016, as well as studies with RTEC consumed at all times of the day, not only at breakfast.

Abbreviations used: BMI, body mass index; OR, odds ratio; RCT, randomized controlled trial; RTEC, ready-to-eat cereal; SES, socioeconomic status; T2D, type-2 diabetes.

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Introduction

In many countries, ready-to-eat cereal (RTEC) is a convenient and popular breakfast option, particularly for children. Numerous observational studies in children and adolescents have reported frequent consumers of RTEC to have higher diet quality, including lower intakes of saturated fat and cholesterol, and higher intakes of dietary fiber, thiamin, riboflavin, niacin, pyridoxine, folate, vitamins A and D, calcium, iron, magnesium, and zinc [1–8]. RTEC is also a major source of whole grain in the diet as well as a driver for dairy intake, with the addition of milk to RTEC accounting for ~25% of milk consumed by children and adolescents [1, 9]. However, frequent consumers of RTEC may also have higher intakes of refined grains and sugars, which creates uncertainty around the potential dietary benefits of RTEC [1, 10].

Results from observational and intervention studies have also showed that RTEC may be associated with several health benefits in children and adolescents, such as healthier BMIs, lower risk of developing overweight/obesity, and improved cognitive and academic performance [1, 10, 11]. Previous systematic reviews examining the relationship between RTEC intake and body weight and body composition outcomes in children typically were limited to RTEC consumed only at breakfast [11, 12]. However, children and adolescents are more likely to consume RTEC at other times of the day compared to adults, and many observational studies do not indicate the time of RTEC consumption [13]. Additionally, several new observational studies and randomized controlled trials (RCTs) have been published since the most recent systematic review [11]. Therefore, the purpose of this systematic review is to provide an updated analysis of data from both observational studies and controlled trials in children and adolescents examining the relationship of RTEC intake at any time of the day with outcomes related to body weight and body composition.

Materials and methods

Literature search

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [14] and was registered with PROSPERO (CRD42022311805). A comprehensive literature search was performed using PubMed and CENTRAL databases to identify English-language–published literature from the year 2000 to February, 2022. Most studies on RTEC intake have been published since 2000, so this timeframe encompassed most RTEC research and was more likely to include studies with better quality of reporting. The search was designed to identify publications of observational studies and controlled trials examining RTEC intake (excluding hot cereals) and outcomes related to body weight and body composition in adults and children. This article includes findings in children and a second publication includes findings in adults. Full search terms are provided in Supplemental Table 1.

Inclusion and exclusion criteria

Inclusion criteria consisted of prospective cohort, cross-sectional, and controlled intervention studies in human subjects, where the primary exposure variable (observational studies) or intervention arm (controlled trials) was RTEC. The studies were also required to include a body weight outcome [for example, BMI, BMI z-score, weight change, odds ratio (OR) for overweight/obesity, prevalence of obesity] or body composition outcome (for example, waist circumference, waist-to-height ratio, percent body fat). Studies were excluded if they were retrospective, case-control, single-arm (no control), or conducted in vitro or in animals. Exclusion criteria also included studies in pregnant or lactating women; studies in subjects with a chronic disease, except for overweight/obesity, metabolic syndrome, prediabetes, or type-2 diabetes (T2D); and intervention studies in subjects taking medications that may impact weight or those with a history of surgical interventions for weight loss. Studies including hot cereal as an intervention or as part of observational assessments of cereal intake were excluded, as were studies prior to the year 2000.

Screening and data extraction

Titles and abstracts of articles collected through the search were read and evaluated for potential inclusion according to the inclusion/exclusion criteria. Full texts of potentially eligible publications were obtained and reviewed by a member of the research team (LMS). Inclusion of publications was determined independently by two members of the research team (LMS and MRD), and excluded publications were reviewed by the research team for agreement. Publications that were unclear regarding eligibility were also discussed among the research team to determine inclusion or exclusion. After full-text review, PICO (population, intervention, control, and outcome) data from included manuscripts were extracted into a database by one researcher (LMS) and verified for accuracy by a second researcher (MRD). Any discrepancies were resolved by discussion with the research team and referencing the original article.

Assessment of study quality

The risk of bias for observational studies was evaluated using the NIH quality assessment tool (https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools), which uses the terms "good," "fair," and "poor" as indicators of study quality. All controlled trials were randomized; therefore, the risk of bias for each trial was assessed with the Cochrane Risk of Bias (ROB2) tool for randomized trials using the appropriate tools for parallel vs. cross-over studies [15]. For consistency in this review, the terms in the ROB2 tool were used (for example, "low" risk of bias = "good", "some concerns" = "fair", "high" risk of bias = "poor").

Results

A flow diagram summarizing the literature search and review process is shown in Figure 1. Ninety-one full-text articles were identified in the search after title and abstract review. An additional 36 articles were identified in reference lists of full-text publications and systematic reviews. Seventy-six articles did not meet the inclusion/exclusion criteria and were excluded (Supplemental Table 2), leaving 51 publications for inclusion in the systematic review. Twenty-five publications included children and/or adolescents (2–18 y) and are

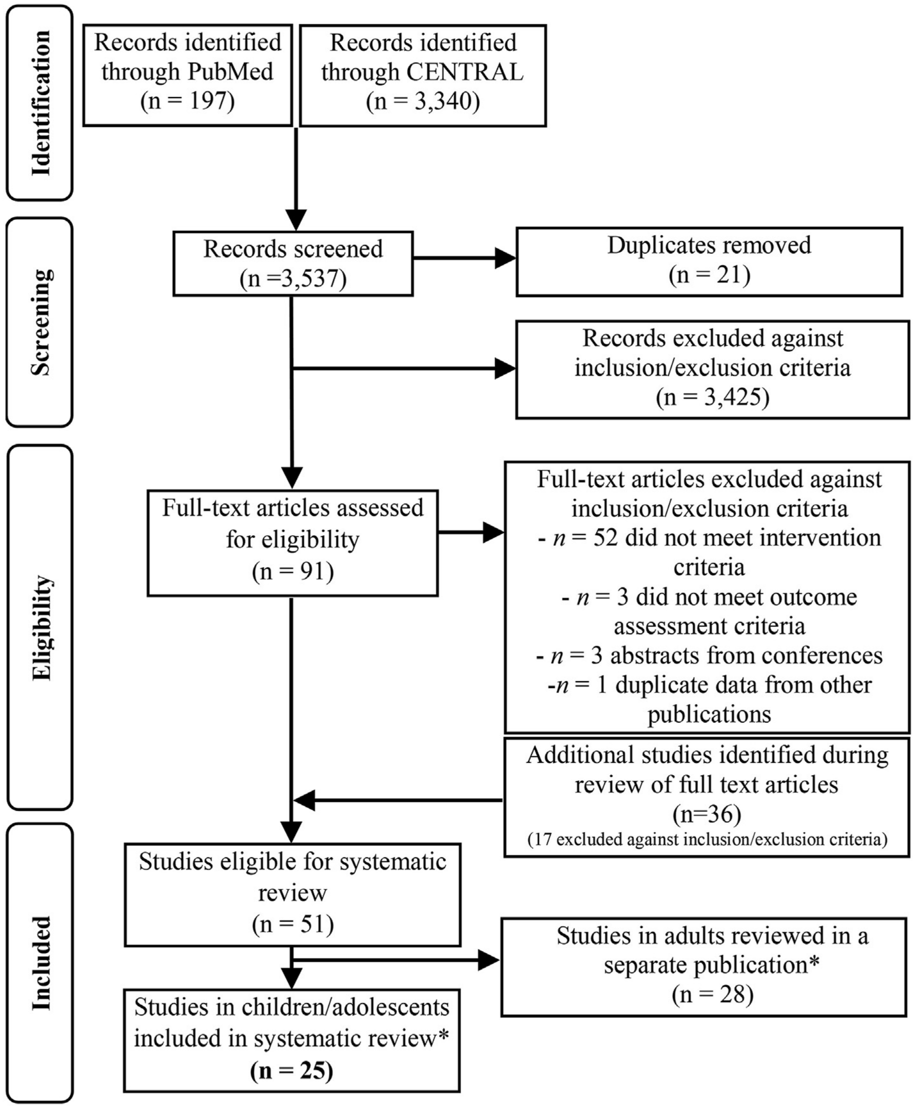

Figure 1. Flow chart of study selection for the systematic review of RTEC intake and body weight/body composition outcomes in children and adolescents.*Two publications contained data in adults and children and were included in both reviews.

reviewed in this article. The remaining publications included adults (≥18 y) and are reviewed in a separate article. Two publications included data in adults and children and are included in both reviews.

There were 20 observational studies [2, 4, 5, 16–32] and five RCTs [33–37] evaluating the relationship of RTEC with body weight and body composition outcomes. Most observational studies were cross-sectional in design, with only two prospective analyses from cohorts or longitudinal intervention studies [17, 22]. Most of the RCTs employed a parallel design, with one utilizing a cross-over design [36].

RTEC intake and body weight/body composition outcomes in observational studies in children and adolescents

Eighteen cross-sectional analyses were conducted in children and/or adolescents primarily in European countries and the US [2, 4, 5, 16, 18, 19, 21, 23–32, 38] (Table 1). Twelve of these studies reported an inverse association of RTEC intake and body weight and/or body composition outcomes [2, 5, 18, 19, 23–28, 32, 38], whereas six studies reported no association [4, 16, 21, 29–31]. No studies reported a positive association of RTEC and body weight or body composition outcomes. Table 2 provides a summary of the observational studies for each outcome. There were considerable differences in study designs, with some studies assessing RTEC consumers vs. nonconsumers; RTEC consumption at breakfast vs. non-RTEC breakfasts and/or breakfast skippers; breakfast patterns including RTEC vs. patterns excluding RTEC; and quantiles of the amount of RTEC or frequency of consumption. Outcomes reported also varied, although most studies reported BMI or BMI z-score, followed by prevalence of overweight/obesity, OR of overweight/obesity, and waist circumference. Fewer studies included the outcomes of body weight, waist: height and waist: hip ratios, and measures of fat mass.

The most reported body weight outcome was BMI or BMI z-score, with two studies reporting lower BMI in RTEC consumers than nonconsumers [19, 26], five studies reporting lower BMI in children and adolescents consuming RTEC breakfasts than

Table 1
Summary of observational studies on RTEC intake and body weight/body composition outcomes in children and adolescents

Reference	Design	Subjects	Dataset and location	Risk of bias	Groups	Outcomes	Key findings
Affenito et al., 2013 [16]	Cross-sectional	2298 children and adolescents (5–18 y)	School Nutrition Dietary Assessment Study (2004–2005), United States	Low	1) bf skippers 2) Out of school non-RTEC bf 3) Out of school RTEC bf 4) In school—non-RTEC bf 5) In school—RTEC bf	BMI BMI z-score % ow/ob	No difference in BMI or BMI z-score between RTEC bf and non-RTEC bf or bf skipper No difference in % ow/ob between groups
Albertson et al., 2009 [17]	Prospective analysis of longitudinal RCT	660 children (8–10 y) at baseline	Dietary Intervention Study in Children (1987–1996), United States Follow-up: 7.5 y	Some concerns	RTEC frequency 0, 1, 2, or 3 d of recall	BMI BMI z-score	RTEC frequency inversely related to BMI in boys only lowers BMI with 3 d RTEC compared to 0 d RTEC No difference in BMI z-score
Albertson et al., 2003 [18]	Cross-sectional	603 children (4–12 y)	NHANES (1989–1996) National Eating Trends (1998–1999), United States	High	RTEC frequency over 14 d 1) ≤3 svg 2) 4–7 svg 3) ≥8 svg	BMI % ow	RTEC frequency inversely related to BMI BMI different in each group RTEC frequency inversely related to % ow % ow higher in ≤ 3 svg compared to other groups
Albertson et al., 2013 [4]	Cross-sectional	4737 children (4–12 y)	NHANES (2003–2008), United States	Low	1) Food-secure RTEC 2) Food-secure non-RTEC 3) Food-insecure RTEC 4) Food-insecure non-RTEC	BMI z-score Waist: height ratio	no difference in BMI z-score between groups no difference in waist: height ratio between groups
Albertson et al., 2011 [19]	Cross-sectional	8848 children and adolescents (6–18 y)	NHANES (2001–2006), United States	Low	RTEC consumers divided into tertiles of sugar content 1) <17 g/100g 2) 17–33 g/100 g 3) >33 g/100 g 4) Non-RTEC	BMI BMI for age Waist: hip ratio % ow/ob	All groups of sweetened RTEC had lower BMI and BMI for age than the non-RTEC group All groups of sweetened RTEC had lower %ow/ob than the non-RTEC group Top two tertiles of sugar intake had lower waist: hip ratio than the non-RTEC group
Castillo Valenzuela et al., 2015 [38]	Cross-sectional	1477 children (6–13 y)	NA (2009–2010), Chile	Low	1) No RTEC 2) 1–29 g/d 3) 30–59 g/d 4) ≥60 g/d	BMI BMI z-score Waist circumference OR ow/ob	BMI, BMI z-score, waist circumference, and OR ow/ob inversely related to RTEC servings (BMI subgroup—low SEL no relationship, high SEL inverse relationship)
Deshmukh-Taskar et al., 2010 [2]	Cross-sectional	4320 children and adolescents (9–13 y and 14–18 y)	NHANES (1996–2006), United States	Low	1) bf skippers 2) RTEC bf 3) Non-RTEC bf	BMI for age Waist circumference % ob	RTEC bf had lower BMIz-score and waist circumference compared to bf skippers and non-RTEC bf

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Table 1 (*continued*)

Reference	Design	Subjects	Dataset and location	Risk of bias	Groups	Outcomes	Key findings
							9–13 y RTEC bf had lower % ob compared to bf skippers 14–18 y RTEC bf had lower %ob compared to bf skippers and non-RTEC bf
Frantzen et al., 2013 [22]	Prospective analysis of longitudinal RCT	625 children (9–12 y) 78% Mexican American 62% low-income	Bienestar Diabetes Prevention Program (August, 2001–May, 2004), United States Follow-up: 3 y	Low	1) No RTEC bf 2) 1-d RTEC bf 3) 2-d RTEC bf 4) 3-d RTEC bf	BMI	BMI inversely related to RTEC frequency
Kafatos et al., 2005 [23]	Cross-sectional analysis of longitudinal RCT	392 adolescents Mean: 15 y	NA (2001–2002), Greece	Low	1) RTEC nonconsumers (<1 time/wk) 2) Occasional RTEC (1–4 times/wk) 3) Daily RTEC (≥5 times/wk)	BMI Waist circumference Waist: hip Waist: height	BMI inversely related to RTEC frequency Waist circumference and waist: hip inversely related to RTEC frequency No relationship of waist: height to RTEC frequency
Kosti et al., 2007 [24]	Cross-sectional	2008 adolescents (12–17 y)	Vyronas Study (2004–2005), Greece	Some concerns	1) RTEC consumers 2) RTEC nonconsumers	% RTEC consumers by wt status OR ow/ob	ow/ob adolescents were less likely to consume RTEC compared to normal wt adolescents RTEC consumers had lower odds of being ow/ob
Kosti et al., 2008 [25]	Cross-sectional	2008 adolescents (12–17 y)	Vyronas Study (2004–2005), Greece	Some concerns	RTEC consumption 1) Never/rare 2) 1–3 times/mo 3) 1 time/wk 4) 2–6 times/wk 5) Daily 6) >2 svgs/d (>80 g) Presweetened vs. nonpresweetened	BMI OR ow/ob	BMI was lower in daily or >2 svg/d RTEC compared to never/rare consumption BMI inversely related to RTEC frequency in girls, but only approached significance in boys ($P = 0.08$) BMI lower in consumers of presweetened RTEC vs. nonpresweetened RTEC and vs. no RTEC OR ow/ob lower in adolescents choosing RTEC as a first choice for bf
Michels et al., 2015 [26]	Cross-sectional	1215 adolescents (12.5–17.5 y)	HELENA European Study (2006–2007), Europe	Low	1) RTEC nonconsumers (<1 time/wk) 2) Occasional RTEC (once/wk) 3) Frequent RTEC (2–4 times/wk) 4) Daily RTEC (5–6 times or daily/wk)	BMI z-score Waist circumference Waist: hip % Body fat OR ow	Daily RTEC consumers had lower BMI z-score, % body fat, and waist circumference than nonconsumers Frequent and daily RTEC consumers had lower odds of ow compared to nonconsumers No effect of RTEC frequency on waist: hip ratio

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Table 1 (*continued*)

Reference	Design	Subjects	Dataset and location	Risk of bias	Groups	Outcomes	Key findings
Miller et al., 2013 [27]	Cross-sectional	6729 children and adolescents (2–5 y, 6–11 y, 12–17 y)	NHANES (2003–2006), United States	Low	1) Presweetened RTEC (≥9g sugar/svg) 2) Nonpresweetened RTEC (<9g sugar/svg) 3) bf skippers 4) Non-RTEC bf	BMI, BMI for age Waist circumference % ow/ob OR ow/ob	2–5 y: presweetened RTEC consumers had lower % ow/ob and lower OR ow/ob vs. bf skippers -nonpresweetened RTEC consumers had lower body weight than non-RTEC bf 6–11y: presweetened RTEC consumers had lower BMI and BMI for age vs. skippers and non-RTEC bf 12–17 y: presweetened RTEC and nonpresweetened RTEC consumers had lower BMI, BMI for age, and waist circumference vs. skippers and non-RTEC bf Presweetened RTEC consumers had lower body weight, % ow/ob, and OR ow/ob vs. bf skippers and non-RTEC bf
O'Neil et al., 2012 [28]	Cross-sectional	5096 children and adolescents (4–8 y, 9–13 y, 14–18 y)	NHANES (1999–2002), United States	Low	1) Presweetened RTEC (≥6 g/svg) 2) Nonpresweetened RTEC (<6 g/svg) 3) Non-RTEC breakfasts	BMI, BMI for age, weight z-score, waist circumference	9–13 y and 14–18 y: nonpresweetened RTEC consumers had lower BMI and BMI for age vs. non-RTEC bf No difference with presweetened RTEC 14–18 y: nonpresweetened RTEC consumers had lower weight z-score and WC than non-RTEC bf No difference with presweetened RTEC 4–8 y: no effects of RTEC
O'Neil et al., 2015 [5]	Cross-sectional	14, 200 children and adolescents (2–18 y)	NHANES (2001–2008), United States	Low	20 different patterns including 1) presweetened RTEC (≥ 6 g/svg) +low-fat milk 2) presweetened RTEC + whole milk 3) nonpresweetened RTEC (< 6 g/svg) + low-fat milk, 4) nonpresweetened RTEC +whole milk 5) bf skippers	BMI z-score BMI % ow/ob OR ow/ob	Presweetened RTEC + whole milk and nonpresweetened RTEC + whole milk had lower BMI z-score and BMI than bf skippers Presweetened RTEC + whole milk, nonpresweetened RTEC + whole milk, and nonpresweetened RTEC + low-fat milk had lower % ow/ob and lower OR ow/ob vs. bf skippers
Panagiotakos et al., 2008 [29]	Cross-sectional	700 children (10–12 y)	PANACEA Study (2005–2006), Greece	Low	1) RTEC most frequently chosen at bf	% ow/ob OR ow/ob	Girls with more frequent RTEC selection had lower OR ow/ob vs. more

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Table 1 (*continued*)

Reference	Design	Subjects	Dataset and location	Risk of bias	Groups	Outcomes	Key findings
					2) Non-RTEC most frequently chosen at bf		frequent non-RTEC selection No effect of RTEC frequency on % ow/ob
Papoutsou et al., 2014 [30]	Cross-sectional	1558 children (4–8 y)	IDEFICS Study (2007–2008), Cyprus	Some concerns	1) RTEC bf 2) Milk only bf 3) Pastry bf 4) Other non-RTEC bf	BMI BMI z-score Waist circumference Waist: hip Waist: height	No differences by bf type
Vatanparast et al., 2019 [31]	Cross-sectional	6189 children and adolescents (2–12 y and 13–18 y; bootstrapped to entire population)	Canadian Community Health Survey (2015), Canada	Low	1) RTEC consumers 2) RTEC nonconsumers	BMI z-score	No differences in BMI z-score by RTEC consumption
Williams et al., 2009 [32]	Cross-sectional	1389 children (1–12 y; African American)	NHANES (1999–2002), United States	Low	1) bf skippers 2) RTEC bf 3) Non-RTEC bf	BMI BMI for age BMI z-score Waist circumference % ow/ob	RTEC bf consumers had lower BMI and waist circumference than bf skippers and non-RTEC bf consumers RTEC bf consumers had lower % ow/ob vs. bf skippers

bf, breakfast; NA, not available; OR, odds ratio; RTEC, ready-to-eat cereal; ow/ob, overweight/obese.

non-RTEC breakfast and/or breakfast skippers [2, 5, 27, 28, 32], and four studies reporting an inverse relationship of BMI with the amount or frequency of RTEC consumption [18, 23, 25, 38]. The amounts of RTEC evaluated differed substantially, as Albertson et al. [18] evaluated servings (based on age and sex) consumed over 14 d (≤ 3 svg, 4–7 svg, ≥ 8 svg), whereas Castillo et al. [38] evaluated the relationship of BMI with grams consumed in 1 d (0 g, 1–29 g, 30–59 g, ≥60 g). Similarly, the measures of frequency of RTEC consumption also differed. Kafatos et al. [23] evaluated tertiles of weekly consumption (<1 time/wk, 2–4 times/wk, ≥5 times/wk), and Kosti et al. [25] examined the categories of consumption from days to months (<1 time/mo, 1–3 times/mo, 1time/wk, 2–6 times/wk, daily, >2 svg (40 g)/d). Four studies reported no association of RTEC consumption with BMI [4, 16, 30, 31], with two studies comparing RTEC consumers to nonconsumers [4, 31] and two studies comparing RTEC breakfasts to other breakfasts and/or breakfast skippers [16, 30].

Table 2
Summary of outcomes in observational studies on RTEC intake and body weight/body composition outcomes in children and adolescents

Outcome	Inverse association	No association	Positive association
All RTEC			
BMI or BMI z-score	13	4	0
Prevalence ow/ob	7	2	0
Odds ratio ow/ob	7	0	0
Abdominal obesity	7	2	0
Presweetened RTEC			
BMI or BMI z-score	4	1	0
Prevalence ow/ob	0	1	0
Odds ratio ow/ob	0	2	0
Abdominal obesity	2	0	0

BMI, body mass index; ow/ob, overweight/obesity; RTEC, ready-to-eat cereal

Studies examining the prevalence of overweight/obesity and OR for overweight/obesity report similar findings to BMI outcomes. Of the nine studies evaluating the prevalence of overweight/obesity in children and adolescents [2, 5, 16, 18, 19, 24, 27, 29, 32], all but two [16, [29]] found a lower prevalence of overweight/obesity in RTEC consumers than nonconsumers or less frequent RTEC consumers. Children and adolescents consuming RTEC also consistently have significantly lower OR for overweight/obesity, ranging from 26% to >50%, than nonconsumers [5, 24–27, 29, 38], and Panagiotakos et al. [29] found this relationship in girls but not in boys. All studies adjusted for a variety of potential confounders.

Several studies also assessed the differences in body weight outcomes with presweetened RTEC compared to non-presweetened RTEC or categorized RTEC consumers by tertiles of sugar content in the cereal [5, 19, 25, 27, 28]. For most studies, presweetened RTEC was considered any RTEC with ≥6–9 g of added sugar/svg [5, 27, 28]. Kosti et al. [25] defined presweetened RTEC as any RTEC containing sugar, and

Albertson et al. [19] examined the tertiles of RTEC containing <17%, 17–33%, and >33% sugar by weight. Generally, these studies reported that children consuming presweetened RTEC, regardless of the amount of sugar content (up to 33 g/100 g or ~10 g/svg), have a lower BMI than children consuming other breakfasts or skipping breakfast [5, 19, 25, 27], and one study [28] reported no difference in BMI between presweetened RTEC consumers and non-RTEC breakfast consumers. Three studies compared presweetened RTEC to nonpresweetened RTEC and reported either no difference in BMI [27, 28] or a lower BMI in presweetened RTEC consumers compared to nonpresweetened RTEC consumers [25]. Miller et al. [27] found an inverse relationship of presweetened RTEC and BMI percentile in older children (6–11 y) and adolescents (12–17 y), but not in young children (2–5 y). O'Neil et al. [5] also reported a relationship between presweetened RTEC and BMI when whole milk was consumed with the RTEC, but not when low-fat milk was consumed. Three studies reported no differences in prevalence or odds ratio for overweight/obesity based on the sugar content of RTEC [5, 19, 27].

Nine studies assessed the indicators of abdominal obesity, including waist circumference, waist: height, and waist: hip [2, 4, 19, 23, 26, 27, 30, 32, 38]. Five of these studies reported smaller waist circumference and/or waist: height ratio in children consuming RTEC compared to nonconsumers, breakfast skippers, or consumers of non-RTEC breakfasts [2, 19, 26, 27, 32], and two of these studies reported an inverse association of waist circumference and/or waist: height ratio with the amount or frequency of RTEC intake [23, 38]. Similar to the BMI results, Miller et al. [27] found the relationship of RTEC intake and waist circumference only in adolescents 12–17y, but not in younger children. Two studies reported no relationship between RTEC intake and measures of abdominal obesity [4, 30]. Albertson et al. [19] and Miller et al. [27] reported that the relationship of RTEC with abdominal obesity was independent of the sugar content of the cereal. Two studies assessed fat mass based on skinfolds [21, 26], and one reported that daily RTEC consumers had significantly lower percent body fat than nonconsumers [26]. The other study reported numerically lower fat mass index in RTEC groups than that of other breakfast and breakfast skippers, but did not report statistical comparisons between the groups [21].

There were two prospective studies in children that were secondary analyses of longitudinal RCTs in the US [17, 22] (Table 1). Albertson et al. [17] examined the association of RTEC with BMI in 660 children over 7.5 y (~9.5 y of age at baseline) in the Dietary Intervention Study in Children, which was designed to test the impact of a low-fat diet on low density lipoprotein cholesterol reduction in children. BMI and dietary intake were assessed at 1, 3, 5, and 7.5 y of follow-up and the results demonstrated a significant inverse relationship of BMI with increasing frequency of RTEC consumption in boys, but not in girls. Similarly, Frantzen et al. [22] reported a significant inverse relationship of BMI with the increasing frequency of RTEC consumption in low-income, minority children at the risk of developing T2D, who were followed for 3 y. Neither prospective study considered the sugar content of cereals in their analyses, but Albertson et al. [17] found an increase in sugar intake in boys as RTEC frequency increased. Furthermore, Frantzen et al. [22] reported that the majority of the RTEC consumed by adolescents in the study were presweetened.

Table 3
Summary of RCTs on RTEC intake and body weight/body composition outcomes in children and adolescents

Reference	Subjects	Location	Risk of bias	Treatment	Comparator	Duration	Outcomes	Key findings
Boutelle et al., [33]	30 ow/ob children (8–12.9 y)	United States	Some concerns	RTEC bf 5 d/wk	2 egg bf 5 d/wk	120 d (~4 mo)	BMI z-score	No difference in BMI z-score between or within treatments\
Donin et al., [34]	261 children (9–10 y)	United Kingdom	Low	High-fiber RTEC daily	Low-fiber RTEC daily	30 d (1 mo)	Body weight % Fat mass	No difference between treatments Did not report within treatment outcomes
Leidy et al., [35]	54 bf skipping, ow/ob adolescents (13–20 y)	United States	Low	RTEC bf daily	Egg + pork bf daily no bf	12 wk (~3 mo)	Body weight BMI Lean mass Fat mass % Body fat	No difference in body weight, BMI, or fat/lean mass outcomes between treatments or within treatments
Maki et al., [36]	18 children (6–14 y) LDL ≥ 110 mg/dL	United States	Low	Whole grain RTEC twice daily	Refined grain RTEC twice daily	4 wk (~1 mo)	Body weight	No difference in body weight between treatments Did not report within treatment outcomes
Rosado et al., [37]	178 ow/ob children (6–12 y)	Mexico	Low	RTEC daily RTEC twice daily RTEC daily + nutr education	Usual diet	12 wk (~3 mo)	Weight change BMI % Fat mass % Fat free mass	RTEC + nutr education lost more weight and had lower BMI compared to all other interventions RTEC + nutr education had lower % body fat than daily RTEC and usual diet, but not RTEC twice daily Body weight increased in RTEC daily and twice daily

bf, breakfast; nutr, nutrition; ow/ob, overweight/obese; RTEC, ready-to-eat cereal

RTEC intake and body weight/body composition outcomes in randomized controlled trials in children and adolescents

Five RCTs evaluating the impact of RTEC on body weight and body composition outcomes in children were identified [33–37] (Table 3). Two long-term RCTs (3–4 mo) compared daily RTEC breakfasts with egg-based or high-protein breakfasts in overweight/obese children and adolescents and found no difference in body weight, BMI, and/or fat mass between the RTEC intervention and the egg-based or high-protein breakfast [33, 35]. However, Boutelle et al. [33] reported a moderate but significant decrease in BMI z-score in children within the RTEC and egg-based breakfast groups over the 4-mo study period (both treatments also received nutrition and physical activity education). One RCT in 178 overweight/obese children in Mexico reported daily RTEC consumption over 12 wk, compared with a usual breakfast, contributed to weight loss (0.9 kg) and lower percent body fat when combined with nutrition education, whereas when RTEC was provided daily, or twice daily, without nutrition education, children gained 0.9 kg over the 12 wk [37]. Two short-term studies (1 mo) compared high-fiber and low-fiber RTECs with the primary outcome of increasing cereal fiber intake [34] or reducing blood lipids [36]. Body weight and fat mass were secondary outcomes, and neither study demonstrated a significant change in these measures over the short study period.

Most RCTs utilized nonpresweetened cereals, although one study did not report the type of RTEC. Interestingly, the one study that found a benefit of RTEC for weight loss when combined with nutrition education included presweetened RTEC, but it was limited to 3svg/wk [37].

Study quality

Risk-of-bias assessments for observational studies and RCTs are included in Tables 1 and 3, respectively. Most observational studies in children had a low risk of bias, although five were determined to have some concerns or high risk. Concerns about bias were typically the lack of statistical consideration of potential confounding variables, a loss to follow-up of >20%, or self-reporting of body weight outcomes. Among RCTs, four studies were determined to have a low risk of bias and one posed some concerns due to high attrition (40%).

Although not formally evaluated in the standardized risk of bias assessments, the funding source was also considered. Twelve observational studies were funded by the food industry or included food industry authors, and seven were funded through governmental health organizations (for example, NIH, Diabetes UK) or research foundations. One study did not report the funding source. Overall, 75% and 71% of the observational studies that were funded by the food industry and other sources, respectively, reported an inverse relationship between RTEC and body weight and/or body composition–related outcomes. Four of the five RCTs were funded by the food industry and among these, three reported a neutral effect of RTEC on body weight and/or body composition.

Discussion

The results of this systematic review demonstrate consistent evidence from observational studies that children and adolescents consuming RTEC have lower BMI, lower prevalence of overweight/obesity, lower odds of overweight/obesity, and more favorable indicators of abdominal obesity such as waist circumference. However, there were substantially fewer RCTs compared to observational studies, and most of these studies did not report differences in body weight or body composition with RTEC intake in children and/or adolescents. The only RCT that reported significant improvements in body weight and body composition with RTEC consumption included a combined intervention of nutrition education with daily consumption of RTEC on weight loss [37]. The results of this review are consistent with those from previous systematic reviews and meta-analyses [1, 10, 12].

Although observational studies were more consistent in supporting an inverse relationship of RTEC to body weight and body composition, they also have limitations. Observational studies rely on 24-h recalls of dietary information or food frequency questionnaires that are prone to measurement error, and may not accurately reflect typical intake. Furthermore, most observational studies in this review were cross-sectional, which do not track dietary changes and body weight or body composition outcomes over time. However, the two prospective studies included in this review that followed children for 3 y and 7.5 y reported an inverse relationship of RTEC consumption frequency with BMI [17, 22]. One of the most important limitations of the observational studies is residual confounding from numerous potential covariates. Almost all observational studies in this review included several different covariates, such as age, sex, race, physical activity, energy intake, socioeconomic status (SES), dairy intake, and others, yet still, there may have been residual confounding that is unaccounted for with these covariates.

Energy intake was one of the most frequently used covariates, yet several observational studies evaluating energy intake in RTEC consumers reported mixed results. Some studies reported an increase in energy intake with increasing RTEC frequency or compared to breakfast skippers [2, 3, 32, 38], whereas others indicated lower energy intake or no difference with increasing frequency of RTEC consumption [17, 18, 26, 31]. These differing findings may be partially due to the comparator (for example, breakfast skippers vs. consumers of non-RTEC breakfasts) or the varying sugar contents of cereals. In the current review, the inverse association of RTEC intake with body weight and body composition outcomes did not differ by the sugar content of the cereal [5, 19, 25, 27], nor did the outcomes differ between presweetened and non-presweetened RTEC consumers [27, 28] despite higher energy intake among presweetened RTEC consumers. Thus, there may be other mechanisms beyond energy intake that can explain the observed favorable associations of RTEC with body weight and body composition outcomes.

In addition to energy intake, energy expenditure in the form of physical activity may also confound the findings of observational studies. Studies have reported that children who eat cereal more frequently are also more likely to be physically active and less likely to engage in sedentary behaviors, such as television watching [1, 39, 40]. Thus, RTEC intake may be an indicator of other healthy lifestyle habits. In the current review, studies examining physical activity were mixed with some reporting greater physical activity in RTEC consumers [2, 23, 26], whereas others report no difference [29, 38] Additionally, observational studies that included a covariate for physical activity still found an effect of RTEC on body weight and/or body composition [2, 5, 17, 24–26, 29], suggesting that the benefits of RTEC may be independent of physical activity.

Socioeconomic status is also frequently used as a covariate, yet, in this review, studies were mixed on the impact of SES. Two studies reported no association of RTEC and body weight or body composition among children with food insecurity or low SES [4, 38], whereas another study reported an inverse association with body weight [22]. Similarly, one study reported that breakfast skippers were more likely to have lower SES [2], whereas another study reported greater RTEC consumption by lower SES children [26].

Additional potential confounders in observational studies include other aspects of dietary intake, such as overall diet quality, milk consumption that often accompanies RTEC intake, and whole grain intake. Some studies reported better dietary quality in RTEC consumers [5, 26, 31, 38], higher whole grain intake [4, 16, 19, 31], and higher milk intake or contribution of RTEC to milk intake [4, 31], all of which might contribute to a healthy body weight [41–45]. After adjustment for these confounders, studies still report an inverse association of RTEC on body weight and/or body composition outcomes [5, 19, 26, 38]. However, it is challenging to fully account for dietary differences in statistical analyses, so there may be residual confounding and these potential mechanisms should be further evaluated in RCTs.

The RCTs included in this review also have some limitations. First, these studies were often small and of short duration (≤4 mo), and thus, longer studies (≥16 wk) are needed. Clinical trials should also consider examining many of the confounders discussed previously when designing clinical trials. For example, studies evaluating diverse types or RTEC with or without milk consumption may help clarify the potential relationship of whole grain or milk contribution with body weight and body composition outcomes. In this review, two studies included whole grain or high-fiber RTEC in interventions but were short term (~1 mo), so more long-term studies are needed [34, 36]. The comparator diet should also be carefully considered. Some RCTs compared a RTEC breakfast to an egg-based or high-protein breakfast [33, 35], both of which may have been different than a typical breakfast for the subjects; thus, studies that use a typical breakfast as a control are also needed. Controlling for energy intake and physical activity is also critical, particularly since the one RCT demonstrating a benefit of RTEC intake on body weight and body composition did not measure energy intake or physical activity [37], so it is unclear how these variables may have contributed to the results.

Most studies in this review had low risk of bias or some concerns about risk of bias. One observational study was considered high risk due to the lack of covariates in the analysis, merging of different datasets for intake and serving size, and the use of self-reported body weights. There is possible publication bias as most studies reported inverse relationships of RTEC and body weight or body composition outcomes; however, industry funding did not appear to influence the outcome of studies, as a similar proportion of industry-funded and government/foundation-funded studies reported inverse relationships of RTEC and body weight or body composition outcomes.

The strengths of this systematic review include broad inclusion criterion (for example, RTEC at any time of the day) to capture as many studies as possible, a search in more than one database, inclusion of studies published since 2000 to have the most up-to-date findings, and a risk-of-bias analysis. However, this review was limited by geographical location as most studies were conducted in developed countries of North America and Europe. This geographical limitation may have been due to English language limitations in the search, which may have excluded articles published in countries where English is not a primary language. RTEC is not a frequently consumed food in some countries and many countries also do not have national dietary datasets or cohorts, which may have contributed to fewer studies from other countries. Although not in the original scope of the work, a meta-analysis may have provided a more quantitative assessment of the results but would likely be difficult to interpret, considering the heterogeneity of study designs, populations, comparators, and outcome measures. Additionally, the low number of RCTs would make a meaningful meta-analysis with appropriate subgroup analyses challenging.

In conclusion, evidence from cross-sectional and prospective studies suggests that children and adolescents who consume RTEC have a healthier BMI, lower prevalence and odds of overweight/obesity, and improvements in markers of adiposity, such as waist circumference. Although there are many potential confounders, none seem to be able to fully account for the body weight and body composition benefits of RTEC intake. Furthermore, the outcomes were similar for presweetened and non-presweetened RTEC consumers, suggesting that the sugar content of cereals does not contribute to increases in body weight or unfavorable changes in body composition. However, RCTs do not confirm the benefits of RTEC on body weight and body composition observed in epidemiological studies unless nutrition education is also incorporated into the intervention. Thus, RTEC may be an indicator of a healthy diet and lifestyle in children, rather than having a direct effect on body weight and composition, although direct effects are plausible. Considering the limitations of cross-sectional studies, additional prospective and longer-term RCTs are necessary to further elucidate the relationship of RTEC intake with body weight and body composition in children and adolescents.

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Data Availability

Data reviewed during this systematic review are available from the corresponding author upon reasonable request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.advnut.2022.11.003.

References

[1] P.G. Williams, The benefits of breakfast cereal consumption: A systematic review of the evidence base, Advances in Nutrition: An International Review Journal. Adv Nutr. 5 (5) (2014) 636S–673S.
[2] P.R. Deshmukh-Taskar, T.A. Nicklas, C.E. O'Neil, D.R. Keast, J.D. Radcliffe, S. Cho, The relationship of breakfast skipping and type of breakfast consumption with nutrient intake and weight status in children and adolescents: the National Health and Nutrition Examination survey 1999–2006, J Am Diet Assoc 110 (6) (2010) 869–878.
[3] A.M. Albertson, S.G. Affenito, J.M. Culp, P. Buklis, N.A. Joshi, The association between ready-to-eat cereal consumption, nutrient intakes of the Canadian population 12 years and older and body weight measures: results from a nationally representative Canadian population, J Food Res 2 (3) (2013) 11–21.
[4] A.M. Albertson, D.L. Franko, D.R. Thompson, C. Tuttle, N.M. Holschuh, Ready-to-eat cereal intake is associated with an improved nutrient intake profile among food insecure children in the United States, J Hunger Environ Nutr 8 (2) (2013) 200–220.
[5] C.E. O'Neil, T.A. Nicklas, V.L. Fulgoni III, Nutrient intake, diet quality, and weight measures in breakfast patterns consumed by children compared with breakfast skippers: NHANES 2001–2008, AIMS Public Health 2 (3) (2015) 441–468.
[6] J.D. Smith, Y. Zhu, V. Vanage, N. Jain, N. Holschuh, A. Hermetet Agler, Association between ready-to-eat cereal consumption and nutrient intake, nutritional adequacy, and diet quality among infants, toddlers, and children in the National health and nutrition examination survey 2015–2016, Nutrients 11 (9) (2019) 1989.
[7] S.I. Barr, L. DiFrancesco, V.L. Fulgoni, Breakfast consumption is positively associated with nutrient adequacy in Canadian children and adolescents, Br J Nutr 112 (8) (2014) 1373–1383.
[8] S.I. Barr, L. DiFrancesco, V.L. Fulgoni, Breakfast consumption is positively associated with nutrient adequacy in Canadian children and adolescents – corrigendum, Br J Nutr 113 (1) (2015) 190.
[9] L. Harnack, S.-A.H. Walters, D.R. Jacobs, Dietary intake and food sources of whole grains among US children and adolescents: data from the 1994–1996 Continuing Survey of Food Intakes by Individuals, J Am Diet Assoc 103 (8) (2003) 1015–1019, 2003/08/01/; 103:1015–9.
[10] G.C. Rampersaud, M.A. Pereira, B.L. Girard, J. Adams, J.D. Metzl, Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents, J Am Diet Assoc 105 (5) (2005) 743–760, quiz 761.
[11] M.G. Priebe, J.R. McMonagle, Effects of ready-to-eat-cereals on key nutritional and health outcomes: A systematic review, PLOS ONE 11 (10) (2016), e0164931.
[12] A. de la Hunty, S. Gibson, M. Ashwell, Does regular breakfast cereal consumption help children and adolescents stay slimmer? A systematic review and meta-analysis, Obes Facts 6 (1) (2013) 70–85.
[13] A. De la Hunty, M. Ashwell, Are people who regularly eat breakfast cereals slimmer than those who don't? A systematic review of the evidence, Nutr Bulletin 32 (2) (2007) 118–128.
[14] D. Moher, A. Liberati, J. Tetzlaff, D.G. Altman, PRISMA Group, Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement, PLOS Med 6 (7) (2009), e1000097.
[15] J.A.C. Sterne, J. Savović, M.J. Page, et al., RoB 2: a revised tool for assessing risk of bias in randomised trials, BMJ 366 (2019) l4898.
[16] S.G. Affenito, D. Thompson, A. Dorazio, A.M. Albertson, A. Loew, N.M. Holschuh, Ready-to-eat cereal consumption and the School Breakfast Program: relationship to nutrient intake and weight, J Sch Health 83 (1) (2013) 28–35.
[17] A.M. Albertson, S.G. Affenito, R. Bauserman, N.M. Holschuh, A.L. Eldridge, B.A. Barton, The relationship of ready-to-eat cereal consumption to nutrient intake, blood lipids, and body mass index of children as they age through adolescence, J Am Diet Assoc 109 (9) (2009) 1557–1565.
[18] A.M. Albertson, G.H. Anderson, S.J. Crockett, M.T. Goebel, Ready-to-eat cereal consumption: its relationship with BMI and nutrient intake of children aged 4 to 12 years, J Am Diet Assoc 103 (12) (2003) 1613–1619.
[19] A.M. Albertson, D.R. Thompson, D.L. Franko, N.M. Holschuh, Weight indicators and nutrient intake in children and adolescents do not vary by sugar content in ready-to-eat cereal: results from National Health and Nutrition Examination survey 2001–2006, Nutr Res 31 (3) (2011) 229–236.
[20] S. Cho, M. Dietrich, C.J. Brown, C.A. Clark, G. Block, The effect of breakfast type on total daily energy intake and body mass index: results from the Third National Health and Nutrition Examination Survey (Nhanes III), J Am Coll Nutr 22 (4) (2003) 296–302.
[21] A.S. Donin, C.M. Nightingale, C.G. Owen, et al., Regular breakfast consumption and Type 2 diabetes risk markers in 9- to 10-year-old children in the child Heart and health study in England (CHASE): A cross-sectional analysis, PLOS Med 11 (9) (2014), e1001703.
[22] L.B. Balvin Frantzen, R.P. Treviño, R.M. Echon, O. Garcia-Dominic, N. DiMarco, Association between frequency of ready-to-eat cereal consumption, nutrient intakes, and body mass index in fourth- to sixth-grade low-income minority children, J Acad Nutr Diet 113 (4) (2013) 511–519.
[23] A. Kafatos, M. Linardakis, G. Bertsias, I. Mammas, R. Fletcher, F. Bervanaki, Consumption of ready-to-eat cereals in relation to health and diet indicators among school adolescents in Crete, Greece, Ann Nutr Metab 49 (3) (2005) 165–172.
[24] R.I. Kosti, D.B. Panagiotakos, C.C. Mihas, et al., Dietary habits, physical activity and prevalence of overweight/obesity among adolescents in Greece: the Vyronas study, Med Sci Monit 13 (10) (2007) CR437–CR444.
[25] R.I. Kosti, D.B. Panagiotakos, A. Zampelas, et al., The association between consumption of breakfast cereals and BMI in schoolchildren aged 12–17 years: the VYRONAS study, Public Health Nutr 11 (10) (2008) 1015–1021.
[26] N. Michels, S. De Henauw, C. Breidenassel, et al., European adolescent ready-to-eat-cereal (RTEC) consumers have a healthier dietary intake and body composition compared with non-RTEC consumers, Eur J Nutr 54 (4) (2015) 653–664.
[27] K.B. Miller, D.J. Liska, V.L. Fulgoni, The association between body metrics and breakfast food choice in children, ICAN: Infant Child & Adolescent Nutrition 5 (1) (2013) 43–50.
[28] C.E. O'Neil, M. Zanovec, T.A. Nicklas, S.S. Cho, Presweetened and nonpresweetened ready-to-eat cereals at breakfast are associated with improved nutrient intake but not with increased body weight of children and adolescents: NHANES 1999–2002, Am J Lifestyle Med 6 (1) (2012) 63–74.
[29] D.B. Panagiotakos, G. Antonogeorgos, A. Papadimitriou, et al., Breakfast cereal is associated with a lower prevalence of obesity among 10–12-year-old children: the PANACEA study, Nutr Metab Cardiovasc Dis 18 (9) (2008) 606–612.
[30] S. Papoutsou, G. Briassoulis, C. Hadjigeorgiou, et al., The combination of daily breakfast consumption and optimal breakfast choices in childhood is an important public health message, Int J Food Sci Nutr 65 (3) (2014) 273–279.
[31] H. Vatanparast, N. Islam, R.P. Patil, et al., Consumption of ready-to-eat cereal in Canada and its contribution to nutrient intake and nutrient density among Canadians, Nutrients 11 (5) (2019) 1009.
[32] B.M. Williams, C.E. O'Neil, D.R. Keast, S. Cho, T.A. Nicklas, Are breakfast consumption patterns associated with weight status and

nutrient adequacy in African-American children? Public Health Nutr 12 (4) (2009) 489–496.
[33] K.N. Boutelle, M.A. Manzano, D.R. Strong, K.E. Rhee, Evaluating the acceptability and feasibility of providing egg or cereal breakfast during a family-based treatment for children with overweight/obesity: the families and breakfast pilot trial, Child Obes 15 (8) (2019) 502–509.
[34] A.S. Donin, C.M. Nightingale, M.R. Perkin, et al., Evaluating an intervention to increase cereal fiber intake in children: A randomized controlled feasibility trial, J Nutr 151 (2) (2021) 379–386, 2021/2//.
[35] H.J. Leidy, H.A. Hoertel, S.M. Douglas, K.A. Higgins, R.S. Shafer, A high-protein breakfast prevents body fat gain, through reductions in daily intake and hunger, in "breakfast skipping"adolescents, Obesity (Silver Spring) 23 (9) (2015) 1761–1764, 2015/9//.
[36] K.C. Maki, M.H. Davidson, K.A. Ingram, P.E. Veith, M. Bell, E. Gugger, Lipid responses to consumption of a beta-glucan containing ready-to-eat cereal in children and adolescents with mild-to-moderate primary hypercholesterolemia, Nutr Res 23 (11) (2003) 1527–1535.
[37] J.L. Rosado, A. MDR, K. Montemayor, O.P. García, C. Caamaño Mdel, An increase of cereal intake as an approach to weight reduction in children is effective only when accompanied by nutrition education: a randomized controlled trial, Nutr J 7 (2008) 28.
[38] O. Castillo Valenzuela, J. Liberona Zúñiga, A. Dominguez de Landa, et al., Consumption of READY-TO-eat cereal is inversely associated with body mass index in 6–13 years old Chilean schoolchildren, Nutr Hosp 32 (5) (2015) 2301–2308.
[39] A.M. Albertson, D. Thompson, D.L. Franko, N.M. Holschuh, R. Bauserman, B.A. Barton, Prospective associations among cereal intake in childhood and adiposity, lipid levels, and physical activity during late adolescence, J Am Diet Assoc 109 (10) (2009) 1775–1780.
[40] R.I. Kosti, D.B. Panagiotakos, A. Zampelas, Ready-to-eat cereals and the burden of obesity in the context of their nutritional contribution: are all ready-to-eat cereals equally healthy? A systematic review, Nutr Res Rev 23 (2) (2010) 314–322.
[41] K.C. Maki, O.M. Palacios, K. Koecher, et al., The relationship between whole grain intake and body weight: results of meta-analyses of observational studies and randomized controlled trials, Nutrients 11 (6) (2019) 1245.
[42] J.C.Y. Louie, V.M. Flood, D.J. Hector, A.M. Rangan, T.P. Gill, Dairy consumption and overweight and obesity: a systematic review of prospective cohort studies, Obes Rev 12 (7) (2011) e582–e592.
[43] H. Wang, L.M. Troy, G.T. Rogers, et al., Longitudinal association between dairy consumption and changes of body weight and waist circumference: the Framingham Heart Study, Int J Obes (Lond). 38 (2) (2014) 299–305.
[44] S. Setayeshgar, K. Maximova, J.P. Ekwaru, et al., Diet quality as measured by the Diet Quality Index–International is associated with prospective changes in body fat among Canadian children, Public Health Nutr 20 (3) (2017) 456–463.
[45] A. Jennings, A. Welch, E.M.F. van Sluijs, S.J. Griffin, A. Cassidy, Diet quality is independently associated with weight status in children aged 9–10 years, J Nutr 141 (3) (2011) 453–459.