Advertising as a cue to consume: a systematic review and meta-analysis of the effects of acute exposure to unhealthy food and nonalcoholic beverage advertising on intake in children and adults[1,2]

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ABSTRACT

Background: Several studies have assessed the effects of food and nonalcoholic beverage (hereafter collectively referred to as food) advertising on food consumption, but the results of these studies have been mixed. This lack of clarity may be impeding policy action.

Objective: We examined the evidence for a relation between acute exposure to experimental unhealthy food advertising and food consumption.

Design: The study was a systematic review and meta-analysis of published studies in which advertising exposure (television or Internet) was experimentally manipulated, and food intake was measured. Five electronic databases were searched for relevant publications (SCOPUS, PsycINFO, MEDLINE, Emerald Insight, and JSTOR). An inverse variance meta-analysis was used whereby the standardized mean difference (SMD) in food intake was calculated between unhealthy food advertising and control conditions.

Results: Twenty-two articles were eligible for inclusion. Data were available for 18 articles to be included in the meta-analysis (which provided 20 comparisons). With all available data included, the analysis indicated a small-to-moderate effect size for advertising on food consumption with participants eating more after exposure to food advertising than after control conditions (SMD: 0.37; 95% CI: 0.09; 0.65; $I^2 = 98\%$). Subgroup analyses showed that the experiments with adult participants provided no evidence of an effect of advertising on intake (SMD: 0.00; $P = 1.00$; 95% CI: -0.08, 0.08; $I^2 = 8\%$), but a significant effect of moderate size was shown for children, whereby food advertising exposure was associated with greater food intake (SMD: 0.56; $P = 0.003$; 95% CI: 0.18, 0.94; $I^2 = 98\%$).

Conclusions: Evidence to date shows that acute exposure to food advertising increases food intake in children but not in adults. These data support public health policy action that seeks to reduce children's exposure to unhealthy food advertising. *Am J Clin Nutr* 2016;103:519–33.

Keywords: children, consumption, food advertising, food intake, marketing

INTRODUCTION

Obesogenic food environments are thought to be a key driver of the obesity epidemic (1). Because of this association, environmental factors that promote unhealthy dietary habits and excess consumption are of public health concern (2, 3). Specifically, the role of food marketing, particularly to children [because of concerns about their comprehension of marketing and its persuasive intent (4, 5)], has been closely scrutinized. Such marketing is extensive, perhaps most notable on television and the Internet, and almost entirely promotes high-fat, -sugar, and -salt foods (6–9). However, despite guidance from the WHO (10, 11) and numerous policy initiatives (12), few countries have enforced effective restrictions in this area (7, 13).

A small number of systematic reviews have sought to capture and evaluate the evidence base that links unhealthy food promotion to diet-related outcomes for the purposes of informing policy action (14–17). These narrative reviews have been in broad agreement that unhealthy food marketing has a detrimental impact on children, although the data relating to adults was deemed too limited to draw firm conclusions (17).

There is a growing body of research that explores the acute experimental effects of unhealthy food advertising [the most prominent form of marketing (4)] on food intake. Such studies are important because they have indicated the potential impacts of exposure to longer-term food advertising, which is more difficult to measure within fully controlled paradigms. Several studies have shown that, relative to control conditions (nonfood advertisements or no advertisements), ad libitum food intake of participants was greater after exposure to unhealthy food advertising in terms of the amount consumed (18–20) and/or caloric load

(21–26). However, some studies have either failed to show an effect (27, 28) or produced mixed findings (29–31). Moreover, where effects have been shown, in some studies they were moderated by food neophobia (21) and weight status (26), which indicated that the potentially harmful effects that food advertising has on food intake may be particularly exhibited in specific population subgroups.

A synthesis of the available evidence is required to draw firm conclusions. Therefore, we conducted a systematic review and meta-analysis of studies that have manipulated the acute exposure to experimental unhealthy food advertising and measured food intake. We also investigated subgroup differences with an examination of whether effects of advertising on food intake were moderated by the primary medium of advertising (television and the Internet) and age (children and adults).

METHODS

Data sources and search strategy

The current systematic review is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (32). An a priori protocol for this study was not published. No substantive changes were made to the study design after inception. The following 5 electronic databases were searched during September 2014: SCOPUS (http://www.scopus.com/), PsycINFO (http://www.apa.org/pubs/databases/psycinfo/index.aspx), MEDLINE (http://www.ncbi.nlm.nih.gov/pubmed/), Emerald Insight (http://www.emeraldinsight.com/), and JSTOR (http://www.jstor.org). Searches included a combination of relevant key words (**Supplemental Material**). Two authors (EJB and BK) performed the searches independently. The formal electronic searches were supplemented by a manual search of reference sections in eligible articles. Corresponding authors of eligible articles were contacted to inquire if they had conducted any additional relevant work, published or unpublished, to reduce risk of publication bias. One author provided an additional study (24). Supplementary searches of these databases (March 2015) before submission identified one additional article (33).

Study selection

For inclusion, studies were required to have manipulated acute advertising exposure (including at least one condition in which participants were exposed to unhealthy food or nonalcoholic beverage advertising on television or the Internet and another condition with a nonfood advertisement or a no-advertisement control) and formally measured food or nonalcoholic beverage intake, which was assessed as either energy intake or the quantity of item consumed. We did not include studies of product-placement exposure (because this content is not controlled entirely by the food or beverage manufacturer) but did include studies with participants of any age or weight status. Only studies with experimental designs were included, and both within-subjects/repeated-measures and between-subjects/independent-groups designs were suitable. Two authors (EJB and BK) were responsible for the evaluation of articles for inclusion by independently screening the titles, abstracts, and full texts of articles that appeared to meet the criteria. There were no disagreements.

Data extraction

A single author (EJB) extracted data from the included studies, and these data were checked independently by a different author (AJ). Corresponding authors were contacted to request the data required for the meta-analysis when these had not been reported in the publication. Information about the data extracted from each article is shown in **Table 1**.

Quality assessment

To be eligible for inclusion, a control group or condition had to have been used, and because the studies reviewed were either laboratory or school-based experiments, the usual quality filters for randomized trials or observational epidemiologic studies did not apply. However, we examined whether studies used designs in which participants were randomly allocated to groups or order of conditions (i.e., control first or experimental first in a within-subjects design) because this selection may have influenced consumptive behaviors.

Quantitative synthesis

From the extracted data, we calculated the standardized mean difference (SMD) and the SE of the SMD between food intakes of the experimental (food advertising) and control conditions in each study (34). We formally assessed the effect of advertising exposure with the use of a generic inverse-variance meta-analysis that was conducted in Review Manager software [RevMan version 5.3.5 (35)]. The use of the SMD, which is a measure of the effect size, was necessary because there was variability in the type of measurement scales used for our main outcome of interest (e.g., food intake could be measured in ounces, grams, kilocalories, kilojoules, or number

TABLE 1
Description of data extracted from included articles

Criterion	Data extracted
Study design	Within or between subjects
Random assignment of participants to conditions (between-subjects designs) or randomization of condition order (within-subjects designs)	Yes or no
Experimental setting	School, summer camp, or laboratory
Advertising medium	Television or Internet
Details of advertising medium	Any available information on the length of advertising exposure and types of products depicted
Sample size by sex	Number of male participants and number of female participants
Participant age	Child (<18 y of age) or adult
Participant weight status	Any available information, e.g., the number or proportions of participants who were normal weight, overweight, and obese
Test foods used	Type of food and whether it was depicted in the food advertising shown
Main outcome	Food intake in ounces, grams, kilocalories, kilojoules, or number of items eaten

of items eaten). The interpretation of the SMD was as follows: 0.2 was indicative of a small effect, 0.5 was indicative of a moderate effect, and 0.8 was indicative of a large effect (36). In the current analysis, a positive SMD was indicative of greater consumption after exposure to unhealthy food advertising relative to a control condition.

For within-subjects/repeated-measures designs, the correlation between experimental and control condition intake values was taken into account in the calculation of the SE of the SMD (37). Authors of 5 of these experiments (18, 21, 25, 26, 28) provided us with the correlation. We were unable to retrieve this information for one of the studies (38), and thus, we estimated the correlation to be the same as that of the only other included within-subjects study with adult participants (28). We also carried out a sensitivity analysis over a range of correlations, and the conclusions were not changed. We were also unable to extract mean and SD scores for the total food consumed for 3 studies (19, 20, 38); scores were presented separately by food type. Therefore, the total mean and SD scores were calculated from the scores presented. Seven studies offered one or 2 healthy test foods within a selection of mainly unhealthy items (19–21, 25, 26, 28, 38). Because these healthy options were minimal, we did not separate out intakes of healthy foods. Total mean intakes across all items were used.

One study (39) had 2 conditions of exposure to unhealthy food advertising (i.e., commercials for a branded potato chip and another snack food), and thus, we adjusted the sample size of each comparison in the meta-analysis accordingly. One other study provided more than one unique comparison (19), whereby similar trials were carried out with adult and child participants separately, and thus, each eligible comparison was entered.

The statistical heterogeneity between studies was assessed with the use of the I^2 statistic. Because of the variability in study designs and measures, we used random-effects models for all meta-analyses. Random-effects models are more conservative than fixed-effects models are and generate wider CIs (40). Subgroup analyses (with the use of chi-square tests for subgroup differences) were conducted to examine whether the type of media (television or Internet) or age of participants (children or adults) influenced ad libitum intake after food advertising exposure. Because there was evidence of considerable heterogeneity in the main analysis, we also conducted exploratory subgroup analyses on specific participant and study characteristics that may have contributed to the heterogeneity. We examined publication bias with the use of Egger's regression method (41) and a trim-and-fill analysis (42).
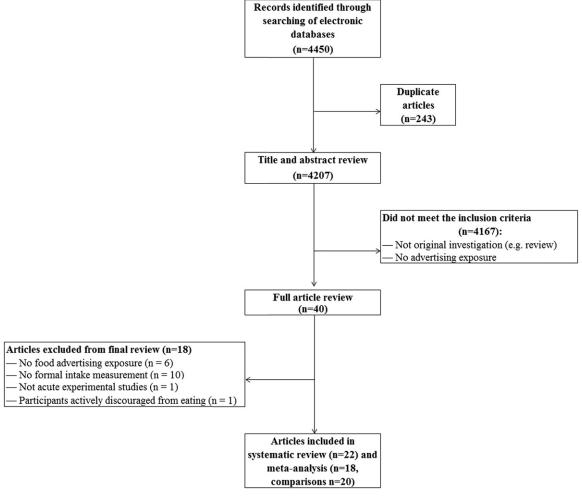

FIGURE 1 Flowchart of the study selection process.

RESULTS

The study-selection process is depicted in **Figure 1**. From this process, 22 articles were deemed to meet the eligibility criteria for a systematic review; however, 4 of these articles (33, 43–45) had to be excluded from the meta-analysis because we were unable to retrieve the required information from the authors (i.e., intake means and SDs). Therefore, 18 articles were included in the meta-analysis from which there were 19 experiments and 20 relevant comparisons [one article (19) incorporated 2 separate experiments and another article (39) provided 2 comparisons within the same experiment]. Only one study (45) measured beverage intake; all other studies measured food intake. Of the 4 articles included in the review but not in the meta-analysis, 2 articles reported that food advertising exposure increased food intake [one article on adults and one article on children (43, 45)]; one article reported that advertising exposure did not have an effect on consumption in children (44), and one article reported mixed findings whereby food advertising exposure increased intakes in overweight and obese girls but not in normal-weight girls or in boys (33). **Table 2** presents detailed characteristics and the main outcomes of the research described in all 22 articles that met the stated eligibility criteria for review.

Participants and designs

Of the 22 eligible publications, 7 articles reported on experiments with adult participants (aged ≥18 y) only (27, 28, 31, 38, 45–47), and 13 articles described studies of child participants only (18, 20–26, 29, 30, 33, 39, 44). One article tested both adults and adolescents in a single experiment (43), and another article reported on 2 separate experiments, one with adults and one with children (19). Seven studies used a within-subjects design (18, 21, 25, 26, 28, 33, 38), and the remaining 15 articles report on between-subjects experiments (19, 20, 22–24, 27–31, 39, 43–47). Eighteen studies measured the impact of television advertising on consumption (18, 19, 21, 25–31, 33, 38, 39, 43–47), and the remaining 4 articles examined exposure to Internet advergaming (20, 22–24) whereby food branding is incorporated into an online game. The vast majority of studies measured participant intakes of snack foods; the exceptions were 3 studies that used meal items (28, 33, 38), one study that offered a dessert item [ice cream (44)] and another study that measured consumption of a soda beverage (45).

Other study information

Studies with child participants were almost exclusively conducted within the school environment except for when attendees at a summer camp (19) or scout group (44) were sampled or when children visited the research laboratory (20, 33). All studies of adult participants (aged ≥18 y) were conducted in laboratories. A random assignment to the condition was carried out in all between-subject design experiments, and all articles that were based on within-subjects designs reported the randomization of the condition order. The blinding of researchers to experimental condition is problematic in studies of this type (if a single researcher is used, this person must facilitate the advertising exposure and assess consumption), and thus, there is risk of experimenter bias. Insufficient information was provided in the published articles for this to be assessed; however, risk was relatively low because the outcome measures were objectively measured (i.e., the weight or count of food items).

Meta-analyses

With all 20 possible comparisons included, an SMD of 0.37 ($P = 0.01$; 95% CI: 0.09, 0.65; $I^2 = 98\%$) was observed, which constituted a small-to-moderate effect size that showed that participants ate more after food advertising than after the control conditions. The removal of the one study that examined beverage consumption did not change the results.

Planned subgroup analysis: age of participants

A subgroup analysis that was based on the age of participants (adults compared with children) showed a significant subgroup difference ($\chi^2 = 8.14$, $P = 0.004$, $I^2 = 87.7\%$). For the 7 experiments that included adult participants only, there was no evidence of an effect of food advertisement exposure on food intake (SMD: 0.00; $P = 1.00$; 95% CI: −0.08, 0.08; $I^2 = 8\%$). From the remaining 13 comparisons from 12 experiments involving child participants, advertising exposure had a significant effect on food intake with participants consuming a greater amount of food after food advertisements than after the control condition (SMD: 0.56; $P = 0.003$; 95% CI: 0.18, 0.94; $I^2 = 98\%$) (**Figure 2**).

Planned subgroup analysis: type of media

The subgroup analysis that was based on the advertising media types (television compared with Internet advergaming) was NS ($\chi^2 = 0.32$, $P = 0.57$, $I^2 = 0\%$). Both media types had an effect on intake; the 16 comparisons in which participants were exposed to television food advertising produced a small-medium effect (SMD: 0.40; $P = 0.03$; 95% CI: 0.04, 0.75; $I^2 = 98\%$) as did the 4 studies (20, 22–24) that involved Internet advergaming exposure (SMD: 0.27, $P = 0.04$; 95% CI: 0.01, 0.53; $I^2 = 87\%$). When only studies of child participants were analyzed by media type, the difference between subgroup effects remained nonsignificant ($\chi^2 = 2.07$, $P = 0.15$, $I^2 = 51.6\%$) although studies that exposed participants to television food advertising appeared to produce a larger effect (SMD: 0.69; $P = 0.009$; 95% CI: 0.18, 1.21; $I^2 = 98\%$) than did studies in which children had played Internet advergames (SMD: 0.27; $P = 0.04$; 95% CI: 0.01, 0.53; $I^2 = 87\%$). A similar analysis for studies of adult participants was not possible because all such studies used television-advertising exposure.

Exploratory subgroup analyses

Because there was considerable heterogeneity across studies of child participants, we investigated differences in study designs that may have contributed to this variability. Effect sizes were larger when studies *1*) used within-subjects designs [the subgroup difference was significant at $P = 0.003$; there was a significant SMD of 1.35 for within-subjects designs (4 studies contributed 4 comparisons; $I^2 = 99\%$) compared with a significant SMD of 0.21 for between-subjects designs (8 studies contributed 9 comparisons; $I^2 = 84\%$)], *2*) offered a selection of foods [the subgroup difference was significant at $P = 0.03$; there was a significant SMD of 0.81 for multi-item food intake (8 studies contributed 8 comparisons; $I^2 = 99\%$) compared with

TABLE 2
Characteristics of the articles meeting stated eligibility criteria for review[1]

Reference	Participants and design	Advertising medium and manipulation	Outcome (food intake measure used as DV in analysis)	Main results reported for food intake	Values used in meta-analysis (source of data)	Methodologic notes
Anschutz et al., 2011 (27)	Sample: adults (students) $n = 82$ total ($n = 41$/group) Sex: M and F Age: 20.9 ± 2.5 y (M); 20.4 ± 1.5 y (F) Exclusion criteria: intake outliers excluded from analysis (>800 kcal) Design: between subjects	Television Two advertisement breaks within a 30-min movie Experimental group exposed to 8 advertisements in each break (3 energy-dense foods; 5 nonfoods) Control group exposed to 8 nonfood advertisements in each break	Ad libitum consumption of chips and chocolate confectionery (g)	Commercial condition did not increase explained variance in regression model Interaction commercial condition × sex on food intake	Experimental: 188.1 ± 195.3[2] g (data from article) Control: 203.1 ± 207.9 g (data from article)	Laboratory study Test foods available for consumption during advertising exposure Advertised foods not offered Random assignment to experimental conditions
Anschutz et al., 2009 (29)	Sample: children $n = 120$ total ($n = 63$: food advertisement condition; $n = 57$: control) Sex: M and F Age: 9.8 ± 1.2 y Exclusion criteria: none reported Design: between subjects	Television Two advertisement breaks in a 20-min movie Experimental group exposed to 5 advertisements in each break (3 energy-dense foods; 2 nonfoods) Control group exposed to 5 nonfood advertisements in each break	Ad libitum consumption of chocolate-coated peanuts (g)	No main effect of commercial condition on food intake Interaction commercial condition × sex on food intake	Experimental: 32.6 ± 45.2 g (data from article) Control: 31.0 ± 40.9 g (data from article)	School-based study Test foods available for consumption during advertising exposure Advertised foods not offered Random assignment to experimental conditions
Anschutz et al., 2010 (30)	Sample: children $n = 121$ total ($n = 40$: food advertisement condition; $n = 40$: control)[3] Sex: M and F Age: from 8.08 ± 0.7 y in grade 3 to 11.4 ± 0.6 y in grade 6 Exclusion criteria: none reported Design: between subjects	Television Two advertisement breaks in a 20-min movie Experimental group exposed to 5 advertisements in each break (4 energy-dense foods; one nonfood) Control group exposed to 5 nonfood advertisements in each break	Ad libitum consumption of chocolate-coated peanuts (g)	No main effect of commercial condition on food intake Interaction commercial condition × maternal encouragement to be thin on food intake	Experimental: 32.1 ± 31.7 g (data from authors) Control: 36.6 ± 33.4 g (data from authors)	School-based study Test foods available for consumption during advertising exposure Advertised foods not offered Random assignment to experimental conditions
Bellisle et al., 2009 (38)	Sample: adults $n = 40$ Sex: F Age: 26.4 ± 1.5 y (low restraint); 25.9 ± 0.9 y (high restraint) Exclusion criteria: nonnormal weight status, eating pathology, pregnancy, or midrange dietary restraint Design: within subjects	Television Exposure to television program with series of food advertisements (experimental condition) or no advertisements (control)	Ad libitum consumption of ground beef, mashed potatoes, and fruit sherbets (dessert) (kJ)	No main effect of condition on total or individual item food intake No effect of restraint group, no interaction condition × restraint on food intake	Experimental: 25,98.0 ± 665.2 kJ (mean from article; SD from authors) Control: 2657 ± 761.6 kJ (mean from article; SD from authors)	Laboratory study Test foods available for consumption during advertising exposure Advertised foods not offered Order of conditions was randomized

(Continued)

TABLE 2 (*Continued*)

Reference	Participants and design	Advertising medium and manipulation	Outcome (food intake measure used as DV in analysis)	Main results reported for food intake	Values used in meta-analysis (source of data)	Methodologic notes
Boland et al., 2013 (31)	Sample: adults (students) $n = 125$ total ($n = 42$: indulgent food advertisements; $n = 42$: control)[4] Sex: M and F Age: 18–29 y; mean: 19.3 y Exclusion criteria: none reported Design: between subjects	Television Three advertisement breaks in 30-min program; experimental group exposed to 3 advertisements in each break (one indulgent food advertisement; 2 nonfood advertisements) Control group exposed to 3 nonfood advertisements in each break	Ad libitum consumption of M&M's (oz) (Mars Inc.)	Marginally significant main effect of condition on intake Interaction commercial condition × time of day on food intake	Experimental: 1.3 ± 1.4 oz (data from authors) Control: 1.6 ± 1.4 oz (data from authors)	Laboratory study Test foods available for consumption during advertising exposure Advertised foods not offered Random assignment to experimental conditions
Boyland et al., 2013 (39)	Sample: children $n = 181$ total ($n = 51$: endorsed brand food advertisement group; $n = 41$: nonendorsed brand food advertisement group; $n = 39$: control) Sex: M and F Age: 10.0 ± 0.9 y Exclusion criteria: none reported Design: between subjects	Television One 45-s advertisement within a 20-min cartoon One experimental group exposed to endorsed brand food advertisement, other experimental group exposed to nonendorsed brand food ad Control group exposed to nonfood ad	Ad libitum consumption of chips (g)	Interaction condition × food type on food intake	Experimental group 1 (endorsed brand): 52.5 ± 20.1 g; experimental group 2 (nonendorsed brand): 39.8 ± 18.6 g (data from authors) Control: 38.9 ± 22.8 g (data from authors)	School-based study Test foods available for consumption after advertising exposure Advertised food offered Random assignment to experimental conditions
Dovey et al., 2011 (21)	Sample: children $n = 66$ Sex: M and F Age: 6.0 ± 0.7 y Exclusion criteria: none reported Design: within subjects	Television 2 min of advertising in a 14-min cartoon Experimental condition exposed to unhealthy food advertisements Control condition exposed to nonfood advertisements	Ad libitum consumption of rice crackers, candy, chocolate, chips, grapes, and carrot sticks (kcal)	Main effect of condition on food intake Interaction condition × neophobia on food intake	Experimental: 461.2 ± 52.8 kcal (data from authors) Control: 400.3 ± 50.2 kcal (data from authors)	School-based study Test foods available for consumption after advertising exposure Advertised foods not offered Order of conditions was randomized and counterbalanced
Folkvord et al., 2013 (23)	Sample: children $n = 270$ total ($n = 69$: energy-dense food advergame; $n = 65$: control) Sex: M and F Age: 8.4 ± 0.6 y in grade 3; 9.4 ± 0.5 y in grade 4 Exclusion criteria: none stated Design: between subjects	Internet (advergames) 5 min of gameplay Experimental group exposed to unhealthy food advergame Control group exposed to nonfood advergame	Ad libitum consumption of candy and chocolate (kcal)	Main effect of condition on food intake	Experimental: 197.2 ± 111.4 kcal (data from article) Control: 128.9 ± 83.4 kcal (data from article)	School-based study Test foods available for consumption after advertising exposure Some advertised foods offered Random assignment to experimental conditions

(*Continued*)

TABLE 2 (*Continued*)

Reference	Participants and design	Advertising medium and manipulation	Outcome (food intake measure used as DV in analysis)	Main results reported for food intake	Values used in meta-analysis (source of data)	Methodologic notes
Folkvord et al., 2014 (22)	Sample: children $n = 261$ ($n = 69$: energy-dense food advergame; $n = 62$: control)[5] Sex: M and F Age: 7.8 ± 0.8 y (experimental) and 7.7 ± 0.7 y (control) Exclusion criteria: None stated Design: between subjects	Internet (advergames) 5 min of gameplay Experimental group exposed to unhealthy food advergame Control group exposed to nonfood advergame	Ad libitum consumption of candy and chocolate (kcal)	Main effect of condition on food intake Effect moderated by inhibition	Experimental: 156.3 ± 135.2 kcal (data from article) Control: 101.3 ± 74.1 kcal (data from article)	School-based study Test foods available for consumption after advertising exposure Some advertised foods offered Random assignment to experimental conditions
Folkvord et al., 2015 (24)	Sample: children $n = 92$ total ($n = 50$: energy-dense food advergame; $n = 42$: control) Sex: M and F Age: 8.5 ± 1.1 y (experimental); 8.3 ± 1.1 y (control) Exclusion criteria: allergy to test food Design: between subjects	Internet (advergames) 5 min of gameplay Experimental group exposed to unhealthy food advergame Control group exposed to nonfood advergame	Ad libitum consumption of candy and chocolate (kcal)	Main effect of condition on food intake Interaction condition × latency of initial fixation on food intake	Experimental: 178.0 ± 99.5 kcal (data from article) Control: 132.9 ± 87.0 kcal (data from article)	School-based study Test foods available for consumption after advertising exposure Some advertised foods offered Random assignment to experimental conditions
Halford et al., 2004 (18)	Sample: children $n = 42$ Sex: M and F Age: 9–11 y; mean: 10.4 y Exclusion criteria: any food allergy Design: within subjects	Television Ten-minute cartoon including 8 advertisements; experimental condition exposed to all unhealthy food advertisements Control condition exposed to nonfood advertisements	Ad libitum consumption of crackers, candy, chocolate, popcorn (g)	Main effect of condition on food intake	Experimental: 109.9 ± 32.1 g (data from authors) Control: 95.5 ± 28.8 g (data from authors)	School-based study Test foods available for consumption after advertising exposure Advertised foods not offered Order of conditions was randomized and counterbalanced
Halford et al., 2007 (25)	Sample: children $n = 93$ Sex: M and F Age: from 5 y 2 mo to 7 y 9 mo; mean: 6 y 3 mo Exclusion criteria: None stated Design: within subjects	Television Ten-minute cartoon including 10 advertisements; experimental condition exposed to all unhealthy food advertisements Control condition exposed to nonfood advertisements	Ad libitum consumption of crackers, candy, chocolate, potato chips, and grapes (kcal)	Main effect of condition on food intake	Experimental: 667.1 ± 272.7 kcal (data from authors) Control: 559.3 ± 196.0 kcal (data from authors)	School-based study Test foods available for consumption after advertising exposure Advertised foods not offered Order of conditions was randomized and counterbalanced

(*Continued*)

TABLE 2 (*Continued*)

Reference	Participants and design	Advertising medium and manipulation	Outcome (food intake measure used as DV in analysis)	Main results reported for food intake	Values used in meta-analysis (source of data)	Methodologic notes
Halford et al., 2008 (26)	Sample: children n = 59 Sex: M and F Age: from 9 y 6 mo to 11 y 2 mo; mean: 10 y 2 mo Exclusion criteria: None stated Design: within subjects	Television Ten-minute cartoon including 10 advertisements; experimental condition exposed to all unhealthy food advertisements Control condition exposed to nonfood advertisements	Ad libitum consumption of crackers, candy, chocolate, potato chips, and grapes (kcal)	Main effect of condition on food intake	Experimental: 604.6 ± 202.8 kcal (data from authors) Control: 295.9 ± 121.5 kcal (data from authors)	School-based study Test foods available for consumption after advertising exposure Advertised foods not offered Order of conditions was randomized and counterbalanced
Harris et al., 2009 (19), experiment 1	Sample: children n = 118 (n = 59/group) Sex: M and F Age: 7–11 y; mean: 8.8 y Exclusion criteria: none stated Design: between subjects	Television Two advertisement breaks in a 14-min cartoon Experimental group exposed to 2 food advertisements in each break Control group exposed to 2 nonfood advertisements in each break	Ad libitum consumption of crackers (g)	Main effect of condition on food intake	Experimental: 28.5 ± 18.0 g (data from authors) Control: 19.7 ± 11.4 g (data from authors)	Experiment 1a in school, 1b in summer camp Test foods available for consumption during advertising exposure Advertised foods not offered Random assignment to experimental conditions
Harris et al., 2009 (19), experiment 2	Sample: adults n = 98 (n = 34: snack food advertisements; n = 33: control)[6] Sex: M and F Age: 18–24 y Exclusion criteria: none stated Design: between subjects	Television Two advertisement breaks in 16-min program Experimental group exposed to 11 advertisements (4 snack foods; 7 nonfoods) Control group exposed to 11 nonfood advertisements	Ad libitum consumption of carrots, celery with dip, chocolate chip cookies, cheese snack mix, trail mix, and multigrain tortilla chips (g)	Main effect of condition on food intake	Experimental: 89.8 ± 35.4 g (data from authors) Control: 83.3 ± 31.4 g (data from authors)	Laboratory study Test foods available for consumption after advertising exposure Advertised foods not offered Random assignment to experimental conditions
Harris et al., 2012 (20)	Sample: children n = 152 (n = 52: unhealthy advergames; n = 50: control)[7] Sex: M and F Age: 7–12 y; mean: 9.4 y Exclusion criteria: none stated Design: between subjects	Internet (advergames) 12 min of gameplay Experimental group exposed to unhealthy food advergames Control group exposed to nonfood advergames	Ad libitum consumption of carrots, grapes, fruit snacks, crackers, potato chips, and chocolate chip cookies (g)	Main effect of condition on food intake Trend for interaction condition × previous advergame play on food intake	Experimental: 124.2 ± 49.1 g (data from authors) Control: 133.5 ± 54.9 g (data from authors)	Laboratory study Test foods available for consumption after advertising exposure Advertised foods not offered Random assignment to experimental conditions

(*Continued*)

TABLE 2 (*Continued*)

Reference	Participants and design	Advertising medium and manipulation	Outcome (food intake measure used as DV in analysis)	Main results reported for food intake	Values used in meta-analysis (source of data)	Methodologic notes
Martin et al., 2009 (28)	Sample: adults n = 48[8] Sex: M and F Age: 18–54 y; 31.9 ± 1.5 y Exclusion criteria: use of medication affecting appetite or body weight Design: within subjects	Television Episode of neutral program embedded with advertisements Experimental condition exposed to 6 food and 6 nonfood advertisements Control condition; no advertising exposure	Ad libitum consumption of 16-item buffet including low-fat and high-fat or high-sugar items [measured twice (at lunch and at dinner) (kcal)]	No main effect of condition on food intake	Experimental: 1039.0 ± 324.0 kcal (data from authors) Control: 1028.0 ± 372.0 kcal (data from authors)	Laboratory study Test foods available for consumption during advertising exposure Advertised foods not offered Order of conditions was randomized
van Strien et al., 2012 (46)	Sample: adults n = 125 (n = 66: food advertisements; n = 63: nonfood advertisements) Sex: M and F Age: 21.3 ± 3.7 y Exclusion criteria: subjects with Dutch Eating Behavior Questionnaire external eating subscale scores near the mean Design: between subjects	Television Two advertisement breaks in 30-min movie Experimental group exposed to 5 advertisements in each break (3 energy dense foods; 5 nonfoods) Control group exposed to 8 nonfood advertisements in each break	Ad libitum consumption of potato chips and chocolate (kcal)	No main effect of condition on food intake	Experimental: 233.7 ± 231.8 kcal (data from authors) Control: 231.1 ± 272.4 kcal (data from authors)	Laboratory study Test foods available for consumption during advertising exposure Advertised foods not offered Random assignment to experimental conditions
Wonderlich-Tierney et al., 2013 (47)	Sample: adults n = 83 (n = 26: food advertisements; n = 26 nonfood advertisements)[9] Sex: M and F Age: 19.6 ± 3.5 y Exclusion criteria: eating pathology, BMI (in kg/m²) <17.5, food allergies, or medical conditions resulting in food restrictions Design: between subjects	Television Four advertisement breaks in 40-min program Experimental group exposed to 7 advertisements in each break (6 food advertisements, 1 nonfood ad) Control group exposed to 7 nonfood advertisements in each break	Ad libitum consumption of cookies (number eaten)	No main effect of condition on food intake Interaction condition × transportability	Experimental: 5.0 ± 4.2 cookies (data from authors) Control: 4.0 ± 2.6 cookies (data from authors)	Laboratory study Test foods available for consumption during advertising exposure Advertised foods not offered Random assignment to experimental conditions
Data from 4 articles not included in meta-analysis because of lack of relevant means and SDs						

(*Continued*)

TABLE 2 (*Continued*)

Reference	Participants and design	Advertising medium and manipulation	Outcome (food intake measure used as DV in analysis)	Main results reported for food intake	Values used in meta-analysis (source of data)	Methodologic notes
Anderson et al., 2014 (33)	Sample: children $n = 23$ Sex: M and F Age: 9–14 y Exclusion criteria: intake outliers or individuals not completing all sessions Design: within subjects	Television Four advertisement breaks in a 22-min cartoon Exposure to 15 advertisements in each condition, food (experimental) or nonfood (control)	Ad libitum consumption of pizza (g)	No main effect of commercial condition on food intake Interaction commercial condition × preload in boys and commercial condition × body weight status in girls	NA	Laboratory study Test foods available for consumption during advertising exposure Advertised foods not offered Order of conditions was randomized and counterbalanced
Falciglia and Gussow, 1980 (43)	Sample: adults and adolescents $n = 102$ ($n = 51$/group) Sex: F Age: adults, ≥21 y; adolescents, 13–18 y Exclusion criteria: dieting or juvenile onset obesity (for adult obese sample) Design: between subjects	Television Two advertisements inserted into 9-min program Experimental group exposed to 2 food advertisements Control group exposed to 2 nonfood advertisements	Ad libitum consumption of cookies (number eaten)	Main effect of condition on food intake	NA	Laboratory study Test foods available for consumption during advertising exposure Advertised foods not offered Random assignment to experimental conditions
Gorn and Goldberg, 1980 (44)	Sample: children $n = 111$ ($n = 21$ in one food advertisement group; $n = 33$ in 3 same food advertisements group; $n = 20$ in 3 different food advertisement group; $n = 19$ in 5 same food advertisements group; $n = 18$ in 5 different food advertisements group; $n = 40$ in no advertisements group) Sex: M Age: 8–10 y Exclusion criteria: none stated Design: between subjects	Television Cartoon with various advertisement manipulations; experimental groups exposed to either one food advertisement, 3 same food advertisements, 3 different food advertisements, 5 same food advertisements, or 5 different food advertisements Control group exposed to no advertisements	Ad libitum consumption of ice cream (oz)	No main effect of condition on food intake	NA	Scout group study Test foods available for consumption after advertising exposure Advertised food offered Random assignment to experimental conditions

(*Continued*)

TABLE 2 (*Continued*)

Reference	Participants and design	Advertising medium and manipulation	Outcome (food intake measure used as DV in analysis)	Main results reported for food intake	Values used in meta-analysis (source of data)	Methodologic notes
Koordeman et al., 2010 (45)	Sample: adults n = 51 [n = 23: soda advertisements; n = 28: water advertisements (control)] Sex: F Age: 18–29 y; 21.2 ± 3.2 y Exclusion criteria: BMI <16 or >30 Design: between subjects	Television Two advertisement breaks in 35-min movie Experimental group exposed to 5 nonfood and 2 soda advertisements per break Control group exposed to 5 nonfood and 2 water advertisements per break	Ad libitum consumption of 3 soda beverages and water	Main effect of condition on soda intake	NA	Laboratory study Test beverages available for consumption during advertising exposure Advertised beverages not offered Random assignment to experimental conditions

[1]DV, dependent variable; NA, not applicable.
[2]Mean ± SD (all such values).
[3]Article also reported data for a "light food commercials" group; means for "energy-dense food commercials" and nonfood commercials groups only were used in our analyses.
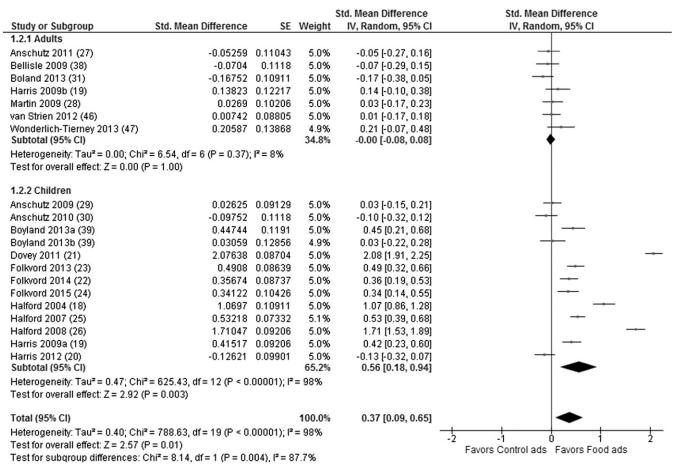[4]Article also reported data for a "healthy food commercials" group; means for "indulgent food commercials" and nonfood commercials groups only were used in our analyses. Also, the article reported data split by the time of day (morning or afternoon); collapsed means for all time periods were used in our analyses.
[5]Article reported data split by inhibition task; means for experimental and control groups who did not complete inhibition task only were used in our analyses.
[6]Article also reported data for a "nutrition advertisements" group; means for "snack food advertisements" and "nonfood advertisements" groups only were used in our analyses.
[7]Article also reported data for a "healthy advergames" group; means for "unhealthy advergames" and nonfood advergames groups only were used in our analyses.
[8]Article report data for "no television" and "reading" conditions; means for "advertising" and "no advertising" conditions only were used in our analyses.
[9]Article also reported data for "no advertisements" group; means for "food advertisements" and "nonfood advertisements" groups only were used in our analyses.

Study or Subgroup	Std. Mean Difference	SE	Weight	Std. Mean Difference IV, Random, 95% CI	Std. Mean Difference IV, Random, 95% CI
1.2.1 Adults					
Anschutz 2011 (27)	-0.05259	0.11043	5.0%	-0.05 [-0.27, 0.16]	
Bellisle 2009 (38)	-0.0704	0.1118	5.0%	-0.07 [-0.29, 0.15]	
Boland 2013 (31)	-0.16752	0.10911	5.0%	-0.17 [-0.38, 0.05]	
Harris 2009b (19)	0.13823	0.12217	5.0%	0.14 [-0.10, 0.38]	
Martin 2009 (28)	0.0269	0.10206	5.0%	0.03 [-0.17, 0.23]	
van Strien 2012 (46)	0.00742	0.08805	5.0%	0.01 [-0.17, 0.18]	
Wonderlich-Tierney 2013 (47)	0.20587	0.13868	4.9%	0.21 [-0.07, 0.48]	
Subtotal (95% CI)			34.8%	-0.00 [-0.08, 0.08]	
Heterogeneity: Tau² = 0.00; Chi² = 6.54, df = 6 (P = 0.37); I² = 8%					
Test for overall effect: Z = 0.00 (P = 1.00)					
1.2.2 Children					
Anschutz 2009 (29)	0.02625	0.09129	5.0%	0.03 [-0.15, 0.21]	
Anschutz 2010 (30)	-0.09752	0.1118	5.0%	-0.10 [-0.32, 0.12]	
Boyland 2013a (39)	0.44744	0.1191	5.0%	0.45 [0.21, 0.68]	
Boyland 2013b (39)	0.03059	0.12856	4.9%	0.03 [-0.22, 0.28]	
Dovey 2011 (21)	2.07638	0.08704	5.0%	2.08 [1.91, 2.25]	
Folkvord 2013 (23)	0.4908	0.08639	5.0%	0.49 [0.32, 0.66]	
Folkvord 2014 (22)	0.35674	0.08737	5.0%	0.36 [0.19, 0.53]	
Folkvord 2015 (24)	0.34122	0.10426	5.0%	0.34 [0.14, 0.55]	
Halford 2004 (18)	1.0697	0.10911	5.0%	1.07 [0.86, 1.28]	
Halford 2007 (25)	0.53218	0.07332	5.1%	0.53 [0.39, 0.68]	
Halford 2008 (26)	1.71047	0.09206	5.0%	1.71 [1.53, 1.89]	
Harris 2009a (19)	0.41517	0.09206	5.0%	0.42 [0.23, 0.60]	
Harris 2012 (20)	-0.12621	0.09901	5.0%	-0.13 [-0.32, 0.07]	
Subtotal (95% CI)			65.2%	0.56 [0.18, 0.94]	
Heterogeneity: Tau² = 0.47; Chi² = 625.43, df = 12 (P < 0.00001); I² = 98%					
Test for overall effect: Z = 2.92 (P = 0.003)					
Total (95% CI)			100.0%	0.37 [0.09, 0.65]	
Heterogeneity: Tau² = 0.40; Chi² = 788.63, df = 19 (P < 0.00001); I² = 98%					
Test for overall effect: Z = 2.57 (P = 0.01)					
Test for subgroup differences: Chi² = 8.14, df = 1 (P = 0.004), I² = 87.7%					

-2 -1 0 1 2
Favors Control ads Favors Food ads

FIGURE 2 Forest plot of subgroup analysis by age of participant (adult and children). An IV meta-analysis with the use of an SMD was used. I^2 is an indicator of between-comparison heterogeneity. IV, inverse variance; SMD, standardized mean difference.

a nonsignificant SMD of 0.14 for single-item food intake (4 studies contributed 5 comparisons; $I^2 = 82\%$)], and 3) offered the food after advertising exposure only [the subgroup difference reached significance at $P = 0.05$; there was a significant SMD of 0.73 for intake after advertising exposure (8 studies contributed 9 comparisons; $I^2 = 98\%$) compared with a nonsignificant SMD of 0.18 when intake included that which occurred during advertising exposure (4 studies contributed 4 comparisons; $I^2 = 85\%$)] (additional details of these analyses are shown in Supplemental Material). In addition, because 5 (18, 21, 25, 26, 39) of the 12 studies that featuring child participants were from the same research group, we performed a subgroup analysis that was based on this categorization of study origin (studies that originated from the same research group compared with other studies). The subgroup analysis indicated a significant effect ($\chi^2 = 5.30$, $P = 0.02$, $I^2 = 81\%$). For the 6 comparisons from the same research group, there was evidence of a large significant effect (SMD: 0.98; $P = 0.002$; 95% CI: 0.35, 1.61; $I^2 = 98\%$), and for the remaining 7 comparisons, there was evidence of a small significant effect (SMD: 0.20; $P = 0.003$; 95% CI: 0.02, 0.39; $I^2 = 86\%$).

The relatively small number of comparisons in many subgroups and the large amount of heterogeneity indicated that caution is required when interpreting the results of these exploratory subgroup analyses. Meaningful subgroup analyses that were based on pertinent participant characteristics were not possible in the current article because of the lack of availability of clearly demarked participant data across weight status, age, or sex in the published studies.

Publication bias

A visual inspection of funnel plots showed evidence of asymmetry. We formally examined publication bias with the use of Egger's test (41) in which the standard normal deviate (SMD/SE SMD) is regressed against the estimate's precision (inverse of the SE). The Egger's test P value was 0.06, which suggested evidence of asymmetry that could have been attributable to publication bias. Although these results should be interpreted with caution because of the substantial heterogeneity between studies that may have contributed to this result (48), we also performed a trim-and-fill analysis (42) to further explore the potential bias. This method showed no evidence of missing studies.

DISCUSSION

We conducted a systematic review (22 articles) and meta-analysis (18 articles, which contributed 20 effect sizes) of studies that experimentally manipulated advertising exposure (unhealthy food compared with a control) and measured concurrent or subsequent food intake. The meta-analysis, which was based on

all available study data, showed that the difference in food consumption was significant with a small-to-moderate magnitude of effect in the direction of increased intake after exposure to unhealthy food advertising than to the control. Subgroup analyses suggested that, although acute experimental exposure to food advertising did not increase food intake in adults, in children, there was a significant effect of a moderate magnitude.

There are 3 important considerations for interpreting this information. First, small effects at an individual level can have huge impacts across populations (49) because almost all children in Westernized societies are exposed to large amounts of unhealthy food advertising. Second, the current global escalation in obesity prevalence is the result of only relatively small but cumulative increases in absolute energy intake at the individual level (50). Third, the assessed studies examined responses to acute advertising exposure only. The collective effects of continued exposure to food marketing that occurs in real life and over a lifetime may lead to an amplification of these effects, particularly when the marketing is repetitive and delivered over multiple platforms and in many settings. Because of these findings, we argue that recommendations for enacting environmental strategies (4) and policy options (10) to reduce children's exposure to food advertising are evidence based and warranted.

The effect that food advertising exposure has on food consumption in children appears highly variable. The meta-analysis showed high heterogeneity across studies. Exploratory subgroup analyses indicated that differences in study designs may have contributed to this variability. For example, we showed larger effect sizes for studies that used within-subjects than between-subjects designs. It is plausible that this difference was related to demand characteristics (the notion of participants being aware of what the researcher is trying to investigate or anticipates finding and what this awareness implies for how participants may be expected to behave) that influenced the results of within-subjects studies. However, all such studies with children enforced either a 2-wk or 1-mo washout period between conditions to minimize the likelihood of participants being able to accurately recall their eating behaviors at the previous test session. It was not possible to explore other methodologic factors in separate analyses (e.g., the duration of advertising exposure and eating opportunity), but these factors were also likely to be important considerations that could have affected the findings. Participant characteristics (e.g., weight status, age, and sex) may also explain some of the variability. For example, there was notable variability in children's ages in the included studies (ranging from 5 to 12 y old) which could have affected both the children's susceptibility to advertising and their likelihood of conforming to socially desirable responses. However, we were unable to explore this aspect with the use of the subgroup analysis because of insufficiently demarked participant data across these factors. There is a need for greater methodologic and reporting consistency across research studies with consideration given to defining individual groups who may show particular vulnerability [e.g., individuals who are already overweight or obese, which was shown to substantially affect the food intake response in Halford et al. (26)]. Increased consistency of the experimental design and approach would ensure that the resulting evidence base would show a clear, replicable, and reliable effect for the purposes of informing appropriate policy action. However, it may also be useful and policy relevant to systematically explore the impact of these methodologic variations on outcomes (e.g., to establish whether a dose-response relation exists, or whether varying the food offered and its presentation may affect findings).

The findings of the current article are consistent with previous narrative reviews that have concluded that food advertising exposure has an effect on children's eating. A narrative review of studies of adult participants showed insufficient evidence to draw conclusions (17); our findings concur with this result. To our knowledge, only 7 published studies have focused on adult intake responses to acute advertising exposure, and thus, it is clear that more research is needed. In addition, it is reasonable to speculate that the lack of an effect shown in the few existing studies may have been due to several factors. One such factor may have been the greater cognitive ability of adults to be critical viewers of advertising. It has long been suggested that young children may be particularly vulnerable to the effects of marketing because they are unable to understand its selling or persuasive intent (4). Although older children may develop these skills, they do not necessarily use them (4). Similarly, although adults are likely to possess these skills, whether they are routinely activated during advertising exposure remains to be elucidated. Future studies should address this issue.

In addition, studies with children tended to be conducted in more-naturalistic settings (e.g., school environments), whereas adults participated in the laboratory. It may be that the adult participants were more aware of their eating behaviors in such a scenario than they would have been otherwise (51, 52); this possibility is important because it has previously been shown that, although the effect of a portion size on intake is widespread and robust, it is weaker in contexts in which more attention is given to the food being eaten (53). It may also be that the experimental aims were insufficiently disguised; evidence of attempts to mask the true purpose of the experiment was given in some studies (e.g., reference 27) but not in other studies. It would be useful to directly examine whether demand characteristic contribute to the lack of effects seen in adult studies that explored the impact of acute experimental advertising exposure on food intake.

Although studies of adult participants showed substantially less heterogeneity of an effect size than did studies with children, a notable methodologic variation was still apparent. For example, articles reported the extent of advertising exposure as either the number of television advertisements (advertisements may have been of varying length), the duration of exposure, or simply that a series of advertisements were presented, and thus, direct comparisons are difficult. Although the majority of studies reported having exposed participants to 5–10 food advertisements in the experimental condition or group (e.g., references 27, 28, 31), others studies used as few as 2 advertisements (43) or 4 advertisements (45). In addition, although some studies offered participants a single snack-food item (47), other studies offered a 16-item buffet meal (28). Greater consistency in such methodologic considerations is required to aid the interpretation of findings.

To our knowledge, this study is the first meta-analysis of the effect of food advertising exposure on food intake. The current article shows that, with the use of all available data to date, acute exposure to experimental food advertising significantly increases subsequent food intake in children. This finding provides strong evidence to support immediate policy action in this area. There

remains a need for future research to particularly show the effects of sustained or longer-term exposures to food advertising and to test whether the observed increases in intake after acute exposures are not later compensated for and, therefore, could lead to weight gain over time (54).

The current meta-analysis had limitations. Four articles were not included in our quantitative synthesis because they lacked the required data. However, because of the moderate effect sizes shown, it was unlikely that the addition of the 4 studies (of which 2 studies showed a significant effect of food advertising promoting greater intake overall, and an additional study showed this effect in overweight and obese girls) would have changed the overall conclusions.

In conclusion, our systematic review and meta-analysis provide evidence that acute exposure to unhealthy food advertisements increases food intake in children. Policymakers should take these findings into account and target policy action to reduce children's exposure to advertising of unhealthy foods.

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