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ARTICLE

Mealtime exposure to food advertisements while watching television increases food intake in overweight and obese girls but has a paradoxical effect in boys

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Abstract: Food advertisements (ads) in TV programs influence food choice and have been associated with higher energy intake from snacks in children; however, their effects at mealtime have not been reported. Therefore, we measured energy intake at a pizza meal consumed by normal weight (NW) and overweight/obese (OW/OB) children (aged 9–14 years) while they watched a TV program with or without food ads and following pre-meal consumption of a sweetened beverage with or without calories. NW and OW/OB boys (experiment 1, $n = 27$) and girls (experiment 2, $n = 23$) were randomly assigned to consume equally sweetened drinks containing glucose (1.0 g/kg body weight) or sucralose (control). Food intake was measured 30 min later while children watched a program containing food or nonfood ads. Appetite was measured before (0–30 min) and after (60 min) the meal. Both boys and girls reduced energy intake at the meal in compensation for energy in the glucose beverage ($p < 0.05$). Food ads resulted in further compensation (51%) in boys but not in girls. Food ads increased energy intake at the meal (9%; $p = 0.03$) in OW/OB girls only. In conclusion, the effects of TV programs with food ads on mealtime energy intake and response to pre-meal energy consumption in children differ by sex and body mass index.

Key words: children, appetite, compensation, thirst.

Résumé : Les publicités télévisées pour les aliments influencent le choix des aliments et, selon des études, elles sont associées à des collations contenant un apport énergétique plus élevé chez les enfants; toutefois, il n'y a pas d'études de leurs effets sur les repas. En conséquence, on évalue chez des enfants (âgé de 9–14 ans) de poids normal (« NW ») et en surpoids/obèses (« OW/OB ») l'apport énergétique au cours d'un repas constitué d'une pizza lors d'une émission télévisée incluant ou pas des publicités pour aliments et à la suite de la consommation préprandiale d'une boisson sucrée avec ou sans calories. Les garçons (expérimentation 1, $n = 27$) et les filles (expérimentation 2, $n = 23$) NW et OW/OB sont assignés aléatoirement à consommer une boisson de même teneur en sucre constitué de glucose (1,0 g/kg de masse corporelle) ou du sucralose (contrôle). Trente minutes plus tard, on évalue l'apport alimentaire des enfants au moment d'une émission de télévision incluant ou pas des annonces publicitaires d'aliments. On évalue l'appétit avant (0–30 min) et après (60 min) le repas. Tant les garçons que les filles diminuent leur apport énergétique au repas par compensation pour l'énergie contenu dans la boisson contenant du glucose ($p < 0,05$). Les annonces télévisées suscitent une compensation supplémentaire chez les garçons (51 %), mais pas chez les filles. Les publicités pour les aliments accroissent l'apport énergétique au repas (9 %; $p = 0,03$) chez les filles OW/OB seulement. En conclusion, les effets chez les enfants des émissions télévisées incluant des publicités pour les aliments sur l'apport énergétique au repas et sur la consommation préprandiale d'énergie diffèrent selon le sexe et l'indice de masse corporelle. [Traduit par la Rédaction]

Mots-clés : enfants, appétit, compensation, soif.

Introduction

Mealtime TV viewing (TVV) accounts for about a quarter of total daily energy intake (Matheson et al. 2004). Epidemiologic studies have associated increased obesity with TVV (Dietz and Gortmaker 1985; Kaur et al. 2003) and higher energy intake in youth who watch TV while eating (Van den Bulck and Van Mierlo 2004). Children who watch the most hours of TV are more likely to consume the foods advertised on TV (Utter et al. 2006); this is concerning because more than 90% of food advertisements (ads) viewed by children (aged 2–17 years) are high in fat, sugars, or sodium (Powell et al. 2007) and countries with a higher proportion of food ads promoting energy-dense foods have a higher rate of overweight children (Lobstein and Dibb 2005). In addition, food ads account for one-third of total ads on TV and Canadian children on average are exposed to 5 food ads per hour (Dietitians of Canada 2010).

A recent study suggested that food ads on TV, and not TVV per se, contribute to childhood obesity (Zimmerman and Bell 2010). In support of this, exposure to food ads while snacking increased energy intake from peanut M&Ms (M&M Chocolate Candy, Mars Inc.) in boys but not girls (Anschutz et al. 2009) and fish crackers in both boys and girls (Harris et al. 2009). In children, weight status may be a factor influencing the food intake response to food ads.

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Specifically, overweight/obese (OW/OB) compared with normal weight (NW) children recognized more food ads (Halford et al. 2004), and obese children (aged 9–11 years) had greater snack intakes (155%) in response to food versus nonfood ads than overweight (100%) and NW (89%) children (Halford et al. 2008). However, greater snack intake may not reflect changes in energy intake in response to physiological signals present at a meal consumed to satiation (Johnson and Anderson 2010).

In contrast, experimental studies show that TVV per se overrides physiological satiation signals at a meal to increase food intake and reduces compensation for calories in a pre-meal drink in 9- to 14-year-old boys (Bellissimo et al. 2007*b*). In girls, TVV reduced compensation for calories in a glucose drink in those who were peri-pubertal but not postpubertal (Patel et al. 2011). Because these studies did not include ads in the program, it is unclear if they have an additive effect to that of program content alone. Furthermore, the effect of food ads in a TV program at mealtime on satiety signals from a previously ingested food consumed before the meal has not been investigated.

Therefore, the objective of this study was to investigate the effect of mealtime exposure to food compared with nonfood ads on food intake and subjective appetite 30 min after consumption of a glucose or noncaloric sweetened drink in NW and OW/OB children. We hypothesized that (*i*) food ads in a program watched during a meal would increase mealtime energy intake by blocking the satiating effect of pre-meal energy intake and by increasing the amount of calories to achieve meal satiation in OW/OB but not NW children; and (*ii*) compensation would be sex-dependent.

Materials and methods

Participants

Children (aged 9–14 years old) born full-term and of normal birth weight participated. This study was performed according to the guidelines in the Declaration of Helsinki. All treatments and procedures were approved by the Human Participants Review Committee, Ethics Review Office, University of Toronto. Study population and recruitment strategies were similar to those reported previously (Bellissimo et al. 2007*a*, 2007*b*, 2008*a*; Bozinovski et al. 2009; Patel et al. 2011; Tamam et al. 2012). An in-person screening was scheduled at the Department of Nutritional Sciences, University of Toronto, where written informed consent was obtained from the parent and written assent from their child. Height (m) and weight (kg) were measured in light clothing and without shoes to determine age- and sex-specific body mass index (BMI) percentiles, according to the Canadian terminology (Secker 2010) of the World Health Organization growth charts (de Onis et al. 2007). Children were classified as NW, OW, and OB based on their BMI percentiles (15th and 84th, 85th and 96th, and 97th and above, respectively). Bioelectrical Impedance Analysis (RJL Systems BIA 101Q, Detroit, Mich., USA) was used to estimate body fat percentage using sex-specific equations (Horlick et al. 2002).

Protocol

Two experiments were conducted: experiment 1 in boys and experiment 2 in girls. Both experiments followed a within-subject repeated measures design. All participants attended 4 sessions that were scheduled once per week for 4 weeks. The 4 treatment sessions were (*i*) glucose drink with food ads, (*ii*) glucose drink with nonfood ads, (*iii*) control drink with food ads, and (*iv*) control drink with nonfood ads. Children were randomly assigned to a counterbalanced treatment session order. In each experimental session, food intake was measured from an ad libitum meal. Appetite and physical comfort were measured before and after the drink and ad libitum meal. Protocol procedures were similar to those reported previously (Bellissimo et al. 2007*a*; Patel et al. 2011). On 4 weekend mornings, each participant arrived at the laboratory between 0900 and 1200 h, 2 h after the consumption of a standardized breakfast at home. Appetite, thirst, physical comfort, sweetness, palatability of dietary treatments, and pizza were measured with visual analog scale questionnaires (VAS) as previously described (Bellissimo et al. 2007*b*, 2008*a*, 2008*b*; Bozinovski et al. 2009; Patel et al. 2011; Tamam et al. 2012). At baseline (0 min), appetite, physical comfort, and thirst were assessed and then participants were provided with a sweetened drink of either 1.0 g of glucose per kilogram body weight (glucose monohydrate; Grain Process Enterprises, Toronto, Ont., Canada) or a noncaloric control drink that was equally sweetened by addition of 0.15 g of SPLENDA Sucralose (Tate and Lyle Sucralose Inc., Deautur, Ill., USA) to determine the response to previously ingested calories (calorie compensation). This preload paradigm has been used in several of our studies (Bellissimo et al. 2007*a*, 2008*a*; Patel et al. 2011; Tamam et al. 2012). Aspartame-sweetened orange-flavoured crystals (1.1 g, Sugar Free Kool-Aid, Kraft Canada Inc., Don Mills, Ont., Canada) were added to each drink to standardize flavour. Drinks were prepared in 250 mL of water in covered opaque cups and stored in the refrigerator overnight. Participants consumed the drinks within 5 min followed by 50 mL of water to minimize aftertaste. Drink sweetness, thirst, and physical comfort were measured postdrink. Appetite, thirst, and physical comfort were measured again at 15 and 30 min.

Thirty minutes after drink consumption, participants were escorted to a feeding room and seated in individual cubicles, in front of a TV, and served an ad libitum pizza lunch along with 500 mL of water. After the participants were provided with the first tray of 3 pizzas, the program was started and they were asked to put on headphones to prevent disturbing other participants. An episode of *The Simpsons* (Fox Broadcasting Co.) including either food ads or nonfood ads was played based on their randomized treatment for that day. Additional trays of freshly baked pizza were provided every 10 min or as soon as participants finished their pizza. Participants were asked to remain seated for the meal (30 min) and instructed to eat until they were "comfortably full". Two varieties of Deep 'N Delicious 5″ diameter pizza (180 kcal each) were used: pepperoni and 3 cheese (provided by McCain Foods Ltd., Florenceville, N.B., Canada). The pizzas were cooked at 430 °F (221 °C) for 8 min and cut into 4 equal pieces and weighed before serving, and the amount left after the meal was subtracted from the initial weight to measure food intake in grams. This was then converted to kilocalories using information provided by the manufacturer. Cumulative energy intake was calculated from the sum of calories from the drink and meal. Water intake (g) was determined by subtracting the weight of the leftover from the initial weight of the water. Immediately after the pizza meal (postmeal), appetite, thirst, physical comfort, palatability of the pizza, and TV show acceptability were measured using VAS.

Food ads protocol

Commonly watched ads were incorporated into the TV show (Table 1). Four episodes of *The Simpsons* were screened to ensure the absence of food cues; any scene that contained food-related topics was removed while keeping the storyline intact. For each participant, 2 episodes were randomly selected to include food ads; the other 2 included nonfood ads. There were 4 commercial breaks in each episode and each commercial break was 2 min long. The first commercial break was incorporated right after the titles. The remaining commercial breaks were incorporated at 5-min intervals. The length of the episodes including the commercials was 30 min (Fig. 1). The commercials were recorded from appropriate children's programs played on Saturday mornings or during weekday afternoons. The episode with food ads contained 15 commercials including 8 fast-food restaurants, 4 candies, 2 breakfast cereals, and 1 orange drink advertisement. The episodes without food ads included 15 commercials that did not have food cues, which included ads for 8 toys, 3 sneakers, 2 theme parks, 1 movie, and 1 toy store. The food ads were randomly sequenced to make a total of

Table 1. Types of food and nonfood advertisements.

Nonfood	Food
African Lion Safari	Wendy's Baconator
Build A Bear	SunnyD Orange Drink
Sketchers Strap	Subway Breakfast
Zoobles	MacDonald's Happy Meal (I)
Kong Zhu Toy (I)	Pizza Hut Wings
Tech Deck	Hershey's Milk Chocolate
Twinkle Toe	Fruit loop Breakfast Cereal
Bakugan Toy	Wendy's Salad
Liv Dolls	Chili's To Go
Toy Story 3	MacDonald's Happy Meal (II)
Sketchers Shoe Light	Twizzlers
Fozoodles	MacDonald's Beef Burger
Marineland	Oh Henry!
Small Frys	Frosty Flakes
Fliktrix	Kit Kat

8 min (four 2-min intervals) of ads. The same sequence of ads was used for all participants and the same procedure was employed with nonfood ads.

Eating behaviour assessment

The Dutch Eating Behavior Questionnaire for children was administered to assess restrained eating (scores ranged from 1.0 to 2.4) (van Strien and Oosterveld 2008). Younger participants received assistance if they had difficulty interpreting the questionnaire's language.

Statistical analysis

Power analysis using the data from studies employing a similar cohort and research design (Bellissimo et al. 2007*a*; Patel et al. 2011) determined the sample size required for a food intake difference of 200 kcal and a power of 80% was estimated at 8–11 subjects per group (NW and OW/OB in each experiment). A total of 31 boys (13 NW and 18 OW/OB) and 28 girls (16 and 12 OW/OB) were recruited to account for potential dropouts.

One-factor ANOVA was used to compare group (NW vs. OW/OB) baseline characteristics. Pre-meal appetite, thirst, and physical comfort were expressed as change from baseline. Postmeal subjective appetite, thirst, and physical comfort were expressed as the change from 30 min. Three-factor ANOVA with the PROC Mixed procedure was used to assess the effect of weight, drink, time, and interactions between factors on pre-meal subjective appetite, thirst, and physical comfort. Three-factor ANOVA with the PROC Mixed procedure was used for analysis of the effect of weight (NW vs. OW/OB), drink (control vs. glucose), advertisement type (food ads vs. nonfood ads), and interactions between factors on food intake (kcal), cumulative energy intake (kcal), water intake, food palatability, TV program acceptability, and postmeal subjective appetite, thirst, and physical comfort. Two-factor ANOVA, using the PROC MIXED procedure, was used for analysis of the effect of weight and drink and weight-by-drink interactions on drink sweetness and drink palatability. For all ANOVA, Tukey–Kramer post hoc tests were used to determine differences among factors when there was significance. Also, 1- and 2-factor ANOVAs with the PROC Mixed procedure were used to further explain interactions. Age was included as a covariate in all analyses. Interactions between main factors are only reported when significant. Average appetite (Bellissimo et al. 2007*a*, 2007*b*, 2008*a*; Patel et al. 2011) and percent caloric compensation (Black and Anderson 1994; Bellissimo et al. 2007*b*, 2008*a*; Patel et al. 2011) were calculated as done previously. Data are presented as means ± SE. Significance was considered at $p < 0.05$. Statistical Analysis Software (SAS) version 9.2 (SAS Institute Inc., Carey, N.C., USA) was used to perform statistical analyses.

Results

Participants

Subject characteristics are presented in Table 2. For experiment 1, 31 boys were recruited; however, 2 boys did not complete all sessions and 2 (1 NW, 1 OW/OB) were removed from analysis because they were outliers (food intake responses > 2 SD from the mean). The final number of boys included in the analysis was 27 (11 NW and 16 OW/OB). For experiment 2, 28 girls were recruited; however, 1 girl did not complete all sessions and 4 (2 NW, 2 OW/OB) were removed from analysis because they were outliers (food intake responses > 2 SD from the mean). The final number of girls included in the analysis was 23 (14 NW and 9 OW). In both boys and girls, OW/OB participants had higher weight, BMI percentile, and fat mass compared with NW participants ($p < 0.05$). Restraint scores were lower in NW compared with OW/OB boys ($p = 0.003$), but there was no difference between NW and OW/OB girls.

Food and water intake

Experiment 1 (boys)

Mealtime food intake was reduced after the glucose drink by 18% ($p < 0.0001$), but there was no main effects of ads or weight on food intake in boys (Table 3). Cumulative energy intake (drink plus food calories) was not affected by drink, ads, or weight. However, there was a drink-by-ads interaction ($p = 0.02$), which is explained by the fact that cumulative food intake was higher following glucose compared with control with nonfood ads ($p = 0.03$), but not with food ads ($p = 0.08$). Both ads ($p = 0.03$) and weight ($p = 0.04$) affected caloric compensation. Caloric compensation was higher with food ads (121%) compared with nonfood ads (70%) and in NW (131%) compared with OW/OB boys (71%). Water intake was not affected by any of the main factors or their interactions.

Experiment 2 (girls)

Similarly in girls, mealtime food intake was 15% lower after the glucose drink ($p < 0.001$), but neither ads nor weight affected food intake (Table 4). There was a weight-by-drink interaction ($p = 0.02$), where food intake was 21% lower after the glucose drink in OW/OB ($p < 0.0001$), but only 11% lower in NW girls ($p = 0.003$), which was consistent with the higher energy content of the glucose preload consumed by the OW/OB girls. There was also an weight-by-ads interaction ($p = 0.02$). Food intake was 9% higher when OW/OB girls watched food ads compared with nonfood ads ($p = 0.03$), but was not different in NW girls ($p = 0.25$). Cumulative energy intake was 12% higher after the glucose drink compared with the control drink ($p < 0.0001$). There was also a weight-by-ads interaction ($p = 0.02$) on cumulative energy intake. Cumulative food intake was significantly higher in OW/OB girls with food ads compared with nonfood ads (895.8 ± 57.0 vs. 833.2 ± 43.3, $p = 0.04$), but not different in NW (716.5 ± 31.9 vs. 741.0 ± 25.7, $p = 0.26$) girls. Caloric compensation was not affected by ads or weight. Water intake was not affected by any of the main factors or their interactions.

Appetite and thirst

Experiment 1 (boys)

In the pre-meal period, change from baseline average appetite increased (Fig. 2A) and thirst decreased over time ($p < 0.005$) (data not shown), but were not affected by drink or weight. In the postmeal period (change from 30 min), average appetite (Fig. 2A), and thirst (data not shown) decreased after the meal ($p < 0.05$). Postmeal average appetite was not affected by weight, drink, or ads. Postmeal thirst was reduced less after food ads compared with nonfood ads (–1.1 ± 4.3 mm vs. –14.2 ± 3.4 mm, $p < 0.001$) but was not affected by drink or weight.

Fig. 1. Ads protocol. Food ads (FAs) were randomly sequenced to make a total of 8 min of ads and incorporated in an episode of *The Simpsons* (Fox Broadcasting Inc.) that contained no food cues to make a total of 30 min of a TV show. The same procedure was used with nonfood ads.

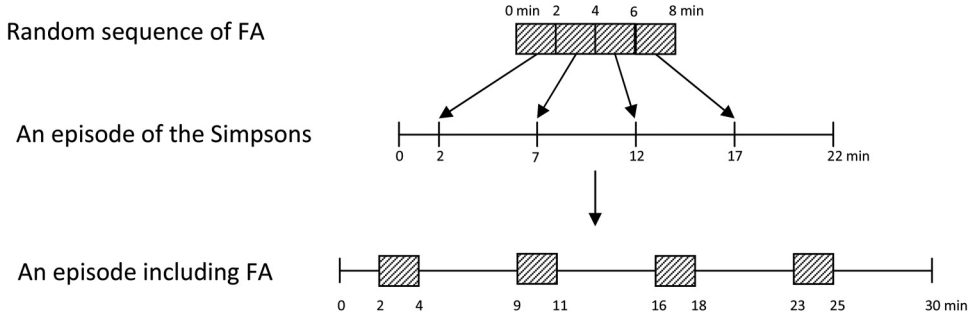


Table 2. Baseline characteristics of participants.

	Boys			Girls		
	NW (n = 11)	OW/OB (n = 16)	p	NW (n = 14)	OW/OB (n = 9)	p
Weight (kg)	43.1±1.3	64.6±2.2	<0.01	43.0±1.3	62.3±1.7	<0.001
BMI percentile	54.4±2.6	94.0±0.5	<0.001	55.2±3.1	95.0±0.4	<0.001
Fat mass (%)	14.8±1.7	30.4±1.7	<0.001	24.6±1.9	36.2±3.2	<0.01
Restraint	1.4±0.1	1.8±0.1	<0.01	1.6±0.1	1.8±0.1	0.18

Note: Data are presented as means ± SE. A 1-factor ANOVA, with weight as the main factor, was used to compare group (NW vs. OW/OB) baseline characteristics. BMI, body mass index; NW, normal weight; OB, obese; OW, overweight.

Experiment 2 (girls)

In the pre-meal period, change from baseline average appetite increased (Fig. 2B) and thirst (data not shown) decreased over time ($p < 0.005$), but they were not affected by drink or weight. Postmeal (change from 30 min) average appetite (Fig. 2B) and thirst (data not shown) decreased after the meal ($p < 0.05$), but were not affected by weight, drink, or ads.

Physical comfort, sweetness, palatability, and enjoyment of the TV program

Experiment 1 (boys)

Drink sweetness was not affected by type of drink or weight. There was no main effect of type of drink or weight on drink palatability; however, there was a significant weight-by-drink interaction ($p = 0.01$). This interaction is explained by the 14% lower drink palatability after glucose (65 ± 5 mm) compared with control (76 ± 5 mm) in NW boys ($p < 0.01$), whereas responses to drinks were not significantly different in the OW/OB group (glucose, 71 ± 5 mm vs. control, 65 ± 5 mm; $p = 0.21$).

In the pre-meal period, time ($p = 0.04$) but not drink or weight affected physical comfort. Physical comfort was 7% lower after consumption of the drinks (0 min vs. 5 min, 82 ± 2 mm vs. 76 ± 3 mm, $p < 0.05$) and then increased to baseline at 30 min (80 ± 2 mm). Postmeal physical comfort was not affected by weight, drink, or ads (data not shown).

TV program acceptability was also not affected by weight, drink, or ads. Overall, program acceptability with food ads was 84 ± 2 mm and nonfood ads was 85 ± 2 mm. There was a main effect of drink ($p = 0.02$) on food palatability, but it was not affected by ads or weight. Food palatability was 6% lower after the glucose (82 ± 2 mm) compared with the control (87 ± 2 mm) drink.

Experiment 2 (girls)

Drink sweetness and palatability were not affected by drink or weight and there were no interactions (data not shown).

Time ($p = 0.003$) but not drink or weight affected pre-meal physical comfort. Physical comfort was on average 6% less than baseline after consumption of the drinks (0 min vs. 5 min, 79 ± 2 mm vs. 74 ± 3 mm, $p = 0.02$), then increased to the baseline value at 30 min (80 ± 2 mm). Postmeal physical comfort scores were not affected by weight, drink, or ads (data not shown).

TV program acceptability was not affected by weight or drinks; however, it was 5% higher ($p = 0.01$) when girls watched food ads (84 ± 3 mm) compared with nonfood ads (80 ± 3 mm). Food palatability was not affected by weight, drink, or ads. Overall, palatability with food ads was 82 ± 3 mm and nonfood add was 82 ± 3 mm.

Discussion

The results of this study showed the effects of TV programs with food ads on mealtime energy intake and that the response to pre-meal energy consumption in children differed by sex and BMI. Food ads in a TV program watched during a meal increased calorie intake in only OW/OB girls and enhanced caloric compensation after the pre-meal glucose drink in boys. Therefore, our results only partially supported the hypothesis that OW/OB children consume more energy while watching a TV program with food ads compared with nonfood ads.

The present study is the first to report the effect of children's mealtime exposure to food ads in TV programs on the satiating effects of a pre-meal beverage and on calorie intake at the meal. The results contradict the suggestion that the effect of TVV on increasing food intake is due to higher exposure to food ads alone and not because of TVV per se (Halford et al. 2008; Zimmerman and Bell 2010). Caloric compensation was incomplete in girls regardless of their weight or the type of ads (58% in nonfood ads vs. 50% food ads) and it was incomplete in boys with nonfood ads (70%) but not with food ads (121%). This supports our previous studies showing that mealtime TVV alone distracts 9- to 14-year-old children from physiological satiety signals, resulting in reduced compensation for the calories consumed before a meal from 112% to 66% in boys (Bellissimo et al. 2007*a*) and 139% to 16% in peripubertal girls (Patel et al. 2011).

The possibility that interest in the TV program per se is a primary driver of food intake is also a potential explanation for the increase in food intake in only OW/OB girls. Overall, girls rated the TV program acceptability higher when it contained food ads compared with nonfood ads. This suggests that girls have learned to associate higher levels of TVV enjoyment with the presence of food; however, this greater enjoyment only leads to higher food intake in those who are OW/OB. In contrast, others have shown that concurrent food ads increased M&M (Mars Inc.) intake in 8- to 12-year-old boys but not in girls, and BMI did not correlate with food intake (Anschutz et al. 2009). The authors speculated that this was because the food ads were primarily directed towards boys and had more male characters. They also note that boys are more represented in ads (including food) directed towards children compared with girls (Browne 1998; Childs and Maher 2003). However, in the present study, this potential confounder was reduced because ads were equally directed to both girls and boys.

Food intake 30 min after the glucose drink was lower in boys and girls, which is consistent with other studies of children in the

Table 3. Experiment 1: Effect of weight, advertisements (ads), and drink on food intake, drink calories, food plus drink calories, caloric compensation, and water intake in boys.

	NW				OW/OB				*p*		
	Nonfood		Food		Nonfood		Food		Main effects		
	Control	Glucose	Control	Glucose	Control	Glucose	Control	Glucose	Drink	Weight	Ads
Food intake (kcal)[a]	950 ±79	782 ±67	1010 ±64	728 ±52	1094 ±103	970 ±94	1184 ±90	957 ±91	<0.0001	0.22	0.20
Cumulative food intake (kcal)[b]	950 ±79	958 ±71	1010 ±64	904 ±55	1094 ±103	1223 ±105	1184 ±90	1210 ±101	0.62	0.14	0.59
Caloric compensation (%)[c]	—	99 ±24	—	162 ±34	—	50 ±12	—	93 ±25	—	0.04	0.03
Water intake (g)[d]	175 ±47	164 ±32	189 ±50	181 ±37	275 ±43	264 ±39	257 ±41	235 ±42	0.92	0.12	0.68

Note: Data are presented as means ± SE (n = 27). A 3-factor ANOVA was used to analyze the effect of weight, ads, drinks, and their interactions on food intake, food plus drink calories, and water intake. A 2-factor ANOVA was used to assess the effect of weight and ads on caloric compensation. NW, normal weight; OB, obese; OW, overweight.

[a]Interactions: drink-by-ads, p = 0.16; weight-by-ads, p = 0.34; weight-by-drink, p = 0.27; weight-by-drink-by-ads, p = 0.89.

[b]Interactions: drink-by-ads, p = 0.02; weight-by-ads, p = 0.38; weight-by-drink, p = 0.06; weight-by-drink-by-ads, p = 0.98.

[c]Interactions: weight-by-ads, p = 0.66.

[d]Interactions: drink-by-ads, p = 0.99; weight-by-ads, p = 0.41; weight-by-drink, p = 0.70; weight-by-drink-by-ads, p = 0.85.

Table 4. Experiment 2: Effect of weight, advertisements (ads), and drink on food intake, drink calories, food plus drink calories, caloric compensation, and water intake in girls.

	NW				OW/OB				*p*		
	Nonfood		Food		Nonfood		Food		Main effects		
	Control	Glucose	Control	Glucose	Control	Glucose	Control	Glucose	Drink	Weight	Ads
Food intake (kcal)[a]	696±41	617±17	670±42	594±47	798±59	619±66	852±85	690±77	0.001	0.18	0.28
Cumulative intake (kcal)[b]	696±41	786±28	670±42	763±46	798±59	868±65	852±85	939±78	<0.0001	0.07	0.48
Caloric compensation (%)[c]	—	47±17	—	39±24	—	75±18	—	67±20	—	0.19	0.72
Water intake (g)[d]	120±38	136±40	123±36	132±34	212±56	218±37	215±50	231±51	0.32	0.08	0.80

Note: Data are presented as means ± SE (n = 23). A 3-factor ANOVA was used to analyze the effect of weight, ads, drinks, and their interactions on food intake, food plus drink calories, and water intake. A 2-factor ANOVA was used to assess the effect of weight and ads on caloric compensation. NW, normal weight; OB, obese; OW, overweight.

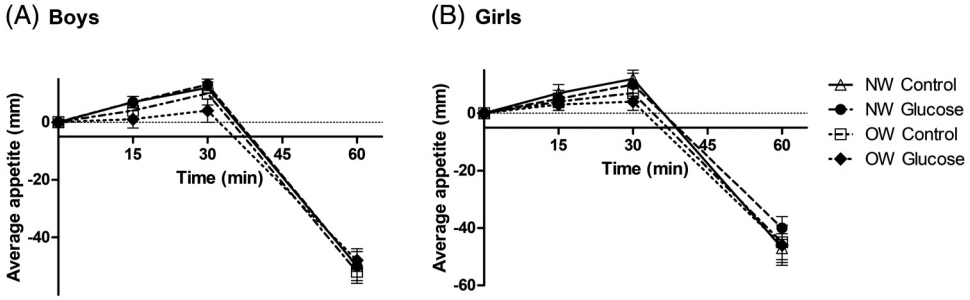
[a]Interactions: drink-by-ads, p = 0.78; weight-by-ads, p = 0.02; weight-by-drink, p = 0.02; weight-by-drink-by-ads, p = 0.85.

[b]Interactions: drink-by-ads, p = 0.79; weight-by-ads, p = 0.02; weight-by-drink, p = 0.57, weight-by-drink-by-ads, p = 0.78.

[c]Interactions: weight-by-ads, p = 0.99.

[d]Interactions: drink-by-ads, p = 0.93; weight-by-ads, p = 0.87; weight-by-drink, p = 0.98; weight-by-drink-by-ads, p = 0.27.

Fig. 2. Effect of drink weight status and time on change in average appetite in boys (A) and girls (B). Conditions were control, normal weight (NW) (triangle); glucose, NW (circles); control, overweight (OW)/obese (OB) (squares); glucose, OW/OB (diamonds). Time affected change from baseline average appetite in both girls and boys (3-way ANOVA, $p < 0.005$).



same age group (Bellissimo et al. 2007*a*, 2008*b*; Patel et al. 2011; Tamam et al. 2012). However, caloric compensation for the pre-meal glucose drink was affected by weight and type of ads in boys only. It was higher in NW boys (131%) than in OW/OB boys (71%), which is consistent with the higher restraint scores in OW/OB boys and the inverse association between restraint and caloric compensation in all boys (r = −0.28, p = 0.04) but not in girls in this study (r = 0.11, p = 0.45) or in a previous study (Patel et al. 2011). Lower compensation for calories in the glucose drink in OW/OB children may be due to the dose (1 g/kg body weight) of glucose provided (OW/OB consumed more calories from glucose) and that mealtime compensation for pre-meal calorie loads is not linearly related to dose (Panahi et al. 2013). More surprising, NW and OW boys had better compensation for the pre-meal calories when watching TV with food ads compared with TV with nonfood ads. This leads to the suggestion that perception of pizza enjoyment may have decreased as they became aware of alternate meals they would have preferred.

Consistent with our previous studies in children (Anderson et al. 1989; Bellissimo et al. 2007*a*, 2008*a*, 2008*b*; Patel et al. 2011), average appetite did not decrease after the glucose drink compared with control in either boys or girls. Because the glucose drink resulted in lower food intake but had no effect on appetite, it can be suggested that subjective appetite and food intake following liquid calories are disconnected. However, children reported a decrease in appetite after the pizza meal, indicating that children are able to interpret the VAS and reflect their subjective appetite after consumption of a solid food, which is similar to previous studies in this age range (Anderson et al. 1989; Bellissimo et al. 2007*a*, 2008*a*; Patel et al. 2011, 2013). In contrast, both boys and girls decreased their thirst scores after consumption of both glucose and control drinks and further after consumption of water during the meal. Because postmeal thirst ratings were higher after food ads compared with nonfood ads in boys, further studies are required to examine the effect of food ads on subjective thirst.

A possible explanation is that beverages in the ads (Table 1) created a desire for them and this was expressed as greater thirst.

While the results of this study clearly show that both sex and weight are important factors in determining the impact of food ads on food intake regulation and should be considered when designing future studies, there are limitations to the design. First, to isolate the effect of food ads, level of exposure to food ads was 11 times that of what children are usually exposed to in a 30-min period. Furthermore, pizza, which is a preferred food for children of this age, was rated highly palatable and led to high caloric intake at the meal, as observed in other studies (Drewnowski 1997; Larson et al. 2012). This may have contributed to the lack of effect of food ads in NW girls and NW and OW/OB boys. Also, the environment in the feeding room is not representative of in-home eating and perhaps affects normal behavioural response to food cues. It is also possible that the amount of time between the drink and pizza meal may not have been long enough to fully assess the impact of food ads on food intake and appetite responses. In conclusion, the effects of TV programs with food ads on mealtime energy intake and response to pre-meal energy consumption in children differ by sex and BMI.

Conflict of interest statement

None of the authors have conflicts of interest.

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