Title
Longitudinal relations of television, electronic games, and digital versatile discs with changes in diet in adolescents 1 , 2 , 3

Journal
American Journal of Clinical Nutrition, 100(4)

ISSN
0002-9165

Authors
Falbe, Jennifer
Willett, Walter C
Rosner, Bernard
et al.

Publication Date
2014-10-01

DOI
10.3945/ajcn.114.088500

Peer reviewed

Longitudinal relations of television, electronic games, and digital versatile discs with changes in diet in adolescents[1–3]

Jennifer Falbe, Walter C Willett, Bernard Rosner, Steve L Gortmaker, Kendrin R Sonneville, and Alison E Field

ABSTRACT

Background: Youth spend more time with screens than any activity except sleeping. Screen time is a risk factor for obesity, possibly because of the influence of food and beverage advertising on diet.

Objective: We sought to assess longitudinal relations of screen time [ie, television, electronic games, digital versatile discs (DVDs)/videos, and total screen time] with the 2-y changes in consumption of foods of low nutritional quality (FLNQ) that are commonly advertised on screens [ie, sugar-sweetened beverages, fast food, sweets, salty snacks, and the sum of these foods (total FLNQ)] and fruit and vegetables.

Design: With the use of 2004, 2006, and 2008 waves of the Growing Up Today Study II, which consisted of a cohort of 6002 female and 4917 male adolescents aged 9–16 y in 2004, we assessed screen time (change and baseline) in relation to the 2-y dietary changes. Regression models included 4604 girls and 3668 boys with complete screen time and diet data on ≥2 consecutive questionnaires.

Results: Each hour-per-day increase in television, electronic games, and DVDs/videos was associated with increased intake of total FLNQ (range: 0.10–0.28 servings/d; $P < 0.05$). Each hour-per-day increase in total screen time predicted increased intakes of sugar-sweetened beverages, fast food, sweets, and salty snacks (range: 0.02–0.06 servings/d; $P < 0.001$) and decreased intakes of fruit and vegetables (range: −0.05 to −0.02 servings/d; $P < 0.05$). Greater screen time at baseline (except electronic games in boys) was associated with subsequent increased intake of total FLNQ, and greater screen time at baseline (except DVDs/videos) was associated with decreased intake of fruit and vegetables ($P < 0.05$). Across sex and food groups and in sensitivity analyses, television was most consistently associated with dietary changes.

Conclusions: Increases in screen time were associated with increased consumption of foods and beverages of low nutritional quality and decreased consumption of fruit and vegetables. Our results caution against excessive use of screen media, especially television, in youth. *Am J Clin Nutr* 2014;100:1173–81.

INTRODUCTION

Results from longitudinal studies and interventions to reduce screen time support a causal link between television viewing and unhealthy weight gain in youth (1–5). Several explanatory mechanisms (6) have been proposed; television may displace exercise, reduce the resting metabolic rate, and promote excess energy intake in part by exposing viewers to marketing for unhealthy foods. Studies that assessed mechanisms have provided little evidence that television displaces physical activity (7–11) or reduces the resting metabolic rate (12, 13). In contrast, the hypothesis that television affects diet has been supported by cross-sectional evidence (14, 15). Fewer longitudinal (16–22) and experimental studies (23–26) have examined this mechanism but have generally provided support for it.

Other media have also been linked to weight gain (5, 27–29), although not consistently (30, 31), and there is a dearth of evidence on mediators. Digital versatile discs (DVDs)[4] typically have fewer commercials than television (unless they consist of recorded television), but many DVDs contain ads before the content begins, and video-gaming websites often contain visual display ads for foods (32). Furthermore, DVDs and television shows later available on DVD can contain food-product placements, which debuted in 1982 when Reese's Pieces (The Hershey Company) appeared in the movie *ET* (33). Likewise, product placements in video games and advergames (ie, games designed to market a product) have been on the rise for over a decade (33). However, compared with television viewing, it may be harder to eat while gaming if both hands are occupied. Other pathways through which screen time may affect diet include the possibility that youth have been conditioned to eat during leisurely sitting, or screens have a distracting effect that promotes unconscious overeating. However, experimental studies that have compared media with and without food marketing indicated an additional effect of advertising on diet (23, 34).

The marketing of sugar-sweetened beverages (SSBs) and fast food are of particular concern because of the strong evidence that

[1] From the Departments of Nutrition (JF and WCW), Epidemiology (JF, WCW, and AEF), and Social and Behavioral Sciences and Prevention Research Center (SLG), Harvard School of Public Health, Boston, MA; the Channing Division of Network Medicine, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA (BR, WCW, and AEF); and the Division of Adolescent Medicine, Boston Children's Hospital, Boston, MA (AEF and KRS).

[2] Supported by grants from the Breast Cancer Research Foundation and DK084001 from the NIH for the initiation of the cohort and collection and management of data during follow-up. JF's work was supported by an NIH Training Grant in Academic Nutrition (DK007703).

[3] Address correspondence to J Falbe, 50 University Hall #7360, Berkeley, CA 94720-7360. E-mail: jfalbe@mail.harvard.edu.

[4] Abbreviations used: DVD, digital versatile disc; FLNQ, foods of low nutritional quality; FV, fruit and vegetable; GUTS, Growing Up Today Study; SES, socioeconomic status; SSB, sugar-sweetened beverage; Δ, change in or change in consumption of.

Received March 19, 2014. Accepted for publication July 18, 2014.

First published online August 13, 2014; doi: 10.3945/ajcn.114.088500.

has linked them to adiposity and excess energy intake (35–38). In addition, restaurant foods and carbonated beverages constituted the first and second largest categories of youth-targeted marketing expenditures in 2009 (39).

Longitudinal studies are needed to examine nontelevision media in relation to the consumption of heavily marketed products. Specifically, there is a need to evaluate how changes in screen time relate to concurrent changes in diet because these associations may correspond to outcomes expected from intervention strategies. Therefore, we sought to assess associations of baseline and change in separate forms of screen time (ie, television, electronic games, and DVDs/videos) with the changes in the consumption of foods of low nutritional quality (FLNQ) that are commonly advertised and foods not commonly advertised [ie, fruit and vegetables (FVs)] in adolescents in the Growing Up Today Study (GUTS) II. We examined these associations by using 3 assessments (2004, 2006, and 2008) of GUTS II participants aged 9–16 y in 2004 and 11–19 y on return of the 2006 questionnaire.

SUBJECTS AND METHODS

The ongoing GUTS II cohort was established in 2004 by sending letters that explained the study to 20,700 mothers in the Nurses' Health Study II who had children aged 9–15 y living across the United States. Invitation letters and questionnaires were mailed to 8826 girls and 8454 boys whose mothers had granted written consent. A total of 6002 girls and 4917 boys returned

TABLE 1
Groups of foods of low nutritional quality[1]

Group	Food-frequency questionnaire items (serving specified in question)
Sugar-sweetened beverages	Soda, not diet (1 can or glass)
	Hawaiian Punch,[2] lemonade, Kool-Aid,[3] or other noncarbonated fruit drink (1 glass)
	Sports drinks (Powerade[4] or Gatorade[5]) (individual bottle)
	Chocolate or other flavored milk (glass)
	Milkshake or frappe (1)
Fast food	Cheeseburger (1)
	Hamburger (1)
	Pizza (2 slices)
	Tacos/burritos/enchiladas (1)
	Chicken nuggets (6)
	Hot dogs (1)
	French fries (large order)
Sweets	Fruit snacks or fruit rollups (1 pack)
	Pop-Tarts[6] (1)
	Cake (1 slice)
	Snack cakes, such as Twinkies[7] (1 package)
	Danish, sweet rolls, pastry (1)
	Donuts (1)
	Cookies (1)
	Brownies (1)
	Pie (1 slice)
	Chocolate (1 bar or packet) such as Hershey's[8] or M&M's[9]
	Other candy bars (Milky Way,[9] Snickers[9])
	Other candy without chocolate (Skittles[9]) (1 pack)
	Ice cream
	Popsicles
Salty snacks	Potato chips (1 small bag)
	Corn chips/Doritos[10] (small bag)
	Popcorn (1 small bag)
	Pretzels (1 small bag)
	Crackers, such as Wheat Thins[11] or Ritz[11]

[1] Identified by comparing marketing expenditure reports and content analyses of advertising on television and other media to comparable food items on Growing Up Today Study II questionnaires.
[2] Dr Pepper Snapple Group.
[3] Kraft Foods Group.
[4] The Coca-Cola Company.
[5] PepsiCo.
[6] Kellogg Company.
[7] Hostess Brands, LLC.
[8] The Hershey Company.
[9] Mars, Incorporated.
[10] Frito-Lay North American, Inc.
[11] Mondelēz International, Inc.

completed questionnaires, thereby assenting to participate. Follow-up questionnaires were sent in the fall of 2006 and 2008. Approximately 80% of girls (n = 4779) and 79% of boys (n = 3863) returned the 2006 questionnaire, and 68% of girls (n = 4098) and 61% of boys (n = 3014) returned the 2008 questionnaire. Participants with complete data on media and diet on ≥2 consecutive questionnaires were eligible for the analysis. The study was approved by the Human Subjects Committee at Brigham and Women's Hospital, and analyses presented in this article were approved by the institutional review boards at Brigham and Women's Hospital and Boston Children's Hospital.

Outcomes

Outcomes were the 2-y changes in the consumption of servings per day of FLNQ (ΔFLNQ) commonly advertised on screens, including SSBs, fast foods, sweets (including candy), and salty snacks, and the 2-y ΔFVs. Groups of FLNQ were identified by comparing marketing expenditure reports and content analyses of advertising on television and other media (40–47) to comparable food items on GUTS II questionnaires.

GUTS II questionnaires included the previously validated Youth/Adolescent Questionnaire (48), which is a self-administered, semiquantitative food-frequency questionnaire that assesses the usual consumption of specific foods and beverages over the past year. For example, to assess soda consumption (a can or individual bottle), response options included never, 1–3 servings/mo, 1 serving/wk, 2–6 servings/wk, 1 serving/d, 2–3 servings/d, and >3 servings/d. We calculated average servings per day of each food group and the total FLNQ by using midpoints of response options. When the highest response option was reported (eg, >3 servings/d), this intake was coded as the lowest

TABLE 2
Subject characteristics in 2006 and 2-y change values[1]

	Girls (n = 4604)	Boys (n = 3668)
Characteristics		
Age (y)	15.7 ± 1.9 (15.8)[2]	15.6 ± 1.9 (15.6)
Non-Hispanic white (%)[3]	93.6	92.5
Height (in)	64.4 ± 2.9 (64)	67.9 ± 4.4 (68)
ΔHeight (in)	0.8 ± 1.4 (0.0)	4.5 ± 2.7 (5.0)
BMI (kg/m^2)	21.4 ± 3.7 (20.8)	21.7 ± 3.9 (21.0)
Obese (%)[4]	3.7	6.0
Overweight or obese (%)[4]	16.3	23.5
Physical activity (h/wk)[5]	9.7 ± 7.2 (8.3)	11.8 ± 8.6 (10.0)
ΔPhysical activity (h/wk)[5]	−0.62 ± 6.57 (−0.50)	−0.32 ± 7.8 (−0.31)
Census-tract median income (×$1000)	70 ± 26 (66)	71 ± 26 (67)
Frequency of family dinner ≥3 times/wk (%)	79.7	84.8
Dietary variables (servings/d)		
Sugar-sweetened beverages	0.79 ± 0.85 (0.57)	1.29 ± 1.08 (1.07)
ΔSugar-sweetened beverages	−0.17 ± 0.80 (−0.07)	−0.13 ± 1.09 (−0.07)
Fast food	0.42 ± 0.30 (0.34)	0.64 ± 0.43 (0.55)
ΔFast food	−0.03 ± 0.30 (−0.01)	0.03 ± 0.45 (0.01)
Sweets	1.25 ± 0.99 (0.99)	1.58 ± 1.27 (1.25)
ΔSweets	−0.14 ± 0.99 (−0.09)	−0.16 ± 1.24 (−0.13)
Salty snacks	0.52 ± 0.44 (0.41)	0.59 ± 0.50 (0.42)
ΔSalty snacks	−0.05 ± 0.46 (−0.01)	−0.04 ± 0.52 (0.00
Total foods of low nutritional quality	2.98 ± 1.80 (2.64)	4.10 ± 2.31 (3.67)
ΔTotal foods of low nutritional quality	−0.40 ± 1.64 (−0.32)	−0.31 ± 2.14 (−0.28)
Fruit and vegetables	3.07 ± 1.54 (2.76)	2.89 ± 1.34 (2.68)
ΔFruit and vegetables	0.11 ± 1.46 (0.08)	0.06 ± 1.32 (0.01)
Screen time (h/d)		
Television	1.35 ± 1.07 (0.93)	1.48 ± 1.12 (0.93)
ΔTelevision	−0.19 ± 1.01 (0.00)	−0.08 ± 1.12 (0.00)
Electronic games[6]	0.20 ± 0.39 (0.07)	1.14 ± 1.15 (0.93)
ΔElectronic games[6]	0.01 ± 0.46 (0.00)	0.07 ± 1.18 (0.00)
DVDs/videos	0.72 ± 0.54 (0.93)	0.74 ± 0.62 (0.93)
ΔDVDs/videos	0.07 ± 0.63 (0.00)	0.12 ± 0.74 (0.00)
Total screen time[7]	2.26 ± 1.43 (1.93)	3.36 ± 2.13 (2.79)
ΔTotal screen time[7]	−0.11 ± 1.43 (0.00)	0.11 ± 2.14 (0.00)

[1] Values measured in 2008 minus values measured in 2006 (3200 girls and 2330 boys). DVD, digital versatile disc; Δ, change in or change in consumption of.

[2] Mean ± SD; median in parentheses (all such values).

[3] Calculation of the percentage did not include individuals with missing values in the denominator.

[4] On the basis of cutoffs defined by the International Obesity Task Force.

[5] Moderate-to-vigorous recreational physical activity (≥3 metabolic equivalents).

[6] Video and computer games.

[7] Did not include computer or Internet use for homework, work, or other recreational use (except for computer and Internet games, which were encompassed by electronic games).

frequency for that response (eg, 4 servings soda/d). Food and beverage items from the Youth/Adolescent Questionnaire that contributed to groups of FLNQ are shown in **Table 1**. FVs included all FVs assessed except juice and white potatoes. Each participant contributed 1–2 outcomes for ΔFLNQ and ΔFVs (change in servings per day from 2004 to 2006 and/or change in servings per day from 2006 to 2008). To reduce the influence of extreme outcome values, we identified and excluded outliers by using the extreme Studentized deviate many-outlier procedure (49).

Exposures

Exposures included baseline and the 2-y change (in h/d) of television, electronic games (video and computer games, including online games), DVDs/videos, and total screen time. For weekends and weekdays separately, participants could report up to ≥31 h/wk for each media by using categorical response options (eg, 0–0.5 h). The midpoint of each option, or 31 h for the highest option, was used to calculate the total daily time with each media, which was treated as a continuous variable in analyses. Electronic games were assumed to be predominantly passive. Computer and internet use for purposes other than games was not included in the analysis. A similar instrument that assessed inactivity was reasonably correlated with the 24-h recall ($r = 0.54$) (50). We excluded outlying (49) or implausible (5) screen times (ie, ≥8 h of television/d, ≥7 h of games/d, or ≥120 h of total screen time/wk).

Covariates

Hours per week of moderate-to-vigorous recreational physical activity (≥3 metabolic equivalents) (51) was assessed by asking participants to recall by season the amount of time per week over the past year in 18 activities. BMI (in kg/m^2) was calculated from self-reported height and weight. Overweight/obese status was determined by using International Obesity Task Force cutoffs (52). We used medians by age and sex to impute missing physical activity, height, and BMI. Outliers (49) and implausible values (ie, activity >40 h/wk) were excluded.

Race-ethnicity was assessed by asking participants to select one or more of the following: white; black or African American; Spanish, Hispanic, or Latino; Asian; American Indian or Alaskan Native; Native Hawaiian or Pacific Islander; or other. Because of small numbers of nonwhites, race-ethnicity was categorized as non-Hispanic white or other. Other potential confounders included the census-tract median income and frequency of family dinners.

Sample

A total of 4711 girls and 3793 boys had complete data on screen time and diet from ≥2 consecutive questionnaires. We excluded 3 girls and 1 boy with ≤12 mo between questionnaires, 13 girls and 15 boys with an outlying change in diet, 39 girls and 45 boys with an outlying or implausible screen time, and 52 girls and 64 boys with outlying or implausible BMI, height, or physical activity variables. After these exclusions, the analytic sample comprised 4604 girls and 3668 boys.

Statistical analysis

To assess the potential for bias as a result of a loss to follow-up, we compared baseline (2004) values between subjects included and excluded from the analyses and tested for differences by using the Mann-Whitney-Wilcoxon test.

To examine relations of screen time with ΔFLNQ and ΔFVs, we used sex-specific multivariate linear regression models. Generalized estimating equations were used for estimation by specifying an exchangeable covariance structure to account for repeated measures and siblings (53). We examined relations of baseline and the 2-y change in screen time with the concurrent 2-y change in diet in the same models (eg, television time in 2006 and Δtelevision time from 2006 to 2008 in relation to ΔFLNQ from 2006 to 2008). All models that examined separate media simultaneously included television, electronic games, and DVDs/videos.

Models were adjusted for age, age squared, race-ethnicity, months between questionnaires, and baseline diet in each period. To account for the baseline and change in energy requirements,

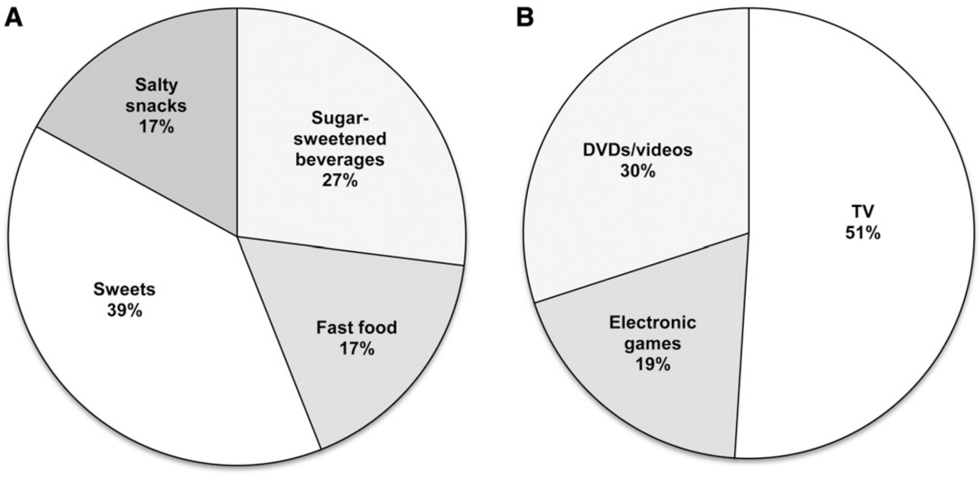

FIGURE 1. Mean composition of reported intakes of total foods of low nutritional quality and total screen time in 8272 Growing Up Today Study II participants in 2006. A: Proportion of total foods of low nutritional quality by food and beverage groups. B: Proportion of total screen time by types of media assessed. DVD, digital versatile disc; TV, television.

all models also included baseline BMI, height, physical activity, Δheight, and Δphysical activity in each time period. Final models further adjusted for the quintile of the census tract median income and frequency of family dinners to address confounding by neighborhood environments and parenting. Indicators were used for missing race-ethnicity and family dinners. To determine whether overweight/obesity modified observed relations, we included an indicator for overweight/obesity and cross-products of this term with screen time in models.

In a sensitivity analysis, we ran fixed-effects models (54) by using generalized estimating equations for the estimation that examined the changes in screen time in relation to the change in dietary intake without adjustment for the baseline screen time or diet that controls for all time-invariant confounders.

To assess whether the potential effect of increasing screen time was similar to decreasing it, we plotted predicted means of ΔFLNQ and ΔFVs from models by using linear splines terms for Δtotal screen time with knots at 0 h/d. Analyses were conducted with SAS software (version 9.2; SAS Institute).

RESULTS

Subject characteristics in 2006 and change values from 2006 to 2008 are presented in **Table 2**. Ninety-three percent of participants were non-Hispanic white, which reflected the composition of the Nurses' Health Study II. Boys were more likely to be overweight/obese and spend more time playing electronic games than were girls. Girls and boys consumed about the same amount of FVs, but boys consumed more FLNQ than did girls. In all participants, the largest proportion of total FLNQ comprised sweets, followed by SSBs, and television accounted for the largest proportion of screen time (**Figure 1**). Spearman's correlations between different media at baseline ranged from 0.15 to 0.34, and correlations between the baseline and change in a single form of screen time (eg, baseline television time and change in television time) ranged from −0.43 to −0.59.

There were minor differences between subjects included and excluded from analyses because of a loss to follow-up. In girls, the 2 groups were comparable on total screen time, total FLNQ, FVs, physical activity, and census-tract median income. However, subjects not included were slightly older (0.5 y) and had higher age-adjusted BMI (0.4) (all $P < 0.001$). In boys, groups were comparable on total FLNQ, physical activity, and census-tract median income. Excluded boys were slightly older (0.5 y) and had higher age-adjusted BMI (0.4) and total screen time (0.6 h/d) and lower intake of FVs (−0.2 servings/d) (all $P < 0.01$). In girls and boys, mothers of those included in the analysis had somewhat lower BMIs (−0.6 for girls and −0.9 for boys; all $P < 0.001$) than those of mothers of those not included, but mothers' age, television viewing (h/d), and diet quality (ie, Alternate Healthy Eating Index score) (55) were comparable between groups.

Associations between baseline screen time and diet are shown in **Table 3**. In girls and boys, all forms of screen time at baseline, except electronic games in boys, were significantly associated with 2-y increases in the consumption of total FLNQ, and all forms of baseline screen time, except DVDs/videos, predicted a decreased consumption of FVs. In girls only, greater baseline screen time of DVDs/videos was significantly associated with increased intake of FVs.

TABLE 3
Adjusted change in consumption of foods of low nutritional quality and fruit and vegetables associated with baseline screen time[1]

	Girls (n = 4604; 7690 observations)				Boys (n = 3668; 5906 observations)			
Outcome	Television	Electronic games	DVDs/videos	Total screen time	Television	Electronic games	DVDs/videos	Total screen time
ΔSugar-sweetened beverages (servings/d)	0.05 (0.03, 0.07)***	0.07 (0.01, 0.13)*	0.06 (0.01, 0.10)*	0.06 (0.04, 0.07)***	0.05 (0.02, 0.08)***	0.05 (0.02, 0.08)**	0.08 (0.03, 0.14)**	0.06 (0.04, 0.07)***
ΔFast food (servings/d)	0.02 (0.01, 0.03)***	0.03 (0.00, 0.05)*	0.04 (0.03, 0.06)***	0.03 (0.02, 0.03)***	0.03 (0.01, 0.04)***	0.01 (0.00, 0.02)	0.04 (0.02, 0.06)***	0.02 (0.02, 0.03)***
ΔSweets (servings/d)	0.02 (0.00, 0.05)*	0.03 (−0.03, 0.09)	0.10 (0.05, 0.15)***	0.04 (0.03, 0.06)***	0.08 (0.04, 0.11)***	0.00 (−0.03, 0.03)	0.05 (−0.02, 0.12)	0.04 (0.02, 0.06)***
ΔSalty snacks (servings/d)	0.02 (0.01, 0.03)***	0.00 (−0.02, 0.03)	0.04 (0.02, 0.06)***	0.02 (0.02, 0.03)***	0.02 (0.01, 0.04)**	0.00 (−0.01, 0.01)	0.05 (0.02, 0.08)***	0.02 (0.01, 0.02)***
ΔTotal foods of low nutritional quality (servings/d)	0.10 (0.06, 0.14)***	0.11 (0.01, 0.22)*	0.21 (0.13, 0.29)***	0.13 (0.10, 0.16)***	0.16 (0.10, 0.22)***	0.05 (−0.01, 0.10)	0.21 (0.10, 0.32)***	0.12 (0.09, 0.15)***
ΔFruit and vegetables (servings/d)	−0.12 (−0.16, −0.09)***	−0.09 (−0.17, −0.01)*	0.10 (0.03, 0.17)**	−0.07 (−0.09, −0.05)***	−0.06 (−0.09, −0.02)***	−0.06 (−0.09, −0.03)***	0.00 (−0.06, 0.07)	−0.05 (−0.06, −0.03)***

[1] All values (2-y change in servings per day per hour per day of screen time at baseline) are βs; 95% CIs in parentheses. Values were estimated by using sex-stratified linear regression models (with the use of generalized estimating equations). Models were adjusted for age, age squared, baseline BMI, baseline height, Δheight, months between questionnaires, race-ethnicity [non-Hispanic white (yes or no)], physical activity (h/wk), Δphysical activity (h/wk), quintile of census tract median income, and frequency of family dinners. All models included the baseline and change in screen time (h/d) in the same model. Electronic games included video and computer games. Total screen time did not include computer or Internet use for homework, work, or other recreational use (except for computer and Internet games, which were encompassed by electronic games). *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. DVD, digital versatile disc; Δ, change in or change in consumption of.

TABLE 4
Adjusted change in consumption of foods of low nutritional quality and fruit and vegetables associated with change in screen time[1]

Outcome	Girls (n = 4604; 7690 observations)				Boys (n = 3668; 5906 observations)			
	ΔTelevision	ΔElectronic games	ΔDVDs/videos	ΔTotal screen time	ΔTelevision	ΔElectronic games	ΔDVDs/videos	ΔTotal screen time
ΔSugar-sweetened beverages (servings/d)	0.05 (0.03, 0.07)***	0.00 (−0.04, 0.05)	0.07 (0.04, 0.11)***	0.05 (0.03, 0.06)***	0.07 (0.04, 0.10)***	0.04 (0.01, 0.07)**	0.06 (0.01, 0.10)*	0.05 (0.04, 0.07)***
ΔFast food (servings/d)	0.01 (0.00, 0.02)*	0.03 (0.01, 0.04)**	0.06 (0.04, 0.07)***	0.02 (0.02, 0.03)***	0.02 (0.01, 0.03)***	0.02 (0.01, 0.03)**	0.05 (0.03, 0.07)***	0.02 (0.02, 0.03)***
ΔSweets (servings/d)	0.04 (0.01, 0.06)**	0.05 (0.00, 0.10)	0.10 (0.06, 0.14)***	0.06 (0.04, 0.07)***	0.06 (0.03, 0.10)***	0.04 (0.01, 0.07)**	0.04 (−0.01, 0.10)	0.05 (0.03, 0.07)***
ΔSalty snacks (servings/d)	0.02 (0.01, 0.03)***	0.02 (0.00, 0.05)	0.05 (0.03, 0.07)***	0.03 (0.02, 0.04)***	0.03 (0.01, 0.04)***	0.01 (0.00, 0.03)*	0.02 (0.00, 0.04)*	0.02 (0.01, 0.03)***
ΔTotal foods of low nutritional quality (servings/d)	0.11 (0.07, 0.15)***	0.10 (0.01, 0.19)*	0.28 (0.21, 0.34)***	0.15 (0.12, 0.18)***	0.18 (0.12, 0.24)***	0.10 (0.05, 0.16)***	0.17 (0.07, 0.26)***	0.14 (0.11, 0.18)***
ΔFruit and vegetables (servings/d)	−0.08 (−0.11, −0.05)***	−0.07 (−0.14, 0.01)	0.03 (−0.03, 0.09)	−0.05 (−0.08, −0.03)***	−0.03 (−0.07, 0.00)*	−0.01 (−0.04, 0.02)	0.00 (−0.06, 0.05)	−0.02 (−0.03, 0.00)*

[1] All values (change in servings per day per hour per day change in screen time over a 2-y period) are βs; 95% CIs in parentheses. Values were estimated by using sex-stratified linear regression models (with the use of generalized estimating equations). Models were adjusted for age, age squared, baseline BMI, baseline height, Δheight, months between questionnaires, race-ethnicity [non-Hispanic white (yes or no)], physical activity (h/wk), Δphysical activity (h/wk), quintile of census tract median income, and frequency of family dinners. All models included the baseline and change in screen time (h/d) in the same model. ΔTotal screen time did not include computer or Internet use for homework, work, or other recreational use (except for computer and Internet games, which were encompassed by electronic games). *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. DVD, digital versatile disc; Δ, change in or change in consumption of.

Relations of changes in screen time with ΔFLNQ and ΔFVs are summarized in **Table 4**. Changes in all types of screen time (Δtelevision, Δelectronic games, ΔDVDs/videos, and Δtotal screen time) predicted increased intake of total FLNQ. Changes in these media also predicted changes in all specific groups of FLNQ, except for Δelectronic games in girls and ΔDVDs/videos in boys. ΔElectronic games in girls was significantly associated with only Δfast food and Δtotal FLNQ, and ΔDVDs/videos in boys was not significantly associated with Δsweets. ΔTelevision and Δtotal screen time corresponded to decreased intake of FVs in girls and boys. None of these associations varied by overweight/obesity.

In sensitivity analyses that used fixed-effects regression, associations between changes in screen time and Δtotal FLNQ were similar to those shown in Table 4 (all $P < 0.01$), with the exception of Δelectronic games in girls and ΔDVDs/videos in boys, which were not significantly associated with Δtotal FLNQ (data not shown). Magnitudes of coefficients from fixed-effects models were generally similar to those shown in Table 4, but some were marginally attenuated (eg, βs relating Δtotal screen time to Δtotal FLNQ decreased from 0.15 to 0.14 servings/d in girls), whereas others were strengthened (eg, β relating Δelectronic games to Δtotal FLNQ increased from 0.10 to 0.13 servings/d in boys). In fixed-effects models, changes in screen time were not significantly related to ΔFV intake except for Δtelevision (−0.03 servings/d) and Δtotal screen time (−0.03 servings/d) in girls (all $P < 0.05$).

Predicted means for ΔFLNQ and ΔFVs from models in which splines were used for Δtotal screen time are shown in **Figure 2**. Relations between Δtotal screen time and changes in diet were similar for both negative and positive Δtotal screen time.

DISCUSSION

In 8272 youth across the United States, increases in total screen time and greater baseline total screen time were associated with increased intake of all FLNQ, particularly SSBs and sweets, and decreased intake of FVs. All forms of baseline and change in screen time (ie, television, electronic games, and DVDs/videos) were associated with increased intake of total FLNQ except baseline electronic games in boys. Several forms of baseline screen time and Δtelevision, but not Δelectronic games or ΔDVDs/videos, were associated with decreased FV intake. Spline models revealed similar slopes for changes in dietary intake whether screen time increased or decreased, which suggested that screen time–reduction interventions are likely to improve diet.

Overall, magnitudes of screen time–diet associations appeared modest and were likely underestimated because of random errors in exposure assessment, but they constituted clinically meaningful changes. For instance, in girls, each hour-per-day increase in total screen time was associated with a 0.15-servings/d increase in total FLNQ. For a 16-oz cola, this amount would translate into an ~30.3-cal/d increase, which over 1 y, would result in an excess of >11,000 cal or several pounds.

Other longitudinal studies of youth have also shown associations between television viewing and greater intakes of SSBs (18, 19, 22), fast food (17–19), sweets (19), candy (19), and snacks (18, 19, 22) and lower intake of FVs (16, 18, 22). Together with experimental evidence of an advertising effect on

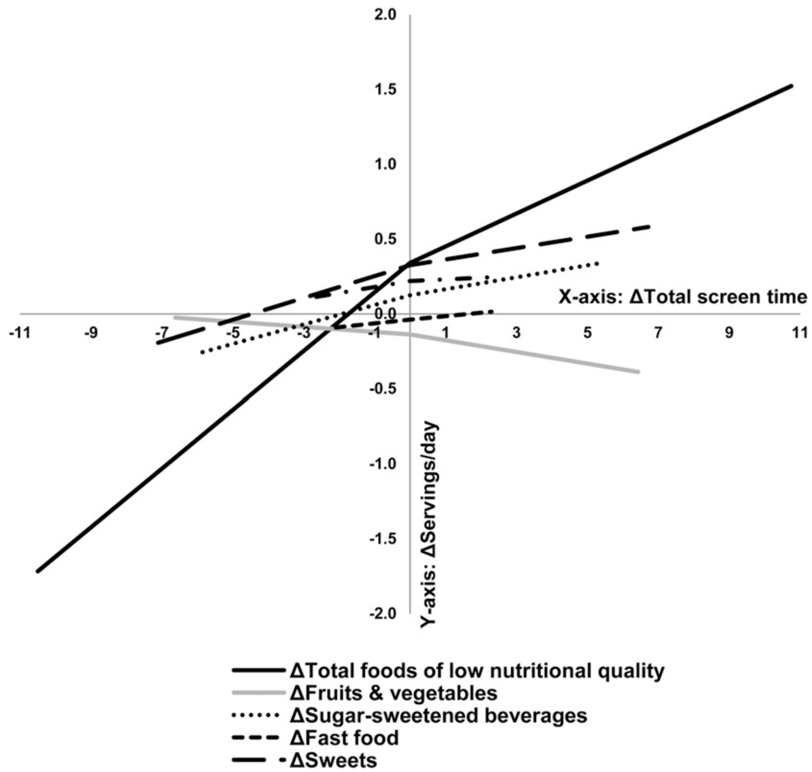

FIGURE 2. Results from linear spline models: predicted means of change in diet from models including linear spline terms for *Δ*total screen time (h/d) with a knot at 0 h/d (*n* = 8272; observations = 13,596). Models were adjusted for sex, age, age squared, baseline BMI, baseline height, *Δ*height, months between questionnaires, race-ethnicity, physical activity (h/wk), *Δ*physical activity (h/wk), baseline total screen time (h/d), quintile of census tract median income, and frequency of family dinners. *Δ*, change in or change in consumption of.

children's food preferences and intakes (23, 24, 56), these results suggest that the television-adiposity link is partly mediated by food and beverage marketing.

Few longitudinal studies have assessed nontelevision screen time separately from television in relation to diet, and we are unaware of other studies that have examined DVDs and diet. As observed for television, baseline and *Δ*DVDs/videos were associated with *Δ*FLNQ. This result may be partially attributed to the exposure to commercials through recordings of television or to product placements. The majority of top box-office movies from 1996 to 2005 contained ≥1 food/beverage-product placement (57), and in 2008, youth saw more brand appearances than commercials for soft drinks during prime-time programming (58) later available on DVD. A third possibility is that advertising for unhealthy foods before movies in theaters have conditioned youth to consume those items while watching DVDs. In addition, we observed a positive association between baseline DVDs/videos and *Δ*FV in girls only. This finding may have only been due to chance or may reflect that greater DVD/video viewing is associated with an increased consumption of all foods in girls.

To our knowledge, one other prospective cohort study has assessed electronic games in relation to *Δ*FLNQ in youth. Gebremariam et al (22) reported significant associations between baseline and *Δ*computers/games and increases in SSBs and snacks and decreases in FVs. We observed similar associations. Like DVDs, electronic games may contain marketing through advergames, which are product placements within games (eg, a character drinks a branded soda), or display advertising on gaming websites. A content analysis of food-industry websites advertised on children's networks showed that >80% contained advergames (40). Experimental studies have shown that advergames affect children's snack choices and consumption (34, 59, 60).

All media that we assessed were related to *Δ*FLNQ. However, across sex and food groups and in sensitivity analyses, television was most consistently associated with a dietary change. These results may reflect that television is still the dominant medium for youth-directed marketing, even amid growing advertising expenditures elsewhere (61). Moreover, because watching television is a hands-free activity (relative to video games), it is easier to snack at the same time.

An additional mechanism linking screens with overeating is that screens may pose a distraction that promotes excess energy intake (62–65) and interferes with the memory of consumption (64) and appetite (66). Video games may also elicit the mental stress-induced reward system, in which food is the reward (67). Other possibilities are that youth have been conditioned to eat during screen time, or in the case of television and DVD viewing, having idle hands leads to snacking. However, experimental studies that compared media with and without food marketing have shown an additional advertising effect (23, 34).

This study had several limitations, including a lack of assessment of media content, exposure to specific advertisements, and multitasking (68) and the possibility of unmeasured confounding by factors such as parenting style. However, our adjustment for the frequency of family dinners partially addressed the latter. Participants were predominantly white children of nurses and had a lower prevalence of overweight and obesity (69) and screen time (70) than the national average, which potentially limited generalizability to youth of color and low socioeconomic status (SES). Although the direction of associations between screen time and diet would not be expected to differ in lower SES youth, the strength may vary. For instance, the diet of lower SES youth may be more susceptible to effects of screen time if their food environments provide greater access to FLNQ. Alternatively, susceptibility would be lower if the youth had less money to purchase food. In addition, boys (but not girls) who were not included in the analyses because of missing or outlying follow-up data had a higher total screen time and lower intake of FVs at baseline, which potentially biased the association between these variables in boys. The direction of the influence was uncertain because we did not have the screen time or dietary trajectories of these boys, but if they maintained or increased screen time and decreased intake of FVs, these variables would have attenuated our results. Associations between screen time and Δtotal FLNQ were less likely to be biased by missing data because subjects lost to follow-up did not differ significantly from subjects in the analyses with respect to both total screen time and total FLNQ at baseline. Last, our measures relied on self-reports. In our sample, the reported consumption of FLNQ declined from 2004 to 2008. Although this trend was consistent with national declines in energy intake during this period (71), it is possible that FLNQ were underreported because of a growing awareness about their health implications. Despite these limitations, this study had numerous strengths, including its large sample, longitudinal design with repeated measures, and novel examination of separate media. Although most experiments provided strong evidence of short-term effects, cohorts are essential for examining long-term relations. Cohorts should begin to incorporate more-detailed measures of screen content (eg, advergames, type of DVD, and recordings of live television) to better characterize the exposure to marketing.

This study, which showed a correspondence between increases in screen time and concurrent increases in intake of foods and beverages of low nutritional quality most frequently advertised on screens provided additional evidence that food marketing may mediate links between screen time, diet, and adiposity. Consequently, screens could possibly be made less obesogenic by reducing youth-directed marketing for unhealthy products. Although national recommendations include limits on screen time, a growing ubiquity of product placements, advergames, and access to television content through multiple devices makes it difficult for parents to enforce media rules. Alternatives, such as regulatory approaches, that take into account product placements and new media should be studied and considered.

In conclusion, increased time with television, electronic games, and DVDs/videos was associated with an increased consumption of foods and beverages of low nutritional quality. These results support the hypothesis that diet is a mediator of the relation between screen time and adiposity in youth.

We thank the thousands of young people across the country who are participating in the GUTS II as well as their mothers.

The authors' responsibilities were as follows—JF, WCW, BR, SLG, and AEF: designed the research; JF: performed statistical analyses, wrote the manuscript, and had primary responsibility for the final content of the manuscript; and all authors: contributed to the interpretation of data and read, revised, and approved the final manuscript. None of the authors had a conflict of interest.

REFERENCES

1. van Grieken A, Ezendam NP, Paulis WD, van der Wouden JC, Raat H. Primary prevention of overweight in children and adolescents: a meta-analysis of the effectiveness of interventions aiming to decrease sedentary behaviour. Int J Behav Nutr Phys Act 2012;9:61.
2. Tremblay MS, Leblanc AG, Kho ME, Saunders TJ, Larouche R, Colley RC, Goldfield G, Gorber SC. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. Int J Behav Nutr Phys Act 2011;8:98.
3. Council on Communications Media, Strasburger VC. Children, adolescents, obesity, and the media. Pediatrics 2011;128:201–8.
4. Rey-López JP, Vicente-Rodriguez G, Biosca M, Moreno LA. Sedentary behaviour and obesity development in children and adolescents. Nutr Metab Cardiovasc Dis 2008;18:242–51.
5. Falbe J, Rosner B, Willett WC, Sonneville KR, Hu FB, Field AE. Adiposity and different types of screen time. Pediatrics 2013;132:e1497–505.
6. Robinson TN. Television viewing and childhood obesity. Pediatr Clin North Am 2001;48:1017–25.
7. Epstein LH, Roemmich JN, Robinson JL, Paluch RA, Winiewicz DD, Fuerch JH, Robinson TN. A randomized trial of the effects of reducing television viewing and computer use on body mass index in young children. Arch Pediatr Adolesc Med 2008;162:239–45.
8. Taveras EM, Field AE, Berkey CS, Rifas-Shiman SL, Frazier AL, Colditz GA, Gillman MW. Longitudinal relationship between television viewing and leisure-time physical activity during adolescence. Pediatrics 2007;119:e314–9.
9. Jenvey VB. The relationship between television viewing and obesity in young children: a review of existing explanations. Early Child Dev Care 2007;177:809–20.
10. Marshall SJ, Biddle SJ, Gorely T, Cameron N, Murdey I. Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. Int J Obes Relat Metab Disord 2004;28:1238–46.
11. Kahn EB, Ramsey LT, Brownson RC, Heath GW, Howze EH, Powell KE, Stone EJ, Rajab MW, Corso P. The effectiveness of interventions to increase physical activity. A systematic review. Am J Prev Med 2002;22(suppl):73–107.
12. Dietz WH, Bandini LG, Morelli JA, Peers KF, Ching PL. Effect of sedentary activities on resting metabolic rate. Am J Clin Nutr 1994;59:556–9.
13. Cooper TV, Klesges LM, Debon M, Klesges RC, Shelton ML. An assessment of obese and non obese girls' metabolic rate during television viewing, reading, and resting. Eat Behav 2006;7:105–14.
14. Ford C, Ward D, White M. Television viewing associated with adverse dietary outcomes in children ages 2-6. Obes Rev 2012;13:1139–47.
15. Pearson N, Biddle SJ. Sedentary behavior and dietary intake in children, adolescents, and adults a systematic review. Am J Prev Med 2011;41:178–88.
16. Boynton-Jarrett R, Thomas TN, Peterson KE, Wiecha J, Sobol AM, Gortmaker SL. Impact of television viewing patterns on fruit and vegetable consumption among adolescents. Pediatrics 2003;112:1321–6.
17. Larson NI, Neumark-Sztainer DR, Story MT, Wall MM, Harnack LJ, Eisenberg ME. Fast food intake: longitudinal trends during the transition to young adulthood and correlates of intake. J Adolesc Health 2008;43:79–86.
18. Barr-Anderson DJ, Larson NI, Nelson MC, Neumark-Sztainer D, Story M. Does television viewing predict dietary intake five years later in high school students and young adults? Int J Behav Nutr Phys Act 2009;6:7.
19. Wiecha JL, Peterson KE, Ludwig DS, Kim J, Sobol A, Gortmaker SL. When children eat what they watch: impact of television viewing on dietary intake in youth. Arch Pediatr Adolesc Med 2006;160:436–42.
20. Sonneville KR, Gortmaker SL. Total energy intake, adolescent discretionary behaviors and the energy gap. Int J Obes (Lond) 2008;32 (suppl 6):S19–27.
21. Pearson N, Ball K, Crawford D. Mediators of longitudinal associations between television viewing and eating behaviours in adolescents. Int J Behav Nutr Phys Act 2011;8:23.
22. Gebremariam MK, Bergh IH, Andersen LF, Ommundsen Y, Totland TH, Bjelland M, Grydeland M, Lien N. Are screen-based sedentary behaviors longitudinally associated with dietary behaviors and leisure-time physical activity in the transition into adolescence? Int J Behav Nutr Phys Act 2013;10:9.
23. Harris JL, Bargh JA, Brownell KD. Priming effects of television food advertising on eating behavior. Health Psychol 2009;28:404–13.

24. Halford JC, Boyland EJ, Hughes G, Oliveira LP, Dovey TM. Beyond-brand effect of television (TV) food advertisements/commercials on caloric intake and food choice of 5-7-year-old children. Appetite 2007; 49:263–7.
25. Gorn GJ, Goldberg ME. Behavioral evidence of the effects of televised food messages on children. J Consum Res 1982;9:200–5.
26. Anschutz DJ, Engels RC, Van Strien T. Side effects of television food commercials on concurrent nonadvertised sweet snack food intakes in young children. Am J Clin Nutr 2009;89:1328–33.
27. Berkey CS, Rockett HR, Gillman MW, Colditz GA. One-year changes in activity and in inactivity among 10- to 15-year-old boys and girls: relationship to change in body mass index. Pediatrics 2003;111: 836–43.
28. Berkey CS, Rockett HR, Colditz GA. Weight gain in older adolescent females: the internet, sleep, coffee, and alcohol. J Pediatr 2008;153: 635–9, 639.e1.
29. O'Loughlin J, Gray-Donald K, Paradis G, Meshefedjian G. One- and two-year predictors of excess weight gain among elementary school-children in multiethnic, low-income, inner-city neighborhoods. Am J Epidemiol 2000;152:739–46.
30. Zimmerman FJ, Bell JF. Associations of television content type and obesity in children. Am J Public Health 2010;100:334–40.
31. Janz KF, Burns TL, Levy SM. Tracking of activity and sedentary behaviors in childhood: the Iowa Bone Development Study. Am J Prev Med 2005;29:171–8.
32. Ustjanauskas AE, Harris JL, Schwartz MB. Food and beverage advertising on children's web sites. Pediatr Obes (Epub ahead of print 2 July 2013).
33. Institute of Medicine. Food marketing to children and youth: threat or opportunity? Washington, DC: Institute of Medicine, 2005.
34. Folkvord F, Anschutz DJ, Buijzen M, Valkenburg PM. The effect of playing advergames that promote energy-dense snacks or fruit on actual food intake among children. Am J Clin Nutr 2013;97:239–45.
35. Hu FB, Malik VS. Sugar-sweetened beverages and risk of obesity and type 2 diabetes: epidemiologic evidence. Physiol Behav 2010;100:47–54.
36. Ebbeling CB, Feldman HA, Chomitz VR, Antonelli TA, Gortmaker SL, Osganian SK, Ludwig DS. A randomized trial of sugar-sweetened beverages and adolescent body weight. N Engl J Med 2012;367: 1407–16.
37. de Ruyter JC, Olthof MR, Seidell JC, Katan MB. A trial of sugar-free or sugar-sweetened beverages and body weight in children. N Engl J Med 2012;367:1397–406.
38. Rosenheck R. Fast food consumption and increased caloric intake: a systematic review of a trajectory towards weight gain and obesity risk. Obes Rev 2008;9:535–47.
39. Federal Trade Commission. A review of food marketing to children and adolescents: follow-up report. Washington, DC: Federal Trade Commission, 2012.
40. Culp J, Bell RA, Cassady D. Characteristics of food industry web sites and "advergames" targeting children. J Nutr Educ Behav 2010;42: 197–201.
41. Henry AE, Story M. Food and beverage brands that market to children and adolescents on the internet: a content analysis of branded web sites. J Nutr Educ Behav 2009;41:353–9.
42. Kovacic WE, Harbour PJ, Leibowitz J, Rosch TJ. marketing food to children and adolescents: a review of industry expenditures, activities, and self-regulation. A report to Congress. Washington, DC: Federal Trade Commission, 2008.
43. Batada A, Seitz MD, Wootan MG, Story M. Nine out of 10 food advertisements shown during Saturday morning children's television programming are for foods high in fat, sodium, or added sugars, or low in nutrients. J Am Diet Assoc 2008;108:673–8.
44. Batada A, Wootan MG. Nickelodeon markets nutrition-poor foods to children. Am J Prev Med 2007;33:48–50.
45. Bell RA, Cassady D, Culp J, Alcalay R. Frequency and types of foods advertised on Saturday morning and weekday afternoon English- and Spanish-language American television programs. J Nutr Educ Behav 2009;41:406–13.
46. Gallo A. Food advertising in the United States. In: Frazao E, ed. America's eating habits: changes and consequences. Washington, DC: Economic Research Service, US Dept of Agriculture, 1999:173–80.
47. Fairclough SJ, Boddy LM, Hackett AF, Stratton G. Associations between children's socioeconomic status, weight status, and sex, with screen-based sedentary behaviours and sport participation. Int J Pediatr Obes 2009;4:299–305.
48. Rockett HR, Breitenbach M, Frazier AL, Witschi J, Wolf AM, Field AE, Colditz GA. Validation of a youth/adolescent food frequency questionnaire. Prev Med 1997;26:808–16.
49. Rosner B. Percentage points for a generalized ESD many-outlier procedure. Technometrics 1983;25:165–72.
50. Gortmaker SL, Peterson K, Wiecha J, Sobol AM, Dixit S, Fox MK, Laird N. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. Arch Pediatr Adolesc Med 1999;153:409–18.
51. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, O'Brien WL, Bassett DR Jr, Schmitz KH, Emplaincourt PO, et al. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc 2000;32(suppl):S498–504.
52. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000;320:1240–3.
53. Hanley JA, Negassa A, Edwardes MD, Forrester JE. Statistical analysis of correlated data using generalized estimating equations: an orientation. Am J Epidemiol 2003;157:364–75.
54. Allison P. Fixed effects regression methods for longitudinal data using SAS. Cary, NC: SAS Institute Inc, 2005.
55. McCullough ML, Feskanich D, Stampfer MJ, Giovannucci EL, Rimm EB, Hu FB, Spiegelman D, Hunter DJ, Colditz GA, Willett WC. Diet quality and major chronic disease risk in men and women: moving toward improved dietary guidance. Am J Clin Nutr 2002;76:1261–71.
56. Borzekowski DL, Robinson TN. The 30-second effect: an experiment revealing the impact of television commercials on food preferences of preschoolers. J Am Diet Assoc 2001;101:42–6.
57. Sutherland LA, MacKenzie T, Purvis LA, Dalton M. Prevalence of food and beverage brands in movies: 1996–2005. Pediatrics 2010;125: 468–74.
58. Speers SE, Harris JL, Schwartz MB. Child and adolescent exposure to food and beverage brand appearances during prime-time television programming. Am J Prev Med 2011;41:291–6.
59. Harris JL, Speers SE, Schwartz MB, Brownell KDUS. Food company branded games on the internet: children's exposure and effects on snack consumption. J Children Media 2012;6:51–68.
60. Pempek TA, Calvert SL. Tipping the balance: use of advergames to promote consumption of nutritious foods and beverages by low-income African American children. Arch Pediatr Adolesc Med 2009;163: 633–7.
61. Powell LM, Harris JL, Fox T. Food marketing expenditures aimed at youth: putting the numbers in context. Am J Prev Med 2013;45: 453–61.
62. Bellissimo N, Pencharz PB, Thomas SG, Anderson GH. Effect of television viewing at mealtime on food intake after a glucose preload in boys. Pediatr Res 2007;61:745–9.
63. Temple JL, Giacomelli AM, Kent KM, Roemmich JN, Epstein LH. Television watching increases motivated responding for food and energy intake in children. Am J Clin Nutr 2007;85:355–61.
64. Higgs S, Woodward M. Television watching during lunch increases afternoon snack intake of young women. Appetite 2009;52:39–43.
65. Oldham-Cooper RE, Hardman CA, Nicoll CE, Rogers PJ, Brunstrom JM. Playing a computer game during lunch affects fullness, memory for lunch, and later snack intake. Am J Clin Nutr 2011;93:308–13.
66. Blass EM, Anderson DR, Kirkorian HL, Pempek TA, Price I, Koleini MF. On the road to obesity: Television viewing increases intake of high-density foods. Physiol Behav 2006;88:597–604.
67. Chaput JP. Do active video games increase food intake? Am J Clin Nutr 2011;94:1155; author reply 1156.
68. Foehr UG. Media multitasking among American youth: prevalence, predictors and pairings. Menlo Park, CA: Kaiser Family Foundation, 2006.
69. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of childhood and adult obesity in the United States, 2011-2012. JAMA 2014;311: 806–14.
70. Rideout VJ, Foehr UG, Roberts DF. Generation M2: media in the lives of 8- to 18-year-olds. Menlo Park, CA: Kaiser Family Foundation, 2010.
71. Ng SW, Slining MM, Popkin BM. Turning point for US diets? Recessionary effects or behavioral shifts in foods purchased and consumed. Am J Clin Nutr 2014;99:609–16.