

Longitudinal relations of television, electronic games, and digital versatile discs with changes in diet in adolescents^{1–3}

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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

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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.

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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 adver-

tised [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 quality¹

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 Mondelez 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 (Δ FLNQ) commonly advertised on screens,

including SSBs, fast foods, sweets (including candy), and salty snacks, and the 2-y Δ FVs. 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 values¹

	Girls ($n = 4604$)	Boys ($n = 3668$)
Characteristics		
Age (y)	15.7 \pm 1.9 (15.8) ²	15.6 \pm 1.9 (15.6)
Non-Hispanic white (%) ³	93.6	92.5
Height (in)	64.4 \pm 2.9 (64)	67.9 \pm 4.4 (68)
Δ Height (in)	0.8 \pm 1.4 (0.0)	4.5 \pm 2.7 (5.0)
BMI (kg/m ²)	21.4 \pm 3.7 (20.8)	21.7 \pm 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 \pm 7.2 (8.3)	11.8 \pm 8.6 (10.0)
Δ Physical activity (h/wk) ⁵	-0.62 \pm 6.57 (-0.50)	-0.32 \pm 7.8 (-0.31)
Census-tract median income (\times \$1000)	70 \pm 26 (66)	71 \pm 26 (67)
Frequency of family dinner ≥ 3 times/wk (%)	79.7	84.8
Dietary variables (servings/d)		
Sugar-sweetened beverages	0.79 \pm 0.85 (0.57)	1.29 \pm 1.08 (1.07)
Δ Sugar-sweetened beverages	-0.17 \pm 0.80 (-0.07)	-0.13 \pm 1.09 (-0.07)
Fast food	0.42 \pm 0.30 (0.34)	0.64 \pm 0.43 (0.55)
Δ Fast food	-0.03 \pm 0.30 (-0.01)	0.03 \pm 0.45 (0.01)
Sweets	1.25 \pm 0.99 (0.99)	1.58 \pm 1.27 (1.25)
Δ Sweets	-0.14 \pm 0.99 (-0.09)	-0.16 \pm 1.24 (-0.13)
Salty snacks	0.52 \pm 0.44 (0.41)	0.59 \pm 0.50 (0.42)
Δ Salty snacks	-0.05 \pm 0.46 (-0.01)	-0.04 \pm 0.52 (0.00)
Total foods of low nutritional quality	2.98 \pm 1.80 (2.64)	4.10 \pm 2.31 (3.67)
Δ Total foods of low nutritional quality	-0.40 \pm 1.64 (-0.32)	-0.31 \pm 2.14 (-0.28)
Fruit and vegetables	3.07 \pm 1.54 (2.76)	2.89 \pm 1.34 (2.68)
Δ Fruit and vegetables	0.11 \pm 1.46 (0.08)	0.06 \pm 1.32 (0.01)
Screen time (h/d)		
Television	1.35 \pm 1.07 (0.93)	1.48 \pm 1.12 (0.93)
Δ Television	-0.19 \pm 1.01 (0.00)	-0.08 \pm 1.12 (0.00)
Electronic games ⁶	0.20 \pm 0.39 (0.07)	1.14 \pm 1.15 (0.93)
Δ Electronic games ⁶	0.01 \pm 0.46 (0.00)	0.07 \pm 1.18 (0.00)
DVDs/videos	0.72 \pm 0.54 (0.93)	0.74 \pm 0.62 (0.93)
Δ DVDs/videos	0.07 \pm 0.63 (0.00)	0.12 \pm 0.74 (0.00)
Total screen time ⁷	2.26 \pm 1.43 (1.93)	3.36 \pm 2.13 (2.79)
Δ Total screen time ⁷	-0.11 \pm 1.43 (0.00)	0.11 \pm 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 \pm 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 Δ FLNQ and Δ FVs (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 Δ FLNQ and Δ FVs, 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 Δ television time from 2006 to 2008 in relation to Δ FLNQ 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,

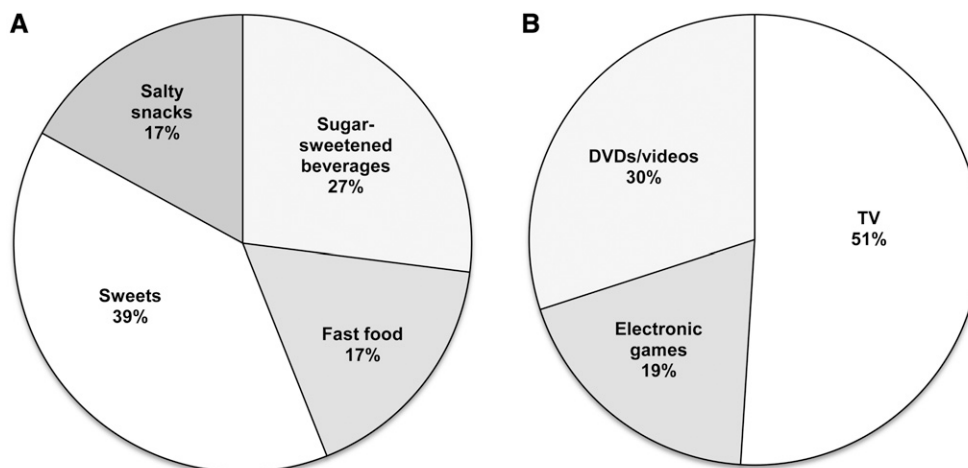


FIGURE 1. Mean composition of reported intakes of total foods of low nutritional quality and total screen time in 8272 Growing Up Today Study II participants in 2006. A: Proportion of total foods of low nutritional quality by food and beverage groups. B: Proportion of total screen time by types of media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

all models also included baseline BMI, height, physical activity, Δ height, and Δ physical 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 Δ FLNQ and Δ FVs from models by using linear splines terms for Δ total 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 time¹

Outcome	Girls (n = 4604; 7690 observations)					Boys (n = 3668; 5906 observations)						
	Television	Electronic games	DVDs/videos	Total screen time	Television	Electronic games	DVDs/videos	Total screen time	Television	Electronic games	DVDs/videos	Total screen time
Δ Sugar-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)***	0.03 (0.01, 0.04)***	0.01 (0.00, 0.02)	0.04 (0.02, 0.06)***	0.02 (0.02, 0.03)***
Δ Fast 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)***	0.08 (0.04, 0.11)***	0.00 (-0.03, 0.03)	0.05 (-0.02, 0.12)	0.04 (0.02, 0.06)***
Δ Sweets (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)	0.02 (0.01, 0.02)***	0.02 (0.01, 0.04)***	0.00 (-0.01, 0.01)	0.05 (0.02, 0.08)***	0.02 (0.01, 0.02)***
Δ Salty 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)***	0.12 (0.09, 0.15)***	0.16 (0.10, 0.22)***	0.05 (-0.01, 0.10)	0.21 (0.10, 0.32)***	0.12 (0.09, 0.15)***
Δ Total 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)***	0.05 (-0.01, 0.10)	0.05 (-0.02)***	-0.06 (-0.09, -0.03)***	0.00 (-0.06, 0.07)	-0.05 (-0.06, -0.03)***
Δ Fruit 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 β s; 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, Δ height, months between questionnaires, race-ethnicity [non-Hispanic white (yes or no)], physical activity (h/wk), Δ physical 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^a

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)*

^a 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. ΔElectronic games included video and computer games. 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

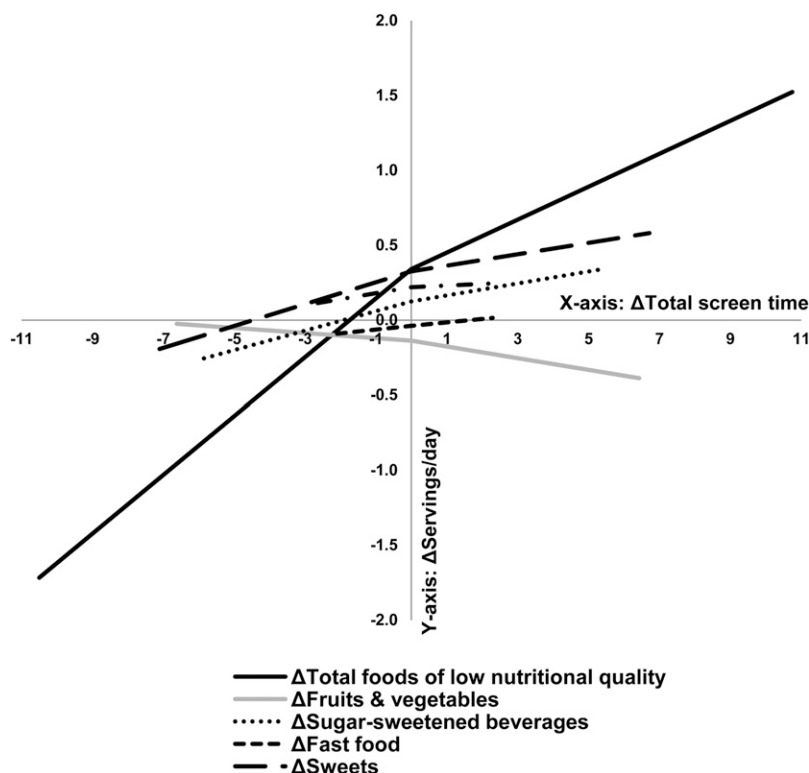


FIGURE 2. Results from linear spline models: predicted means of change in diet from models including linear spline terms for Δ total screen time (h/d) with a knot at 0 h/d ($n = 8272$; observations = 13,596). Models were adjusted for sex, age, age squared, baseline BMI, baseline height, Δ height, months 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 FNLQ. 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 FNLQ 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 FNLQ. 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 Δ total 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, advergaming, 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, advergaming, 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.

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