Adiposity and Different Types of Screen Time

AUTHORS: Jennifer Falbe, ScD, MPH,^{a,b} Bernard Rosner, PhD,^c Walter C. Willett, MD, DrPH,^{a,b,c} Kendrin R. Sonneville, ScD, RD,^d Frank B. Hu, MD, PhD,^{a,b,c} and Alison E. Field, ScD^{b,c,d}

^aDepartments of Nutrition and ^bEpidemiology, Harvard School of Public Health, Boston, Massachusetts; ^cChanning Division of Network Medicine, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts; and ^dDivision of Adolescent Medicine, Boston Children's Hospital, Boston, Massachusetts

KEY WORDS

television, video games, sedentary lifestyle, BMI, body weight, adolescent, adiposity, longitudinal studies

ABBREVIATIONS

CI—confidence interval

DVD—digital versatile disc

GUTSII—Growing Up Today Study II

Dr Falbe conceptualized and carried out the analysis, drafted the initial manuscript, and revised the manuscript; Drs Rosner, Willett, Sonneville, and Hu contributed to the concept, design, analysis, and interpretation, and reviewed and revised the manuscript; Dr Field contributed to the concept, design, analysis, and interpretation, supervised the analysis, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

Dr Falbe's current affiliation is Division of Community Health and Human Development, University of California, Berkeley School of Public Health, Berkeley, California.

www.pediatrics.org/cgi/doi/10.1542/peds.2013-0887

doi:10.1542/peds.2013-0887

Accepted for publication Sep 23, 2013

Address correspondence to Jennifer Falbe, ScD, MPH, Division of Community Health and Human Development, University of California, Berkeley School of Public Health, 50 University Hall #7360, Berkeley, CA 94720. E-mail: jfalbe@berkeley.edu

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2013 by the American Academy of Pediatrics

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: Funded by the Breast Cancer Research Foundation and grant DK084001 from the National Institutes of Health for initiation of the cohort and collection/management of the data during follow-up. Dr Falbe's work was supported by the National Institutes of Health Training Grant in Academic Nutrition (DK007703). Funded by the National Institutes of Health (NIH).

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

WHAT'S KNOWN ON THIS SUBJECT: Screen time has risen to unprecedented levels among youth. Greater television time is known to be associated with gains in pediatric adiposity, but few studies have examined the longitudinal relations of other forms of screen-based media with weight gain.

WHAT THIS STUDY ADDS: Among adolescents aged 9 to 19 years, television viewing was the type of screen time most consistently associated with gains in BMI. However, time with digital versatile discs/videos and video/computer games was also associated with gains in BMI among girls.

abstract

OBJECTIVE: Few prospective studies have examined separate forms of screen time in relation to adiposity. Our objective was to assess independent relations of television, electronic games (video/computer), and digital versatile disc (DVD)/videos and total screen time with change in adolescent BMI.

METHODS: Using data from the 2004, 2006, and 2008 waves of the ongoing Growing up Today Study II, we assessed baseline and 2-year change in reported screen time in relation to concurrent change in BMI among 4287 girls and 3505 boys aged 9 to 16 years in 2004. Gender-specific models adjusted for previous BMI, age, race/ethnicity, growth/development, months between questionnaires, and physical activity.

RESULTS: Among girls and boys, each hour per day increase in reported television viewing was associated with a 0.09 increase in BMI ($P_s < .001$), and each hour per day increase in total screen time was associated with a 0.07 increase among girls and 0.05 increase among boys ($P_s < .001$). Among girls only, greater baseline television, games, and total screen time and change in DVDs/videos were associated with gains in BMI ($P_s < .05$). BMI gains associated with change in television and total screen time were stronger among overweight girls than lean girls (P_s -heterogeneity $< .001$).

CONCLUSIONS: Television, which remains the steady source of food advertising, was most consistently associated with BMI gains. Among girls, electronic games and DVDs/videos were also related to increased BMI, possibly due to influences of product placements and advergames on diet and/or distracted eating. Adolescents, especially overweight adolescents, may benefit from reduced time with multiple types of media. *Pediatrics* 2013;132:e1497–e1505

Screen time occupies a prominent place in children's environments. In 2009, youth aged 8 to 18 years were exposed to an average of >7 hours per day of television (TV), digital versatile discs (DVDs)/videos, video games, and computers: an increase from 2004 of almost 1.5 hours per day.¹ Excessive screen time has been linked to poor health outcomes, including childhood obesity and unhealthy weight gain.²

Longitudinal studies of screen time and weight have focused on TV or a composite of screen time including TV, which in most studies was associated with increased adiposity.^{3,4} Moreover, in clinical trials, children randomized to reduced TV experienced healthier changes in weight.^{5–7} Although TV continues to account for most screen time among youth, the proportion of time composed of broadcast TV has declined, while time with other media has risen.¹ How these other media affect adiposity is uncertain,⁴ as there is a dearth of prospective studies examining how video games,^{8–13} DVDs/videos,^{13,14} or computers¹⁵ independently relate to weight gain among youth. TV is hypothesized to increase adiposity through exposure to marketing for unhealthy foods/beverages,^{16–18} leading to overconsumption and positive energy balance.^{19–23} In contrast, electronic games and DVDs/videos are usually commercial-free, but companies are spending increasing amounts of money on product placements in these media.^{24,25}

The aims of this study were to examine independent associations between separate forms of screen time (ie, TV, video/computer games, and DVDs/videos) and changes in adolescent BMI, and to determine if these relations differ by weight status. We assessed these aims by using 3 assessments (2004, 2006, and 2008) among participants in the Growing Up Today Study (GUTS) II who were aged 9 to 16 years in

2004 and aged 11 to 19 years in 2006. Additionally, we were interested in examining associations for youth aged 12 to 17 independently, as the Children's Food and Beverage Advertising Initiative, an agreement among food/beverage companies to self-regulate child-directed advertising, applies only to children <12 years of age.²⁶

METHODS

The ongoing GUTSII cohort was established in 2004 to assess relations of diet and activity to height velocity and weight gain. To recruit participants, investigators sent letters explaining the study to 20 700 mothers from the Nurses' Health Study II²⁷ who had children aged 9 to 15 years. Invitation letters and questionnaires were mailed to 8826 girls and 8454 boys whose mothers had granted consent. A total of 6002 girls and 4917 boys returned completed questionnaires, thereby assenting to participate. Follow-up questionnaires were sent in the fall of 2006 and 2008. Approximately 80% of the girls ($n = 4779$) and 79% of the 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 screen time and BMI on ≥ 2 consecutive questionnaires were eligible for analysis. The study was approved by the Human Subjects Committee at Brigham and Women's Hospital, and the analyses presented in this article were approved by the institutional review boards at Brigham and Women's Hospital and Children's Hospital Boston.

Outcome

The outcome was 2-year change (Δ) in adiposity, modeled as Δ BMI, adjusted for age and time between questionnaires. For longitudinal studies of child and adolescent adiposity, Δ BMI is recommended over Δ BMI z-score.^{27,28} BMI z-scores are obtained from Centers

for Disease Control and Prevention standards derived from cross-sectional data, so they contain no information on how adiposity typically changes as children grow.²⁸ Further, Δ z-score represents a broad range of adiposity changes for children measured at the same 2 ages, reducing power in longitudinal assessments.²⁸ BMI was calculated from self-reported height and weight, which has been validated among preadolescents and adolescents.^{29–31} Additionally, Field and colleagues³² found only small discrepancies between Δ weight based on self-report and Δ weight based on measurements in Add Health. Discrepancies were unrelated to attempts to lose weight, physical activity, or screen time, suggesting that reporting errors were random.³² Each participant contributed up to 2 outcomes: Δ BMI from 2004 to 2006 and/or Δ BMI from 2006 to 2008. In stratified analyses, participants were dichotomized as overweight (overweight/obese) or lean (not overweight/obese) based on International Obesity Task Force cutoffs.³³ We excluded participants with BMI <12 (the biological lower limit based on clinical opinion); 2-year Δ height ≤ 2 inches; or outlying values for BMI, Δ BMI, or Δ height detected through the generalized extreme Studentized deviate many-outlier procedure.³⁴

Exposures

Exposures were self-reported hours per day of TV, electronic games (video/computer), DVDs/videos, and total screen time. For weekends and weekdays separately, participants could report 0 to 31+ hours per week of each media. Questions also assessed computer/Internet (not games), but because the question in 2004, but not 2006 or 2008, included computer time for schoolwork, computer/Internet was excluded and did not contribute to total screen time. Moderate validity has been reported for similar questionnaires

assessing media among youth; Gortmaker and colleagues⁵ reported a correlation of $r = 0.54$ for TV and videos compared with interview-administered 24-hour recall, and Schmitz and colleagues³⁵ reported correlations of $r = 0.47$ and $r = 0.39$ for TV and computers compared with 7-day log.

To reduce influence of extreme screen times, we excluded outliers detected by the extreme Studentized deviate procedure and implausibly high values (ie, >8 hours per day of TV, >7 hours per day of games, or >120 hours per week of total screen time).

Covariates

Hours per week of moderate-to-vigorous recreational physical activity (≥ 3 metabolic equivalents) were assessed by asking participants to recall by season the amount of time per week over the past year in 18 activities. A compendium was used to classify activities as moderate-to-vigorous.³⁶ Median changes were used to impute missing physical activity. Outliers were reassigned to the most extreme nonoutlying values, and remaining values >40 hours per week were reassigned to 40 hours per week; $n = 48$ girls and 68 boys.

We determined Tanner stage of pubertal development through a validated scale of pubic hair illustrations.³⁷ There are 5 Tanner stages, with stage 1 indicating prepubescence and stage 5 indicating maturity. Menarcheal status was assessed by asking if and when periods had begun. We also considered census tract median income and frequency of family dinners as confounders.

Sample

We excluded 4 girls and 1 boy with ≤ 12 months between questionnaires; 95 girls and 89 boys with outlying or implausible BMI, Δ BMI, or Δ height; and 37 girls and 42 boys with outlying screen time. After exclusions, the analytic sample included 4387 girls and 3505

boys with complete data on BMI and reported screen time from ≥ 2 consecutive questionnaires.

Statistical Analysis

Gender-specific multivariate linear regression models were used to examine relationships between reported screen time and Δ BMI. We used SAS Proc Mixed (SAS Institute, Inc, Cary, NC) with an unstructured covariance matrix to account for nonindependence of multiple outcomes per subject.

We examined relations of baseline screen time and 2-year Δ screen time with concurrent 2-year Δ BMI in the same model (eg, TV time in 2006 and Δ TV time from 2006 to 2008 in relation to Δ BMI from 2006 to 2008). Models examining separate forms of media included TV, electronic games, and DVD/videos simultaneously.

All models adjusted for age, age², race/ethnicity (Hispanic, black, Asian, and/or other versus non-Hispanic white), time between questionnaires, and baseline BMI in each period. To account for normal Δ BMI that occurs during adolescence, we adjusted for Tanner stage, Δ height, and menarcheal status (for girls) in all models. Indicators were used for missing race/ethnicity, menarcheal status, and Tanner stage. Final models additionally adjusted for baseline and Δ physical activity (hours per week). Census tract median income and frequency of family dinners were also considered. However, in multivariate models, there was no evidence to suggest they confounded the screen time– Δ BMI relationship and were therefore not retained. *F*-tests were used to detect differences in screen time coefficients.

To confirm that linear terms for screen time and physical activity were appropriate, we examined possibly nonlinear relationships using restricted cubic splines.³⁸ Tests for nonlinearity used likelihood ratio tests, comparing models

with only the linear term to models with the linear and cubic spline terms.

To determine if associations were similar among those aged 12 to 17 years (80% of observations) compared with observations from the entire sample, aged 9 to 19 years, we repeated the analysis, restricting to ages 12 to 17. To examine heterogeneity by weight, we stratified models by weight status, and by using the entire sample, we included an indicator for overweight and a cross-product of this term with screen time.

To determine if the relationships between Δ total screen time and Δ BMI were symmetrical for screen time decreases and increases, we examined symmetry by graphing predicted means of Δ BMI from models including restricted cubic spline terms for Δ total screen time. Analyses were conducted with SAS (versions 9.1–9.2; SAS Institute, Inc).

RESULTS

The mean age of observations at the start of each period (2004–2006 and 2006–2008) was 14.4 years for girls (range: 9.6–19.8) and 14.1 years for boys (range: 9.2–19.9). Table 1 summarizes subject characteristics in 2006 and change values for 2006 to 2008. Most participants (93%) were non-Hispanic white, reflecting the composition of the Nurses' Health Study II. Boys spent more time physically active and playing electronic games than girls. In 2006, 17% of girls and 24% of boys were overweight or obese, and median Δ BMI from 2006 to 2008 was 0.89 for girls and 1.37 for boys.

Table 2 presents results from regression models relating reported screen time to Δ BMI. Tests for nonlinearity ($P_s \geq .05$) suggested that linear terms for screen time and physical activity were appropriate. In fully adjusted models, among girls, each hour per day of baseline TV, electronic games,

TABLE 1 Self-Reported Characteristics in 2006 and 2-Year Change (Δ) Values From 2006 to 2008^a for Growing Up Today Study II Participants

	Girls (<i>n</i> = 4287)				Boys (<i>n</i> = 3505)			
	Age 11–14 y (<i>n</i> = 1502)		Age 15–19 y (<i>n</i> = 2785)		Age 11–14 y (<i>n</i> = 1382)		Age 15–19 y (<i>n</i> = 2123)	
	50th (10th, 90th) %tile	%	50th (10th, 90th) %tile	%	50th (10th, 90th) %tile	%	50th (10th, 90th) %tile	%
BMI	19.8 (16.5, 24.9)		21.3 (18.5, 25.9)		19.6 (16.7, 25.8)		21.8 (18.7, 27.3)	
2-y Δ BMI	1.21 (–0.89, 3.28)		0.76 (–0.94, 2.62)		1.69 (–0.63, 3.90)		1.14 (–0.73, 3.16)	
Obese ^b		3.5		3.8		6.2		5.8
Overweight or obese ^b		17.8		16.3		23.6		24.2
TV, h/d	0.93 (0.5, 3.07)		0.93 (0.07, 2.36)		0.93 (0.50, 3.07)		0.93 (0.50, 3.07)	
2-y Δ TV, h/d	0.00 (–1.43, 0.71)		0.00 (–1.43, 0.86)		0.00 (–1.43, 1.43)		0.00 (–1.43, 0.86)	
Electronic games, h/d	0.07 (0.07, 0.93)		0.07 (0.07, 0.50)		0.93 (0.07, 2.36)		0.93 (0.07, 2.36)	
2-y Δ electronic games, h/d	0.00 (–0.43, 0.43)		0.00 (0.00, 0.43)		0.00 (–1.43, 1.43)		0.00 (–1.00, 1.43)	
DVDs/videos, h/d	0.5 (0.07, 0.93)		0.93 (0.07, 0.93)		0.50 (0.07, 1.21)		0.93 (0.07, 1.64)	
2-y Δ DVDs/videos, h/d	0.00 (–0.43, 0.71)		0.00 (–0.71, 0.86)		0.00 (–0.86, 0.86)		0.00 (–0.71, 0.86)	
Total ^c screen time, h/d	1.93 (1.07, 4.21)		1.93 (1.07, 4.07)		2.93 (1.50, 6.36)		2.79 (1.07, 5.93)	
2-y Δ total ^c screen, h/d	0.00 (–1.86, 1.43)		0.00 (–1.57, 1.43)		0.00 (–2.57, 2.71)		0.00 (–2.14, 2.57)	
Physical activity, ^d h/wk	7.8 (2.5, 18.3)		8.6 (1.5, 19.7)		9.4 (3.0, 22.3)		10.9 (2.06, 24.3)	
2-y Δ physical activity, ^d h/wk	0.38 (–7.19, 8.13)		–1.00 (–9.19, 5.88)		0.3 (–8.3, 10.3)		–0.9 (–11.5, 7.9)	
Height, in.	63 (59, 67)		65 (62, 68)		65 (59, 70)		70 (66, 74)	
2-y Δ height, in.	1 (0, 4)		0 (–1, 1)		5 (2, 8)		1 (0, 3)	
Census tract median income, \$1000 ^e	67 (43, 102)		65 (43, 101)		68 (45, 104)		66 (43, 104)	
Non-Hispanic white ^f		93.2		93.9		92.3		93.0
Tanner stage 4 or 5 ^{f,g}		70.8		96.8		55.7		97.2

^a Values measured in 2008 minus values measured in 2006 (3078 girls and 2285 boys).

^b Based on cutoffs defined by the International Obesity Task Force.

^c Does not include computer/Internet use for homework, work, or other recreational use (except for computer games, which is encompassed by electronic games).

^d Moderate-to-vigorous recreational physical activity (≥ 3 metabolic equivalents).

^e Determined from mother's home address.

^f Calculation of percentage does not include individuals with missing values in the denominator.

^g Tanner stage of pubic hair development.

and total screen time were associated with gains in BMI (P s < .05). Among girls, the association with Δ BMI was significantly stronger (P < .001) for baseline electronic games (β = 0.18) than it was for baseline TV (β = 0.06). Among boys, baseline screen time was not significantly associated with Δ BMI.

Among girls and boys, 2-year changes in TV and total screen time were associated with greater 2-year Δ BMI (Table 2). In fully adjusted models, among girls, for each hour per day increase in TV, there was a 0.09 increase in BMI (95% confidence interval [CI] 0.04–0.13), and for each hour per day increase in DVDs/videos, there was a 0.09 increase in BMI (95% CI 0.01–0.16). Change in total screen time also predicted gains in BMI among girls (0.07; 95% CI 0.04–0.11). Overweight girls experienced significantly greater gains in BMI than lean girls per hour per day increase in TV and total screen time (P s-heterogeneity

< .001). Among boys, each hour per day increase in TV was associated with a 0.09 increase in BMI (95% CI 0.04–0.14), and each hour per day increase in total screen time was associated with a 0.05 increase in BMI (95% CI 0.03–0.08). These associations were stronger among overweight boys, but differences by weight status were nonsignificant for Δ TV (P -heterogeneity = .10) and borderline significant for Δ total screen time (P -heterogeneity = .08).

Among boys aged 12 to 17 (79% of male observations), coefficients for Δ TV and Δ total screen time (not shown) were at least as strong as those among all boys (P s < .01). Among girls aged 12 to 17 (81% of female observations), coefficients for baseline TV and Δ DVDs/videos (not shown) were nonsignificant, but associations with Δ BMI persisted for each hour per day of baseline games (0.19), baseline total screen time (0.05),

Δ TV (0.08), and Δ total screen time (0.07) (P s < .01).

Whether screen time increased or decreased, BMI changed symmetrically for girls (Fig 1). For boys, Δ BMI was flatter when Δ total screen time was negative but increased in response to positive Δ total screen time (Fig 1); however, the test for nonlinearity was nonsignificant ($P \geq .05$).

DISCUSSION

Among 7792 adolescents throughout the United States, we found that higher baseline reported screen time, particularly TV and electronic games, was associated with greater 2-year gains in BMI among girls. Additionally, increasing hours per day of DVDs/videos among girls and increasing hours per day of TV and total screen time among girls and boys were associated with 2-year increases in BMI. Overall, the

TABLE 2 Linear Regression Coefficients (β) and 95% CIs Corresponding to 2-Year Change in BMI per Hour per Day (h/d) of Reported Screen Time at the Start of Each 2-Year Period and Concurrent 2-Year Change (Δ) in Reported Screen Time

	Girls						Boys					
	Basic Model ^a			Fully Adjusted ^b			Basic Model ^a			Fully Adjusted ^b		
	All Girls	All Girls	All Girls	Lean ^c	Overweight ^d		All Boys	All Boys	All Boys	Lean ^c	Overweight ^d	
	$n = 4287$	$n = 4287$	$n = 4287$	$n = 3689$	$n = 871$		$n = 3505$	$n = 3505$	$n = 3505$	$n = 2797$	$n = 952$	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Reported screen time, h/d												
Baseline screen time in each period												
Television	0.05*	(0.01 to 0.10)	0.06*	(0.01 to 0.10)	0.02	(-0.02 to 0.06)	0.17*	(0.03 to 0.32)	0.03	(-0.03 to 0.08)	0.02	(-0.03 to 0.07)
Electronic games ^e	0.17**	(0.05 to 0.29)	0.18**	(0.06 to 0.30)	0.19**	(0.07 to 0.31)	0.17	(-0.20 to 0.53)	0.00	(-0.05 to 0.05)	0.01	(-0.04 to 0.07)
DVDs/videos	0.04	(-0.05 to 0.13)	0.03	(-0.06 to 0.12)	0.03	(-0.06 to 0.11)	0.03	(-0.27 to 0.34)	0.02	(-0.08 to 0.12)	0.01	(-0.09 to 0.11)
Total screen time ^f	0.06***	(0.03 to 0.10)	0.07***	(0.04 to 0.10)	0.04**	(0.01 to 0.07)	0.14**	(0.03 to 0.24)	0.01	(-0.01 to 0.04)	0.01	(-0.01 to 0.04)
Δ Screen time concurrent with Δ BMI												
Δ Television	0.09***	(0.04 to 0.13)	0.09***	(0.04 to 0.13)	0.01	(-0.04 to 0.05)	0.29***	(0.15 to 0.43)	0.10***	(0.05 to 0.15)	0.09***	(0.04 to 0.14)
Δ Electronic games ^e	-0.02	(-0.13 to 0.10)	-0.01	(-0.12 to 0.10)	0.00	(-0.11 to 0.11)	-0.04	(-0.38 to 0.30)	0.00	(-0.05 to 0.05)	0.01	(-0.04 to 0.06)
Δ DVDs/videos	0.09*	(0.01 to 0.17)	0.09*	(0.01 to 0.16)	0.07	(0.00 to 0.15)	0.04	(-0.21 to 0.28)	0.06	(-0.02 to 0.15)	0.06	(-0.03 to 0.14)
Δ Total screen ^f	0.07***	(0.04 to 0.10)	0.07***	(0.04 to 0.11)	0.02	(-0.01 to 0.05)	0.18***	(0.08 to 0.28)	0.05***	(0.02 to 0.08)	0.03*	(0.00 to 0.05)

Obs, observations.

^a Gender-stratified models adjusted for age, age², baseline BMI, height change, Tanner stage, menarcheal status (yes/no) for girls, months between questionnaires, and non-Hispanic white (yes/no). All models included baseline screen time and change in screen time in the same model.^b Additionally adjusted for recreational moderate-to-vigorous physical activity (h/wk) and change in physical activity (h/wk).^c Defined as not overweight or obese based on cutoffs defined by the International Obesity Task Force.^d Overweight or obese based on cutoffs defined by the International Obesity Task Force.^e Video and computer games.^f Does not include computer/Internet use for homework, work, other recreational use (except for computer games, which is encompassed by electronic games).* $P < .05$;** $P < .01$;*** $P < .001$.

FIGURE 1

Predicted means of change in BMI from gender-stratified fully adjusted models, including restricted cubic spline terms for change in hours per day (h/d) of total reported screen time with knots at the 5th, 25th, 50th, 75th, and 95th percentile of change in total reported screen time. Models adjusted for age, age², baseline BMI, height change, Tanner stage, menarcheal status (yes/no) for girls, months between questionnaires, non-Hispanic white (yes/no), recreational moderate-to-vigorous physical activity (h/wk) and change in physical activity (h/wk), and baseline total reported screen time (h/d).

magnitudes of associations were modest, but if exposure to screens increases or persists with time, cumulative effects on BMI would be clinically important. Also, it is likely that magnitudes of associations were substantially underestimated because of random errors in exposure assessment.

Our findings regarding TV and total screen time are concordant with results from other prospective studies and interventions.^{3,4,7,13,39} As observed in previous longitudinal studies,³ we found that the associations between screen time and Δ BMI were independent of physical activity, suggesting that screen time affects diet. The influence of TV

food marketing on dietary intake and preference has been documented in experiments,^{23,40,41} and is a likely mechanism behind the TV-adiposity link. Food marketing may also be responsible for the association we detected between Δ DVDs/videos and Δ BMI among girls, because movies and TV shows on DVD/video may contain product placements. For instance, 69% of 1996 to 2005 box office movie hits contained ≥ 1 food/beverage product placement.⁴² Very few studies have examined DVDs/videos separately from TV. One found that Δ videos predicted Δ BMI among boys,¹³ and another study, which combined DVDs/videos with other

“noncommercial” screen media, found no significant association with BMI z score.¹⁴

Our finding that use of electronic games was related to Δ BMI among girls is consistent with a longitudinal study in which girls who played video games daily had 2.5 times the odds of being in the highest decile for Δ BMI.⁹ Other longitudinal studies have not found an association between electronic games and adiposity,^{10,12,13} except for one in which frequent gaming was associated with a lower risk of overweight among Asian boys but a higher risk among Asian girls.¹¹ Because the associations we observed were independent of

physical activity, electronic games may have induced excess energy intake. This mechanism is consistent with a study in which each hour per day Δ video/computer games was associated with a 92 kcal per day increase in intake among sixth to seventh graders.²⁰ Similarly, in a trial among adolescent boys, ad libitum energy intake after video game play was greater compared with sitting at rest and was not compensated for later in the day.⁴³ Exposure to food marketing through “advergaming” (games developed to advertise a product) or product placement within games may partially explain influences on intake. In a recent trial, children playing advergaming containing food cues consumed more energy during a subsequent snack than children playing advergaming with nonfood products.⁴⁴ Gaming has also been associated with cardiovascular risk factors,^{45–47} possibly mediated by diet.

We observed particularly strong associations between some types of media and Δ BMI among overweight youth, who may be especially responsive to food advertising. A recent functional MRI study demonstrated that when exposed to food logos, obese children showed less brain activation in regions associated with cognitive control than did healthy weight children.⁴⁸ Some behavioral studies also support this hypothesis. For instance, overweight children consumed more calories from branded meals than nonbranded meals, but nonoverweight children did not,⁴⁹ and when children were randomized to food ads or nonfood ads, obese children exhibited the largest intake in response to food ads.⁵⁰ Taken together, results suggest that limiting screen media containing food marketing should be included in obesity prevention and treatment interventions.

Among 12- to 17-year-olds, we observed associations similar to those among all ages, supporting recommendations of

the Federal Interagency Working Group on Food Marketed to Children that industry make “significant improvements in the nutritional quality of foods marketed to...ages 2-17 years.”⁵¹ The current scope of the Children’s Food and Beverage Advertising Initiative is children <12 years old.²⁶ Our results imply that older youth are not resistant to food marketing.

Among media we assessed, TV was most consistently associated with Δ BMI across subgroups. Similarly, a recent study reported that higher proportions of primary attention to TV, but not other media, were associated with higher adolescent BMI,⁵² perhaps reflecting that the largest proportion of food-marketing expenditures is still dedicated to TV.⁵³ Additionally, simultaneous eating may be easier while watching TV than while gaming, as one’s hands would be free of a controller/keyboard/mouse. However, it is possible to eat while gaming, as not all electronic games require constant interaction, and games can be paused.

In addition to exposing viewers to marketing, screens provide a distraction that may promote unconscious overeating. Experiments have shown that watching TV while eating can result in higher intake in current^{54,55} and subsequent eating occasions⁵⁶ and may affect memory of consumption⁵⁶ and appetite.²¹ Playing computer games during lunch has also been observed to reduce feelings of fullness and induce greater intake after lunch.⁵⁷ Future studies should determine relative contributions of distraction and marketing on concurrent eating, but 1 experiment in which children watching TV with food ads ate more while viewing than those watching nonfood ads suggests an additional marketing effect.²³

This study has several limitations. GUTSII includes few children of color and low socioeconomic status and a smaller proportion of overweight/

obese youth than the national average,⁵⁸ potentially limiting its generalizability. Second, data were self-reported; however, errors were likely random, as errors in weight change based on self-report have been found to be unrelated to physical activity or screen time.³² Third, we did not assess active video games, but data were collected before their widespread use. Last, we did not measure media content or simultaneous use of multiple media.⁵⁹ Strengths of this study include its longitudinal design with repeated measurements, large sample, and assessment of multiple screen-based media.

The omnipresence of screens in children’s lives necessitates identifying ways to reduce screen exposure and its obesogenicity. A recent review of interventions to reduce TV found that the most effective interventions used electronic monitors, contingent feedback systems, and clinic-based counseling.⁶⁰ Effective interventions also recruited overweight/obese children, suggesting that screen time is modifiable in this population. Future studies should identify strategies for reducing electronic gaming, an effort complicated by access to games via consoles, laptops, phones, and other hand-held devices. Last, to make screens less obesogenic, improvements to child-directed advertising are recommended.⁵¹ Regulatory efforts, either industry or government-initiated, should be evaluated for adherence and health impact.

CONCLUSIONS

This is among the few longitudinal studies to examine how different types of screen time independently relate to Δ adiposity. TV, which remains the steadiest medium for delivering food advertising, was most consistently associated with Δ BMI across subgroups. Findings that DVDs/videos and electronic games were also associated with gains in BMI in girls support

current American Academy of Pediatrics recommendations to limit children's total noneducational screen time.⁶¹ Limits may be particularly beneficial for overweight youth and should be integrated into clinic-based counseling. As the marketing landscape

further evolves, exposing children to increased food marketing through Web sites, advergames, social networking, and product placements, researchers should continue to monitor how specific media and marketing techniques affect adiposity and identify

effective strategies for reducing exposure to harmful marketing.

ACKNOWLEDGMENTS

The authors thank the thousands of young people across the country participating in GUTSII as well as their mothers.

REFERENCES

1. Rideout VJ, Foebr UG, Roberts DF. *Generation M2: Media in the Lives of 8- to 18-Year-Olds*. Menlo Park, CA: Kaiser Family Foundation; 2010
2. Strasburger VC, Jordan AB, Donnerstein E. Health effects of media on children and adolescents. *Pediatrics*. 2010;125(4):756–767
3. Tremblay MS, LeBlanc AG, Kho ME, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *Int J Behav Nutr Phys Act*. 2011;8:98
4. Rey-López JP, Vicente-Rodríguez G, Biosca M, Moreno LA. Sedentary behaviour and obesity development in children and adolescents. *Nutr Metab Cardiovasc Dis*. 2008;18(3):242–251
5. Gortmaker SL, Peterson K, Wiecha J, et al. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. *Arch Pediatr Adolesc Med*. 1999;153(4):409–418
6. Epstein LH, Roemmich JN, Robinson JL, et al. 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(3):239–245
7. Robinson TN. Reducing children's television viewing to prevent obesity: a randomized controlled trial. *JAMA*. 1999;282(16):1561–1567
8. Lajunen HR, Keski-Rahkonen A, Pulkkinen L, Rose RJ, Rissanen A, Kaprio J. Leisure activity patterns and their associations with overweight: a prospective study among adolescents. *J Adolesc*. 2009;32(5):1089–1103
9. O'Loughlin J, Gray-Donald K, Paradis G, Meshefedjian G. One- and two-year predictors of excess weight gain among elementary schoolchildren in multiethnic, low-income, inner-city neighborhoods. *Am J Epidemiol*. 2000;152(8):739–746
10. Janz KF, Burns TL, Levy SM; Iowa Bone Development Study. Tracking of activity and sedentary behaviors in childhood: the Iowa Bone Development Study. *Am J Prev Med*. 2005;29(3):171–178
11. Gordon-Larsen P, Adair LS, Popkin BM. Ethnic differences in physical activity and inactivity patterns and overweight status. *Obes Res*. 2002;10(3):141–149
12. Hesketh K, Carlin J, Wake M, Crawford D. Predictors of body mass index change in Australian primary school children. *Int J Pediatr Obes*. 2009;4(1):45–53
13. Berkey CS, Rockett HR, Gillman MW, Colditz GA. One-year changes in activity and inactivity among 10- to 15-year-old boys and girls: relationship to change in body mass index. *Pediatrics*. 2003;111(4 pt 1):836–843
14. Zimmerman FJ, Bell JF. Associations of television content type and obesity in children. *Am J Public Health*. 2010;100(2):334–340
15. Berkey CS, Rockett HR, Colditz GA. Weight gain in older adolescent females: the Internet, sleep, coffee, and alcohol. *J Pediatr*. 2008;153(5):635–639, 639.e1
16. 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(6):406–413
17. Harris JL, Weinberg ME, Schwartz MB, Ross C, Ostroff J, Brownell KD. Trends in television food advertising progress in reducing unhealthy marketing to young people? 2010. Available at: www.yaleruddcenter.org/resources/upload/docs/what/reports/RuddReport_TVFoodAdvertising_2.10.pdf. Accessed January 24, 2012
18. 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(4):673–678
19. Swinburn B, Shelly A. Effects of TV time and other sedentary pursuits. *Int J Obes (Lond)*. 2008;32(suppl 7):S132–S136
20. Sonnevile KR, Gortmaker SL. Total energy intake, adolescent discretionary behaviors and the energy gap. *Int J Obes (Lond)*. 2008;32(suppl 6):S19–S27
21. 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(4-5):597–604
22. Miller SA, Taveras EM, Rifas-Shiman SL, Gillman MW. Association between television viewing and poor diet quality in young children. *Int J Pediatr Obes*. 2008;3(3):168–176
23. Harris JL, Bargh JA, Brownell KD. Priming effects of television food advertising on eating behavior. *Health Psychol*. 2009;28(4):404–413
24. Montgomery KC, Grier S, Chester J, Dorfman L. Food marketing in the digital age: a conceptual framework and agenda for research. April 1, 2011. Available at: http://digitalads.org/documents/Digital_Food_Mktg_Conceptual_Model%20Report.pdf. Accessed January 19, 2013
25. PQMedia. Global product placement spending up 10% to \$7.4 billion in 2011, pacing for 11% growth in 2012, as wireless technology, changing consumer habits & looser regulations compel brands to invest in alternative marketing solutions. December 4, 2012. Available at: www.pqmedia.com/about-press-201212.html. Accessed February 8, 2013
26. Kolish ED. The Children's Food & Beverage Advertising Initiative white paper on CFBAI's uniform nutrition criteria. July 2011. Available at: www.bbb.org/us/storage/0/Shared%20Documents/White%20Paper%20on%20CFBAI%20Uniform%20Nutrition%20Criteria%20July%202011.pdf. Accessed January 8, 2012
27. Rich-Edwards JW, Goldman MB, Willett WC, et al. Adolescent body mass index and infertility caused by ovulatory disorder. *Am J Obstet Gynecol*. 1994;171(1):171–177
28. Berkey CS, Colditz GA. Adiposity in adolescents: change in actual BMI works better

- than change in BMI z score for longitudinal studies. *Ann Epidemiol*. 2007;17(1):44–50
29. Strauss RS. Comparison of measured and self-reported weight and height in a cross-sectional sample of young adolescents. *Int J Obes Relat Metab Disord*. 1999;23(8):904–908
 30. Shannon B, Smiciklas-Wright H, Wang MQ. Inaccuracies in self-reported weights and heights of a sample of sixth-grade children. *J Am Diet Assoc*. 1991;91(6):675–678
 31. Goodman E, Hinden BR, Kandelwal S. Accuracy of teen and parental reports of obesity and body mass index. *Pediatrics*. 2000;106(1 pt 1):52–58
 32. Field AE, Aneja P, Rosner B. The validity of self-reported weight change among adolescents and young adults. *Obesity (Silver Spring)*. 2007;15(9):2357–2364
 33. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ*. 2000;320(7244):1240–1243
 34. Rosner B. Percentage points for a generalized ESD many-outlier procedure. *Technometrics*. 1983;25(2):165–172
 35. Schmitz KH, Harnack L, Fulton JE, et al. Reliability and validity of a brief questionnaire to assess television viewing and computer use by middle school children. *J Sch Health*. 2004;74(9):370–377
 36. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc*. 2000;32(suppl 9):S498–S504
 37. Morris NM, Udry JR. Validation of a self-administered instrument to assess stage of adolescent development. *J Youth Adolesc*. 1980;9(3):271–280
 38. Durrleman S, Simon R. Flexible regression models with cubic splines. *Stat Med*. 1989;8(5):551–561
 39. Berkey CS, Rockett HR, Field AE, et al. Activity, dietary intake, and weight changes in a longitudinal study of preadolescent and adolescent boys and girls. *Pediatrics*. 2000;105(4). Available at: www.pediatrics.org/cgi/content/full/105/4/e56
 40. 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(1):263–267
 41. 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(1):42–46
 42. Sutherland LA, Mackenzie T, Purvis LA, Dalton M. Prevalence of food and beverage brands in movies: 1996-2005. *Pediatrics*. 2010;125(3):468–474
 43. Chaput JP, Visby T, Nyby S, et al. Video game playing increases food intake in adolescents: a randomized crossover study. *Am J Clin Nutr*. 2011;93(6):1196–1203
 44. Folkvord F, Anschütz 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(2):239–245
 45. Martinez-Gómez D, Gomez-Martinez S, Ruiz JR, Ortega FB, Marcos A, Veiga OL. Video game playing time and cardiometabolic risk in adolescents: the AFINOS study. *Med Clin (Barc)*. 2012;139(7):290–292
 46. Gopinath B, Baur LA, Hardy LL, et al. Relationship between a range of sedentary behaviours and blood pressure during early adolescence. *J Hum Hypertens*. 2012;26(6):350–356
 47. Goldfield GS, Kenny GP, Hadjiyannakis S, et al. Video game playing is independently associated with blood pressure and lipids in overweight and obese adolescents. *PLoS ONE*. 2011;6(11):e26643
 48. Bruce AS, Lepping RJ, Bruce JM, et al. Brain responses to food logos in obese and healthy weight children. *J Pediatr*. 2013;162(4):759–764.e2
 49. Forman J, Halford JC, Summe H, MacDougall M, Keller KL. Food branding influences ad libitum intake differently in children depending on weight status. Results of a pilot study. *Appetite*. 2009;53(1):76–83
 50. Halford JC, Boyland EJ, Hughes GM, Stacey L, McKean S, Dovey TM. Beyond-brand effect of television food advertisements on food choice in children: the effects of weight status. *Public Health Nutr*. 2008;11(9):897–904
 51. Interagency Working Group on Food Marketed to Children. Preliminary proposed nutrition principles to guide industry self-regulatory efforts: request for comments. April 2011. Available at: www.ftc.gov/os/2011/04/110428foodmarketproposedguide.pdf. Accessed November 8, 2012
 52. Bickham DS, Blood EA, Walls CE, Shrier LA, Rich M. Characteristics of screen media use associated with higher BMI in young adolescents. *Pediatrics*. 2013;131(5):935–941
 53. 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
 54. 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(6):745–749
 55. 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(2):355–361
 56. Higgs S, Woodward M. Television watching during lunch increases afternoon snack intake of young women. *Appetite*. 2009;52(1):39–43
 57. 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(2):308–313
 58. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. *JAMA*. 2012;307(5):483–490
 59. Foehr UG. *Media Multitasking Among American Youth: Prevalence, Predictors and Pairings*. Menlo Park, CA: Kaiser Family Foundation; 2006
 60. Schmidt ME, Haines J, O'Brien A, et al. Systematic review of effective strategies for reducing screen time among young children. *Obesity (Silver Spring)*. 2012;20(7):1338–1354
 61. Strasburger VC; Council on Communications and Media. Children, adolescents, obesity, and the media. *Pediatrics*. 2011;128(1):201–208