Adiposity and Different Types of Screen Time

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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

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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

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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 ($Ps < .001$), 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 ($Ps < .001$). Among girls only, greater baseline television, games, and total screen time and change in DVDs/videos were associated with gains in BMI ($Ps < .05$). BMI gains associated with change in television and total screen time were stronger among overweight girls than lean girls (Ps-heterogeneity $< .001$).

CONCLUSIONS: Television, which remains the steadiest 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 computers[15] 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 II[27] 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 ΔBMI, adjusted for age and time between questionnaires. For longitudinal studies of child and adolescent adiposity, ΔBMI is recommended over ΔBMI 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, Δz-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 colleagues[32] found only small discrepancies between Δweight based on self-report and Δweight 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: ΔBMI from 2004 to 2006 and/or ΔBMI 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 Δheight ≤2 inches; or outlying values for BMI, ΔBMI, or Δheight 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 colleagues[5] reported a correlation of $r = 0.54$ for TV and videos compared with interview-administered 24-hour recall, and Schmitz and colleagues[35] 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, ΔBMI, or Δheight; 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 ΔBMI. 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 Δscreen time with concurrent 2-year ΔBMI in the same model (eg, TV time in 2006 and ΔTV time from 2006 to 2008 in relation to ΔBMI from 2006 to 2008). Models examining separate forms of media included TV, electronic games, and DVD/videos simultaneously.

All models adjusted for age, age^2, 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 ΔBMI that occurs during adolescence, we adjusted for Tanner stage, Δheight, 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 Δphysical 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–ΔBMI 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 Δtotal screen time and ΔBMI were symmetrical for screen time decreases and increases, we examined symmetry by graphing predicted means of ΔBMI from models including restricted cubic spline terms for Δtotal 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 ΔBMI 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 ΔBMI. Tests for nonlinearity (Ps ≥ .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 (n = 4287)				Boys (n = 3505)			
	Age 11–14 y (n = 1502)		Age 15–19 y (n = 2785)		Age 11–14 y (n = 1382)		Age 15–19 y (n = 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 ΔBMI	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 0, 3.07)		0.93 (0.07, 2.36)		0.93 (0.50, 3.07)		0.93 (0.50, 3.07)	
2-y ΔTV, 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 Δelectronic 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 ΔDVDs/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 Δtotal[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 Δphysical 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 Δheight, 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 (Ps < .05). Among girls, the association with ΔBMI 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 ΔBMI.

Among girls and boys, 2-year changes in TV and total screen time were associated with greater 2-year ΔBMI (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 (Ps-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 ΔTV (P-heterogeneity = .10) and borderline significant for Δtotal screen time (P-heterogeneity = .08).

Among boys aged 12 to 17 (79% of male observations), coefficients for ΔTV and Δtotal screen time (not shown) were at least as strong as those among all boys (Ps < .01). Among girls aged 12 to 17 (81% of female observations), coefficients for baseline TV and ΔDVDs/videos (not shown) were nonsignificant, but associations with ΔBMI persisted for each hour per day of baseline games (0.19), baseline total screen time (0.05), ΔTV (0.08), and Δtotal screen time (0.07) (Ps < .01).

Whether screen time increased or decreased, BMI changed symmetrically for girls (Fig 1). For boys, ΔBMI was flatter when Δtotal screen time was negative but increased in response to positive Δtotal screen time (Fig 1); however, the test for nonlinearity was nonsignificant (P ≥ .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		Lean[c]		Overweight[d]		All Boys		All Boys		Lean[c]		Overweight[d]	
	n = 4287		n = 4287		n = 3689		n = 871		n = 3505		n = 3505		n = 2797		n = 952	
	Obs = 7154		Obs = 7154		Obs = 5970		Obs = 1184		Obs = 5658		Obs = 5658		Obs = 4329		Obs = 1329	
Reported screen time, h/d	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
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)	0.01	(–0.04 to 0.06)	0.05	(–0.09 to 0.20)
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)	−0.01	(–0.06 to 0.04)	0.06	(–0.09 to 0.21)
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)	−0.02	(–0.11 to 0.07)	0.11	(–0.19 to 0.41)
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)	−0.01	(–0.03 to 0.02)	0.06	(–0.01 to 0.13)
ΔScreen time concurrent with ΔBMI																
ΔTelevision	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)	0.06*	(0.01 to 0.11)	0.16*	(0.01 to 0.30)
ΔElectronic 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)	−0.02	(–0.07 to 0.02)	0.09	(–0.04 to 0.22)
ΔDVDs/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)	0.07	(–0.01 to 0.15)	0.04	(–0.20 to 0.28)
ΔTotal 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)	0.05***	(0.03 to 0.08)	0.03*	(0.00 to 0.05)	0.11**	(0.04 to 0.18)

Obs, observations.

[a] Gender-stratified models adjusted for age, age^2, 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).

* $P < .05$;

** $P < .01$;

*** $P < .001$.

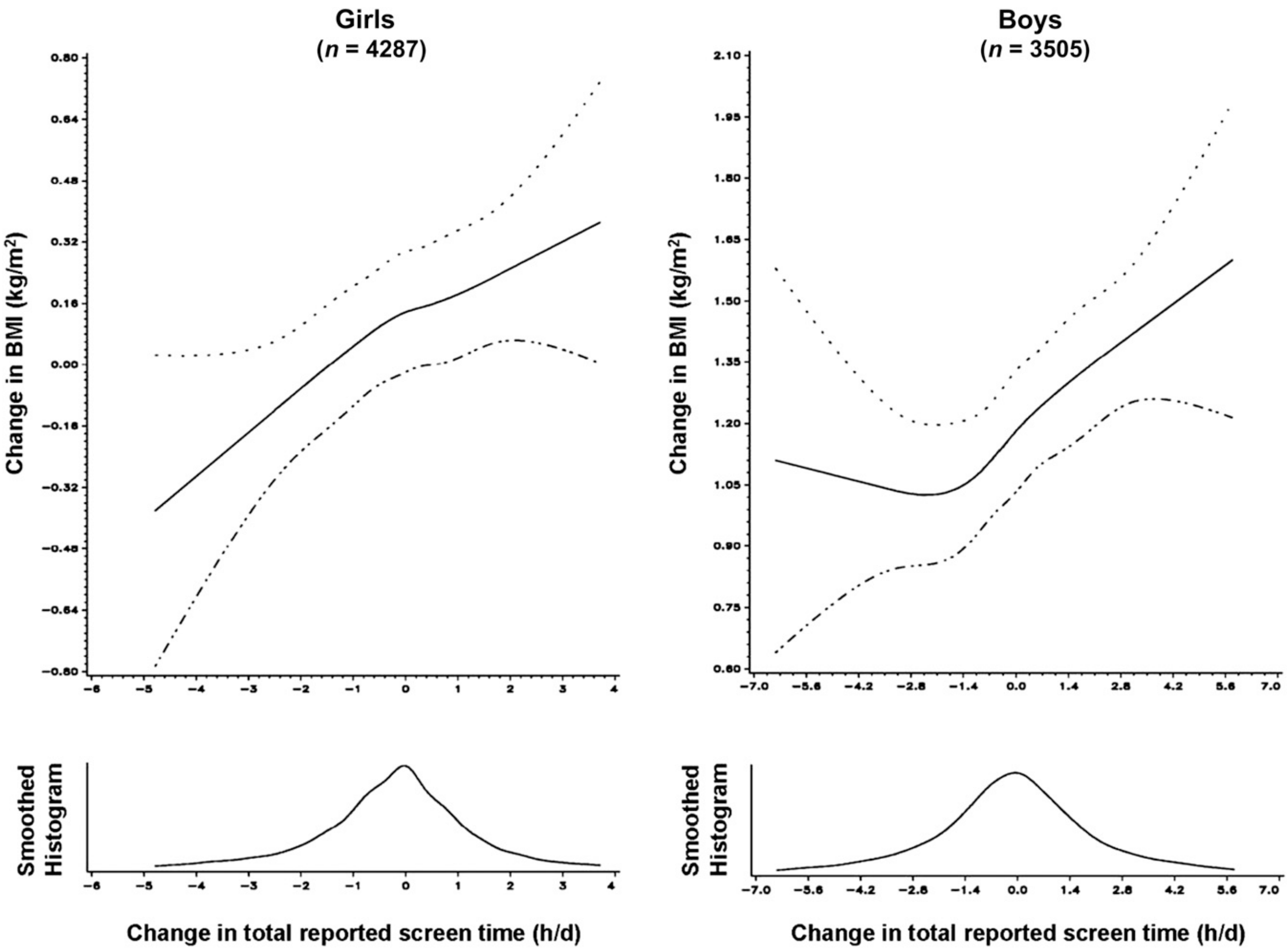

FIGURE 1
Predicted means of change in BMI from gender-stratified fully adjusted models, including restricted cubic spline terms for change in hours per day (h/d) of total reported screen time with knots at the 5th, 25th, 50th, 75th, and 95th percentile of change in total reported screen time. Models adjusted for age, age^2, 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 ΔBMI 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 ΔDVDs/videos and ΔBMI 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 $\geq$1 food/beverage product placement.[42] Very few studies have examined DVDs/videos separately from TV. One found that Δvideos predicted ΔBMI 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 ΔBMI 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 ΔBMI.[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 Δvideo/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 "advergames" (games developed to advertise a product) or product placement within games may partially explain influences on intake. In a recent trial, children playing advergames containing food cues consumed more energy during a subsequent snack than children playing advergames 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 ΔBMI 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 ΔBMI 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 occasions[56] and may affect memory of consumption[56] 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 Δadiposity. TV, which remains the steadiest medium for delivering food advertising, was most consistently associated with ΔBMI 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.

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