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Media Use and Obesity in Adolescent Females

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Abstract

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Objective: In the context of growing public health concern with the obesity rates among children and adolescents, much attention has focused on the role of television as a contributor to the problem. Less attention has been devoted to interactive media (internet surfing and video games), despite the fact that these forms of entertainment are fast gaining in popularity among youth. This study investigated the relative associations of TV viewing and interactive media use with body fat and BMI, controlling for both physical activity participation and cardiovascular fitness.

Research Methods and Procedures: Female high-school adolescents ($N = 194$) were assessed for cardiovascular fitness (cycle ergometer), percent body fat (DXA), and BMI. Time spent in moderate, vigorous, and sedentary activities was assessed with a 3-day recall.

Results: Multivariate regression analysis showed that only interactive media use was associated with percentage body fat and BMI, and the relationship remained strong even after controlling for physical activity participation and cardiovascular fitness.

Discussion: It appears that, among this group of adolescent females, the association between interactive media use and obesity is not explained by a reduction in moderate or vigorous activity commensurate with media use.

Key words: television, computer, fitness, body fat

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Introduction

Current epidemiological trends in the United States indicate that the prevalence of childhood obesity has reached the level of a public health crisis (1). Rates of obesity among children and adolescents have experienced a dramatic increase, with the latest Youth Risk Behavior Surveillance Survey (2) showing that almost 25% of high school females (grades 9 to 12) can be classified as either overweight (9.4%; ≥95th percentile for age- and sex-specific BMI) or at-risk-for-overweight (15.3%; between the 85th and 95th percentile for age- and sex-specific BMI). These numbers are of considerable concern because of the many negative health consequences associated with obesity in youth, including sleep apnea, gallbladder disease, elevated blood pressure, hyperlipidemia, and hyperinsulinemia (3,4).

Debate as to the reasons for the high rates of obesity among youth has centered on the two sides of the energy balance equation: energy intake and energy expenditure. Those who argue that a reduction in energy expenditure is largely to blame point to decreased levels of moderate to vigorous physical activity and increased levels of sedentary activity. Specifically, a number of studies have found evidence for an association between television (TV)[1] viewing (a popular sedentary activity) and obesity (5–8), yet a recent meta-analysis casts doubt on the clinical relevance of the TV viewing and body fat relationship (9).

The current generation of American youth is, however, in the midst of a media revolution. Although recent data on *Kids and Media in America* (10) affirm that TV still accounts for the majority of overall media exposure, it is clear that more interactive media "are moving inexorably to center stage of young people's media experience (p. 113)." In particular, children who come from higher socioeconomic status households watch less TV and are more likely to live in a home with a computer or internet connection, raising the question of whether interactive media is in the process of replacing TV as the most popular sedentary behavior among adolescents. The authors of the report on *Kids and Media in America* (10) argue that "the day when interactive

[1] Nonstandard abbreviations: TV, television; SD, standard deviation; 3DPAR, 3-Day Physical Activity Recall; MET, metabolic equivalent; Vo_{2peak}, peak oxygen consumption; NEAT, nonexercise activity thermogenesis.

media do come to dominate may be drawing near. . . To a large extent, interactive media probably lag behind other media because they have not yet fully penetrated the population (p. 134)." Unclear as of yet is whether interactive media will replace TV as the form of media most closely linked with obesity. Thus, the present study was designed to ascertain the independent associations of interactive media and TV with body fat among female adolescents residing in a relatively affluent and internet-wired community.

In addition to documenting a relationship between media use and obesity, some investigators have attempted to identify the mechanism for this association. One hypothesis is that time spent in sedentary media use displaces time that would otherwise be spent engaged in physically active pursuits (11). Evidence in favor of this hypothesis comes from research showing that reducing sedentary behaviors in children increases physical activity (12). It has also been proposed that energy intake increases in conjunction with TV viewing (13). Support for this hypothesis comes from research showing that high TV and video use among adolescents is associated with more unhealthful dietary behaviors (14), and that adolescents' energy intake decreases when sedentary behavior is decreased (15).

Most of the research attempting to disentangle the mechanisms of the media-obesity link has focused primarily on TV and has failed to systematically distinguish between interactive media (internet surfing, computer games) and noninteractive screen media (TV, videos, and movies). One exception to this general trend is a study of sedentary behavior and BMI among adolescents, which found that computer use was positively associated with BMI among girls but not boys (14). Another study found a relationship between computer use and BMI among 9- to 12-year-olds (16). Although BMI remains the preferred method of assessing obesity in large samples or when limited resources are available, recent research has called into question the accuracy of BMI for determining body composition (17). In the present research, we examined the relationship of both noninteractive screen media and interactive media to body fat, assessed via both DXA, which is considered the "gold standard" technique for assessing fat mass in children (18) and BMI, to allow for comparisons with other studies. The present study also extends prior work by controlling for cardiovascular fitness and physical activity participation to determine whether the association between media use and obesity is accounted for by decreased physical activity.

Research Methods and Procedures

Participants

Participants in this study were 194 high school females [mean ± standard deviation (SD) age, 15.2 ± 0.8 years; range, 14 to 17 years] recruited using flyers and posters. To obtain a wide range of physical activity and fitness levels, both high- and low-active adolescent females were recruited. One set of flyers advertised for participants who were members of a sports team or club, and a second set of flyers advertised for participants who were not members of a sports team or club and were "insufficiently active" as defined by the Centers for Disease Control (19), meaning that they engaged in fewer than three 20-minute bouts of vigorous activity and fewer than five 30-minute bouts of moderate activity per week. The ethnic composition of the sample reflected that of the surrounding community (60% European-American, 14% Asian, 19% Latina, 7% mixed or other). U.S. Census data indicate that the median household income level ($68,311) within this school district was above the median for the United States as a whole (20).

Procedures

All data were obtained during a 2- to 3-hour visit to a university-based General Clinical Research Center. Visits were scheduled during the summer vacation, when school was not in session. Participants and their parent or guardian provided written consent before data collection, and all research procedures were approved by the University's Institutional Review Board.

Measures

Sedentary Behaviors and Physical Activity. Self-reported activities were measured using a 3-Day Physical Activity Recall (3DPAR) validated by Motl et al. (21). Participants recalled their activity for the previous 3 days between 7:00 AM and 11:30 PM, segmented into 30-minute intervals. When a respondent was engaged in two tasks simultaneously (multi-taking), the respondent was instructed to record the more active task. For example, if a respondent were watching TV while riding a stationary bike, she would be instructed to record the stationary bike riding. Activities were converted into metabolic equivalents (METs) using the compendium published by Ainsworth et al. (22) and grouped to calculate average daily hours spent in moderate activity (3 to 5.9 METS), and vigorous activity (≥6 METs). The number of average daily hours spent engaged in sedentary activities was determined from the 3DPAR based on the number of 30-minute blocks during which the respondent endorsed the following activities: 1) playing video games/surfing the internet (hereafter referred to as interactive media); 2) reading; 3) doing homework; 4) talking on the phone; and 5) watching TV or a movie. The reading and doing homework categories were subsequently combined. The (combined) hours per day spent engaged in the four sedentary activity categories was also calculated (i.e., total sedentary behavior).

Cardiovascular Fitness. Absolute peak oxygen consumption ($\dot{V}O_{2peak}$ in L/min) and relative peak oxygen consumption ($\dot{V}O_{2peak}$ in mL/min per kg) were obtained through a ramp-type progressive exercise test on an electronicallybraked cycle ergometer (23). After a 3-minute warm-up with unloaded pedaling (i.e., 0 W), power output was increased in a graded fashion (i.e., 15 W/min). Participants were encouraged to pedal at a rate of 70 revolutions/min throughout the test phase of the protocol until they reached voluntary fatigue. The test portion of the protocol lasted between 8 to 12 minutes, followed by an appropriate cool-down period. Vo_{2peak} was obtained using the SensorMedics Vmax 229 metabolic cart (Yorba Linda, CA), through a method previously designed for children and adolescents (24). Gas exchange was measured breath-by-breath throughout the exercise protocol (25).

Percent Body Fat and BMI. Percent body fat was assessed by DXA using a hologic QDR *4500 densitometer (Hologic, Inc., Bedford, MA). Participants were scanned in a hospital patient gown while lying flat on their backs. On each day of testing, the DXA machine was calibrated using the procedures provided by the manufacturer. To calculate BMI, height was measured to the nearest 0.01 cm using a stadiometer and weight was measured to the nearest 0.1 kg using a calibrated scale

Data Analysis

Before analyses, continuous data were screened for violations of statistical assumptions, including normality, linearity, etc. Due to the substantial number of participants reporting no vigorous physical activity ($n = 86$) during the 3-day recall period, this variable (originally calculated in terms of number of 30-minute blocks) was subsequently dichotomized into some vs. no vigorous physical activity. Moderate activity was retained as a continuous variable but was sufficiently skewed that a logarithmic transformation of this variable was performed. The four sedentary behaviors (i.e., TV, interactive media, reading/homework, and phone) and the total sedentary behavior scale were each converted into categorical variables with three levels: low use, medium use, and high use. Zero was designated as the lowest category for all of the individual sedentary behaviors, and the 33rd percentile was used as the cut-off point between the low and medium categories for the total sedentary behavior variable. The cut-off point between the medium and high categories on all sedentary behavior variables was determined by the 66th percentile for the distribution of each variable. Cut-off points were rounded to the nearest one-half-hour per day. Thus, categories did not have equal numbers of participants.

To understand the relationships among the hypothesized predictor variables in our model, preliminary analyses examined the bivariate associations among sedentary behaviors, moderate and vigorous physical activity, and cardiovascular fitness. Depending on whether the variables were continuous or categorical, these bivariate associations were examined using a t test (fitness with vigorous activity), Pearson's correlation coefficient (fitness with moderate activity), χ^2 (sedentary behaviors with vigorous activity), or one-way ANOVA (sedentary behaviors with moderate activity and fitness).

Relationships between sedentary behaviors and body fat (operationalized as BMI and percentage body fat) were examined using multivariate linear regression analyses. Levels of each sedentary behavior were dummy coded, with "low" as the reference group. All analyses were adjusted for age, which was found to be correlated with several of the study variables, and ethnicity (white vs. non-white). Separate analyses were conducted for each sedentary behavior (i.e., TV, interactive media, reading/homework, phone) and the total sedentary behavior variable.

Multivariate linear regressions also examined the independent effects of sedentary behaviors on BMI and percentage body fat (DXA) controlling for cardiovascular fitness and moderate and vigorous physical activity. Age and ethnicity were entered as covariates. All of the sedentary behaviors were entered into the same model sequentially (in a stepwise manner), and we examined the additional variance explained by each one after adjusting for the others.

Results

Descriptive Statistics

Table 1 shows the mean (SD) and range for all of the key study variables before being recoded into categories or log transformed. Values are provided for study participants overall as well as for the two groups obtained using different recruitment materials. Results of Student's t tests comparing the two groups are also provided. These data indicate that we were successful in recruiting both sedentary and active adolescents and that these two groups differed significantly on BMI, body fat, vigorous activity participation, and cardiovascular fitness. Interestingly, the two groups did not differ significantly in terms of total sedentary behavior or moderate activity participation. Active girls, however, watched less TV and spent less time talking on the phone, whereas sedentary girls spent less time on homework and reading. The two groups did not differ in terms of their time spent on interactive media. Examination of the ranges for each variable illustrated that we accomplished our objective of increasing the variability of the study variables by recruiting the two groups, and that there was sufficient overlap between the two groups to justify the merging of all participants into a single group for analysis.

Bivariate Associations Between Fitness, Physical Activity, and Sedentary Behavior

Vigorous activity was associated with Vo_{2peak}[2] [$t(191) = 4.43$, $p < 0.001$], whereas moderate activity was not. Ad-

[2]All analyses including cardiovascular fitness were also run using relative fitness (Vo_{2peak} in mL/min per kg). The results remained essentially the same.

Table 1. Descriptive statistics for sedentary behaviors, moderate and vigorous physical activity, BMI, percent body fat (DXA), and cardiovascular fitness (VO_2peak)

	All (N = 194)	Active (N = 40)	Sedentary (N = 154)	t
Sedentary behavior (mean hours per day)				
TV	1.79	1.10	1.96	
	(1.67)	(0.96)	(1.76)	
	0–10.17	0–3.67	0–10.17	4.10†
Interactive media	0.58	0.45	0.61	
	(0.91)	(0.58)	(0.97)	
	0–6.67	0–2.67	0–6.67	NS
Reading/homework	0.56	1.15	0.41	
	(0.80)	(1.02)	(0.64)	
	0–4.33	0–4.33	0–3.00	−5.12†
Phone	0.50	0.30	0.55	
	(0.78)	(0.38)	(0.84)	
	0–6.67	0–1.50	0–6.67	1.80*
Total sedentary behavior	3.44	3.02	3.54	
	(2.00)	(1.42)	(2.11)	
	0–11.00	0.33–6.0	0–11.00	NS
Physical activity (mean hours per day)				
Vigorous activity	0.69	1.54	0.46	
	(0.93)	(1.14)	(0.71)	
	0–4.00	0–3.50	0–4.00	−5.68†
Moderate activity	1.96	1.69	2.02	
	(1.53)	(1.31)	(1.84)	
	0–9.83	0–5.50	0–9.83	NS
Physical measures				
BMI (kg/m^2)	22.75	21.62	23.04	
	(4.16)	(2.13)	(4.50)	
	15.8–37.6	18.4–27.2	15.8–37.6	2.86*
Body fat (%)	30.49	24.95	31.88	
	(6.37)	(4.17)	(6.07)	
	17.3–44.9	17.3–33.6	19.20–44.9	6.73†
Vo_{2peak} (L/min)	1.54	2.10	1.38	
	(0.41)	(0.36)	(0.27)	
	0.72–2.99	1.37–2.99	0.71–2.08	−13.75†
Vo_{2peak} (mL/kg per min)	26.10	35.67	23.61	
	(7.06)	(4.92)	(5.15)	
	10.9–50.5	25.9–49.0	10.9–50.5	−13.29†

* $p < 0.01$.
† $p < 0.001$.
Values are mean (SD); range. NS, not significant.

olescents who reported any vigorous activity on the 3DPAR had a mean Vo_{2peak} of 1.65 L/min (SD = 0.43 L/min), and those who reported no vigorous activity had a mean Vo_{2peak} of 1.40 L/min (SD = 0.34 L/min). In addition, bivariate analyses revealed a number of significant differences between total time spent in sedentary activity and both activity

Table 2. Means of cardiovascular fitness and moderate activity and proportion of participants vigorously active by categories of sedentary activities ($N = 194$)

	N	Vo_{2peak} Mean	Vo_{2peak} SD	Moderate activity‡ Mean	Moderate activity‡ SD	Vigorous activity %
Total sedentary behavior						
Low (<2.5 hours)	66	1.54	0.39	2.63*†	2.22	56.9†
Medium (2.5 to 4 hours)	64	1.64*	0.48	1.67*	1.47	68.8*
High (>4 hours)	64	1.43*	0.30	1.54†	1.17	40.6*†
TV						
Low (0 hours)	18	1.87	0.49	2.21	1.83	47.1
Medium (0 to 1 hour)	61	1.52	0.39	2.11	2.12	65.6
High (>1 hour)	115	1.49	0.38	1.84	1.74	51.3
Interactive media						
Low (0 hours)	89	1.51	0.41	2.29	2.14	48.9
Medium (0 to 1 hour)	65	1.58	0.45	1.69	1.34	67.7
High (>1 hour)	40	1.53	0.32	1.65	1.13	50.0
Reading/homework						
Low (0 hours)	35	1.44†	0.31	2.30	2.01	46.2*
Medium (0 to 0.5 hours)	65	1.50*	0.41	1.75	1.72	68.6†
High (>0.5 hours)	63	1.71*†	0.48	1.56	1.17	61.5*†
Phone						
Low (0 hours)	75	1.62	0.40	1.76	1.54	56.5
Medium (0 to 0.5 hours)	56	1.49	0.42	2.30	2.05	54.7
High (>0.5 hours)	86	1.52	0.38	1.71	1.45	55.4

*† Means with the same superscripts are significantly different ($p < 0.05$).
‡ For the sake of interpretation, non-transformed moderate activity values are presented.

and fitness (Table 2). Total time spent in sedentary activity was associated with moderate activity ($F(2191) = 5.42$, $p = 0.005$), vigorous activity ($\chi^2(df = 2) = 10.33$, $p = 0.006$), and cardiovascular fitness ($t(128) = 2.11$, $p = 0.037$). The associations were in the expected direction, with more activity and higher fitness being related to less time spent being sedentary. Interestingly, for both vigorous activity and fitness, the source of the significant difference was the contrast between the "medium" and "high" groups of sedentary behavior. The "low" and "medium" groups did not differ significantly.

Bivariate analyses of the specific sedentary activities with fitness and with physical activity revealed a significant relationship of reading/homework with both vigorous activity and cardiovascular fitness, though not with moderate activity (Table 2). Adolescents who spent the most time reading and doing homework were more likely to engage in vigorous activity than those who spent the least time on homework and reading ($\chi^2(df = 2) = 6.61$, $p = 0.037$). The more studious children also had higher cardiovascular fitness ($t(157) = 3.93$, $p < 0.001$). Neither interactive media nor TV was significantly associated with physical activity or fitness.

Regression Analyses Predicting BMI and Percentage Body Fat

In separate regression analyses controlling for age and ethnicity (white vs. non-white), time spent on interactive media was significantly associated with percentage body fat ($\beta = 0.157$, $p = 0.035$) and the association with BMI was marginally significant ($\beta = 0.147$, $p = 0.051$). The "high" interactive media group had greater BMI and percentage body fat values than the "low" interactive media group, and there was no significant difference between the low and medium interactive media users. None of the other sedentary behaviors significantly predicted either percentage body fat or BMI.

When the independent associations between sedentary behaviors on the one hand and BMI and body fat on the other were examined after controlling for fitness and phys-

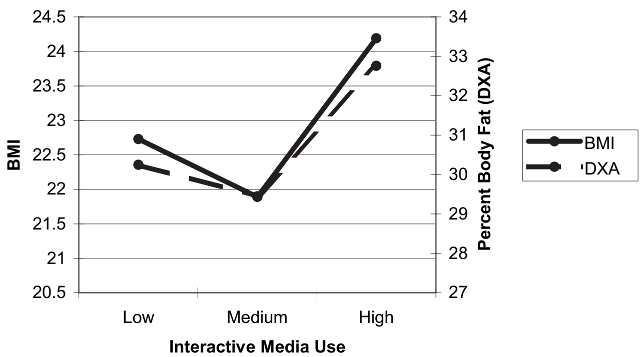

Figure 1: BMI and body fat (DXA) by levels of interactive media use.

ical activity, interactive media still significantly predicted both BMI ($\beta = 0.153$, $p = 0.039$) and percentage body fat ($\beta = 0.17$, $p = 0.018$). Again, the source of the difference was the greater BMI and percentage body fat values in the "high" as compared with "low" interactive media users (Figure 1). Hours of TV, reading/homework, telephone, and total sedentary behavior were unrelated to BMI and percentage body fat.

In the final analysis, when all of the individual sedentary behaviors were entered sequentially into the regression equations predicting BMI and body fat after controlling for age, ethnicity, Vo_{2peak}, and moderate and vigorous physical activity, the results mirrored those of the independent regressions (Table 3). That is, only the step including interactive media use explained significant variation in BMI ($\Delta R^2 = 0.040$, $p = 0.015$) and percentage body fat ($\Delta R^2 = 0.038$, $p = 0.018$). The overall percentage of variance explained by the full model was 11% for BMI and 13% for percentage body fat.

Discussion

Our results provide evidence for a link between interactive media use and obesity among adolescent females. An association between media use and obesity has also been demonstrated in a number of other studies (5,26), some of which have specifically found support for the relationship between computer use and obesity (14,16). The present study extends earlier work by demonstrating that the association is robust even when controlling for both cardiovascular fitness and participation in both moderate and vigorous physical activity. Our study diverges, however, from earlier work in that TV did not emerge as a correlate of body fat. Rather, in this population of adolescent females, it was time spent on interactive media that corresponded with body

Table 3. Linear regression model coefficients with standard errors and *p* values predicting BMI and percent body fat (DXA) by sedentary behaviors ($N = 194$)

	BMI		Body fat (%)	
	β (SE)	***p***	**β (SE)**	***p***
TV				
Low	(referent)			
Medium	−1.05 (1.11)	0.34	−0.29 (0.72)	0.68
High	0.40 (1.03)	0.69	0.60 (0.67)	0.37
Interactive media				
Low	(referent)			
Medium	−0.66 (1.01)	0.51	−0.86 (0.66)	0.19
High	2.73 (1.17)	0.02	1.49 (0.77)	0.05
Reading/homework				
Low	(referent)			
Medium	−1.02 (1.03)	0.41	0.10 (0.81)	0.89
High	−0.47 (1.04)	0.64	−0.06 (0.68)	0.92
Phone				
Low	(referent)			
Medium	0.58 (1.04)	0.57	0.00 (0.68)	0.99
High	1.64 (1.12)	0.14	0.83 (0.74)	0.26

The four factors were entered into the model sequentially after controlling for age, ethnicity (white vs. non-white), cardiovascular fitness (Vo_{2peak}), and moderate and vigorous physical activity.

fat; a finding that is consistent with a recent survey showing that computer use was associated with BMI among female adolescents (14).

In attempting to deconstruct the purported association between TV watching and obesity, two mechanisms have been offered to explain the connection: displacement of physical activity and increased calorie consumption while watching or caused by the effects of advertising (6). A recent analysis of the data from the Youth Risk Behavior Survey (5) suggests that each of these mechanisms may play a role in the TV-obesity link, although there may be differences among population subgroups in terms of how salient a role each mechanism plays.

The current study does not support the displacement of physical activity hypothesis, since the link between interactive media use and body fat remained significant even after controlling for moderate and vigorous activity participation. Rather, the finding that the association between interactive media use and body fat persisted even after controlling for participation in physical activity highlights the independence of these two behaviors. That is, time spent engaging in interactive media did not seem to be related to body fat through the mechanism of decreased physical activity.

In line with recent work by Epstein et al. (15), demonstrating that decreasing adolescents' sedentary behavior led to a marked decrease in energy intake, the present study is consistent with the hypothesis that much of the relationship between "screen time" and obesity may be explained not by lower energy expenditure, but rather by higher energy intake. This hypothesis also has been supported by research indicating that youth do much of their eating during "screen time," perhaps in the form of high-fat snack foods and high-sugar drinks (14). It is worth noting, however, that increased caloric intake during interactive media use may be attenuated by the fact that the user's hands are usually occupied (27).

If the association between interactive media time and body fat cannot be explained by either decreased physical activity or increased caloric intake, the question that emerges is whether the effect might be mediated by a decrease in nonexercise activity thermogenesis (NEAT) (28). NEAT is the energy expended by activity that is incidental and would not register on an instrument, such as the 3DPAR, yet accounts for a significant proportion of daily energy expenditure because it varies so widely among individuals and is pervasive throughout the day. Research suggests that NEAT may have a genetic component, as indicated by a classic overfeeding study in identical twins, during which the extremely variable weight gain under conditions of controlled physical activity and energy intake was observed to cluster for "twinness" (29). In addition to genetics, however, both the environment and behavior seem to modify NEAT (28). The biological mechanisms through which behavior may impact NEAT have yet to be delineated, but it is theoretically plausible that increased time spent engaged in interactive media could result in decreased NEAT throughout the day and, therefore, bring about increased body fat.

Regardless of the mechanism through which interactive media use influences body fat, the implication of this study is that interventions designed to reduce the risk of obesity in this age group should focus not only on increasing participation in physical activity but also on decreasing time spent engaged in interactive media use. Indeed, the reduction of sedentary activities has been shown to facilitate weight loss even in the absence of a physical activity intervention (30).

Much of the past research in this area has focused on TV as the primary source of sedentary behavior among adolescents (5,6), often finding a relationship between TV viewing and obesity (7), yet not across all subgroups (5). Interestingly, the Framingham Children's Study (26), which reported a significant longitudinal correspondence between TV watching and increases in body fat from childhood to adolescence, included time spent playing video games in their assessment of "TV time." Thus, their findings may be compatible with our own results, indicating that time spent in interactive media was the only category of sedentary behavior significantly associated with percentage body fat among adolescent females. It is possible that the absence of a correlation between TV time and body composition in this study could have been influenced by girls' multitasking; that is, they could have been exercising while watching TV, thus essentially making TV time active time. It is unlikely, however, that this pattern of behavior would have had a substantial effect on our data, since the participants knew that this was a study focused on physical activity, and were instructed when completing the 3DPAR that they should record the more active of two activities if they were unsure of what to enter for a particular 30-minute block.

It is worth noting that the current research looked at both moderate and vigorous activity and found that time spent engaged in interactive media explained approximately 4% of the variance in body composition after controlling for physical activity. Although this is a relatively small percentage of the variance, the compounded effects of time spent in interactive media over the course of years is likely to be much greater. The evidence indicates that those who are high TV watchers during youth are likely to continue to spend large amounts of time watching TV as they mature (31). Future research may wish to examine the long-term effects of media use on body composition.

Limitations

The participants in the present study were drawn from a relatively affluent suburb, within which most adolescents are likely to have easy access to internet-linked computers and video game players. The relative role of TV as a contributor to body fatness may be different in less advantaged communities. In addition, the sample was one of convenience, which may limit generalization. Moreover, the data are cross-sectional and cannot be used to demonstrate a causal link between interactive media use and obesity.

In summary, overall, the results lend further credence to the widespread concern that rising levels of obesity among youth may be related to ever greater availability and appeal of sedentary forms of entertainment. In particular, high interactive media use may contribute to elevated levels of body fat among female adolescents.

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References

1. **Ebbeling CB, Pawlak DB, Ludwig DS.** Childhood obesity: public-health crisis, common sense cure. *Lancet*. 2002;360:473–82.
2. **Centers for Disease Control.** Surveillance summaries. *MMWR*. 2004;53(SS-2).
3. **Dietz WH.** Overweight in childhood and adolescence. *N Engl J Med*. 2004;350:855–7.
4. **Dietz WH.** Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics*. 1998;101:518–25.
5. **Lowry R, Wechsler H, Galuska DA, Fulton JE, Kann L.** Television viewing and its associations with overweight, sedentary lifestyle, and insufficient consumption of fruits and vegetables among US high school students: differences by race, ethnicity, and gender. *J Sch Health*. 2002;72:413–21.
6. **Robinson TN.** Television viewing and childhood obesity. *Pediatr Clin North Am*. 2001;48:1017–25.
7. **Jakes RW, Day NE, Khaw KT, et al.** Television viewing and low participation in vigorous recreation are independently associated with obesity and markers of cardiovascular disease risk: EPIC-Norfolk population-based study. *Eur J Clin Nutr*. 2003;57:1089–96.
8. **Eisenmann JC, Bartee RT, Wang MQ.** Physical activity, TV viewing, and weight in U.S. youth: 1999 Youth Risk Behavior Survey. *Obes Res*. 2002;10:379–85.
9. **Marshall SJ, Biddle SJ, Gorely T, Cameron N, Murdey I.** Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. *Int J Obes Relat Metab Disord*. 2004;28:1238–46.
10. **Roberts D, Foehr U.** *Kids and Media in America*. New York: Cambridge University Press; 2004.
11. **Biddle SJ, Gorely T, Stensel DJ.** Health-enhancing physical activity and sedentary behaviour in children and adolescents. *J Sports Sci*. 2004;22:679–701.
12. **Epstein LH, Roemmich JN.** Reducing sedentary behavior: role in modifying physical activity. *Exerc Sport Sci Rev*. 2001;29:103–8.
13. **Dietz WH, Gortmaker SL.** Preventing obesity in children and adolescents. *Annu Rev Public Health*. 2001;22:337–53.
14. **Utter J, Neumark-Sztainer D, Jeffery R, Story M.** Couch potatoes or french fries: are sedentary behaviors associated with body mass index, physical activity, and dietary behaviors among adolescents? *J Am Diet Assoc*. 2003;103:1298–305.
15. **Epstein LH, Roemmich JN, Paluch RA, Raynor HA.** Influence of changes in sedentary behavior on energy and macronutrient intake in youth. *Am J Clin Nutr*. 2005;81:361–6.
16. **Arluk SL, Branch JD, Swain DP, Dowling EA.** Childhood obesity's relationship to time spent in sedentary behavior. *Mil Med*. 2003;168:583–6.
17. **Nevill AM, Stewart AD, Olds T, Holder R.** Relationship between adiposity and body size reveals limitations of BMI. *Am J Phys Anthropol*. 2006;129:151–6.
18. **Goran MI, Driscoll P, Johnson R, Nagy TR, Hunter G.** Cross-calibration of body-composition techniques against dual-energy X-ray absorptiometry in young children. *Am J Clin Nutr*. 1996;63:299–305.
19. **Pate RR, Pratt N, Blair SN, et al.** Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA*. 1995;273:402–7.
20. **U.S. Census Bureau.** *United States Census 2000.* www.census.gov (Accessed January 2006).
21. **Motl RW, Dishman RK, Dowda M, Pate RR.** Factorial validity and invariance of a self-report measure of physical activity among adolescent girls. *Res Q Exerc Sport*. 2004;75:259–71.
22. **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(9 Suppl):S498–504.
23. **Whipp BJ, Davis JA, Torres F, Wasserman, K.** A test to determine parameters of aerobic function during exercise. *J Appl Physiol*. 1981;50:217–21.
24. **Cooper DM, Weiler-Ravell D, Whipp BJ, Wasserman K.** Aerobic parameters of exercise as a function of body size during growth in children. *J Appl Physiol*. 1984;56:626–34.
25. **Beaver WL, Lamarra N, Wasserman K.** Breath-by-breath measurement of true alveolar gas exchange. *J Appl Physiol*. 1981;52:1662–75.
26. **Proctor MH, Moore LL, Gao D, et al.** Television viewing and change in body fat from preschool to early adolescence: the Framingham Children's Study. *Int J Obes Relat Metab Disord*. 2003;27:827–33.
27. **Giammattei J, Blix G, Marshak HH, Wollitzer AO, Pettitt DJ.** Television watching and soft drink consumption: associations with obesity in 11- to 13-year-old schoolchildren. *Arch Pediatr Adolesc Med*. 2003;157:882–6.
28. **Levine JA.** Nonexercise activity thermogenesis (NEAT): environment and biology. *Am J Physiol Endocrinol Metab*. 2004;286:E675–85.
29. **Bouchard C, Tremblay A, Despres JP, et al.** The response to long-term overfeeding in identical twins. *N Engl J Med*. 1990;322:1477–82.
30. **Epstein LH, Paluch RA, Gordy CC, Dorn J.** Decreasing sedentary behaviors in treating pediatric obesity. *Arch Pediatr Adolesc Med*. 2000;154:220–6.
31. **Marshall SJ, Gorely T, Biddle SJ.** A descriptive epidemiology of screen-based media use in youth: a review and critique. *J Adolesc*. 2006;29:333–49.