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Linking obesity and activity level with children's television and video game use

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Abstract

This study examined the links between childhood obesity, activity participation and television and video game use in a nationally representative sample of children ($N = 2831$) ages 1–12 using age-normed body mass index (BMI) ratings. Results indicated that while television use was not related to children's weight status, video game use was. Children with higher weight status played moderate amounts of electronic games, while children with lower weight status played either very little or a lot of electronic games. Interaction analyses revealed that this curvilinear relationship applied to children under age 8 and that girls, but not boys, with higher weight status played more video games. Children ages 9–12 with lower weight status used the computer (non-game) for moderate amounts of time, while those with higher weight status used the computer either very little or a lot. This was also true for the relationship between print use and weight status for children of all ages. Results also indicated that children with higher weight status spent more time in sedentary activities than those with lower weight status.

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Introduction

Despite the continuing popular conception that children's television and video game use are causally linked to the increasing prevalence of obesity in children and adolescents (Gortmaker, Dietz, Sobol, & Wehler, 1987), empirical evidence for this link is mixed at best. Studies examining the relationship between television viewing and obesity in children and adolescents have consistently found weak, if any, associations between the two phenomena (Robinson & Killen, 1995). This is not for lack of trying, as a fair number of studies examining this connection exist, most notably epidemiological studies conducted by pediatricians and nutritionists.

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Connecting obesity and activity level with television and video game use

The notion that television and video game use must be responsible, somehow, for the increased prevalence of obesity in American children and adolescents in recent years is dearly held by the lay public and academics alike (see, e.g. [Chen & Kennedy, 2001](#); [Dietz, 2001](#)). There are at least three hypothesized mechanisms for the relationship between television and video game use and obesity ([Robinson, 2001](#)).

First, television viewing and/or video game use is thought to be related to increased weight in children because time spent with these media displaces physical activity. This is essentially the “couch potato” hypothesis, whereby time spent with television and video games is thought to be negatively related to time spent in more energy expending activities and positively related to time spent in sedentary activities (including media use itself). Early evidence for the displacement of physical activity by television came from studies documenting decreases in participation in physical activities following the introduction of television into small, mainly rural, communities ([Brown, Cramond, & Wilde, 1974](#); [Williams, 1986](#)). However, more recent epidemiologic studies of the relationship between activity level and television and video game use among children and adolescents have been inconsistent. [Robinson and Killen \(1995\)](#) report no relationship between physical activity and television viewing. [Robinson et al. \(1993\)](#) and [Durant, Baranowski, Johnson, and Thompson \(1994\)](#) both report a negative but weak association between television viewing and physical activity.

This “couch-potato” hypothesis is by far the most popular hypothesis regarding the connection between electronic media use and obesity in children, and it applies equally well to both television watching and video game use. Both activities are assumed to displace more active activities (e.g. playing outside) and facilitate sedentary lifestyles in children and adolescents.

The second major hypothesis links television viewing, in particular, to increased caloric intake either from eating during viewing or as a result of food advertising on television, which tends to emphasize high-calorie, high-fat foods with poor nutritional content ([Story & Faulkner, 1990](#)). It has also been suggested that such advertising not only increases children’s desire for high-calorie foods, but fosters belief that the consumption of such foods is unrelated to being over weight, as actors portrayed in such advertisements are generally thin to normal weight ([Dietz & Gortmaker, 1985](#)). There is some evidence that amount of television viewing is related to children’s requests for, and parental purchases of, highly advertised foods ([Taras, Sallis, Patterson, Nader, & Nelson, 1989](#)) and that television advertising may produce incorrect nutritional beliefs in children ([Ross, Campbell, Huston-Stein, & Wright, 1981](#)). There is also experimental evidence that there are direct effects of exposure to advertising for high-calorie foods on children’s snack choices and consumption ([Gorn & Goldberg, 1982](#); [Ross, Campbell, Huston-Stein, & Wright, 1981](#)). While this hypothesized mechanism is clearly appropriate for linking television to children’s obesity, it is less relevant to video games unless (or perhaps until) video game developers and companies start including snack food product placement in video games.

The third major hypothesis is that television viewing actually decreases metabolic rates, more so than simply resting or sleeping. [Klesges, Shelton and Klesges \(1993\)](#) found some evidence for this in 8–12 year old children. While this hypothesis has received much attention in the press, efforts to replicate Klesges and colleagues findings have, thus far, not been fruitful ([Buchowski & Sun, 1996](#); [Dietz, Bandini, Morelli, Peers, & Ching, 1994](#)). To our knowledge, no studies have been

conducted to date examining the relationships between video games and metabolic resting rates, making it difficult to speculate what the relationship might be. However, it is generally accepted that video games involve more mental, and perhaps physical, effort and thus this mechanism might also be less relevant for linking video game use and obesity.

Regardless of the specific mechanism involved, confirmation of any or all of the hypotheses above would require a positive relationship between television and/or video game use and increased weight or obesity in youth. It is true that children spend more time watching television than in any other single activity except for sleep (Huston & Wright, 1997). Dietz and Gortmaker (1985) reported a small but significant relationship between television viewing and obesity. They report that the prevalence of obesity in a large epidemiological sample of adolescents 12–17 increased 2% for each additional hour of television watched. They did not examine video game use. It is this study that is widely cited as evidence that television, and, by extension, video game use, causes obesity in children and adolescents. However, the link reported by Dietz and Gortmaker (1985) has been somewhat elusive for ensuing studies. Robinson & Killen (1995) found that while television viewing was associated with increased dietary intake in a large ($N = 1912$) sample of ninth graders, it was only weakly associated with body mass index (BMI), and only among White boys. Robinson et al. (1993) found that baseline hours of television viewing were not associated with either baseline or longitudinal change in BMI in a large ($N = 971$) sample of sixth and seventh grade girls. In one of the few studies to examine video game as well as television use, McMurray et al. (2000) found that there was no relationship between television or video game use and BMI in a sample of 2389 adolescents ages 10–17 once the influence of socioeconomic status and ethnicity were controlled. Finally, Durant, Baranowski, Johnson, and Thompson (1994) also found no relationship between BMI and television watching in a longitudinal sample of young children (ages 3–4).

So what are we to make of this seeming lack of connection between obesity and either television or video game use? One issue is that while existing studies tend to be rather strong in terms of representativeness, sample size and measures of obesity (BMI and/or triceps skinfold), they tend to have rather weak measures of media use and other activities. Indeed, Dietz and Gortmaker (1993) remark that “The most significant problem with all studies that have examined the effects of television viewing on behaviour is that reports of television viewing time cannot be validated” (1992, p. 500). Most, if not all, existing studies rely on general estimates by child participants of the amount of hours they spend weekly watching television or playing video games and in other activities as well. There is some evidence that when asked to estimate the amount of television they watch in general amounts (e.g. weekly, monthly), subjects tend to overestimate the time they spend (Anderson, Field, Collins, Lorch, & Nathan, 1985; Anderson, in personal communication, March 2002). If this is so, then the error introduced by reliance on weak measures of media use might well reduce the magnitude of the relationship found in studies connecting obesity in children and adolescents to their media use.

The current study relies on data from a nationally representative sample of children ages 1–12, using well-established measures of obesity (Body Mass Index or BMI) used in pediatric studies. However, unlike existing studies, we rely on 24-h time-use diaries to estimate amounts of children’s television and video game use as well as the time they spend in physical and sedentary activities. Such diaries, whether written or oral, have been found to be more accurate than the more general time estimates often used in surveys (Anderson & Field, 1991). Moreover, there is a

large body of evidence demonstrating the validity of time-use diaries for estimating the amount of time people spend in various activities (see, e.g. Juster & Stafford, 1985).

Method

Participants

The Panel Study of Income Dynamics (PSID) is an ongoing national survey focusing primarily on the transfer of social and economic capital within families. Data were collected annually from 1968 to 1997 when the study became biennial. At that time, additional data focusing on PSID children and their families were collected in the Child Development Supplement (CDS). All families participating in the PSID in 1997 with children 12 years old and younger were asked to complete the CDS. Of the total 3562 children (Hofferth, Davis-Kean, Davis, & Finkelstein, 1999) participating in the CDS, the sample for this study consisted of 2831 participants ages 1–12 years, who had completed two time-use diaries and had complete data on the variables of interest in this analysis.

The children in the sample, were, on average, 6 years old. Fifty-one per cent of the sample were boys and 49% were girls. Whites comprised 49% of the sample, Blacks 39%, Hispanics 7%, Asians 2%, and other ethnicities 4%. Male head of household families comprised 72.7% of the sample (years of education $M = 12.94$, s.D. = 2.78; age $M = 37.22$, s.D. = 8.04) while female head of household families comprised 27.3% of the sample (years of education $M = 12.05$, s.D. = 2.03; age $M = 34.51$, s.D. = 9.31).

Measures

Covariates: Based on demonstrated relationships with either media use, weight status or both, a number of sociodemographic characteristics were treated as covariates in analyses. These included: (a) *child gender* (0 = boys, 1 = girls), (b) *child race* as a series of dummy variables with White as the referent group (*Black*: 0 = not Black, 1 = Black; *Hispanic*: 0 = not Hispanic, 1 = Hispanic), *age of child* ($M = 6.05$, s.D. = 3.67), (c) *education of household head* ($M = 12.76$, s.D. = 2.98) which denotes the total number of years of education completed by the household head, and (d) *family income to needs ratio*. The family income to needs ratio is a proportion of the family's income by the poverty threshold for that family. Higher income to needs ratios indicate more disposable income in a family.

Because the PSID oversampled minorities, lower income groups, and less educated people, data were weighted to achieve national representation. Thus, all analyses presented here were conducted using weighted data (with weights recalibrated for our subsample), thus allowing us to generalize our results to the population level.

Children's time-use: Two 24-h time-use diaries provide all information regarding media use and activity participation utilized for this study. On one randomly chosen weekday and one randomly chosen weekend day, the primary caregiver of each child reported all of the activities that the child engaged in. A primary activity and its duration were recorded to account for every minute of the two 24-h periods, and, if appropriate, a secondary activity was also noted. If watching television or playing interactive games was recorded as a primary activity, the caregiver was asked to record

the title of the program. Coding was conducted by professional coders employed by the data collection organization; the level of reliability exceeded 90% (Hofferth & Sandberg, 2001). The codebook and coding information is available on the website at www.isr.umich.edu/src/child-development/home.html. Because the diaries document all of children's activities in a 24-h period, we were able to create both media and activity participation measures which captured the actual number of minutes children spend in both active and passive activities rather than relying on general estimates of activity level. Bias analyses comparing children who completed two diaries ($N = 2831$) vs. one diary ($N = 70$) revealed that children who completed two diaries had parents with significantly more years of education and higher income to needs ratios (i.e. more disposable income) than children with one diary only. However, these children did not differ from one another in terms of ethnicity, gender or age.

Time-use for both children and adults is known to differ widely on weekdays versus weekends (Hofferth & Sandberg, 2001; Juster & Stafford, 1985). As would be expected on the basis of previous research, children's media use and activity participation the assessed weekend day and weekday were somewhat, but not highly, correlated (average $r = 0.26$, range = 0.38–0.19). Thus, in order to most accurately capture the total amount of spent by children in either media use or activities of interest, we summed their participation in minutes over the 2 days. Means and standard deviations for the total minutes children spent in the activities of interest are summarized according to age and gender in Table 1.

Children's media use: Using the method described above, we created four variables capturing children's use of different media: (a) *television use* represents the number of minutes children watched television ($M = 225.90$, s.d. = 176.05); (b) *electronic game use* represents the number of minutes children played games on either video game consoles or computers ($M = 21.10$, s.d. = 68.30); (c) *computer use* represents the number of minutes children spent using the computer for any use other than games (e.g. word processing, e-mail) ($M = 12.11$, s.d. = 43.12); and (d) *print use* represents the number of minutes children spent with print media including both being read to and reading alone ($M = 22.20$, s.d. = 40.18).

Children's activity participation. The amount of time children spend in various active and sedentary leisure activities was measured using information in the 24-h time-use diaries. As with minutes of media use, these variables capture the total number of minutes children engaged in various activities over the 2-day period covered by the time-use diaries. It is true that television and video games are themselves sedentary leisure activities. However, in order for television and video game use to be negatively related to activity level or physical exertion, the amount of time children spend using them has to displace some other, more active or physically strenuous, leisure activity. That is, children need to choose to watch television or play video games over some more active leisure such as playing soccer.

Because of our interest in the connections between obesity, media use and activity level, we were mainly interested in capturing the sedentary vs. active nature of the kinds of activities children participate in. Thus, we concentrated on activities that could be categorized along those lines. We created three measures of activity participation by summing the total amount of minutes children participated in highly active, moderately active, and sedentary (i.e. not at all active) activities, respectively. Highly active activities captured leisure activities requiring sustained physical effort or exertion for the duration of the activity. These included all sports activities, such as basketball, soccer, swimming, running or bicycling ($M = 67.85$, s.d. = 105.57). Moderately active activities

Table 1
Means and standard deviations of activities by gender and age

Age	Boys		Girls	
	<i>M</i>	S.D.	<i>M</i>	S.D.
Television use				
1–5	197.04	167.72	183.53	163.16
6–8	263.10	165.46	239.00	159.02
9–12	251.12	184.87	266.47	194.33
Electronic game use				
1–5	7.83	37.92	5.19	40.14
6–8	44.36	113.37	13.56	38.64
9–12	56.91	101.94	17.65	47.02
Computer use				
1–5	7.03	28.38	6.84	35.00
6–8	12.58	42.96	8.06	27.93
9–12	27.17	70.81	15.43	43.24
Print use				
1–5	21.09	32.42	22.99	34.14
6–8	20.30	36.67	20.35	31.53
9–12	18.53	46.50	28.50	55.56
Highly active activities				
1–5	42.47	73.53	33.81	77.76
6–8	106.74	123.20	61.90	91.72
9–12	136.56	148.51	63.12	87.99
Moderately active activities				
1–5	55.36	80.90	58.56	92.27
6–8	30.96	64.85	36.96	69.24
9–12	39.78	72.61	46.03	88.80
Sedentary activities				
1–5	54.59	70.50	53.91	71.04
6–8	75.08	77.02	79.68	83.50
9–12	110.16	109.23	122.08	111.29

Note: Means represent minutes in each activity over a 2 day period.

captured leisure activities, which were indeed active, but do not require sustained physical exertion. These included activities such as fishing, boating, camping, music lessons, and singing ($M = 47.36$, $s.d. = 81.22$). Sedentary activities included things such as talking on the phone, puzzles, board games, and relaxing ($M = 78.87$, $s.d. = 91.00$).

Children's weight status. Children's percentile rank of BMI within our sample was used to measure weight status. BMI is a proportion of weight to height calculated according to the formula provided by the [National Center for Chronic Disease Prevention and Health Promotion \(CDC, 2000\)](#). Parents reported on children's weight. Children's height was measured by in-home interviewers using a tape measure. The CDC provides separate norms for boys and girls of different ages taking into account their differing developmental trajectories. Each of the CDC BMI-for-age growth charts contains a series of curves, representing specific percentile ranks (5th, 10th, 25th, 50th, 75th, 85th, 90th and 95th). While this allows us to compare a child's BMI with

these discrete percentile ranks, it does not provide an exact percentile for each child's BMI. Therefore, in order to prevent the attenuation of variance resulting from use of the CDC's growth curves to assign percentile rankings for our sample, we created a percentile rank of the BMI within age and gender for each child in our sample. This allows us to compare the BMIs of the children in our sample to one another because it adjusts BMI scores according to the age and gender.

Analysis plan

Our main purpose in this paper was to examine the relations between children's media use and physical activities to their weight status. Our first step was to conduct a series of seven ordinary least-squares (OLS) hierarchical multiple regressions with each of the media use and activity participation variables as predictors in each regression, and the percentile BMI as the dependent variable. In each analysis, linear terms as well as curvilinear terms for each predictor were included to test for nonlinear relations. Each of the predictors were centred and then squared. The centred terms were used to test the linear relationships and the centred-squared terms were used to test the non-linear or curvilinear relationships. Each analysis included the following covariates: child gender, age, ethnicity, years of education of household head, and family income-to-needs ratio. In the second step, the linear and non-linear terms of the media and activity participation variables were added.

Our next step was to perform a series of OLS regressions to examine interactions among each of the media use and activity participation predictors and other variables of interest. Since it is known that both children's patterns of media use (Huston, Wright, Marquis, & Green, 1999) and their activity participation (Hofferth & Sandberg, 2001) vary according to age and gender, we examined both gender and age interactions with media use and activity participation. Each regression included the linear term for the respective predictor and the age and gender interaction of that linear term. When a curvilinear term was significant, we added the curvilinear terms and the age and gender interactions for that curvilinear term to the model.

Finally, on the basis of the results from the individual regressions, we built an overall regression model to test the relative contribution of each predictor when examined simultaneously. The first step included the covariates listed above. In the second step, both linear and curvilinear terms of the media use and activity participation variables were included whenever the curvilinear terms were significant in the individual regressions described above, and only linear terms otherwise. In the final step, the interactions that were significant from the individual regressions were included in the model.

Results

Relationships between children's weight status and media use

Zero-order correlations among all variables in the regressions are presented in Table 2. Standardized results for the individual regressions predicting BMI from each of the seven media use and activity participation variables are presented in Table 3. Regression results for the overall model including both media and activity participation variables are presented in Table 4. Since results from the individual models were used to build the overall regression model, our discussion will focus on results from the overall model.

Table 2

Correlation coefficients, means and standard deviations for all variables in regressions

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	M	SD
1. Percentile BMI																					50.37	28.86
2. Gender of child	0.00																				0.49	0.50
3. Age of child	0.00	0.04																			6.05	3.67
4. Is child Black?	0.01	-0.07***	0.03																		0.15	0.36
5. Is child Hispanic?	0.13***	0.02	0.01	-0.16***																	0.13	0.33
6. Education of household head	-0.08***	0.02	-0.03	-0.08***	-0.40***																12.76	2.98
7. Income-to-needs ratio	-0.05**	0.02	0.03	-0.20***	-0.19***	0.42***															2.99	3.11
8. Television (centred)	0.01	-0.01	0.17***	0.13***	0.04*	-0.18***	-0.14***														0.00	167.74
9. Television (curvilinear)	0.01	0.01	0.07***	0.08***	0.01	-0.09***	-0.06	0.58***													28124.54	59455.20
10. Electronic games (centred)	-0.02	-0.14***	0.20***	0.08***	-0.04*	-0.01	-0.02	0.00	-0.02												0.00	68.30
11. Electronic games (curvilinear)	-0.04*	-0.06***	0.05**	0.08***	-0.02	-0.02	-0.02	-0.02	-0.01	0.80***											46663.24	42509.92
12. Computer use (centred)	0.01	-0.05*	0.16***	-0.08***	-0.06**	0.15***	0.14***	-0.03	-0.04	0.01	-0.01										0.00	43.12
13. Computer use (curvilinear)	0.03	-0.04*	0.11***	-0.05*	-0.04*	0.09***	0.08***	-0.01	-0.02	-0.01	-0.01	0.87***									1858.35	11527.39
14. Print use (centred)	-0.01*	0.05**	0.02	-0.10***	-0.11***	0.19***	0.13***	-0.11***	-0.09***	-0.05**	-0.03	0.08***	0.02								0.00	40.18
15. Print use (curvilinear)	0.03	0.02	0.09***	-0.03	-0.05**	0.07***	0.03	-0.02	-0.03	-0.01	-0.01	0.08***	0.03	0.75***							1613.74	7184.64
16. Highly active activities (centred)	-0.02	-0.17***	0.17***	0.01	-0.10***	0.04	0.00	-0.01	-0.05*	0.06**	0.00	0.03	0.01	-0.06**	-0.03						0.00	105.57
17. Highly active activities (curvilinear)	0.01	-0.11***	0.14***	0.01	-0.06**	-0.01	-0.03	-0.02	-0.03	0.04*	0.01	0.00	-0.01	-0.07***	-0.03	0.79***					11140.90	31981.90
18. Moderately active activities (centred)	0.00	0.03	-0.11***	-0.06**	-0.01	0.03	0.03	-0.09***	-0.03	-0.06**	-0.04*	-0.04*	-0.03	-0.02	-0.02	-0.07***	-0.05**				0.00	81.22
19. Moderately active activities (curvilinear)	0.03	0.03	-0.02	-0.03	0.00	-0.01	0.00	-0.02	-0.01	-0.03	-0.01	-0.03	-0.02	-0.04*	-0.02	-0.03	-0.03	0.72***			6594.96	28013.45
20. Sedentary activities (centred)	0.03	0.04*	0.32***	-0.06**	0.00	0.07***	0.08***	-0.12***	-0.11***	0.02	-0.02	0.09***	0.04	0.07***	0.05**	-0.02	-0.03	-0.04*	-0.05**		0.00	91.00
21. Sedentary activities (curvilinear)	0.04*	0.03	0.17***	-0.04	-0.02	0.05*	0.05*	-0.07***	-0.06**	0.00	0.00	0.06***	0.03	-0.09***	-0.03	-0.03	-0.04*	-0.01	-0.02	0.73***	8278.80	20258.27

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3
 Betas for individual regressions with linear and curvilinear media and activity predictors of weight status

	Television	Electronic games	Computer use	Highly active activities	Moderately active activities	Sedentary activities	Print use
Step 1: Covariates							
Gender	−0.00	−0.00	−0.00	−0.01	−0.01	−0.01	−0.00
Age	−0.01	−0.01	−0.00	0.01	−0.00	−0.01	−0.00
Black	0.03	0.03	0.03	0.03	0.03	0.03	0.02
Hispanic	0.15***	0.14***	0.14***	0.14***	0.14***	0.14***	0.14***
Education of household head	−0.01	−0.01	−0.01	−0.01	−0.01	−0.02	−0.01
Income-to-needs ratio	−0.01	−0.02	−0.02	−0.02	−0.02	−0.02	−0.01
R ² change	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***
Step 2: Media and activity predictors							
Linear	−0.01	0.06	−0.04	−0.04	−0.03	0.01	−0.06*
Curvilinear	0.00	−0.09**	0.08*	0.05	0.06*	0.04	0.05#
R ² change	0.00	0.01*	0.00	0.00	0.00	0.00	0.00

Note: $N = 2831$.

Reported betas are all from step 2.

$p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The overall model was significant [$R^2 = 0.06$, $F(8, 2355) = 4.70$, $p < .001$]. Interestingly, the analyses showed no relation between children's weight status and television viewing. However, the overall model regressions indicated that there was a positive linear relationship between electronic game use and weight status. There was also a significant curvilinear relationship between electronic game use and BMI indicating that children with higher weight status played moderate amounts of electronic games, while children with lower weight status played either very little or a lot of electronic games. In addition, there were both linear and curvilinear gender by electronic game use interactions. For boys, the linear component was non-significant, while the curvilinear component was significant in a negative direction, whereas for girls, both the linear and curvilinear components were significant in positive and negative directions, respectively. Thus, the negative curvilinear relationship evident in the overall model held for both boys and girls, while the positive linear relationship between electronic game play and weight status was mainly driven by the existence of this relationship among girls. Linear and curvilinear interactions of age by electronic game use also emerged. For 1- to 5-year olds, only the curvilinear component was significant in a negative direction, while for 6- to 8-year olds, both the linear and curvilinear components were significant in a positive and a negative direction, respectively, and for 9- to 12-year olds, neither the linear nor the curvilinear components were significant. Thus, the relationships evident between electronic game play and weight status were mainly true of the younger (i.e., under age 8) children in our sample (see Table 4).

No significant linear or curvilinear relationships were found between children's weight status and non-game computer use. However, there were significant age by non-game computer use interactions. For 1- to 5-year olds and 6- to 8-year olds, there was no significant relationship, but

Table 4
 Betas from hierarchical regressions with media and activity variables as predictors of weight status

	Model 1	Model 2	Model 3
Age	−0.01	−0.06*	−0.10***
Gender	−0.00	0.00	0.03
Black	0.03	0.03	0.04*
Hispanic	0.15***	0.15***	0.15***
Education of household head	−0.01	−0.00	0.00
Income-to-needs ratio	−0.01	−0.01	−0.01
R^2 change	0.02***		
Television ^a		−0.00	0.01
Electronic games ^a		0.07*	0.22***
Electronic games (curvilinear) ^b		−0.10**	−0.42***
Computer use ^a		−0.03	−0.01
Computer use (curvilinear) ^b		0.07	0.01
Highly active activities ^a		0.00	0.00
Moderately active activities ^a		−0.02	−0.01
Moderately active activities (curvilinear) ^b		0.08**	0.05
Sedentary activities ^a		0.05*	0.06**
Print use ^a		−0.10**	−0.10***
Print use (curvilinear) ^b		0.10***	0.10***
R^2 change		0.02***	
Age ^a × Television ^a			−0.02
Age ^a × Electronic games ^a			−0.09 [#]
Age ^a × Electronic games (curvilinear) ^b			0.12**
Gender ^a × Electronic games ^a			0.10 [#]
Gender ^a × Electronic games (curvilinear) ^b			−0.27***
Age ^a × Computer use ^a			−0.07
Age ^a × Computer use (curvilinear) ^b			0.13*
Age ^a × Moderately active activities ^a			0.04
R^2 change			0.02***

Note: $N = 2831$. [#] $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

^aVariables were centered.

^bVariables were centered and then squared.

for 9- to 12-year olds, both linear and curvilinear components were significant in negative and positive directions, respectively. Thus, among 9–12 year old children, those with lower weight status used the computer for moderate amounts of time, while those with higher weight status used the computer either very little or a lot (see Table 4).

Similar to computer use, the overall regression model indicated negative linear and positive curvilinear relationships between children's weight status and print use (which includes reading or being read to) such that children with lower weight status used moderate amounts of print media, while those with higher weight status used either little or a lot of print media (see Table 4).

Relationships between children's weight status and activity participation

No relationships were found between children's weight status and either highly active or moderately active activities. However, the overall regression indicated a positive linear relationship between the time children spend in sedentary activities and their weight status with those children with a higher weight status spending more time in sedentary activities than those with lower weight status (see Table 4).

Discussion

In this study we examined the hypothesis that television and video game use are implicated in the rising prevalence of obesity in American youth. As in many other studies, we found no evidence that this is so for television. However, our results indicate that video game use, which has been much less studied, is strongly related to children's weight status. There were both linear and curvilinear relationships between children's weight status and their video game use. Moreover, the standardized coefficients for the linear and curvilinear effects of video game play, as well as the curvilinear age and gender by video game play interaction terms, were by far the largest in the overall regression model. The curvilinear relationship indicated that children with higher weight status spent moderate amounts of time playing electronic games, relative to other children in the sample, while children with lower weight status spent either little or a lot of time playing electronic games. Interaction analyses indicated that this was true for children under age 8, but not for children ages 9–12. This may be particularly important because it seems likely that the vast majority of American children, if they play electronic games at all, will play some moderate amount of games. Thus, it may be that video game use, in particular, holds some place in the story behind the increase in the prevalence of pediatric obesity in the United States—especially among very young children. While the overall proportion of variance in weight status explained by the model was relatively small (six percent), the magnitude of the relationship is similar to those found by other studies (Dietz & Gortmaker, 1985; Robinson & Killen, 1995). As Dietz and Gortmaker (1993) cogently argue, the importance of a statistical association "...depends not only on the magnitude of the association, but also on the rarity of the event, and on whether we can know or measure other modifiable causes" (1993, p. 500).

It is important to remember, however, that the data used in the present study are correlational in nature, and thus no causal inferences can be made. For example, analyses of interactions also indicated that there was a positive linear relationship between electronic game use and weight status among girls but not boys. It seems reasonable to speculate that girls who are overweight or obese might turn to electronic media *because* they are socially isolated, thus resulting in a positive linear relationship between weight status and media use. This might well be operating in our sample, given that electronic game use is more normative for boys than it is for girls (Wright et al., 2001), and that girls are more open to social sanction from peers on the basis of their weight than are boys (Gable & Lutz, 2000). Indeed, it seems likely that in some cases, there may well be a causal direction from electronic game use to obesity, while in other cases, the direction of causality may be from obesity to electronic game use. Further research using both experimental and longitudinal designs are clearly needed to disentangle the directions of various effects.

Our findings also indicated that the relationship between weight status and non-game computer use and use of print media were similar to one another, and opposite to the nature of the relationship between weight status and video game play. Specifically, children with lower weight status used the computer for non-game uses for moderate amounts of time, while those with higher weight status used the computer for non-game uses either very little or a lot. That this was true only for the older children in our sample (9–12 year-olds) is likely due to the fact that younger children are less likely to be using the computer for non-game uses such as homework or e-mail. For all children in our sample, the link between weight status and use of print media showed this same curvilinear relationship. The difference between these findings and those regarding video game use are interesting, given that all three activities are essentially sedentary in nature. The bivariate correlations show almost no relationship between electronic game play and non-game computer use, and a negative relationship between video game and print use, but a positive relationship between print use and non-game computer use (see Table 2). It could be, then, that non-game computer use and print use are part of an overall tendency among some children to read and use electronic media for information seeking and educational purposes, rather than for gaming purposes, and that this tendency, at moderate levels, is related to children's weight status in ways both parents and researchers would desire. On the other hand, it may simply be that in terms of absolute minutes, children spend less time reading and using the computer for non-game uses than they do playing games, giving those media less influence over their inactivity and thus their weight status than their video game play. Again, further research is needed to examine the relative merits of the possible reasons behind these relationships.

Finally, our results indicated that spending more time in sedentary activities was related to higher weight status for all children, regardless of age or gender. This was not true for either highly active or moderately active activities, which showed no relationship with weight status. While this makes some sense, the lack of relationship between at least highly active activities and weight status is somewhat puzzling. It may be important that previous studies have had a somewhat difficult time demonstrating the seemingly obvious connection between physical activity and weight status in youth. Some studies have found that overweight youth are less active than their normal weight peers (Eck, Klesges, Hanson, & Slawson, 1992; Obzaraneck et al., 1994). But others have found no discernible connection (Klesges, Haddock, & Eck, 1990; Al-Hazzaa, Sulaiman, Al-Matar, & Al-Mobaireek, 1994; McMurray, Harrell, Levine, & Gansky, 1995; Goran, Hunter, Nagy, & Johson, 1997). At least in terms of highly active activities, it has been suggested that those children who are overweight or obese participate *more* in such activities, at least partly in an effort to lose weight (Klesges et al., 1990). This may partly explain the lack of relationship between participation in highly active activities and children's weight status. Regardless, our findings can be added to others indicating that there is indeed a link between physical inactivity and obesity among children at the population level.

Conclusions and implications

In this study, we found a striking lack of relationship between time spent watching television and children's weight status. Thus, our findings regarding television are similar to those of other researchers who have examined the relationship between television watching and children's weight status while controlling for the effects of socioeconomic status and ethnicity

(Robinson et al., 1993; Durant, Baranowski, Johnson, & Thompson, 1994; Robinson & Killen, 1995). On the basis of both our findings and a plethora of previous research, we find the intractability of the conviction that television in particular is causally linked to obesity in children and adolescents somewhat puzzling. This conviction has led to numerous recommendations to reduce television use and promote active play in children (e.g. Dietz, 1991a, b; Dietz, 2001) despite mixed evidence that either television *or* physical activity is related to weight status among youth.

It is true that the rise in the prevalence of obesity among American children over the past three decades is both disturbing and alarming. It is also true that children spend an inordinate amount of time watching television (e.g. Wright et al., 2001)—more than in any other single activity except for sleep (Huston & Wright, 1997). It could be that youth obesity status is linked to television only at the very highest levels of such use (e.g. 20–30 h or more weekly) as some research has indicated (Gortmaker et al., 1996). However, the question of whether obese youth may turn to television as result of social isolation because of obesity—thus showing extremely high levels of use, awaits more research with prospective data.

Having said this, the story seems very different for the link between electronic game use and obesity. We found a fairly strong relationship between time spent playing electronic games and children's weight status. These results are in opposition to the lack of connection between video game use and weight status reported by McMurray et al. (2000). It may be relevant, however, that the sample used by McMurray et al. (2000) were between the ages of 10–17, and our analyses showed that the relationship between video game use and weight status held only for children under the age of 8. Unfortunately, there are simply too few studies of the relationship between children's video game use and weight status to put our findings in a larger empirical context. It seems, however, on the basis of our findings, that researchers interested in the connections between childhood weight status and media use would do well to include very young children in their sample, and to examine children's electronic game play in addition to their television use.

It seems worth noting that logically, for television or video games to be causally linked to obesity, children need to be choosing to watch television instead of engaging in a more physically demanding activity (such as playing tag) rather than another sedentary activity (such as playing a board game). The lack of association between television and activity is evident in the bivariate correlations (see Table 2). What is interesting about our findings is that while both television and video game play can reasonably be considered sedentary activities, video game play was related to children's weight status while television was not. This may mean that video game play, but not television use, is indeed displacing the time children spend in more physically demanding pursuits (although we found no relationship between highly or moderately active activities and children's weight status). It could also be that television use is related only to weight status among older children and adolescents (i.e. older than the upper age—12—of the children in our sample), while video game play is related to weight status only among younger children (as we found), either through the displacement of physical activity in these ages or some other, as yet unexamined, mechanism. Whatever the case, we believe that our findings underscore the importance of further research.

It would be wonderful if there were a quick and easy solution to the problem of obesity in American youth. Unfortunately, the data available to date do not support the notion that turning off the television or unplugging the video game console amounts to a “magic bullet” which will reduce the prevalence of childhood obesity. As with most other phenomena, the data point to a complex and interrelated pattern of factors contributing to obesity in children and adolescents.

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