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CROSS-SECTIONAL AND LONGITUDINAL ASSOCIATIONS BETWEEN TV VIEWING AND GIRLS' BODY MASS INDEX, OVERWEIGHT STATUS, AND PERCENTAGE OF BODY FAT

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Abstract

Objective—To assess cross-sectional and longitudinal relations between television (TV) viewing and girls' body mass index (BMI), weight status, and percentage of body fat.

Study design—Participants included 169 girls who were measured at ages 7, 9, and 11 years. Height and weight were measured and used to calculate girls' BMI and to classify their weight status. Girls' percentage of body fat was assessed with the use of dual-energy x-ray absorptiometry. Mothers reported the hours per day that girls watched TV on a typical day.

Results—No significant cross-sectional associations were identified. Results from longitudinal analyses showed that in comparison to girls who never exceeded the American Academy of Pediatrics TV viewing recommendations (ie, watched ≤ 2 hours of TV per day), girls who exceeded recommendations at ages 7, 9, and 11 years were 13.2 times more likely be overweight at age 11, were 4.7 times more likely to become overweight between ages 7 and 11, had significantly higher BMI and percentage body fat at age 11, and exhibited significantly greater increases in BMI between ages 7 and 11.

Conclusions—Interventions that target reductions in TV viewing among 7- to 11-year-old girls may help to reduce their risk of weight gain during late childhood.

There is growing public health concern over the effects that sedentary lifestyles are having on the health of young people, particularly in relation to overweight and obesity.¹ Rapid increases in juvenile obesity in many industrialized countries²⁻⁵ have been attributed partly to decreases in habitual physical activity and increases in sedentary behavior.⁶ The most prevalent sedentary behavior among youth is TV viewing, and data from epidemiologic and descriptive large-sample studies indicate that most children and adolescents watch 2.5 to 3.0 hours per day.⁷⁻⁹ However, approximately one third of adolescents watch more than 4 hours daily, which is twice that recommended by the American Academy of Pediatrics (AAP).¹⁰ Because TV viewing is hypothesized to displace physical activity and encourage overeating,¹¹ it has been widely implicated in the cause of pediatric obesity.¹²⁻¹⁴ Despite concurrent trends in high levels of TV viewing and a high incidence of obesity among youth, there is limited evidence that these trends are strongly and causally related.

A recent meta-analysis,¹⁵ based predominantly on data from cross sectional studies, reported that associations between TV viewing and body fatness are weak and of limited clinical relevance. There are few prospective studies of television viewing and body fatness among

youth. The data that are available, however, show a small but consistently positive longitudinal relation between TV viewing and body fatness.^{13,16-20} Few studies have directly compared cross-sectional and longitudinal associations, using the same sample. In addition, only one study to date has examined associations between TV viewing and body fatness using dual-energy x-ray absorptiometry (DXA), a highly valid and reliable clinical measure of body fatness.²¹

This study assessed cross-sectional and longitudinal associations between girls' TV viewing hours and multiple measures of body fatness including body mass index (BMI), overweight status, and percentage of body fat as assessed by DXA. Rather than using TV as a continuous variable, as has been the case in most longitudinal studies to date, television viewing was classified on the basis of whether girls exceeded the AAP recommendations for TV viewing (ie, >2 hours per day). This approach assesses the relevance of the AAP recommendations with respect to children's obesity risk and increases the application of the findings for practitioners. Of particular interest was the effect of repeated viewing in excess of the recommendations across ages 7 to 11 years on their body fatness at age 11, increase in fatness across ages 7 to 11, and the likelihood of becoming overweight between ages 7 and 11 years.

METHODS

Participants

Families were from central Pennsylvania and were part of a longitudinal study of the health and development of girls between ages 5 and 15 years.²² To date, data for this sample have been collected at ages 5, 7, 9, and 11. The current study focuses on data collected at ages 7, 9, and 11 years; data at age 5 are included as covariates. Eligibility criteria for girls' participation at the time of recruitment included living with both biological parents and the absence of severe food allergies or chronic medical problems affecting food intake; families were not recruited on the basis of weight status or concerns about weight. Families were recruited through the use of flyers and newspaper advertisements. In addition, families with age-eligible female children within a five-county radius received mailings and follow-up phone calls (Metromail Inc, Lombard, IL).

Participants included 192 non-Hispanic white girls at age 7 ($M = 7.3$ years ± 0.29), of whom 183 were reassessed at age 9 ($M = 9.3$ years ± 0.29) and 176 were assessed again at age 11 ($M = 11.3$ years ± 0.29). At age 7, 22% of girls were from families with a total family income of less than \$35,000, 31% had a family income of \$35,000 to \$50,000, and 47% had a family income of more than \$50,000. Parents were in general well-educated; mothers and fathers completed a mean of 15 ± 2 (range, 12 to 20) and 15 ± 3 (range, 12 to 20) years of education, respectively. Parents were on average overweight, with a mean BMI score [weight (kg)/height (m)²] of 26.8 ± 6.2 for mothers and 28.4 ± 4.3 for fathers.

Measures

TV Viewing—Mothers provided reports of girls' TV viewing hours at ages 7, 9, and 11 years. Specifically, mothers were asked the following question: "How many hours per day does your daughter spend watching TV/videos?" Mothers responded to this question with reference to an average school day and an average nonschool day (ie, weekend or during summer). Average hours per day spent watching TV was calculated as follows: (5 * weekday hours + 2 * weekend hours)/7 days. At age 11, girls also reported their daily TV viewing hours. Consistent with previous research,^{23,24} girls' and parents' reports of girls' TV viewing were modestly correlated ($r = 0.37$, $P < .01$). All analyses in this study are based on mothers' reports to ensure consistent measurement across time. Information on the stability of girls' TV viewing in this sample across ages 9 and 11 years has been previously reported.²⁵ In short, girls' TV viewing

was highly correlated across ages 9 to 11 ($r = 0.73$, $P < .0001$), and no differences in girls' mean number of hours of TV were noted between ages 9 and 11.

Percentage of Body Fat and Grams of Lean Body Mass—Girls' percentage of body fat and lean body mass (grams) were measured at ages 9 and 11 years, using DXA. A trained technician obtained measurements while girls were in a supine position, wearing a paper gown and no shoes. Whole-body scans were taken by using the Hologic QDR 4500W (S/N 47261) in the array scan mode and were analyzed by using whole-body software, QDR4500 Whole Body Analysis. All scans were conducted at the Pennsylvania State University's General Clinical Research Center. Lean body mass was of interest as a control variable for analyses assessing BMI, which is confounded with lean mass.

Body Mass Index and Overweight Status—Girls' height and weight were measured in triplicate at ages 5, 7, 9, and 11 years of age. Average height and weight at each age were used to calculate girls' BMI [weight(kg)/height(m)²]. Age- and sex-specific BMI percentiles were calculated by using the Centers for Disease Control 2000 growth charts.²⁶ According to Centers for Disease Control recommendations, a BMI percentile ≥ 85 and < 95 is classified as at risk of overweight and a BMI ≥ 95 is classified as overweight.²⁶ In this study, girls who were at risk of overweight and girls who were overweight were examined as a single group (ie, BMI percentile ≥ 85). To simplify the presentation and discussion of results, this group is referred to collectively as overweight.

Pubertal Development—A measure of pubertal development was included in this study to control for the possibility of pubertal growth confounding the association between TV viewing and body fatness. At age 11, breast development was assessed by visual inspection of the breasts by a trained practitioner and an assistant using a Tanner rating scale from 1 (no development) to 5 (mature breast).²⁷ Each breast was rated according to Tanner criteria, and the mean of the breast ratings was calculated. Because this variable was positively skewed, scores were dichotomized such that Tanner scores of 3 or greater were classified as pubertal and scores below 3 were classified as prepubertal.

Statistical Analyses

All analyses were conducted with the use of SAS version 9.1. All analyses included mothers' education and family income as covariates. Pubertal development was included as a covariate in analyses, using age 11 data. Girls' BMI z-score at age 5 was included as a covariate in the longitudinal analyses to control for the possibility that girls who were more overweight at age 5 selected themselves into a higher TV viewing group by age 7. Dietary intake and physical activity were not included as covariates in this study because this would focus the analyses on the mechanisms through which TV viewing and body fatness are related instead of the directionality and strength of the zero-order relation. Also, there is a lack of consistent evidence that TV viewing and physical activity are related.¹⁵ Only girls with complete TV viewing data at ages 7, 9, and 11 years were included in the analyses ($N = 169$). No significant differences in family income, mothers' education, and girls' TV viewing hours were noted for girls with and without complete TV viewing data.

Cross-Sectional Analyses

At each age, three TV viewing groups were created, based on girls' daily TV viewing hours, including girls who watched (a) 1 hour or less per day (0-1 hour), (b) greater than 1 hour and less than or equal to 2 hours per day (>1 -2 hours), or (c) more than 2 hours per day (>2 hours). Watching TV for an hour or less per day was modeled as the referent group. Group differences at each age in the likelihood of girls being overweight were assessed by using multivariate logistic regression. Group differences in girls' BMI and percentage of body fat at each age

were assessed using planned comparisons within analysis of covariance (Table I). The planned comparisons compared girls who watched TV 1 hour or less per day (group A) with girls who watched TV 1 to 2 hours per day (group B) and girls who watched TV more than 2 hours per day (group C). These specific comparisons reduced the number of analyses performed.

Longitudinal Analyses

Information on girls' TV viewing at ages 7, 9, and 11 years was used to quantify the frequency with which girls exceeded the AAP TV viewing recommendations (ie, no more than 2 hours of TV viewing per day) across measurement occasions. Preliminary analyses indicated that there were few differences in body composition outcomes for girls who exceeded recommendations 1 or 2 times; therefore these groups were collapsed to reduce the number of comparisons performed. Consequently, three groups were used in the analyses including girls who (a) never exceeded recommendations, (b) exceeded recommendations 1 or 2 times across ages 7 to 11 years, or (c) exceeded recommendations at all three times of assessment (at ages 7, 9, and 11 years). Never exceeding recommendations was used as the referent, or target, group. Group differences in the likelihood of being overweight at age 11 and the likelihood of becoming overweight between ages 7 and 11 years were assessed by using multivariate logistic regression (Table II). Analyses assessing the likelihood of becoming overweight were limited to girls who were not overweight age at 7. Group differences in girls' BMI and percentage body fat at age 11 and change in girls' BMI (ages 7 to 11 years) and percentage of body fat (ages 9 to 11 years) were assessed by using planned comparisons within analysis of covariance (Figure). The planned comparisons compared girls who never exceed recommendations with girls who exceeded recommendations 1 to 2 times and girls who exceeded recommendations at all times of measurement (group C).

RESULTS

Descriptive Statistics

Girls watched TV for a mean of 1.73 ± 0.89 (age 7), 1.91 ± 0.91 (age 9), and 1.91 ± 0.92 (age 11) hours per day, and 30% (age 7), 40% (age 9), and 37% (age 11) of girls exceeded the AAP TV viewing recommendations (ie, watched more than 2 hours per day). The percentage of girls who had a BMI percentile ≥ 85 increased from 18.9% (age 7) to 29.6% (age 9) and 28.9% (age 11). Girls had a mean percentage body fat of 26.59 ± 7.0 at age 9 and 27.42 ± 5.5 at age 11 (percentage of body fat was not measured at age 7).

Cross-Sectional Associations

No significant associations were identified between TV viewing and girls' BMI, weight status, or percentage of body fat (Table I). Specifically, at age 7, group A (the referent group) did not differ from groups B or C in terms of their mean BMI (group B, $F = 0.01$, $P > .05$; group C, $F = 0.05$, $P > .05$) or the likelihood of being overweight (group B, OR = 1.17, 95% CI = 0.40 to 3.39; group C, OR = 1.86, 95% CI = 0.63 to 5.50). Similarly, at age 9, group A did not differ from groups B or C in BMI (group B, $F = 0.49$, $P > .05$; group C, $F = 2.53$, $P > .05$), percentage of body fat ($F = 0.26$, $P > .05$; group C, 2.45, $P > .05$), or the likelihood of being overweight (group B, OR = 1.67, 95% CI = 0.61 to 4.5; group C, OR = 1.96, 95% CI = 0.74 to 5.26). Furthermore, at age 11, group A did not differ from groups B or C in BMI (group B, $F = 0.04$, $P > .05$; group C, $F = 1.65$, $P > .05$), percentage of body fat ($F = 0.00$, $P > .05$; group C, 2.70, $P > .05$), or the likelihood of being overweight (group B, OR = 1.07, 95% CI = 0.33 to 3.46; group C, OR = 2.88, 95% CI = 0.91 to 9.16). Results at ages 7 and 9 are independent of family income and mothers' education. Results at age 11 are independent of family income, mothers' education, and pubertal status.

Longitudinal Associations

In comparison to girls who never exceeded the AAP TV viewing recommendations, girls who exceeded recommendations at ages 7, 9, and 11 years were 13.2 times more likely to be overweight at age 11 and 4.71 times more likely to become overweight between ages 7 and 11 years (Table II). Furthermore, as shown in the Figure, girls who exceeded the AAP TV viewing recommendations at all ages had significantly higher BMI ($F = 4.32, P < .05$) and percentage body fat ($F = 6.27, P < .05$) at age 11 and exhibited significantly greater increases in BMI across ages 7 to 11 years ($F = 8.36, P < .01$) than girls who never exceeded the recommendations. No significant differences were noted in change in percentage body fat for these two groups ($F = .64, P > .05$). In addition, no significant differences in any measure of body fatness were noted for girls who never exceeded recommendations and girls who exceeded recommendations 1 to 2 times across ages 7 to 11 years.

Additional Analyses

Given that BMI confounds body fat with lean body mass (and that associations between BMI and TV viewing were more numerous than those identified for percentage body fat), the longitudinal analyses that used BMI or overweight as the outcome variable were rerun controlling for lean mass. These analyses essentially examined whether lean mass was driving the associations between BMI and TV viewing. There was no evidence of this possibility. That is, all longitudinal associations with BMI were still statistically significant, and there was no attenuation of effects.

DISCUSSION

Although links between children's TV viewing and body fatness are widely espoused, the vast majority of available data are based on cross-sectional designs showing extremely small associations.¹⁵ This study assessed cross-sectional and longitudinal associations between girls' TV viewing and body fatness across ages 7 to 11 years, using epidemiologic (ie, BMI, overweight status) in addition to clinical measures (ie, DXA) of body fatness. Results clearly indicated that prolonged TV viewing in excess of the AAP recommendations increased girls' risk of overweight across time. In comparison to girls who never exceeded the AAP TV viewing recommendations, girls who exceeded recommendations at ages 7, 9, and 11 years had significantly higher BMI, higher percentage of body fat, and were more likely to be overweight at age 11 and showed significantly greater increases in BMI across ages 7 to 11 years. Furthermore, girls who exceeded recommendations at all ages were 4.7 times more likely to become overweight between ages 7 to 11 years than girls who never exceeded recommendations. Results for BMI and overweight status were independent of lean body mass. The magnitude of these effects suggests that reductions in TV viewing during childhood may have some clinical relevance in the primary prevention of developing excess body fat during childhood.

Our longitudinal findings are remarkably consistent with recent prospective data. In a state-representative sample of 12- to 17-year old children, children who watched more than 2 hours per day of TV at baseline were 2.2 (95% CI = 1.4 to 3.6) times more likely to become overweight after 3 years.²⁰ In a sample of 103 7-year-old Mohawk girls,¹⁸ "excessive" television viewing (equivalent to >2 hours per day) at baseline significantly predicted skinfold thickness 2 years later. Furthermore, Jago et al¹⁹ found that TV viewing at age 3 to 4 years was significantly and positively associated with higher BMI 2 years later. Results from this study, in combination with previous prospective research, suggest that there is a delayed effect of TV viewing on body fatness that may not be apparent when examining cross-sectional data. Additional evidence of this time-lagged effect is provided by Hancox et al,²⁸ who found that TV viewing between ages 5 to 15 years was associated with increased BMI at age 26 years. In addition to

supporting previous research, this study adds to an accumulating body of research on links between children's television viewing and body fatness by showing that results obtained for indirect measures of body fatness such as BMI are also present when using more objective measure of body fat (ie, DXA).

Findings from this study suggest that limiting children's TV viewing to 2 or fewer hours each day, as recommended by the AAP, could reduce their future obesity risk. A reduction in the risk of obesity may not reflect reduced TV viewing per se, but rather a reduction in risk behaviors that are linked with TV viewing. There are a number of mechanisms by which TV viewing has been hypothesized to increase disproportionate weight gain during childhood and adolescence. In particular, TV viewing has been hypothesized to (a) displace physical activity,²⁹ (b) alter the likelihood of becoming active or eating healthy foods due to the social-psychological influences of television program content,³⁰ and (c) decrease resting metabolic rate by reducing lean body mass.³¹ Data are still equivocal regarding the extent to which TV viewing elevates obesity risk through increasing energy intake or reducing energy expenditure. Previous research from this same sample of girls, however, showed that girls who viewed more hours of TV per day consumed more energy-dense snacks.³² Thus, although results from this study and previous research support a significant longitudinal association between TV viewing and children's risk of increased body fatness and overweight, it should be noted that mechanisms used to explain obesity are multifaceted and complex, and it is unlikely that TV viewing alone will explain substantial amounts of variance in body fatness. Moreover, the interrelations between TV viewing and other risk factors for obesity (eg, overeating, habitual physical inactivity) are also largely unknown, and this further limits our ability to attribute changes in body fatness to watching television.

Results from this study cannot be generalized beyond girls from white, generally middle-class, well-educated families. The relation between TV viewing and obesity may differ across groups as the result of differences in physical activity and dietary habits and the extent to which one negative health behavior (eg, TV viewing) is compensated by more positive health behaviors (eg, physical activity). In generalizing results from this study to broader populations, it also needs to be taken into consideration that certain types of families self-select themselves into health-based research studies and that people who choose to participate do not represent a random cross section of the population. Another limitation of this study is the reliance on mothers' reports of girls' TV viewing. Parents may not know how much TV their children watch and may be compelled to provide socially desirable estimates of their children's TV viewing, leading to underreporting. Unfortunately, no criterion validity data exist that compare the accuracy of self-reports (by child or parent) with that of direct observation, the gold standard. We do know from this study and previous research^{13,14,18,23} that child and parent reports are only modestly correlated using current instruments, but these data provide evidence only for concurrent validity of the two self-reports, not an estimate of true behavior. In the case of underreporting, however, it is likely that the pattern of underreporting would underestimate the effects of TV viewing because parents of overweight or at-risk children may be more likely to underreport their TV viewing and overreport their physical activity. Given the likelihood of reporting errors, future research should endeavor to use objective measures of TV viewing.

Although there are a number of limitations to this study, the strengths of this study include its longitudinal design, the use of DXA as a measure of body fatness, the consistent pattern of findings across measures, and the ability to control for lean mass in the analyses assessing BMI at the outcome variable. The results indicated that the association between children's TV viewing and body fatness emerges over the course of a number of years. Among girls who were normal weight at study entry, girls who exceeded the AAP TV viewing recommendations at ages 7, 9, and 11 years were nearly 5 times more likely to become overweight than girls who never exceeded recommendations. Consequently, results from this study clearly speak to the

validity of the AAP recommendations of watching no more than 2 hours of TV per day and indicate the necessity of promoting adherence to these guidelines to reduce children's risk of overweight.²¹

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Figure.

Mean (SE) BMI and percentage of body fat for girls who exceeded TV viewing recommendations 0, 1 to 2, or 3 times across ages 7 to 11. *Significantly ($P < .05$) different from the reference group. Analyses controlled for income, mothers' education, girls' BMI z -score at age 5, and pubertal development at age 11.

Table I

Cross-sectional associations: Differences at each age in BMI, weight status, and percentage of body fat for girls watching 0 to 1, more than 1 to 2, and more than 2 hours of television per day

	Average hours per day girls watched television			Groups significantly different? [*]
	0-1 Group A (referent group)	>1-2 Group B	>2 Group C	
Age 7 [†]	n = 39	n = 78	n = 52	
BMI (mean, SD)	16.50 (2.51)	16.48 (2.04)	16.58 (2.11)	No
BMI ≥85 th percentile	15.38%	16.67%	25.00%	No
Age 9 [†]	n = 36	n = 65	n = 68	
BMI (mean, SD)	17.66 (2.75)	18.20 (2.83)	18.92 (3.45)	No
% Body fat (mean, SD)	25.08 (6.21)	26.03 (6.84)	27.90 (7.42)	No
BMI ≥85 th percentile	19.44%	29.23%	35.29%	No
Age 11 [‡]	n = 29	n = 77	n = 63	
BMI (mean, SD)	19.09 (3.65)	19.47 (3.11)	20.77 (4.34)	No
% Body fat (mean, SD)	25.67 (6.39)	26.48 (6.70)	29.47 (7.34)	No
BMI ≥85 th percentile	17.24%	22.08%	42.86%	No

^{*} The test and inferential statistics are reported in the text.

[†] Analyses controlled for income and mothers' education.

[‡] Analyses controlled for income, mothers' education, and pubertal development.

Table II

Longitudinal associations: Differences in the likelihood of overweight at age 11 for girls who exceeded TV viewing recommendations* 0 to 3 times between ages 7 to 11 years

Predictor variable: Number of times girls exceeded TV viewing recommendations* between ages 7 and 11	Outcome variable	
	Overweight at age 11 OR (95% CI) [†]	Became overweight between ages 7 and 11 OR (95% CI) [‡]
0 times (n = 73) (referent group)	1.0	1.0
1-2 times (n = 67)	2.69 (0.87-8.19)	2.14 (0.70-6.57)
3 times (n = 29)	13.20 (2.92-59.49)	4.71 (1.24-17.86)

* American Academy of Pediatrics TV viewing recommendations no more than 2 hours of TV viewing per day for children 2 to 11 years of age.

[†] Analyses controlled for income, mothers' education, girls' BMI z-score at age 5, and pubertal development at age 11.

[‡] Analyses controlled for income, mother's education, and pubertal development at age 11 (only girls who were not overweight at age 7 were included in the analyses).