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Longitudinal Relationship Between Television Viewing and Leisure-Time Physical Activity During Adolescence

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Abstract

OBJECTIVE—The goal was to examine the longitudinal associations of changes in television viewing and other sources of sedentary behavior with changes in leisure-time moderate/vigorous physical activity in adolescence.

METHODS—We studied a cohort of 6369 girls and 4487 boys who were 10 to 15 years of age in 1997. During each of 4 years of follow-up assessments, participants self-reported their weekly hours of television viewing. By using a seasonal questionnaire, we also obtained detailed information on physical activities over the previous year, from which we calculated total leisure-time moderate/vigorous physical activity. We performed linear regression analyses to assess the longitudinal associations between 1-year changes in television viewing and 1-year changes in leisure-time moderate/vigorous physical activity during the same year, using data from 1997 through 2001.

RESULTS—One-year changes (mean $\pm$ SD) were -0.13 ± 7.2 hours/week for leisure-time moderate/vigorous physical activity, -0.55 ± 7.0 hours/week for television viewing, and -1.02 ± 11.0 hours/week for total sedentary behaviors. In longitudinal models adjusted for age, age², gender, race/ethnicity, Tanner stage, menarche (in girls), baseline physical activity, and baseline television viewing, we found no substantive relationship between year-to-year changes in television viewing and changes in leisure-time moderate/vigorous physical activity (0.03 hours/week, for each 1-hour/week change in television viewing). There were no material associations in age or gender subgroups.

CONCLUSIONS—In this longitudinal study, changes in television viewing were not associated with changes in leisure-time moderate/vigorous physical activity. Our findings suggest that television viewing and leisure-time physical activity are separate constructs, not functional opposites.

Keywords

physical activity; television viewing; sedentary behavior; prospective study

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Early adolescence is characterized by a steep drop in physical activity,^{1–3} an increasing amount of media exposure and sedentary behaviors,^{4,5} and acquisition of unhealthful dietary behaviors,⁶ all of which increase the risk of obesity. Effective obesity prevention strategies include reducing sedentary time (ie, television viewing). Multiple cross-sectional and longitudinal observational studies document the impact of television viewing on overweight,^{7–11} and these observational studies have been corroborated by randomized, controlled trials designed to reduce levels of television viewing.^{12–15} Television viewing may cause overweight through several potential mechanisms.^{10,11} One is by increasing dietary intake through television advertising, which may promote consumption of unhealthful foods,¹⁶ or snacking during television viewing.¹⁷ Another is by displacing physical activity; if that is the case, then interventions to reduce television viewing would result in increased physical activity and thus would limit excess weight gain.

Previous analyses of the Growing Up Today Study cohort showed that, in older children and adolescents, higher and increasing physical activity levels were associated with reduced BMI over time.^{5,18} Furthermore, Berkey et al⁵ showed that increasing sedentary behaviors were associated with increases in BMI in girls. In addition, a recent comprehensive review of prospective observational studies by Must and Tybor¹⁹ found that increased physical activity and decreased sedentary behavior were protective against relative weight and fatness gains over childhood and adolescence. Understanding changes in physical activity when sedentary behaviors are changed could help guide the design of innovative public health programs that promote physical activity and regulate body weight.

Cross-sectional evidence suggests little relationship between the amount of time spent watching television and the time spent on physical activity.^{3,4,20–23} Longitudinal evidence relating changes in television viewing and changes in physical activity levels is limited, and the results have not been consistent.^{22,24} In addition, only 1 of those studies included boys.²⁴ In the current study, we used data from a large prospective cohort of older children and adolescents to examine the association of changes in television viewing, and other sedentary behaviors, with changes in leisure-time moderate/vigorous physical activity.

METHODS

Study Population

The ongoing Growing Up Today Study, which was established in the autumn of 1996, includes 16 882 children, residing in 50 states, who are offspring of Nurses' Health Study II participants. The study was designed to assess prospectively determinants of adolescent dietary intake, physical activity, and sedentary behaviors. We collect all data by means of annual, mailed, self-administered questionnaires.

Details of initial recruitment are available elsewhere.²⁵ Briefly, letters were sent in 1996 to mothers of children in the 9- to 14-year age range, explaining the goals of the study and requesting consent for their children to participate. Approximately 18 526 mothers returned the consent form, providing the name, age, gender, and mailing address of 26 765 children. Introductory letters and gender-specific questionnaires were then mailed directly to children whose mothers had granted consent. These letters assured potential participants that the information they provided would be confidential. The 1996 sample included 8843 girls and 7696 boys, 9 to 14 years of age. In the autumn of 1997, 1998, 1999, and 2001, participants completed mailed or Internet-based follow-up questionnaires to update all information. The current analyses include data starting in 1997, when we introduced the seasonal physical activity questionnaire. We excluded 107 girls and 73 boys with conditions that affected their ability to participate in physical activity (ie, juvenile rheumatoid arthritis, inflammatory bowel

disease, or cerebral palsy) and 147 girls and 289 boys who had missing or implausible physical activity levels (>40 hours/week) or inactivity levels (>80 hours/week) in any study year. A total of 6369 girls and 4487 boys completed ≥ 2 Growing Up Today Study questionnaires between 1997 and 2001 and did not meet any of the exclusion criteria; therefore, they formed our sample for analysis. Human subjects committees at the Harvard School of Public Health and Brigham and Women's Hospital approved the study.

Measurements

Outcome Measure: Physical Activity We developed a physical activity questionnaire specifically for youth, which asked the participants to recall the typical amount of time spent, within each season over the past year, in various activities and team sports.²⁶ Questions included, for each of 17 activities for girls and 18 activities for boys, how many hours per week they participated typically during each season of the past year, outside of gym or physical education class. We computed each child's typical hours spent per week in moderate and vigorous physical activities for each season and over the entire year. We defined total leisure-time moderate/vigorous physical activity as moderate plus vigorous physical activity. Moderate activity was any activity assigned a metabolic equivalent value of <6 , including baseball, biking, dancing, hard work outdoors, skateboarding, walking, gymnastics, exercises, and volleyball. Vigorous activity was any activity assigned a metabolic equivalent value of ≥ 6 , including basketball, hockey, swimming, skating, soccer, tennis, jogging, football, and karate.²⁷ Assessments of an earlier nonseasonal version of this instrument found that estimates of total leisure-time physical activity were moderately reproducible and reasonably correlated with cardiorespiratory fitness in comparisons of total activity hours with time to complete a 1-mile run ($r = -0.23$ for girls; $r = -0.27$ for boys), providing evidence of validity.²⁸ Another validation study reported a correlation of $r = 0.80$ between survey self-reports and 24-hour recalls.¹⁵ The seasonal version used in this article was developed to improve reliability and validity.²⁶

We calculated our main study outcome (1-year change in leisure-time moderate/vigorous physical activity) as leisure-time physical activity in 1998 minus leisure-time physical activity in 1997, leisure-time physical activity in 1999 minus leisure-time physical activity in 1998, and leisure-time physical activity in 2001 minus leisure-time physical activity in 1999, each difference divided by the time interval (in years) between the pair of measurements. Our outcome was 1-year change, depending on the number of years of data present. We included in the analyses participants who had ≥ 2 consecutive measurements of leisure-time moderate/vigorous physical activity.

Main Exposures: Sedentary Behavior We designed a series of questions to measure weekly hours of sedentary behavior, including "watching television," "watching videos or VCR," and "Nintendo/Sega/ computer games (not homework)." For each of these, children selected their usual number of hours from options ranging from 0 to ≥ 31 hours. Gortmaker et al.¹⁵ reported a correlation of $r = 0.54$ between survey self-reports of television and videotape viewing and 24-hour recalls, thus providing evidence for moderate validity for recalled sedentary behavior. Between 1997 and 1999, we asked about sedentary behavior separately for weekdays and for weekends; in 2001, we asked for a combined estimate for the week. We examined 2 possible exposures, with the primary one being television viewing (excluding videotape viewing, video games, and computer games). We also examined a secondary exposure of total sedentary behavior, including television and videotape viewing plus video and computer games.

Covariates—At baseline, children reported their racial/ethnic group. Each year, children reported their Tanner maturation stage in 5 categories of pubic hair development, using a

validated self-rating measure.²⁹ Previous studies showed that boys and girls had similar validity of pubic hair reporting with the instrument.³⁰ Girls also reported whether/when their menstrual periods began. Children self-reported their heights and weights each year from 1997 to 2001, from which we computed their BMI and age- and gender-specific BMI *z* scores by using US national reference data.³¹ A study supported the validity of BMI computed from self-reported height and weight, with a correlation of 0.92 between BMI values computed from children's (grades 7–12) self-reports and measured values.³²

Statistical Analyses

We used linear regression models, with estimation with SAS Proc Mixed,³³ to examine the longitudinal association of our main exposures with 1-year changes in leisure-time moderate/vigorous physical activity levels, adjusting for clustered nonindependent observations among participants. We included participants who had 1 to 3 one-year changes (≥ 2 consecutive data points). The longitudinal analysis included 10 856 participants with 24 504 observations. We assessed effect modification by gender and by age by examining the relationship between changes in exposures and changes in leisure-time moderate/vigorous physical activity within 2 age strata (10–12 years and 13–15 years) in 1997.

In multivariate longitudinal analyses, we estimated the contemporaneous effects of 1-year changes in television viewing and total sedentary behavior on same-year changes in leisure-time moderate/vigorous physical activity. The analyses related change in television viewing (and other sedentary behaviors) from 1997 to 1998 to change in leisure-time moderate/vigorous physical activity from 1997 to 1998, change in television viewing (and other sedentary behaviors) from 1998 to 1999 to change in leisure-time moderate/vigorous physical activity from 1998 to 1999, and change in television viewing (and other sedentary behaviors) from 1999 to 2001 to change in leisure-time moderate/vigorous physical activity from 1999 to 2001. We first tested the assumption of a linear relationship between sedentary behaviors and leisure-time moderate/vigorous physical activity by fitting a regression model with quartiles of change in sedentary behavior. These models confirmed a linear relationship; therefore, we used a continuous variable for sedentary behaviors in all subsequent models. All models adjusted for age, nonlinear age trends (age²), gender, race/ethnicity, menarche (girls only), and Tanner stage, as well as baseline activity and inactivity.

In secondary analyses, we studied the effects of 1-year changes in television viewing on subsequent-interval changes in leisure-time moderate/vigorous physical activity. For these analyses, we included 8370 participants with 13 904 observations who had 3 consecutive years of exposure and outcome data. In the multivariate longitudinal analyses, we related change in television viewing from 1997 to 1998 to change in leisure-time moderate/vigorous physical activity from 1998 to 1999 and change in television viewing from 1998 to 1999 to change in leisure-time moderate/vigorous physical activity from 1999 to 2001. We conducted all analyses by using SAS 8.2 (SAS Institute, Cary, NC).

RESULTS

Baseline and 1-year unadjusted change characteristics of study participants are summarized in Table 1. The cohort was 93% non-Hispanic white, reflecting the race/ethnicity representation of the subjects' mothers, who are participants in Nurses' Health Study II.

The 1-year change (mean $\pm$ SD) in television viewing was less in the younger baseline-age group than in the older age group (-0.32 ± 7.2 hours/week among 10–12-year-old subjects and -0.84 ± 6.7 hours/week among 13–15-year-old subjects). Table 1 shows the mean 1-year changes in leisure-time moderate/vigorous physical activity according to age and gender.

In longitudinal multivariate models, 1-year changes in television viewing were not related substantively to 1-year changes in leisure-time moderate/vigorous physical activity during the same year (Table 2). After adjustment for age, age², gender, race/ethnicity, Tanner stage, menarche, baseline physical activity, and baseline television viewing, leisure-time moderate/vigorous physical activity increased by 0.03 hours/week (95% confidence interval [CI]: 0.02–0.04 hours/week) for each 1-hour/week increase (over 1 year) in television viewing. Estimates were similar for younger and older children (Table 2). We found minimal differences in estimates among boys and girls (Table 3). We observed a positive relationship between changes in total sedentary behavior and changes in changes in leisure-time moderate/vigorous physical activity (Table 2).

Secondary analyses examining associations of 1-year changes in television viewing with changes in leisure-time moderate/vigorous physical activity during the subsequent year yielded similarly null results. Each 1-hour/week change in television viewing was associated with a 0.01-hour/week decrease (95% CI: –0.03 to 0.0004 hours/week) in leisure-time moderate/vigorous physical activity.

DISCUSSION

In this prospective study of 10- to 15-year-old US adolescents, we found that changes in television viewing, or sedentary behaviors in general, were not associated with changes in leisure-time moderate/vigorous physical activity. This finding applied equally to girls and boys and to younger (10–12-year-old) and older (13–15-year-old) adolescents.

Our findings of essentially no relationship between television viewing and leisure-time moderate/vigorous physical activity are consistent with those of cross-sectional studies in children and adolescents. In a national cross-sectional sample of high school youths, Heath et al³ found no relationship between television hours and physical activity. In analyses from Planet Health,¹⁵ a school-based obesity prevention intervention for children in sixth and seventh grades, Gortmaker et al found the coefficient for the correlation between television viewing and total physical activity to be –0.04 (S. L. Gortmaker, PhD, written communication, 2006). Almost all studies of television viewing and physical activity among adults^{20,21} also showed weak relationships between television viewing and moderate/vigorous physical activity.

To our knowledge, only 2 longitudinal studies of the association between television viewing and physical activity among children and adolescents have been published. In a study of sixth- and seventh-grade girls attending 4 northern California middle schools, Robinson et al²² found that baseline hours of after-school television viewing were associated only marginally with changes in levels of physical activity over time (Spearman $r = 0.04$; $P = 0.48$). However, in a crossover trial of three 3-week phases with 58 adolescents, Epstein et al²⁴ observed that targeting decreasing sedentary behaviors was an effective strategy to increase physical activity. Several factors might explain the opposite results found in these 2 studies. The study by Epstein et al²⁴ was a randomized, controlled trial of adolescents in an experimental setting, whereas the study by Robinson et al²² was an observational study within a general population. Similar to the study by Robinson et al,²² ours was an observational study; our sample included >10 000 girls and boys. The overall effect estimates for changes in television viewing and total inactivity that we observed in our study confirm the findings of Robinson et al²² and extend the observation of a null relationship between sedentary behavior and leisure-time physical activity to adolescent boys.

In comparison with the cross-sectional studies published to date, our study had several strengths, including its prospective design, the ability to adjust for several child characteristics

that have been found to be associated with television viewing and physical activity (such as gender, age, and race/ethnicity), and a relatively large sample size. One limitation is that we relied on self-reports of television viewing and physical activity; the attendant random error could have resulted in a bias toward the null results that we observed. In previous analyses of this cohort, however, both television viewing and physical activity were associated with changes in BMI, lending confidence to the validity of their measurement.¹⁸ Also, although the subjects in this study were from all 50 US states, generalizability might be limited because the subjects were sons and daughters of registered nurses, the cohort was >90% white, and the children lived in households with higher household incomes than the general population. However, the narrow socioeconomic range might act to remove confounding by socioeconomic status. Finally, we observed relatively small mean changes in sedentary behaviors. Our results might not be able to guide fully the design of intervention studies that will likely be designed to produce much larger changes in sedentary behaviors.

CONCLUSIONS

We found that changes in sedentary behavior were not associated with corresponding changes in adolescents' leisure-time moderate/vigorous physical activity levels. As suggested previously by Dietz,³⁴ one implication of our study is that television viewing and physical activity are separate constructs, not functional opposites. Our results are in agreement with those of Nelson et al,³⁵ who suggested that physical activity and sedentary behaviors are regulated through a complex series of decision-making mechanisms and that simply restricting television viewing may not be effective in increasing physical activity. Both physical activity and television viewing are important independent determinants of body weight, weight gain, and risk of diseases such as diabetes mellitus.^{2,19,21} Therefore, clinical and public health programs should consider television viewing reduction and physical activity promotion as 2 separate foci of behavior change interventions to reduce excess weight gain during adolescence. As has been suggested by others, possible ways in which television may be related to overweight may be through television's effects on dietary intake; television advertising may promote consumption of unhealthful foods¹⁶ and people tend to snack while watching television.¹⁷

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Abbreviation

CI

confidence interval

TABLE 1

Baseline and 1-Year Change Values for 10 856 Growing Up Today Study Participants (24 504 Observations)

Age, y	No.	Leisure- Time Physical Activity, Mean $\pm$ SD, h/wk	Change in Leisure- Time Physical Activity, Mean $\pm$ SD, h/wk	Television Viewing, Mean $\pm$ SD, h/wk	Change in Television Viewing, Mean $\pm$ SD, h/wk	Sedentary Behaviors, ^a Mean $\pm$ SD, h/wk	Change in Sedentary Behaviors, Mean $\pm$ SD, h/wk	BMI, Mean $\pm$ SD, kg/m ²	Proportion in Tanner Stage 4 or 5, ^b %	Proportion in Menarche, %
Girls										
All	14 924	12.0 $\pm$ 7.7	-0.21 $\pm$ 6.6	9.8 $\pm$ 7.6	-0.65 $\pm$ 6.7	17.3 $\pm$ 10.9	-1.19 $\pm$ 10.0	20.1 $\pm$ 3.3	73	66
10–12	8011	11.3 $\pm$ 7.5	0.32 $\pm$ 6.7	10.2 $\pm$ 7.6	-0.41 $\pm$ 7.0	18.1 $\pm$ 11.2	-0.88 $\pm$ 10.6	19.4 $\pm$ 3.3	53	43
13–15	6913	12.8 $\pm$ 8.0	-0.83 $\pm$ 6.4	9.4 $\pm$ 7.4	-0.94 $\pm$ 6.3	16.2 $\pm$ 10.4	-1.55 $\pm$ 9.2	21.0 $\pm$ 3.1	96	92
Boys										
All	9580	14.4 $\pm$ 8.4	0.002 $\pm$ 8.0	11.6 $\pm$ 8.1	-0.39 $\pm$ 7.4	23.8 $\pm$ 13.2	-0.75 $\pm$ 12.4	20.3 $\pm$ 3.5	57	NA
10–12	5689	13.9 $\pm$ 8.3	0.38 $\pm$ 8.0	11.6 $\pm$ 7.9	-0.21 $\pm$ 7.4	24.0 $\pm$ 12.8	-0.35 $\pm$ 12.3	19.6 $\pm$ 3.4	33	NA
13–15	3891	15.1 $\pm$ 8.6	-0.55 $\pm$ 8.0	11.6 $\pm$ 8.3	-0.66 $\pm$ 7.4	23.6 $\pm$ 13.7	-1.33 $\pm$ 12.4	21.3 $\pm$ 3.5	89	NA

NA indicates not applicable.

^aTotal hours per week spent watching television and videotapes and playing video/computer games.^bTanner stage of pubic hair development.

TABLE 2

Multivariate Adjusted Annual Changes in Leisure-Time Moderate/Vigorous Physical Activity Associated With Changes in Sedentary Behaviors

	Change in Leisure-Time Moderate/Vigorous Physical Activity, β (95% CI), h/wk		
	All (<i>n</i> = 10 856)	10–12 y (<i>n</i> = 5952)	13–15 y (<i>n</i> = 4904)
1-y change in television viewing (per 1-h/wk increment)	0.03 (0.02 to 0.04)	0.04 (0.02 to 0.06)	0.02 (–0.004 to 0.04)
1-y change in sedentary behavior (per 1-h/wk increment)	0.05 (0.04 to 0.06)	0.05 (0.04 to 0.07)	0.04 (0.03 to 0.05)

Longitudinal data were from the 1997, 1998, 1999, and 2001 Growing Up Today Study surveys. Values were adjusted for age, age², gender, race/ethnicity, menarche (in girls), and Tanner stage. Models were also adjusted for physical activity and sedentary behaviors at the start of the year of physical activity change.

TABLE 3

Multivariate Adjusted Annual Changes in Leisure-Time Moderate/Vigorous Physical Activity Associated With Changes in Sedentary Behaviors, Stratified According to Gender

	Change in Leisure-Time Moderate/Vigorous Physical Activity, β (95% CI), h/wk		
	All (<i>n</i> = 10 856)	Girls (<i>n</i> = 6369)	Boys (<i>n</i> = 4487)
1-y change in television viewing (per 1-h/wk increment)	0.03 (0.02 to 0.04)	0.02 (0.01 to 0.04)	0.04 (0.02 to 0.06)
1-y change in sedentary behavior (per 1-h/wk increment)	0.05 (0.04 to 0.06)	0.05 (0.04 to 0.06)	0.05 (0.04 to 0.06)

Longitudinal data were from the 1997, 1998, 1999, and 2001 Growing Up Today Study surveys. Values were adjusted for age, age², gender, race/ethnicity, menarche (for girls), and Tanner stage. Models were also adjusted for physical activity and sedentary behaviors at the start of the year of physical activity change.