American Journal of Epidemiology

Vol. 188, No. 2
DOI: 10.1093/aje/kwy236
Advance Access publication:
October 15, 2018

Original Contribution

The Association of Television Viewing in Childhood With Overweight and Obesity Throughout the Life Course

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Initially submitted May 2, 2018; accepted for publication October 9, 2018.

Few studies have addressed the association between television viewing time in childhood and overweight/obesity across the life course. Among 30,921 mother-daughter dyads from the Nurses' Mothers' Cohort (2001) and the Nurses' Health Study II (1989 and 1991), the following information was collected: daughter's television viewing time and physical activity (PA) level at ages 3–5 and 5–10 years, somatotype at ages 5 and 10 years, and body mass index at age 18 years and in adulthood (ages 26–45 years). According to multivariable-adjusted logistic regression models, television viewing at least 4 hours/day versus no television at ages 3–5 years was associated with odds ratios of overweight/obesity of 1.61 (95% confidence interval (CI): 1.20, 2.17) at age 5 years, 1.46 (95% CI: 1.14, 1.86) at age 10 years, 1.31 (95% CI: 1.00, 1.70) at age 18 years, and 1.32 (95% CI: 1.10, 1.59) in adulthood. A composite variable of high television viewing time/low PA level versus low television viewing time/high PA level at ages 3–5 years was associated with odds ratios of overweight/obesity ranging from 3.22 (95% CI: 2.23, 4.65) at age 5 years to 1.82 (95% CI: 1.36, 2.45) in adulthood. Findings were similar at ages 5–10 years. Long hours of television viewing in childhood alone and in combination with low PA levels were consistently associated with overweight/obesity throughout life.

childhood; life course; obesity; overweight; physical activity; screen time; television viewing

Abbreviations: CI, confidence interval; BMI, body mass index; NHS, Nurses' Health Study; PA, physical activity.

Sedentary screen-based behaviors are popular among children (1, 2) and may track through adolescence (3, 4) and adulthood (5). Long hours of youth screen time have been associated with adverse health outcomes (6–9), including overweight/obesity (10, 11). Although results of several studies indicated a positive association between screen time, primarily television viewing, and higher body mass index (BMI), body fat and obesity in children (12), adolescents (13), and adults (14), others revealed no association (15, 16). In 2 recent reviews of predominantly cross-sectional studies, the association between screen time and adiposity was weak (17, 18), suggesting that prospective cohort studies may clarify this link and the magnitude of the association. Although some longitudinal evidence was reported indicating length of television viewing time at ages 4–5 years was associated with change in BMI from ages 4 to 11 years and with incident obesity at age 30 years (19, 20), lifelong consequences of this exposure on overweight/obesity can be assessed by additional studies with long follow-up.

Television viewing has been the predominant source of screen time among children from the 1950s to the present in the United States (21). In this study, we examined the relation between hours spent watching television daily during childhood and risk of overweight/obesity across the life course. We used an ambidirectional cohort design with independent sources reporting the exposure and outcome to frame this research, and also assessed the joint associations of childhood television viewing time and level of physical activity (PA) with overweight/obesity throughout life.

METHODS

Study population

The study includes data from 2 cohort studies: The Nurses' Health Study (NHS) II and the Nurses' Mothers' Cohort. In the NHS II, which uses a prospective cohort of 116,430 female

nurses across the United States that was established in 1989, researchers aim to examine the relation between dietary and lifestyle habits and risk of disease with health-related updates every 2 years. The nurses are predominantly non-Hispanic white and aged 25–42 years at baseline.

The Nurses' Mothers Cohort, a retrospective cohort study, comprises the mothers of the nurses in the NHS I and II who reported data on themselves, the biological father, and the early life exposures of their daughters (born 1946–1964). A total of 52,155 questionnaires were sent to mothers who were alive, healthy, and willing to participate in 2000. Of the 39,904 questionnaires returned in 2001, the majority ($n = 35{,}349$) were from mothers of nurses in the NHS II (average age at maternal questionnaire return = 72 years); analyses were restricted to these participants (22). Mother-daughter dyads were formed by linking retrospectively recalled exposure data from the mothers in the Nurses' Mothers' Cohort and prospective outcome data reported by the daughters in the NHS II to form an ambidirectional cohort design. Daughters who were adopted or whose adoption status was unknown ($n = 1{,}778$) and who were missing exposure ($n = 569$) or outcome data ($n = 2{,}081$) were excluded from analyses. The final sample comprised 30,921 mother-daughter dyads. The study protocol was approved by the institutional review boards of the Brigham and Women's Hospital and Harvard School of Public Health, Boston, Massachusetts; the National Cancer Institute, Bethesda, Maryland; and The University of Texas at Austin, Austin, Texas.

Assessment of television viewing time and PA level during childhood

The number of hours of their daughters' childhood television viewing was recalled by mothers who were asked, "Between the ages of 3 and 5 years, how many hours/day during the week did your nurse daughter watch [television]?" Response categories were "No television," "up to 0.5 hours/day," "1 hour/day," "2 hours/day," "3 hours/day," "4 hours/day," and "5 or more hours/day." To account for limited responses in the upper category (≥5 hours/day), this response was combined with responses for "4 hours/day." The question is based on a similar self-report question in the Youth Risk Behavior Survey, which was moderately correlated with self-reported weekly viewing diaries ($r = 0.5$) and had fair test-retest reliability ($r = 0.3$) when the same question was answered 1 week later (23, 24). Daughters were aged 3–5 years during the years 1949–1969. The same question was repeated to assess the daughter's television viewing at ages 5–10 years; upper categories were combined in a similar manner. These exposures were analyzed separately to assess potential windows of vulnerability.

Mothers reported their daughters' PA levels between the ages of 3–5 and 5–10 years by answering the following question at both ages: "How would you best describe your nurse daughter's activity level compared to other girls of similar age?" Response categories were: "highly physically active," "active," "mostly inactive," and "inactive." The question was extracted from the Stanford Brief Activity Survey, which was validated for older adults (25). In a population-based cohort, low PA level ("mostly inactive/inactive") was associated with atopic sensitization, atopic dermatitis, and asthma in late childhood, demonstrating predictive validity of the question (26).

Assessment of overweight and obesity

Childhood overweight/obesity (at ages 5 and 10 years) was recalled by the daughters on the baseline (1989) NHS II questionnaire. A 9-level Stunkard pictogram with body shapes ranging from lean (somatotype 1) to obese (somatotype 9) was used (27). Somatotypes ≥5 were categorized as "overweight/obese" in accord with previous research, owing to limited responses on the upper end of the pictogram scale (28, 29). This pictogram has been validated in follow-up of the Third Harvard Growth Study, whereby body sizes at ages 5 and 10 years recalled by women aged 71–76 years were correlated with BMI calculated from measured weight and height at the same ages ($r = 0.60$–0.65) (30). Similar correlations appeared between recalled body size and BMI percentile at menarche (31). Greater childhood somatotype was also positively associated with type 2 diabetes, suggesting predictive validity of the pictogram (28).

Weight at age 18 years and current height in adulthood were obtained from the 1989 baseline NHS II questionnaire and used to assess overweight/obesity at age 18 years; current weight and height in adulthood (obtained from the 1991 and 1989 NHS II questionnaires, respectively) were used to assess overweight/obesity in adulthood (ages 26–45 years). BMI was calculated as weight (kg) divided by height $(\text{m})^2$ and the cutoff for overweight/obesity was BMI of 25 or higher. The correlation coefficient (r) between self-reported weight by NHS I participants and average weight measured by technicians was 0.97 (32). Also, records of measured weight and height for NHS II participants upon entry to college or nursing school were correlated with self-reported measurements. The correlation coefficients were 0.87 between recalled weight at age 18 years and measured weight from records, and 0.94 between reported current height in adulthood and measured height from records (33).

Statistical analyses

Characteristics of daughters and their parents were described using frequencies, percentages, means, and standard deviations. χ^2 was calculated to test for differences in proportions of covariates by hours of television viewing at ages 3–5 years. Spearman correlations were calculated between television viewing time and PA level at ages 3–5 years and in adulthood. Logistic regression models were used to estimate the association between hours spent watching television daily at ages 3–5 years and the odds ratios and 95% confidence intervals for overweight/obesity at ages 5, 10, and 18 years and in adulthood, adjusted for age at daughter's questionnaire return. These models were then adjusted for childhood PA levels during the same period as television viewing. The final models for overweight/obesity at ages 5 and 10 years were adjusted for the aforementioned covariates and parental and daughter covariates associated with overweight/obesity, which were were chosen a priori, including maternal education; maternal prepregnancy BMI and paternal BMI; maternal gestational weight gain, smoking history, and activity during pregnancy; home ownership; and daughter's birth weight, gestational age, birth year, and breastfeeding duration. In addition to these covariates, the model for the odds of overweight/obesity at age 18 years was adjusted for daughter's age at menarche; the model at adulthood was adjusted for daughter's age at menarche and

adult smoking status, PA level, daily television viewing time, caloric intake, and Alterative Healthy Eating Index score.

Two sensitivity analyses were conducted using logistic regression models. One analysis was used to assess the extent of the association between television viewing time at ages 3–5 years and adult overweight/obesity accounted for by adult television viewing time and PA levels. In the second analysis, we examined the association between television viewing time at ages 3–5 years and adult obesity, with adjustment for overweight/obesity at age 5 years and the aforementioned covariates at ages 5 years, 10 years, and 26–45 years (adulthood).

The same analyses and covariates were used to assess the association between hours spent watching television daily at ages 5–10 years and overweight/obesity at ages 10 and 18 years and in adulthood. Missing indicators were used when participants had missing information on covariates.

Next, a variable that combined television viewing time and PA level at ages 3–5 years was classified according to screen time and PA guidelines as follows: 1) no more than 2 hours of television viewing per day + highly active/active (referent group; hereafter called low television/high PA; 2) no more than 2 hours of television viewing per day + mostly inactive/inactive (hereafter, low television/low PA); 3) at least 3 hours of television viewing per day + highly active/active (hereafter, high television/high PA); and 4) at least 3 hours of television viewing per day + mostly inactive/inactive (hereafter, high television/low PA). The association between this composite measure and overweight/obesity at ages 5, 10, 18, and 26–45 years was computed using logistic regression models with adjustment for parental and daughter covariates. A variable that combined television viewing time and PA level at ages 5–10 years was classified and analyzed similarly. All analyses were completed using SAS, version 9.4 (SAS Institute, Inc., Cary, North Carolina). All *P* values were 2-sided.

RESULTS

Descriptive characteristics of the daughter and her parents by the number of hours spent watching television daily at ages 3–5 years are presented in Table 1. Approximately 9% and 15% of daughters watched more than 2 hours of television per day at ages 3–5 and 5–10 years, respectively. At ages 3–5 years, 63% of daughters were active and at ages 5–10 years, 66% were active. The prevalence of overweight/obesity was 6% at age 5 years, 11% at age 10 years, 9% at age 18 years, and 31% in adulthood (ages 26–45 years). The average maternal prepregnancy BMI was 21.3 and the average paternal BMI was 23.6. Most mothers (86%) had at least 12 years of education, 42% gained 20–29 lb (9.1–13.2 kg), 74% were nonsmokers, and 64% were active during pregnancy.

The mean birth weight of daughters was 6.8 lb (3.1 kg) and the mean gestational age was 39.7 weeks; 65% were born between 1950 and 1959 and 59% were not breastfed. The average age at menarche was 12.4 years. The average age of daughters at questionnaire return (1991) was 35.5 years. Most daughters (68%) never smoked; 75% reported metabolic equivalents per week of PA ranging from fewer than 3 to 26; and 93% watched fewer than 3 hours of television daily in adulthood. The average caloric intake in adulthood was 1,800 kilocalories and the mean Alterative Healthy Eating Index score was 43.8. Television viewing time and PA level at ages 3–5 years were minimally correlated ($r = 0.07$) with adult television viewing time and PA level.

Television viewing at ages 3–5 years

Table 2 shows the association between hours spent watching television daily at ages 3–5 years and the adjusted odds ratios and 95% confidence intervals for overweight/obesity at ages 5, 10, 18, and 26–45 years with "no television" as the reference group. Watching television at least 2 hours/day at ages 3–5 years was associated with a dose-dependent higher parental and daughter covariate-adjusted odds of overweight/obesity at age 5 years (for 2, 3, and ≥4 hours of television viewing per day, odds ratios were 1.16 (95% confidence interval (CI): 1.00, 1.35), 1.39 (95% CI: 1.15, 1.69), and 1.61 (95% CI: 1.20, 2.17), respectively). Odds ratios of a slightly smaller magnitude were seen for television viewing time and overweight/obesity at age 10 years. Watching television at least 4 hours daily was associated with a 1.31-fold (95% CI: 1.00, 1.70) higher odds of overweight/obesity at age 18 years and 1.32-fold (95% CI: 1.10, 1.59) higher odds in adulthood in parental and daughter covariate-adjusted models.

In sensitivity analyses, the association between television viewing time at ages 3–5 years and overweight/obesity in adulthood was partially accounted for by adult television viewing time and PA level (age-adjusted odds ratio = 1.71, 95% CI: 1.44, 2.03, versus the association adjusted for adult television viewing time and PA level: odds ratio = 1.24, 95% CI: 1.04, 1.47). Also, television viewing at least 4 hours/day at ages 3–5 years was associated with 1.29-fold (95% CI: 1.07, 1.55) higher odds of overweight/obesity in adulthood after adjusting for early-life overweight/obesity and covariates for ages 5, 10, and 26–45 years (data not shown). Of note, the Spearman correlation coefficient between somatotype at age 5 years and BMI in adulthood was 0.24.

Television viewing at ages 5–10 years

Data on the relation between the number of hours spent watching television daily at ages 5–10 years and overweight/obesity at ages 10, 18, and 26–45 years (using "no television" as the referent) are reported in Table 3. Odds ratios similar to those from television viewing time at ages 3–5 years were seen in the final models for a minimum of 4 hours versus no television viewing daily: 1.45 (95% CI: 1.15, 1.83) at age 10 years, 1.39 (95% CI: 1.08, 1.79) at age 18 years, and 1.25 (95% CI: 1.05, 1.49) in adulthood.

Composite score (television viewing time and PA level)

Table 4 lists the parental and daughter covariate-adjusted odds ratios for overweight/obesity at ages 5, 10, 18, and 26–45 years by a composite score of television viewing time and PA level at ages 3–5 and 5–10 years. Compared with daughters with low television/high PA at ages 3–5 years, those with low television/low PA, high television/high PA, and high television/low PA had higher odds of overweight/obesity throughout life. The highest odds ratios were seen among those who had high

Table 1. Parental and Daughter Characteristics by Daughter's Hours Spent Watching Television Daily at Ages 3–5 Years (n = 30,921 Mother-Daughter Dyads), Nurses' Mothers' Cohort (2001) and Nurses' Health Study II (1989 and 1991)

Characteristics	Daughter's Hours Spent Watching Television Daily at Ages 3–5 Years											
	None (n = 6,588)		0.5 (n = 3,468)		1.0 (n = 10,394)		2.0 (n = 7,588)		3.0 (n = 2,265)		≥4.0 (n = 618)	
	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)
Hours watching television daily at ages 5–10 years, hours[a]												
0	29.6		0.8		0.3		0.3		0.1		0.0	
0.5	17.9		28.0		2.1		0.3		0.1		0.2	
1.0	34.7		61.5		52.1		11.4		3.6		1.3	
2.0	14.7		8.9		42.4		62.8		28.0		13.3	
3.0	2.7		0.7		3.0		23.2		50.9		30.3	
≥4.0	0.5		0.2		0.2		2.1		17.3		55.0	
PA level at ages 3–5 years[a]												
Highly active	34.4		36.0		33.9		31.0		28.8		25.6	
Active	62.1		60.9		63.4		65.1		64.7		64.4	
Mostly inactive	2.5		2.5		2.0		2.9		4.9		6.3	
Inactive	0.8		0.5		0.6		0.8		1.4		3.4	
PA level at ages 5–10 years[a]												
Highly active	30.0		32.2		30.3		27.8		25.8		25.6	
Active	65.9		64.3		66.3		67.8		67.9		63.8	
Mostly inactive	3.2		2.8		2.6		3.6		4.6		7.3	
Inactive	0.7		0.8		0.8		0.8		1.6		3.4	
Overweight/obesity at age 5 years[a]												
Somatotype ≥5[b]	6.2		5.4		6.0		6.7		8.1		9.7	
Overweight/obesity at age 10 years[a]												
Somatotype ≥5	11.2		9.4		10.5		11.8		13.8		15.2	
Overweight/obese BMI[c] at age 18 years[a]												
25.00–29.99	7.1		6.3		6.6		7.4		8.3		10.4	
≥30.00	1.9		1.5		2.1		2.5		2.9		3.2	
Overweight/obese BMI[c] in adulthood[a]												
25.00–29.99	19.9		18.0		18.8		19.0		20.4		23.6	
≥30.00	14.0		9.8		10.3		12.2		13.5		17.6	
Maternal prepregnancy BMI[c]		21.3 (2.6)		21.1 (2.3)		21.2 (2.5)		21.3 (2.6)		21.5 (2.8)		21.5 (2.8)
Paternal BMI[c] at daughter's birth		23.4 (2.5)		23.6 (2.6)		23.6 (2.6)		23.7 (2.6)		23.7 (2.7)		23.8 (2.8)
Maternal education, years[a]												
<12	18.9		11.0		10.7		11.7		16.5		23.5	
12	43.2		43.7		49.1		56.3		58.9		57.1	
13–15	26.4		28.9		28.1		23.3		19.0		16.7	
≥16	11.2		16.2		11.7		8.3		5.2		2.1	

Table continues

Table 1. Continued

Characteristics	Daughter's Hours Spent Watching Television Daily at Ages 3–5 Years											
	None (n = 6,588)		0.5 (n = 3,468)		1.0 (n = 10,394)		2.0 (n = 7,588)		3.0 (n = 2,265)		≥4.0 (n = 618)	
	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)
Maternal gestational weight gain, lb[a,d,e]												
<10	3.9		4.0		3.5		3.1		3.2		4.7	
10–14	13.3		11.8		11.4		10.0		9.3		9.1	
15–19	20.9		22.2		21.0		20.4		16.9		19.0	
20–29	40.4		40.5		42.9		43.0		43.9		36.1	
30–40	16.4		16.4		16.3		17.9		20.3		22.5	
>40	5.2		5.1		5.0		5.5		6.5		8.7	
Maternal smoking during pregnancy[a]											Y	
Nonsmoker	81.3		75.4		72.4		71.0		66.9		70.2	
Quit during pregnancy	2.7		3.9		4.1		4.5		4.6		3.9	
Smoked ≥1 cigarette per day	14.4		18.8		21.5		22.1		26.0		24.1	
Maternal activity during pregnancy[a]												
Highly active	29.2		27.9		27.3		24.5		22.5		18.3	
Active	62.8		63.5		63.6		66.3		64.6		65.5	
Mostly inactive and inactive	7.4		8.1		8.5		8.7		12.1		15.2	
Birthweight, lb[e]		6.9 (1.2)		6.8 (1.1)		6.8 (1.1)		6.8 (1.1)		6.8 (1.1)		6.8 (1.2)
Gestational age, weeks[d]		39.7 (2.6)		39.7 (2.6)		39.7 (2.6)		39.7 (2.6)		39.6 (2.6)		39.7 (2.6)
Birth year[a]												
1946–1949	38.2		10.1		8.2		6.1		5.3		5.0	
1950–1954	38.0		31.9		30.6		27.6		25.3		25.1	
1955–1959	17.7		38.1		38.1		40.0		39.0		40.1	
1960–1964	6.1		19.8		23.1		26.3		30.3		29.8	
Breastfeeding duration, months[a]												
Never or <1 week	45.1		56.9		61.3		65.1		69.0		73.2	
<3	22.6		20.1		19.0		17.7		16.6		12.4	
3–6	13.3		11.5		10.2		8.8		7.5		5.4	
6–9	9.8		6.9		6.0		5.1		3.5		3.9	
9–12	6.3		3.1		2.7		2.6		2.9		3.9	
≥12	2.9		1.5		0.9		0.8		0.6		1.3	
Age at menarche, years		12.4 (1.4)		12.5 (1.4)		12.5 (1.4)		12.4 (1.4)		12.4 (1.4)		12.2 (1.5)
Age at questionnaire return in 1991, years		38.9 (4.2)		35.2 (4.3)		34.7 (4.3)		34.2 (4.3)		33.8 (4.3)		33.7 (4.2)

Table continues

Table 1. Continued

Characteristics	Daughter's Hours Spent Watching Television Daily at Ages 3–5 Years											
	None (n = 6,588)		0.5 (n = 3,468)		1.0 (n = 10,394)		2.0 (n = 7,588)		3.0 (n = 2,265)		≥4.0 (n = 618)	
	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)	%	Mean (SD)
Adult smoking status during the past year[a]												
Never	69.0		68.3		68.7		67.5		67.9		68.3	
Past	21.7		22.4		21.0		21.8		20.9		19.7	
Current	9.1		9.2		10.1		10.6		11.2		11.8	
Adult PA level during the past year, MET/week[a]												
<3–8	41.1		35.5		36.5		38.1		40.5		45.6	
9–26	37.0		37.1		37.1		36.4		36.0		32.5	
≥27	21.9		27.4		26.4		25.5		23.5		21.9	
Adult hours spent watching television daily during the past year, hours[a]												
<3.0	94.3		94.2		93.7		93.1		91.5		87.5	
3.0–5.7	5.2		5.2		5.7		6.4		7.5		11.8	
>5.7	0.5		0.6		0.5		0.6		1.1		0.7	
Caloric intake in adulthood, kcal		1,790 (519)		1,794 (503)		1,804 (518)		1,803 (525)		1,802 (527)		1,816 (554)
Alternative Healthy Eating Index score in adulthood		44.9 (10.4)		45.0 (10.5)		43.9 (10.5)		42.8 (10.3)		42.1 (10.1)		40.8 (10.0)

Abbreviations: BMI, body mass index; MET, metabolic equivalent; PA, physical activity; SD, standard deviation.

[a] $P < 0.05$ for differences by number of hours spent watching television daily at ages 3–5 years, using χ^2 test.

[b] Assessed using the 9-level Stunkard pictogram with body shapes ranging from lean (somatotype 1) to obese (somatotype 9) (27). Somatotypes ≥5 were categorized as "overweight/obese."

[c] Weight (kg)/height (m)^2.

[d] >5% missing.

[e] One pound = 0.45 kg.

television/low PA: 3.22 (95% CI: 2.23, 4.65) at age 5 years, 2.80 (95% CI: 2.03, 3.86) at age 10 years, 2.30 (95% CI: 1.63, 3.26) at age 18 years, and 1.82 (95% CI: 1.36, 2.45) in adulthood. Similar results were seen when the composite score was assessed at ages 5–10 years. Daughters with high television/low PA had the highest odds ratios for overweight/obesity: 4.41 (95% CI: 3.48, 5.57) at age 10 years, 3.91 (95% CI: 3.04, 5.02) at age 18 years, and 2.19 (95% CI: 1.74, 2.76) in adulthood.

DISCUSSION

In this study, we examined the association between the number of hours of daily television viewing during early and late childhood and overweight/obesity throughout the life course. We report that watching television at least 4 hours daily at ages 3–5 and 5–10 years was related to 25%–61% higher odds of overweight/obesity throughout life after adjustment for parental and daughter covariates. A composite score of high daily television viewing time and low PA level during childhood was associated with 82%–441% higher odds of overweight/obesity across the life course. Thus, there appears to be a window of vulnerability for risk factors for obesity in early life with potential associations extending into later life.

Importantly, according to our results, approximately only two-thirds of the excess risk of adult overweight/obesity associated with childhood television viewing time is accounted for by adult television viewing time and PA level. Thus, the association between early-life television viewing time and overweight/obesity in adulthood (ages 26–45 years) may persevere, regardless of adult behaviors. Furthermore, although evidence suggests obesity may track throughout life, we found a persistent association between early-life television viewing time and adult overweight/obesity, irrespective of early-life overweight/obesity.

Nine percent and 15% of mothers reported their daughter watching television for more than 2 hours/day at ages 3–5 and 5–10 years, respectively. However, even with these relatively low proportions from more than 50 years ago, our results suggest

Table 2. Adjusted Odds Ratios for Overweight/Obesity at Ages 5, 10, 18, and 26–45 Years (Adulthood) by Number of Hours Spent Watching Television Daily at Ages 3–5 Years, Nurses' Mothers' Cohort (2001) and Nurses' Health Study II (1989 and 1991)

Variable and No. of Hours Spent Watching Television Daily at Ages 3–5 Years	Age-Adjusted Model[a]		Model Adjusted for Age and Physical Activity at Ages 3–5 Years		Model Adjusted for Parental and Daughter Covariates[b]	
	OR	95% CI	OR	95% CI	OR	95% CI
Somatotype ≥5 at age 5 years[c]						
0	1.00	Referent	1.00	Referent	1.00	Referent
0.5	0.95	0.79, 1.14	0.95	0.79, 1.14	0.96	0.79, 1.15
1.0	1.08	0.95, 1.24	1.08	0.95, 1.24	1.07	0.93, 1.23
2.0	1.22	1.06, 1.41	1.20	1.04, 1.39	1.16	1.00, 1.35
3.0	1.53	1.27, 1.85	1.46	1.21, 1.77	1.39	1.15, 1.69
≥4.0	1.87	1.40, 2.49	1.71	1.28, 2.29	1.61	1.20, 2.17
P for trend		<0.001		<0.001		<0.001
Somatotype ≥5 at age 10 years						
0	1.00	Referent	1.00	Referent	1.00	Referent
0.5	0.91	0.79, 1.04	0.91	0.79, 1.05	0.94	0.81, 1.08
1.0	1.03	0.93, 1.14	1.03	0.93, 1.14	1.05	0.94, 1.17
2.0	1.20	1.07, 1.34	1.18	1.05, 1.32	1.18	1.05, 1.32
3.0	1.44	1.24, 1.67	1.38	1.19, 1.61	1.35	1.15, 1.57
≥4.0	1.62	1.28, 2.06	1.50	1.18, 1.91	1.46	1.14, 1.86
P for trend		<0.001		<0.001		<0.001
BMI[d] ≥25 at age 18 years						
0	1.00	Referent	1.00	Referent	1.00	Referent
0.5	0.84	0.72, 0.98	0.85	0.72, 0.99	0.89	0.76, 1.05
1.0	0.95	0.85, 1.07	0.95	0.85, 1.07	0.98	0.87, 1.11
2.0	1.10	0.97, 1.24	1.08	0.96, 1.22	1.06	0.94, 1.21
3.0	1.26	1.07, 1.48	1.21	1.03, 1.42	1.12	0.94, 1.33
≥4.0	1.57	1.22, 2.01	1.47	1.14, 1.88	1.31	1.00, 1.70
P for trend		<0.001		<0.001	0.04	
BMI[d] ≥25 in adulthood						
0	1.00	Referent	1.00	Referent	1.00	Referent
0.5	0.88	0.80, 0.96	0.88	0.80, 0.97	0.92	0.83, 1.01
1.0	0.95	0.89, 1.02	0.95	0.89, 1.02	0.96	0.89, 1.04
2.0	1.08	1.00, 1.16	1.07	1.00, 1.16	1.02	0.94, 1.11
3.0	1.24	1.12, 1.38	1.22	1.10, 1.36	1.07	0.95, 1.19
≥4.0	1.71	1.44, 2.03	1.65	1.39, 1.96	1.32	1.10, 1.59
P for trend		<0.001		<0.001		0.001

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

[a] Adjusted for age at daughter's questionnaire return.

[b] At ages 5 and 10 years, the models were adjusted for maternal educational level, maternal and paternal BMI, maternal gestational weight gain, smoking during pregnancy, activity during pregnancy, home ownership, daughter's birth weight, gestational age, birth year, breastfeeding duration, physical activity at ages 3–5 years, and age at questionnaire return. At age 18 years, the model was adjusted for covariates above and age at menarche. In adulthood, the model was adjusted for the covariates above and adult smoking status, activity level, hours spent watching television daily, caloric intake, and Alterative Healthy Eating Index score.

[c] Assessed using the 9-level Stunkard pictogram with body shapes ranging from lean (somatotype 1) to obese (somatotype 9) (27). Somatotypes ≥5 were categorized as "overweight/obese."

[d] Weight (kg)/height $(m)^2$.

Table 3. Adjusted Odds Ratios for Overweight/Obesity at Ages 10, 18, and 26–45 Years (Adulthood) by Number of Hours Spent Watching Television Daily at Ages 5–10 Years, Nurses' Mothers' Cohort (2001) and Nurses' Health Study II (1989 and 1991)

Hours Watching Television Daily at Ages 5–10, No.	Age-Adjusted Model[a]		Model Adjusted for Age and Physical Activity at Ages 5–10 Years		Model Adjusted for Parental and Daughter Covariates[b]	
	OR	95% CI	OR	95% CI	OR	95% CI
Somatotype ≥5 at age 10 years[c]						
0	1.00	Referent	1.00	Referent	1.00	Referent
0.5	0.81	0.67, 0.99	0.82	0.68, 1.00	0.83	0.68, 1.02
1.0	0.92	0.79, 1.06	0.92	0.79, 1.07	0.92	0.79, 1.08
2.0	1.06	0.91, 1.23	1.04	0.90, 1.21	1.02	0.87, 1.19
3.0	1.31	1.11, 1.55	1.24	1.04, 1.46	1.18	0.99, 1.41
≥4.0	1.69	1.36, 2.11	1.50	1.20, 1.88	1.45	1.15, 1.83
P for trend		<0.001		<0.001		<0.001
BMI[d] ≥25 at age 18 years						
0	1.00	Referent	1.00	Referent	1.00	Referent
0.5	0.71	0.57, 0.88	0.72	0.57, 0.90	0.75	0.60, 0.95
1.0	0.93	0.79, 1.10	0.94	0.79, 1.11	0.96	0.81, 1.15
2.0	1.06	0.89, 1.25	1.04	0.88, 1.23	1.02	0.86, 1.22
3.0	1.35	1.12, 1.62	1.28	1.06, 1.55	1.20	0.99, 1.45
≥4.0	1.66	1.30, 2.11	1.49	1.17, 1.90	1.39	1.08, 1.79
P for trend		<0.001		<0.001		<0.001
BMI[d] ≥25 in adulthood						
0	1.00	Referent	1.00	Referent	1.00	Referent
0.5	0.84	0.74, 0.96	0.85	0.74, 0.96	0.87	0.76, 1.00
1.0	0.93	0.84, 1.03	0.93	0.84, 1.03	0.91	0.81, 1.01
2.0	1.07	0.97, 1.19	1.06	0.96, 1.18	0.97	0.87, 1.09
3.0	1.35	1.20, 1.52	1.31	1.17, 1.48	1.10	0.97, 1.25
≥4.0	1.64	1.40, 1.93	1.55	1.32, 1.82	1.25	1.05, 1.49
P for trend		<0.001		<0.001		<0.001

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

[a] Adjusted for age at daughter's questionnaire return.

[b] At ages 5 and 10 years, the model was adjusted for maternal educational level, maternal and paternal BMI, maternal gestational weight gain, smoking during pregnancy, activity during pregnancy, home ownership, daughter's birth weight, gestational age, birth year, breastfeeding duration, physical activity at ages 3–5 years, and age at questionnaire return. At age 18 years, the model was adjusted for covariates above and age at menarche. In adulthood, the model was adjusted for the covariates above and adult smoking status, activity level, hours spent watching television daily, caloric intake, and Alterative Healthy Eating Index score.

[c] Assessed using the 9-level Stunkard pictogram with body shapes ranging from lean (somatotype 1) to obese (somatotype 9) (27). Somatotypes ≥5 were categorized as "overweight/obese."

[d] Weight (kg)/height $(m)^2$.

a need for interventions to reduce screen time among youth. This is especially important in the current era of ever-expanding time to be in front of screens with nationally representative statistics indicating that 58%–79% of children engage in screen time for more than 2 hours/day (1, 2). The persistent associations of childhood television viewing time with overweight/obesity later in life, particularly in late adolescence and adulthood, are modest in our study and in others (19, 34). However, given the widespread use of a variety of screen media among infants and children today (21), these associations may have large implications at the population level. In contrast, the strength of the independent and joint associations of television viewing time and PA level with overweight/obesity in our study is relatively large, in comparison with other modifiable, early-life risk factors for obesity (35). The widespread use of screen time and the strength of the independent and joint associations of television viewing time and PA level with obesity suggest that television viewing time and PA level are targets for public health interventions to tackle the overweight/obesity epidemic throughout life.

Table 4. Adjusted Odds Ratios for Overweight/Obesity at Ages 5, 10, 18, and 26–45 Years (Adulthood) by a Composite Score of Number of Hours Spent Watching Television Daily and Physical Activity at Ages 3–5 and 5–10 Years, Nurses' Mothers' Cohort (2001) and the Nurses' Health Study II (1989 and 1991)

Composite Score	Somatotype ≥5 at Age 5 Years[a]		Somatotype ≥5 at Age 10 Years[a]		BMI ≥25 at Age 18 Years[b,c]		BMI ≥25 in Adulthood[c,d]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Ages 3–5 years								
≤2 hours television per day and highly active/active	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
≤2 hours television per day and mostly inactive/inactive	2.01	1.62, 2.49	1.91	1.60, 2.27	1.84	1.52, 2.24	1.30	1.13, 1.51
≥3 hours of television per day and highly active/active	1.33	1.14, 1.55	1.29	1.14, 1.45	1.16	1.01, 1.32	1.12	1.02, 1.23
≥3 hours of television per day and mostly inactive/inactive	3.22	2.23, 4.65	2.80	2.03, 3.86	2.30	1.63, 3.26	1.82	1.36, 2.45
P for trend	<0.001		<0.001		<0.001		<0.001	
Ages 5–10 years								
≤2 hours television per day and highly active/active			1.00	Referent	1.00	Referent	1.00	Referent
≤2 hours television per day and mostly inactive/inactive			2.51	2.14, 2.95	2.13	1.78, 2.56	1.55	1.35, 1.79
≥3 hours of television per day and highly active/active			1.25	1.12, 1.38	1.22	1.09, 1.36	1.19	1.11, 1.28
≥3 hours of television per day and mostly inactive/inactive			4.41	3.48, 5.57	3.91	3.04, 5.02	2.19	1.74, 2.76
P for trend			<0.001		<0.001		<0.001	

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

[a] Adjusted for maternal educational level, maternal and paternal BMI, maternal gestational weight gain, smoking during pregnancy, activity during pregnancy, home ownership, daughter's birth weight, gestational age, birth year, breastfeeding duration, and age at questionnaire return.

[b] Adjusted for the variables above and age at menarche.

[c] Weight (kg)/height $(m)^2$.

[d] Adjusted for the variables above and adult smoking status, activity level, hours spent watching television daily, caloric intake, and Alterative Healthy Eating Index score.

Our results are in accord with those of several studies. Using nationally representative longitudinal data from a more recent cohort (born in the 1970s), each additional hour spent watching television on the weekend at age 5 years was associated with 7% higher odds of obesity at age 30 years (19). In a prospective cohort of preschool-age children in 1987, those watching television for at least 3 hours versus those watching for less than 1.75 hours/day had the greatest increases in mean BMI and body fat from ages 4 to 11 years (20). In a prospective cohort study of adolescents followed from 1995 to 2001 (36), a lower odds of obesity appeared in adulthood for adolescent screen time of 4 hours/week versus 40 hours/week, with stronger associations seen among girls (odds ratio = 0.58, 95% CI: 0.43, 0.80) than among boys (odds ratio = 0.78, 95% CI: 0.61, 0.99). It was found in the same study (36) that a profile of high amounts of screen time and low moderate-to-vigorous PA bouts was associated with higher proportions of obesity than a profile of low amounts of screen time and high moderate-to-vigorous PA bouts.

Interestingly, we found 0.5 hours of television viewing per day at ages 5–10 years was associated with reduced odds of overweight/obesity at age 18 years and in adulthood. These findings may indicate that daughters who watched minimal hours of television per day may have generally healthier lifestyles comparable to those who did not watch television. However, we do not have sufficient data on childhood diet, sleep habits, or activities replacing television viewing to decipher this finding. It is also possible that this result may be due to chance or that mothers may have been inclined to report a low estimate of television viewing time, rather than no television, if her daughter watched very minimal amounts of television.

Several mechanisms have been postulated to explain the association between long hours of television viewing and overweight/obesity. Time in front of the television is sedentary and could displace time being physically active (37, 38). Also, while viewing television, children have higher energy intake (39) and consume more meals and snacks (14), sugar-sweetened beverages, and high-fat diets, and fewer fruits and vegetables (40). Exposure to food advertisements via television viewing influences foods children request (41). Children aged 2–11 years in the United States today watch approximately 12 food-related advertisements per day (42); 86% of advertisements promote foods high in saturated fat, sugar, and sodium (43). Other proposed mechanisms include the hypometabolic state

of watching television (44), impaired sleep quality (45, 46), distraction from habitual food intake control or satiety and satisfaction cues, conditioning of food consumption, interference with memory formation and regulation (47), and fewer family meals (48). Researchers might explore the role of these potential mechanisms as mediators of the relationship between screen time and obesity.

Our study has strengths and limitations. Among the strengths is that we analyzed a large cohort with adjustment for important confounders associated with obesity. Our exposure data were obtained from the mothers independent of and at a different time than the outcome from the daughters. In addition, we have data on childhood and adult television time and PA, but not at age 18 years. Among the limitations, data on childhood television viewing time and PA may be subject to recall bias, given that mothers were asked to recall the exposure decades after it occurred (approximately 32–52 years later). Televisions were relatively new during the birth years of the daughters, which may have made recall slightly more accurate. However, the length of time between occurrence and reporting of the exposure likely introduced measurement error. We expect that any misclassification is nondifferential and thus likely biased associations toward the null. The study is limited by lack of generalizability due to the homogeneous ethnic sample (97% white). We were unable to determine if 1 sex was more negatively affected by screen time than the other (13, 14, 36), because our sample comprises female participants only. Information on PA level of the daughters during childhood may be based on maternal perception (i.e., it is unclear whether a highly active daughter was active because of involvement in scheduled PA or unsupervised PA and whether these could result in differential outcomes). The daughters' recalled somatotype in childhood, weight at age 18 years, and reported current weight and height in adulthood may be subject to self-report bias; however, these measures have been validated in previous studies (28, 30–33). Given the differences in measurements to assess overweight/obesity in childhood versus adulthood, it is unclear whether daughters who were overweight/obese in childhood were also overweight/obese in adulthood. Thus, it is possible that the association between early life television viewing time and obesity is due to tracking of overweight/obesity, or it could be due to the amount of childhood television viewing time. Last, the dietary data at ages 3–5 years were collected with a short semiquantitative food frequency questionnaire that was not validated in this population, and the foods listed do not comprehensively represent a child's diet. Weak correlations were reported between diet records collected in real time and maternal recall of preschool diet about 43 years later in a comparable cohort (49). Therefore, we did not adjust for childhood diet in our analyses. No dietary data were collected at age 18 years, and although we saw a decreasing mean Alterative Healthy Eating Index score in adulthood with increasing hours of daily childhood television viewing time, adult dietary data were collected simultaneously with data on overweight/obesity in adulthood. Thus, there may be an underestimation of associations due to reporting of socially desirable answers and/or reverse causation.

In conclusion, according to our results, television viewing at least 4 hours/day in childhood may be associated with higher odds of overweight/obesity throughout life; the association was stronger when combined with low PA level. Therefore, there is a need for interventions to reduce television viewing time among youth and incorporation of PA as part of interventions, given that less television viewing time may not translate into high PA level (50). Research is needed to replicate our findings.

ACKNOWLEDGMENTS

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The Nurses' Mothers' Cohort Study was funded by the National Cancer Institute (research contract N02-RC-17027). The Nurses' Health Study II was supported by the National Institutes of Health (award UM1CA176726).

Conflict of interest: none declared.

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