

Television viewing and variations in energy intake in adults and children in the USA

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Abstract

Objective: Examine the association between energy intake and television (TV) viewing in Americans.

Design: Nationally representative, cross-sectional study of 2003–2006 National Health and Nutrition Examination Survey.

Setting: Total energy intake was determined by two 24 h recalls. TV viewing was reported as low (≤ 1 h/d), middle (2–3 h/d), and high (≥ 4 h/d). Multivariate linear regression models were used to analyse TV viewing and energy intake, adjusted for BMI (percentile for children 2–18 years), age, ethnicity and physical activity.

Subjects: Pre-school children (2–5 years; n 1369), school-age children (6–11 years; n 1759), adolescents (12–18 years; n 3233) and adults (≥ 19 years; n 7850) in the USA.

Results: There was a significant association between TV viewing and energy intake for adolescent girls (high *v.* low: $\beta = 195.2$, $P = 0.03$) and men (high *v.* low: $\beta = -113.0$, $P = 0.02$; middle *v.* low: $\beta = -131.1$, $P = 0.0002$). Mean adjusted energy intake for adolescent girls was 7801.0, 8088.5 and 8618.2 kJ/d for low, middle and high TV viewing, respectively. Mean adjusted energy intake for men was 9845.9, 9297.2 and 9372.8 kJ/d for low, middle and high TV viewing.

Conclusions: TV viewing was associated with energy intake in US children and adults only in 12–18-year-old girls and men. For girls, the high TV viewing category consumed more energy daily (816.3 kJ (195 kcal)) than the low category. In men, the middle and high TV viewing categories consumed less energy daily (548.4 kJ (131 kcal) and 473.0 kJ (113 kcal), respectively) than the low category. Our findings support some, but not all previous research. Future research is needed to explore this complicated relationship with rigorous measures of energy intake and TV viewing.

Keywords
Television
Dietary patterns
Obesity

Recently, sedentary behaviour among adults and children has received attention as a public health concern^(1–5). Sedentary behaviour is defined as behaviour that does not increase metabolic rate higher than resting and includes sitting^(1,4). Sedentary behaviour can be objectively measured through devices worn that measure posture or intensity of activity as well as by self- or proxy-reported time in sedentary behaviours such as sitting for work or transportation, watching television (TV) or playing video games, and computer use for recreation and school work. TV viewing is the most predominant leisure-time sedentary behaviour in children^(6–10) and adults^(11,12). Higher volumes of sedentary time have been associated with mortality^(13,14), cardiometabolic disease^(15–17) and obesity^(18,19) in adults and elevated disease risk^(20,21) and overweight and obesity^(22–24)

in children. Several hypotheses have been proposed to explain the relationship observed between TV viewing and health and obesity status. These hypotheses include that: (i) TV viewing displaces time for physical activity; (ii) resting energy expenditure is lower while watching TV; (iii) TV advertising may prompt viewers to consume high-energy snacks during viewing as well as prompts to consume advertised foods later; and (iv) individuals passively overconsume food while watching TV since they are distracted and ignoring cues of satiety.

Evidence from epidemiological studies^(10,25), a time-use study of the after-school period⁽²⁶⁾ and a recent meta-analysis⁽²³⁾ support the hypothesis that time spent watching TV may be displacing time spent on physical activity since children with high levels of TV viewing concurrently have

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low levels of physical activity, although this relationship has a small effect⁽²³⁾. There is also evidence to support the contrary (i.e. sedentary behaviour does not displace physical activity)⁽²⁷⁾. An epidemiological study reported no correlation between TV viewing and accelerometer-measured moderate-to-vigorous physical activity ($r=0.013$, $P=0.58$)⁽²⁷⁾. Furthermore, a cross-sectional clinical study using doubly labelled water showed that the relationship between TV viewing and fatness was not mediated by physical activity in children; although children who watched higher amount of TV were significantly less physically active⁽²⁸⁾. Further, studies supporting the complexity of these behaviours detail that interventions that have sought to reduce TV viewing were unable to demonstrate subsequent increases in physical activity, even though decreases in overall body weight were reported^(29,30). Some research has examined whether individuals experience a lowered metabolic rate while viewing TV^(31,32). However, it is generally accepted that metabolic rate is no lower than in any other sedentary pursuit⁽³³⁾. There is evidence that indicates advertisements seen by children while watching TV can impact the brands and types of foods they request^(34–36). Moreover, those children who report paying attention to TV commercials had higher odds of requesting (OR = 3.43; 95% CI 2.55, 4.60), buying (OR = 2.73; 95% CI 2.17, 3.43) and eating snacks while watching TV (OR = 1.60; 95% CI 1.23, 2.07)⁽³⁷⁾. Further, cues of satiety have been shown to be disregarded by children⁽³⁸⁾ and college students⁽³⁹⁾ while watching TV.

Several studies, detailed in a recent review⁽⁴⁰⁾, have examined eating patterns and sedentary behaviours in children and adults. Dietary patterns assessed include snacking, fruit and vegetable consumption, fat intake and total energy intake. While many observational studies support the hypothesis that higher sedentary behaviour is associated with poor dietary quality in children and adults, albeit not necessarily total energy intake, not all studies are in agreement and results vary by age⁽⁴⁰⁾. While it is very important to understand the relationship between dietary patterns and TV viewing, excess energy intake has been reported to be a predominant driver of the obesity epidemic^(41,42). Eight of eleven (73%) studies in children aged <12 years indicate that higher sedentary behaviour is associated with higher energy intake. Among children aged 12–18 years, three of nine studies reported a positive association. In adults, five of seven studies (71%) showed a positive association between sedentary time and energy intake. Total energy intake, which is expected to be directly associated with overweight and obesity status, has been studied less frequently than fruit, vegetable, sweetened beverage and snack food intake. Further investigation into the complex relationship between TV viewing and energy intake is warranted to accurately understand the association of these behaviours and obesity, particularly due to the evidence that supports increased energy intake as a primary contributor to global

obesity issues. This is particularly relevant in the USA where 34% of children and 66% of adults are overweight or obese⁽⁴³⁾ and health costs associated with treatment of obesity and its co-morbidities continue to rise⁽⁴⁴⁾. The purpose of the present epidemiological study was to conduct an analysis of data obtained from US children and adults to examine the association between energy intake and TV viewing.

Experimental methods

The present study is a cross-sectional, epidemiological analysis of children and adults using data collected as part of the National Health and Nutrition Examination Survey (NHANES) 2003–2004 and 2005–2006.

Subjects

NHANES uses a complex, multistage, probability sampling design to select participants who are representative of the US population. The National Center for Health Statistics ethics review board approved the original survey protocols, and informed consent was obtained for all NHANES participants. Data were obtained for adults and children >2 years of age who participated in both dietary recall interviews. NHANES participants with missing data on gender, ethnicity (Mexican American, European American, African American, other), height, weight, TV viewing and physical activity were excluded from the present analyses. Height and weight were used to calculate the BMI (kg/m^2) of each participant. According to BMI, adults were then classified as underweight ($<18.5 \text{ kg}/\text{m}^2$), normal weight ($18.5\text{--}24.9 \text{ kg}/\text{m}^2$), overweight ($25.0\text{--}29.9 \text{ kg}/\text{m}^2$) or obese ($\geq 30.0 \text{ kg}/\text{m}^2$)⁽⁴⁵⁾. For children, BMI percentile based on age and sex was calculated and classifications were as underweight (<5th percentile), normal weight (5th–84th percentile), overweight (85th–94th percentile) and obese (≥ 95 th percentile)⁽⁴⁶⁾. Analyses were stratified by age and conducted separately for pre-school children 2–5 years of age, school-age children 6–11 years of age, adolescents 12–18 years old and adults ≥ 19 years of age.

Dietary measures

Data on the outcome of interest, total energy intake (kJ/d), were obtained from two 24 h dietary recall interviews conducted by trained technicians. For all analyses, total energy intake from day 1 and day 2 were averaged, a method previously used with national dietary analyses⁽⁴⁷⁾. However, each recall day was examined individually in association with TV viewing to determine if there was a difference. A detailed description of the dietary interviews can be found elsewhere^(48,49); however, procedures are summarized here. The first 24 h recall interview was in-person and took place in the mobile examination centre (MEC). The second 24 h recall interview was conducted via telephone three to ten days following the MEC interview on

a different day of the week. Serving sizes and food models were present in the MEC for the initial interview. Participants were given a booklet with information on serving size for the follow-up telephone interview. For children aged 2–5 years, interviews were conducted with the proxy adult who was most knowledgeable about the child's dietary intake, likely a parent. For children aged 6–11 years, interviews were conducted with the child with adult proxy assistance. The US Department of Agriculture's (USDA) Automated Multiple Pass Method, a computerized system, guided the interviewers to probe and collect easily forgotten foods and beverages.

Participants were asked about food consumed in the previous 24 h. In addition, they were asked to compare the day recalled to usual dietary intake (i.e. more than usual, less than usual or usual intake). For pre-school children, 81.9% and 88.1% of the recalled days were usual for day 1 and day 2 of the dietary recall interview. For school-aged children, 74.2% and 88.2% of the recalled days were usual. For adolescents, 67.2% and 79.1% of day 1 and day 2 interviews, respectively, were reported as usual dietary intake. For adults, 73.9% and 79.0% of day 1 and day 2 interviews, respectively, were reported as usual intakes.

The USDA Food and Nutrient Database for Dietary Studies (FNDSS), version 2.0 (for 2003–2004) and version 3.0 (for 2005–2006; USDA Agricultural Research Service, Beltsville, MD, USA), was used for processing the reported dietary intakes. The FNDDS provides comprehensive information that can be used to code the individual foods and portion sizes reported by participants, and also nutrient values for calculating nutrient intakes.

Television viewing and physical activity measures

TV and physical activity measures were collected through an interview conducted in the participants' home (ages 2–11 years and ≥ 16 years) or the MEC (12–15 years). For children aged 2–11 years, a proxy completed the interview questions.

To assess TV viewing, participants were asked 'Over the past 30 d, on average about how many hours per day did you sit and watch TV or videos?' Possible responses included less than 1 h, 1 h, 2 h, 3 h, 4 h and 5 h or more, and were collapsed into low (≤ 1 h/d), middle (2–3 h/d), and high (≥ 4 h/d).

Physical activity for participants 2–11 years of age was assessed using the single question, 'How many times per week does (child) play or exercise enough to make (him/her) sweat and breathe hard?' Responses were reported in whole numbers from 0 (never) to 77. For participants ≥ 12 years of age, minutes of moderate-to-vigorous physical activity was assessed through a series of questions. These questions asked participants to report whether or not they had participated in vigorous or moderate physical activity for at least 10 min over the past 30 d. If participants responded 'yes' to engaging in moderate or

vigorous physical activity, information on the specific activities and the duration was collected. If participants responded 'no' moderate or vigorous physical activity, daily active time was recorded as zero. If participants responded 'yes', then the individual time spent in each moderate and vigorous activity was summed to provide a total time in activity per day.

Data analysis

The SAS statistical software package version 9.2[®] (SAS Institute, Cary, NC, USA) was used for all analyses. Descriptive statistics including means, standard errors and percentages were calculated to summarize population characteristics. Descriptive information has been presented in kJ; however, outcome analyses were conducted using kcal to maintain manageable parameter estimates. Preliminary analyses revealed an interaction between sex and TV viewing and therefore analyses were stratified by sex. Mean daily total energy intake was calculated using least-squared means for each age and sex group adjusted for age in years, BMI (or percentile for children), physical activity and ethnicity. The relationship between TV viewing and daily energy intake was examined by a series of multivariate linear regression models. The first model included TV viewing, BMI (percentile for children aged 2–18 years), age in years and ethnicity. The second model included all variables for model 1 with the addition of either minutes of moderate-to-vigorous physical activity (adolescents and adults) or times per week of hard play (pre-school and school-age children). Appropriate survey analyses and weight variables were used to ensure national representation of the findings.

Results

Data were examined for outliers in dietary and physical activity measures. A conservative and systematic measure to eliminate outliers in addition to inaccurate data as a result from memory or over- and under-reporting issues⁽⁵⁰⁾ was employed and data from participants whose total energy intake fell within the highest and lowest 2% of the distribution were not included in these analyses. Data were excluded for pre-school children if total energy intake was less than 3424.2 kJ/d (n 38) or if it exceeded 12 884.5 kJ/d (n 16). For school-aged children, participants were removed if total energy intake was less than 4123.2 kJ/d (n 33) or if it exceeded 13 755.2 kJ/d (n 48). For adolescents, participants were removed if total energy intake was less than 3415.8 kJ/d (n 61) or exceeded 19 000.3 kJ/d (n 49). For adults, participants were removed if total energy intake was less than 3466.0 kJ/d (n 112) or exceeded 18 066.8 kJ/d (n 260). Additionally, if daily moderate-to-vigorous physical activity exceeded 12 h, those adolescents (n 8) and adults (n 4) were removed (physical activity was assessed differently in younger children). Final analytical

Table 1 Descriptive characteristics of young children (2–11 years), older children (12–18 years) and adults in analyses examining TV viewing and energy intake, 2003–2006 National Health and Nutrition Examination Survey

Variable	Pre-school (2–5 years) %	School-aged (6–11 years) %	Adolescents (12–18 years) %	Adults (≥19 years) %
Sample	(n 1369)	(n 1668)	(n 3233)	(n 7850)
Age (years)				
Mean	3.5	8.4	15.0	46.1
SE	0.04	0.07	0.07	0.5
Sex (%)				
Male	52.4	51.7	51.0	46.4
Female	47.6	48.3	49.0	53.6
Ethnicity (%)				
Mexican American	14.8	13.6	11.6	8.0
European American	58.5	60.6	63.7	73.0
African American	15.0	14.8	14.9	11.2
Other	11.7	11.0	9.7	7.8
Poverty income ratio (%)				
<1.0	27.2	20.3	18.8	11.2
1.0–2.0	24.2	24.1	20.3	19.9
≥2.0	48.6	55.6	60.9	68.9
Obesity classification* (%)				
Underweight	3.1	2.6	3.3	4.7
Normal weight	73.4	67.2	63.0	28.8
Overweight	10.7	12.2	16.1	33.6
Obese	12.8	18.0	17.6	32.9
Daily min of MVPA†				
Mean	n/a	n/a	64.4	29.4
SE	n/a	n/a	2.6	0.9
Weekly days of hard play‡				
Mean	6.8	6.5	n/a	n/a
SE	0.2	0.3	n/a	n/a
TV viewing category (%)				
≤1 h/d (low)	39.4	34.2	38.1	33.6
2–3 h/d (middle)	46.9	48.6	41.6	45.2
≥4 h/d (high)	13.7	17.2	20.3	21.2

TV, television; MVPA, moderate-to-vigorous physical activity; n/a, not applicable.

*For adults classifications are underweight <18.5 kg/m², normal weight 18.5–24.9 kg/m², overweight 25.0–29.9 kg/m² and obese ≥30.0 kg/m². For children obesity status is based on BMI percentiles for age and sex with underweight <5th percentile, normal weight 5th–84th percentile, overweight 85th–94th percentile and obese ≥95th percentile.

†Different questions were asked to children aged 12–18 years and adults *v.* children aged 2–11 years. Adolescents and adults were asked about minutes of MVPA in the previous month, which was used to calculate weekly minutes of MVPA. Pre-school and school-aged children's parent proxy was asked about the times per week the child engaged in exercise or play enough to sweat and breathe hard.

sample sizes for the pre-school children, school-aged children, adolescents and adults were *n* 1369, *n* 1668, *n* 3233, and *n* 7850, respectively.

Descriptive characteristics of each sample can be found in Table 1. The mean participant age was 3.5, 8.4, 15.0 and 46.1 years for pre-school children, school-age children, adolescents and adults, respectively. Females consistently reported lower daily energy intake. In females, the pre-school girls reported 6580.8, school-aged girls reported 7841.5, adolescent girls reported 7925.6 and women reported 7266.4 kJ/d. In males, the pre-school boys reported 6908.0, school-aged boys reported 8707.0, adolescent boys reported 10089.6 and men reported 9782.1 kJ/d. In both males and females, the 12–18 years age group reported the highest daily level of energy intake. The percentage of the sample in the high TV viewing category was 13.7% for pre-school children, 17.2% for school-aged children, 20.3% for adolescents and 21.2% for adults ($P < 0.0001$).

Total energy intake by TV viewing category among age and sex categories can be found in Table 2. There was no

significant association between TV viewing category and energy intake for any of the age and sex groups, with the exception of the adolescent girls and men (Table 3). These findings were similar for analyses with and without physical activity for both adolescent girls and men. In the adolescent girls, the high TV viewing category consumed more energy daily (816.3 kJ (195 kcal) and 820.5 kJ (196 kcal)) than the low TV viewing category ($P = 0.03$) for models with and without physical activity, respectively. Men in both the middle and high TV viewing categories consumed less energy daily than men in the low TV viewing category. For both models with and without physical activity, men in the middle TV viewing category consumed 548.4 kJ (131 kcal) less ($P = 0.0002$); while men in the high TV viewing category consumed 473.0 kJ (113 kcal) ($P = 0.02$) and 464.7 kJ (111 kcal) less ($P = 0.02$) than men in the low TV viewing category for models with and without physical activity, respectively. These findings are in the direction opposite of what would be expected (i.e. higher energy intake in those with higher TV viewing).

Table 2 Total adjusted energy intake (kJ/d) for category of TV viewing by age and gender groups, 2003–2006 National Health and Nutrition Examination Survey

	Low (≤ 1 h/d)		Middle (2–3 h/d)		High (≥ 4 h/d)	
	Mean	SE	Mean	SE	Mean	SE
Pre-school children (2–5 years)						
Boys	6722.5	167.1	6959.6	177.0	7145.5	209.7
Girls	6537.9	190.1	6606.8	108.9	6568.2	204.7
School-aged children (6–11 years)						
Boys	8566.5	160.8	8689.7	136.8	8927.1	267.6
Girls	7632.8	212.9	7919.1	112.8	8016.0	273.8
Adolescents (12–18 years)						
Boys	9914.4	248.6	9996.8	225.2	9866.2	210.1
Girls	7801.0	166.3	8088.5	129.4	8618.2	252.2
Adults (≥ 19 years)						
Men	9845.9	130.5	9297.2	106.8	9372.8	173.3
Women	7540.9	120.7	7416.1	72.2	7611.8	94.0

TV, television.

Least-squared means adjusted for age, BMI (percentile for all children), physical activity (daily minutes of moderate-to-vigorous physical activity (MVPA) for children aged 12–18 years and adults and weekly times of hard play for children aged 2–11 years), ethnicity and smoking status (adults only).

Different questions were asked to children aged 12–18 years and adults v. children aged 2–11 years. Older children and adults were asked about minutes of MVPA in the previous month, which was used to calculate weekly minutes of MVPA. Pre-school and school-aged children's parent proxy was asked about the times per week the child engaged in exercise or play enough to sweat and breathe hard.

Discussion

The present study was unable to show an association between TV viewing and total energy intake in US pre-school children, school-aged children, adolescent boys and adult women. However, an association between TV viewing and total energy intake (kcal/d) was observed among girls aged 12–18 years and men. Adolescent girls in the highest TV viewing category (≥ 4 h/d) were estimated to consume 820.5 kJ (196 kcal) more energy daily than adolescent girls in the lowest TV viewing category (≤ 1 h/d). These findings are similar to those reported in previous studies that report total energy intake (kcal/d)^(24,51–53) but conflict with others^(47,54–57). Men in the middle (2–3 h/d) and high (≥ 4 h/d) TV viewing categories were estimated to consume 464.7–473.0 kJ (111–131 kcal) less energy per day compared with men in the lowest TV viewing category (≤ 1 h/d). This is in contrast with previous reports of a positive⁽⁴⁷⁾ or null⁽⁵¹⁾ relationship. It is worth noting that all age and sex groups reported dietary intake within the recommended ranges of 6694–10 042 kJ (1600–2400 kcal) for women and 8368–12 552 kJ (2000–3000 kcal) for men; albeit energy intake needs for weight maintenance depend on the age, sex, size and physical activity of the individual⁽⁵⁸⁾. Dietary intake and food consumption patterns have been previously reported in a number of studies and are summarized in a review published recently⁽⁴⁰⁾. This review states that while the majority of studies show a positive association between TV viewing and diet, not all studies agree⁽⁴⁰⁾. These discrepancies can likely be attributed to differences in methodology of dietary quality or intake, characteristics of the sample and the complicated nature of the relationship between diet, TV viewing and adiposity.

Measurements of dietary quality have been defined through various methods including but not limited to

amount of snacking, fruit, vegetable, fast food, sugar-sweetened beverage consumption, total energy intake, FFQ, behavioural questionnaires and 24 h recalls. The current study utilizes data obtained from two 24 h dietary recalls, taken 3 to 10 d apart by a trained interviewer using the automated multiple-pass method to calculate an average of total energy intake. For children under the age of 11 years, proxy respondents assisted or completed the interview on behalf of the child. This methodology was used in a previous study by Bowman⁽⁴⁷⁾ using the USDA's Continuing Survey of Food Intakes by Individuals 1994–1996, a nationally representative sample of Americans. Bowman observed that TV viewing was positively associated with energy intake. Men and women who watched >2 h TV/d consumed 573.5 kJ (137 kcal) more energy daily than adults who watched <1 h/d⁽⁴⁷⁾. Bowman's results, with nearly identical methodology of data collection, are incongruent with the current findings. Differences may be attributed to differences in analyses; Bowman did not stratify by sex while our analysis does.

In a study that included children and examined the association between total energy intake using similar methodology of dietary recall, Rosenberg *et al.*⁽⁵³⁾ found no association between TV viewing and energy intake. Congruent with our findings, Crespo *et al.*⁽²⁴⁾ reported an association only in girls such that those viewing >5 h TV/d consumed 732.6 kJ (175 kcal) more energy daily compared with those girls viewing TV for ≤ 1 h/d. Studies that used FFQ to measure total energy intake consistently showed increasing hours of TV viewing was associated with higher total energy intake (205.1–699.1 kJ/d (49–167 kcal/d)) in children ranging from 3 to 12 years of age^(54–56). Energy intake calculated from food frequencies could be different from that in a food recall since kJ/d are determined based on reported patterns of food intake in the food frequency rather than precisely what was

Table 3 Relationship between TV viewing and energy intake by age and gender groups, 2003–2006 National Health and Nutrition Examination Survey

	Adjusted model without physical activity			Adjusted model with physical activity		
	Parameter estimate	SE	P value	Parameter estimate	SE	P value
Pre-school children (2–5 years)						
Boys						
TV						
Low (≤ 1 h/d)	Ref.			Ref.		
Middle (2–3 h/d)	56.6	49.4	0.26	56.7	47.9	0.25
High (≥ 4 h/d)	95.2	63.5	0.14	101.0	64.8	0.13
Girls						
TV						
Low (≤ 1 h/d)	Ref.			Ref.		
Middle (2–3 h/d)	16.6	39.7	0.68	16.5	40.4	0.69
High (≥ 4 h/d)	7.1	60.5	0.91	7.2	60.3	0.90
School-aged children (6–11 years)						
Boys						
TV						
Low (≤ 1 h/d)	Ref.			Ref.		
Middle (2–3 h/d)	31.1	46.4	0.51	29.4	46.7	0.53
High (≥ 4 h/d)	85.8	73.0	0.25	86.1	73.6	0.25
Girls						
TV						
Low (≤ 1 h/d)	Ref.			Ref.		
Middle (2–3 h/d)	67.9	57.2	0.24	68.4	57.2	0.24
High (≥ 4 h/d)	91.5	93.7	0.34	91.6	94.0	0.34
Adolescent (12–18 years)						
Boys						
TV						
Low (≤ 1 h/d)	Ref.			Ref.		
Middle (2–3 h/d)	18.9	73.4	0.80	19.7	73.6	0.79
High (≥ 4 h/d)	–17.2	77.2	0.83	–11.5	80.8	0.89
Girls						
TV						
Low (≤ 1 h/d)	Ref.			Ref.		
Middle (2–3 h/d)	69.0	52.8	0.21	68.7	52.1	0.19
High (≥ 4 h/d)	196.3	87.2	0.03	195.2	85.8	0.03
Adults (≥ 19 years)						
Men						
TV						
Low (≤ 1 h/d)	Ref.			Ref.		
Middle (2–3 h/d)	–130.7	30.5	0.0002	–131.1	30.5	0.0002
High (≥ 4 h/d)	–110.9	44.2	0.02	–113.0	44.6	0.02
Women						
TV						
Low (≤ 1 h/d)	Ref.			Ref.		
Middle (2–3 h/d)	–29.4	27.5	0.29	–29.8	27.5	0.28
High (≥ 4 h/d)	17.4	34.1	0.61	16.9	34.2	0.62

TV, television; Ref., referent category.

Different questions were asked to children aged 12–18 years and adults *v.* children aged 2–11 years. Adolescents and adults were asked about minutes of moderate-to-vigorous physical activity (MVPA) in the previous month, which was used to calculate weekly minutes of MVPA. Pre-school and school-aged children's parent proxy was asked about the times per week the child engaged in exercise or play enough to sweat and breathe hard.

The model without physical activity was adjusted for BMI (percentile for all children), age and ethnicity. The model with physical activity included all previously listed covariates and either minutes of MVPA (children 12–18 years and adults) or times per week of hard play (children aged 2–11 years).

Analyses were conducted with average total kcal rather than kJ to prevent extremely large parameter estimates.

Bold indicates significance ($P < 0.05$).

eaten on the day prior to the recall. It is noteworthy that two of those studies noting an increase in energy intake (as measured by food frequency) and TV viewing^(55,56) were from the same Planet Health Study and thereby the same sample of children. Interestingly, a single study using five consecutive days of a weighed food record showed no association between energy intake and TV viewing, although it was only in sixty adolescents⁽⁵²⁾.

The present study was only able to demonstrate a positive association between total energy intake (kcal/d)

and TV viewing among adolescent girls. The reason why adolescent girls may be at greater risk for higher energy intake with TV viewing is not entirely clear. Boys have consistently been reported to engage in higher volumes of screen-based activities^(6–8) and a higher proportion of boys were found to exceed the American Academy of Pediatrics' TV viewing recommendation of < 2 h/d⁽⁵⁹⁾. Pearson and Biddle's⁽⁴⁰⁾ review did conclude that there is a trend towards more consistent relationships between females regarding TV viewing and dietary quality than

in males. Differences in social and occupational roles between men and women have also been proposed as reasons to explain this relationship observed in women such that the interaction between TV viewing, fast-food eating and weight control are different between genders⁽⁵¹⁾.

Additionally, the results of the present study suggest a negative association between TV viewing and energy intake in men. As noted in the review by Pearson and Biddle⁽⁴⁰⁾, no previous studies in men have reported a negative association between TV viewing and energy intake, although two reported no association^(51,57). A laboratory-based study found that adult participants consumed more food when given a meal while watching TV⁽⁶⁰⁾. A study conducted in children 12–16 years of age that decreased sedentary behaviour by 25–50% for three weeks reported a decrease in energy intake during that time⁽⁶¹⁾. However, when the reverse experiment was performed (increased sedentary behaviours by 25–50% for three weeks) there was not a concomitant increase in energy intake⁽⁶¹⁾. The interventions were counter-balanced in the order received by participants to prevent any timing effect. It is clear that the relationship between TV viewing and dietary patterns is complex. When total energy intake, which would most directly be associated with overweight and obesity, is the dietary outcome of interest, the findings are mixed.

The findings of the current study indicate TV viewing is not positively associated with energy intake, except in 12–18-year-old girls. Additionally, TV viewing is negatively associated with energy intake in men. These findings should be interpreted in light of the study's strengths and weaknesses. The study had a large sample size and utilized data obtained from a nationally representative sample of US men, women and children. Additionally, both 24h dietary recalls were administered by highly trained NHANES interviewers with the assistance of the automated multiple-pass method. These data allowed us to estimate the average total energy (kcal/d) intake for all subjects. Furthermore, participants were sent home with food models and portions size aids to enhance the accuracy of the telephone recall interview. However, limitations in the accuracy, honesty and social desirability of intake in dietary recall methodology are always a concern^(62–64). It is also worth noting that different interview methodologies (i.e. in-person *v.* telephone) were used for the day 1 recall and the day 2 recall. There were no major differences in the association between TV viewing and energy intake between day 1, day 2 and the average with the exception of adolescent girls. The day 2 and averaged analyses were similar while day 1 showed a similar pattern; however statistical significance was not reached. Usage of proxy report and assistance is an additional limitation since proxies may not know exactly what was consumed on the day prior to the interview. TV viewing is also self- or proxy-reported in a categorical fashion. Observation of TV viewing or electronic TV

monitors is a more accurate method to measure TV viewing. Additionally, reporting the continuous number of hours of TV viewing would allow greater flexibility and precision in analysis.

Conclusions

In summary, TV viewing in adult women and children in the 2003–2006 NHANES was not associated with energy intake, with the exception of adolescent girls and adult men. Previous evidence generally shows that higher TV viewing is associated with poorer dietary quality and higher energy intake, although not all studies support this relationship⁽⁴⁰⁾. It is recommended that future studies explore the relationship of TV viewing and energy intake in children and adults due to the discrepant research findings. This is particularly relevant to understand the differences between males and females regarding TV viewing and energy intake. It is likely that TV viewing is associated with diet⁽⁴⁰⁾; however, it may be due to dietary patterns, such as fruit, vegetable and fast-food consumption, than energy intake per se. Another measurement issue future studies may explore would be to ascertain the precision with which people can recall the quantity of food they consume while viewing TV. A recent opinion article addresses the hypothesis that eating while viewing TV leads to distraction⁽⁶⁵⁾ which could potentially impact energy intake as well as recall of food consumed. Viewing TV while eating may lead to under-reporting of energy intake if portion sizes are underestimated or not recalled. There is some evidence, at least in adults^(66,67), that watching TV while eating impairs memory of food consumed during the meal. Therefore, examination of type of foods consumed such as fast food, energy-dense foods or fruit and vegetables may provide better explanations of food patterns *v.* 24h recalls. This may be particularly true because of social desirability leading to under-reporting of intake, compounded with inability to accurately recall the quantity of food consumed while TV viewing, leading to further under-reporting. New technologies that can be used with food reporting such as digital photography pre and post meal could be another avenue to more accurately explore the relationship of energy intake and TV viewing. The dearth of research studying this phenomenon, especially in children, warrants further studies. Other areas for future research should include examination of the hypothesis related to precisely how and why TV viewing is associated with overweight and obesity. The complexity of these relationships is clear and well-designed studies are needed to gain deeper understanding and evidence for or against each hypothesis. Future research should also examine longitudinal and interventions where TV viewing is manipulated to discern if this relationship is amenable to change.

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