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Independent and combined associations of total sedentary time and television viewing time with food intake patterns of 9- to 11-year-old Canadian children

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Abstract: The relationships among sedentary time, television viewing time, and dietary patterns in children are not fully understood. The aim of this paper was to determine which of self-reported television viewing time or objectively measured sedentary time is a better correlate of the frequency of consumption of healthy and unhealthy foods. A cross-sectional study was conducted of 9- to 11-year-old children (n = 523; 57.1% female) from Ottawa, Ontario, Canada. Accelerometers were used to determine total sedentary time, and questionnaires were used to determine the number of hours of television watching and the frequency of consumption of foods per week. Television viewing was negatively associated with the frequency of consumption of fruits, vegetables, and green vegetables, and positively associated with the frequency of consumption of sweets, soft drinks, diet soft drinks, pastries, potato chips, French fries, fruit juices, ice cream, fried foods, and fast food. Except for diet soft drinks and fruit juices, these associations were independent of covariates, including sedentary time. Total sedentary time was negatively associated with the frequency of consumption of sports drinks, independent of covariates, including television viewing. In combined sedentary time and television viewing analyses, children watching >2 h of television per day consumed several unhealthy food items more frequently than did children watching ≤2 h of television, regardless of sedentary time. In conclusion, this paper provides evidence to suggest that television viewing time is more strongly associated with unhealthy dietary patterns than is total sedentary time. Future research should focus on reducing television viewing time, as a means of improving dietary patterns and potentially reducing childhood obesity.

Key words: sedentary behaviour, television watching, screen time, energy intake, food intake, childhood obesity, observational study.

Résumé : Les relations entre le temps consacré aux activités sédentaires, le temps passé devant un téléviseur et les comportements alimentaires ne sont pas bien établies. Cette étude se propose de déterminer laquelle parmi les deux variables suivantes est le meilleur corrélat de la fréquence de consommation d'aliments sains ou malsains : le temps autodéclaré devant un écran de télévision ou le temps objectivement mesuré à des activités sédentaires. On effectue une étude transversale auprès d'enfants âgés de 9 à 11 ans (n = 523; 57,1 % de filles) à Ottawa (Ontario) au Canada. On utilise des accéléromètres pour déterminer le temps consacré à des activités sédentaires et des questionnaires pour déterminer le nombre d'heures passées devant un écran de télévision et la fréquence de consommation d'aliments durant une semaine. L'écoute de la télévision est négativement associée à la fréquence de consommation de fruits, de légumes et de légumes verts et positivement associée à la fréquence de consommation de sucreries, de boissons gazeuses, de boissons-diète, de pâtisseries, de croustilles, de frites, de jus de fruits, de crème glacée, d'aliments frits et d'aliments-minute. À l'exception des boissons-diète et des jus de fruit, ces associations sont indépendantes des covariables y compris le temps consacré à des activités sédentaires. Le temps total consacré à des activités sédentaires est négativement associé à la fréquence de consommation des boissons pour sportifs indépendamment des covariables incluant l'écoute de la télévision. En combinant les analyses du temps consacré à des activités sédentaires et à l'écoute de la télévision, les enfants qui écoutent la télévision >2 h par jour consomment plus fréquemment des aliments malsains que les enfants qui écoutent la télévision ≤2 h par jour, quel que soit le temps consacré à des activités sédentaires. En conclusion, cette étude fournit des preuves selon lesquelles l'écoute de la télévision est plus fortement associée à des comportements alimentaires malsains que le temps total consacré à des activités sédentaires. Les études ultérieures devraient mettre l'accent sur la diminution de

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l'écoute de la télévision comme moyen d'améliorer les comportements alimentaires et de potentiellement diminuer l'obésité chez les jeunes. [Traduit par la Rédaction]

Mots-clés : comportement sédentaire, écoute de la télévision, temps d'écran, apport énergétique, apport alimentaire, obésité chez les enfants, étude observationnelle.

Introduction

Sedentary lifestyles in children are associated with negative physiological and health consequences, including reduced fitness, poor physical and psychosocial health, and obesity (Tremblay et al. 2011*a*, 2010). However, the associations between overall sedentary time and obesity in children are mixed, with studies suggesting that both positive and negative associations are independent of moderate-to-vigorous physical activity (MVPA) (Chaput et al. 2012*b*; Mitchell et al. 2013*a*). Interestingly, there is evidence to suggest that the type of sedentary behaviour, such as screen-based sedentary behaviour (e.g., television, video games), may be more important than overall sedentary time in predicting obesity in children (Chaput et al. 2012*a*). For instance, television viewing has been shown to be positively associated with obesity in children (Dietz and Gortmaker 1985; Mitchell et al. 2013*a*; Tremblay et al. 2011*a*), often independent of physical activity levels. The association between television viewing and obesity in children is thought to be driven by increased food intake (Borghese and Chaput 2013; Epstein et al. 2008; Robinson 2001; Wiecha et al. 2006). One longitudinal mediation analysis showed that dietary patterns mediate the association between television viewing and BMI in children (Fuller-Tyszkiewicz et al. 2012).

Television viewing is inversely associated with fruit and vegetable consumption and positively associated with the consumption of energy-dense snacks and drinks, total energy intake, and fast foods (Pearson and Biddle 2011). However, the association between overall sedentary time and food intake patterns in children has not been documented. Furthermore, a comparison of self-reported television viewing time versus objectively measured total sedentary time, with respect to associations with food intake, has not been undertaken. If the associations between sedentary behaviours and obesity are independent of MVPA, as is suggested by the literature (Chaput et al. 2013, 2012*b*; Cliff et al. 2013; Ekelund et al. 2012; Mitchell et al. 2013*b*; Tremblay et al. 2011*a*), then understanding the role of dietary patterns is paramount.

The aim of this paper was to determine which of self-reported television viewing time or objectively measured total sedentary time is a better predictor of the frequency of consumption of healthy and unhealthy foods in 9- to 11-year-old Canadian children. We hypothesized that higher self-reported television viewing time would be positively associated with the frequency of consumption of unhealthy foods and negatively associated with the frequency of consumption of healthy foods. It was also hypothesized that there would be no association between total sedentary time and healthy or unhealthy food intake patterns. To the best of our knowledge, this study is the first to examine this issue and will provide much-needed evidence of the role for food intake in the link between both television viewing and sedentary time with childhood obesity.

Materials and methods

Participants

The International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE) is a multinational, cross-sectional study conducted in 12 countries; details pertaining to the study design and methods can be found elsewhere (Katzmarzyk et al. 2013). Analyses herein include data from the Canadian ISCOLE site. Data were collected on 567 children in the 5th grade (57.1% female; 9–11 years of age) in 26 schools in Ottawa between September 2012 and May 2013. The city of Ottawa is predominately anglophone with a francophone minority (Statistics Canada 2012); therefore, schools were stratified into 4 groups with proportional representation to reflect the demographic composition of Ottawa: English public (n = 393; 69.3%), French public (n = 60; 10.6%), English Catholic (n = 75; 13.2%), and French Catholic (n = 39; 6.8%). All schools were invited to participate and were included until each stratum was filled. This project was approved by the research ethics boards of the Children's Hospital of Eastern Ontario, the University of Ottawa, and the participating school boards. Written informed parental consent and child assent were obtained for all participants.

Accelerometry

Sedentary time was measured using the ActiGraph GT3X+ accelerometer (ActiGraph LLC, Pensacola, Fla., USA) (Katzmarzyk et al. 2013). The children wore the device on a belt around the waist at the right midaxillary line 24 h per day for 7 consecutive days; they were asked to remove the device for aquatic activities and showering–bathing. Study staff instructed the children on how to wear the device. To increase wear time compliance, study staff conducted an in-person check 2–4 days after initialization to ensure that the child was following the accelerometer wear protocol. Two compliance phone calls (1 weekday call and 1 weekend call) were also made to the parents or guardians to ensure that the device was being worn properly. A valid recording required at least 4 days (including at least 1 weekend day) of at least 10 h of wear time per day. Data were collected at a sampling rate of 80 Hz, downloaded in 1-s epochs, and aggregated to 15-s epochs (Evenson et al. 2008). Sedentary time was defined as all minutes showing <100 counts per minute, which is a widely used cut-point in the literature (Wong et al. 2011). Forty-four children did not provide complete accelerometry data and were excluded from the analysis; thus, data from 523 children (58.3% female) were analyzed.

Television viewing and food frequency questionnaire

During the school visit, the participants completed a diet and lifestyle questionnaire, which included a self-reported measure of television viewing and a food frequency questionnaire (FFQ). To assess television viewing, the children were asked how many hours of television they watched on a typical school day and on a typical weekend day, based on a question adapted from the US Youth Risk Behavior Surveillance System (YRBSS) (2011). The television viewing time question derived from the YRBSS was originally designed for use in population-level surveillance of television viewing patterns, not hypothesis testing; however, this item was shown to have adequate reliability (Spearman correlation = 0.55–0.68) and validity (Spearman correlation = 0.47) (Schmitz et al. 2004). Self-report methods of quantifying screen time have been shown to have acceptable reliability and validity in children (Lubans et al. 2011). The response options included no television watching, <1 h, 1 h, 2 h, 3 h, 4 h, and ≥5 h of television per day. A weighted mean number of hours of television watching per week was calculated as follows: [(hours of television on weekdays × 5) + (hours of television on weekend days × 2)]/7; this method of determining the daily amount of television viewing has been used elsewhere (Herman et al. 2013).

The FFQ was adapted from the Health Behaviours in School-age Children (HBSC) study (Currie et al. 2008) and is a reliable (Spearman correlation = 0.52–0.82) questionnaire that can be used for ranking the frequency of consumption of most food items

(Vereecken and Maes 2003). The FFQ asked the participants how often they consumed 23 food items in a usual week. The 7 response options ranged from "never" to "every day, more than once".

Covariates

Demographic questionnaires completed by parents were used to determine the children's age (from date of birth), gender, ethnicity (White–Caucasian, African American, Asian, First Nations, East Indian, "don't know", or "other"), total annual family income (8 options, ranging from less than $14 999 to $140 000 or more), and the highest level of parental education (less than high school, some high school, high school diploma or GED, diploma or 1–3 years of college, bachelor's degree, or graduate degree (master's or PhD) or professional degree). Fat mass was determined by bioelectric impedance analysis using a Tanita SC-240 Body Composition Analyzer (Arlington Heights, Ill., USA); this is a valid measure of fat mass in field studies (Barreira et al. 2013). Biological maturity was estimated using the maturity offset method, which estimates an individual's age from peak height velocity (Mirwald et al. 2002). Maturation is an important variable to consider in such analyses because children's energy needs are a determinant of their growth (Rogol et al. 2002), and maturation is associated with increased energy needs (Stang and Story 2005). Total sleep period time was assessed using the ActiGraph GT3X+; a detailed description of this novel algorithm developed for the ISCOLE study is available elsewhere (Tudor-Locke et al. 2014). Television viewing time is negatively associated with sleep duration in children (Cain and Gradisar 2010). Sleep duration has also been linked to diet in children (Chen et al. 2008); a recent randomized crossover intervention comparing increased and decreased sleep durations showed that children consumed 138 fewer calories per day when they slept 1.5 h more than their baseline, as compared with 1.5 h below baseline sleep time (Hart et al. 2013). Thus, sleep period time is an important covariate to consider in analyses of sedentary behaviour and food intake in children. Finally, MVPA was assessed using the ActiGraph GT3X+ and was derived using cut-points of >2296 counts per minute (Evenson et al. 2008). These covariates were chosen because of their association with the exposures and (or) outcomes.

Statistical analyses

The correlation between the frequency of consumption of each of the 23 food items and both television viewing time and sedentary time were computed using Spearman's rho and Pearson's r value, respectively. Bonferroni correction for multiplicity was used to reduce the family-wise error rate; the critical p value for the univariate correlations was set at 0.05/23, or $p < 0.002$. Multivariate linear regression and simple linear regression were used to determine the independent associations between both television viewing time and total sedentary time, respectively, and the individual food items that were significantly correlated with each variable.

Models are presented as (*i*) unadjusted; (*ii*) adjusted for age, gender, ethnicity, biological maturity, fat mass (kg), total family annual income, highest level of parental education attained, total sleep period time, and MVPA; and (*iii*) with sedentary time and television viewing time adjusted for one another. The variance inflation factors among all variables entered into the model were <5, suggesting that multicollinearity was not a problem in the models. Types of foods were compared with groups of both high and low sedentary time and television viewing time using multivariate ANOVA (MANOVA). High and low sedentary time was defined as above or below the median (510.9 min per day) and high and low television viewing time was defined as >2 h or ≤2 h per day, as per the Canadian Sedentary Behaviour Guidelines (Tremblay et al. 2011*b*). MANCOVA was performed, adjusting for age, gender, ethnicity, biological maturity, and MVPA. Because of the small sample size of some of the groups, further adjustment was not possible. Bonferroni post hoc tests were used to determine significant differences between groups where the main effects were significant. All statistical analyses were performed using SPSS version 21 (IBM, Armonk, N.Y., USA).

Results

Participant demographic information is available in Table 1. A total of 436 children (83.4%) watched ≤2 h of television per day, and 87 children (16.6%) watched >2 h of television per day. The median number of minutes of total sedentary time was 511 min per day. There were no statistically significant gender interactions between television viewing time or sedentary time and the outcome variables of food items; thus, data for both genders were merged to maintain statistical power. Further, there we no differences in age, gender, ethnicity, biological maturity, fat mass, household annual income, or highest level of parental education between children who provided valid accelerometry data ($n = 523$) and those who did not ($n = 44$) (data not shown).

After Bonferroni correction for multiplicity, television viewing time was negatively correlated with the frequency of consumption of fruits, vegetables, and green vegetables (Table 2) and was positively correlated with the frequency of consumption of sweets, soft drinks, pastries, diet soft drinks, potato chips, French fries, fruit juices, ice cream, fried foods, and fast food. Sedentary time was negatively associated with the frequency of consumption of sports drinks after Bonferroni correction but was not significantly correlated with other food items. In unadjusted multivariate linear regression, television viewing time was associated with all the food items in the directions seen in the univariate analysis (Table 3, model 1). After adjusting for covariates (Table 3, model 2), the food items, except for diet soft drinks and fruit juices, remained significantly associated with television viewing time. Further adjustment for total sedentary time yielded the same results (Table 3, model 3). The proportion of variance in the frequency of consumption of food items explained by television viewing time ranged from 1% to 14%. In linear regression, sedentary time explained a significant proportion of the variance in the frequency of sports drink consumption in unadjusted (3%), partially adjusted (15%), and fully adjusted models (14%) (Table 4, models 1–3).

Frequency of consumption of food items was compared between groups of high and low sedentary time and television viewing time. Children with >2 h of television time consumed soft drinks, diet soft drinks, and fast foods more frequently than did children with ≤2 h of television time, regardless of whether or not they had high or low sedentary time (Table 5). However, after adjustment for age, gender, ethnicity, biological maturity, and MVPA, the high sedentary–high television time group no longer consumed soft drinks, diet soft drinks, or fast food more frequently than did the low sedentary–low television time group. Children with high sedentary time and high television viewing time consumed sweets and ice cream more frequently; however, after adjustment for covariates, the high sedentary–high television time group also consumed sweets more frequently than did the low sedentary–low television time group. In both the unadjusted and the adjusted models, children with low sedentary–high television time consumed pastries more frequently and green vegetables less frequently than did children with low television time and either high or low sedentary time. Finally, in both the unadjusted and the adjusted models, children who had low sedentary–high television time consumed fruit juices more frequently than did those with high sedentary–low television time. A main effect of the consumption of sports drinks between the sedentary time group and the television viewing time group was not observed.

Table 1. Descriptive characteristics of participants (n = 523).

Age, y, mean (SD)	10.0 (0.37)
Gender, No. (%)	
Male	218 (41.7)
Female	305 (58.3)
Ethnicity, No. (%)	
White–Caucasian	345 (66.7)
African American	13 (2.5)
Asian	53 (10.3)
First Nations	2 (0.4)
East Indian	5 (1.0)
Don't know	1 (0.2)
Other	98 (19.0)
Maturity offset, median (IQR)	−1.87 (−2.74, −1.20)
Fat mass, kg, mean (SD)	8.4 (5.4)
Television watching, No. (%)	
No television watching	55 (10.5)
<1 h	156 (29.8)
1 h	138 (26.4)
2 h	87 (16.6)
3 h	51 (9.8)
4 h	22 (4.2)
≥5 h	14 (2.7)
Television watching groups, No. (%)	
≤2 h	436 (83.4)
>2 h	87 (16.6)
Annual household income, No. (%)	
Less than $14 999	14 (2.8)
$15 000–$29 999	27 (5.4)
$30 000–$39 999	15 (3.0)
$40 000–$59 999	35 (7.0)
$60 000–$89 999	67 (13.3)
$90 000–$109 999	75 (14.9)
$110 000–$139 999	73 (14.5)
$140 000 and above	196 (39.0)
Highest level of parental education, No. (%)	
Less than high school	2 (0.4)
Some high school	8 (1.5)
High school diploma–GED	36 (7.0)
Diploma or 1–3 y college	100 (19.3)
Bachelor's degree	159 (30.8)
Graduate (Master's or PhD) or professional degree	212 (41.0)
Daily MVPA, min, mean (SD)	58.7 (19.3)
Sedentary time, min, mean (SD); median	511.4 (63); 510.9
Total sleep period time, min, mean (SD)	544.4 (50.7)
Sedentary time and television viewing time groups, No. (%)	
Low sedentary–low television	210 (40.2)
Low sedentary–high television	52 (9.9)
High sedentary–low television	197 (37.7)
High sedentary–high television	64 (12.2)

Note: IQR, interquartile range; GED, General Educational Development (high school equivalent); MVPA, moderate-to-vigorous physical activity.

Discussion

In the current sample of 9- to 11-year-old Canadian children, television viewing was more strongly associated with dietary patterns in children than was sedentary time. Specifically, television viewing was negatively associated with the frequency of consumption of a number of healthy food items and positively associated with the frequency of consumption of a number of unhealthy food items. To the best of our knowledge, this is the first study to compare television time and sedentary time in their respective associations with food intake in children. These findings provide evidence to suggest that the discrepancies seen between television viewing time and sedentary time in children, with respect to health outcomes, may be influenced by dietary patterns.

Table 2. Correlations between television viewing time (hours per day), total sedentary time (minutes per day) and frequency of consumption of food items in children (n = 523).

	Television viewing time (h/d)		Total sedentary time (min/d)	
	Spearman R	p	Pearson R	p
Sport drinks	—	—	−0.14	<0.0022
Fruits	−0.22	<0.002	—	—
Vegetables	−0.14	<0.002	—	—
Green vegetables	−0.21	<0.002	—	—
Sweets	0.15	<0.002	—	—
Soft drinks	0.20	<0.002	—	—
Pastries	0.17	<0.002	—	—
Diet soft drinks	0.19	<0.002	—	—
Potato chips	0.20	<0.002	—	—
French fries	0.20	<0.002	—	—
Fruit juices	0.14	<0.002	—	—
Ice cream	0.22	<0.002	—	—
Fried foods	0.16	<0.002	—	—
Fast foods	0.22	<0.002	—	—

Note: Critical p value = 0.05/23 comparisons = 0.002. Only food items significantly associated with either television viewing time or sedentary time are shown.

Except for diet soft drinks and fruit juices, these associations were independent of several covariates, including total sedentary time. In combined sedentary time–television viewing time analysis, higher television viewing was associated with higher consumption of several unhealthy food items, regardless of sedentary time. Sedentary time was negatively associated with the consumption of sports drinks, independent of covariates and television viewing, but was not associated with any other food items. The majority of the explained proportion of variance in the frequency of consumption of food items was less than 10%; however, television viewing and sedentary time each explained 14% of the variance in the frequency of consumption of fruits and sports drinks, respectively. In the literature, models tend to predict <30% of the variance in fruit intake, with studies in children predicting as little as 3% (Baranowski et al. 1999). Neumark-Sztainer et al. (2003) were able to predict 13% of the variance in fruit and vegetable intake using data on food availability and taste preferences in adolescents (Neumark-Sztainer et al. 2003). Likewise, Reynolds et al. (1999) found that the availability of, and preferences for, fruit explained 11% of the variance in fruit consumption in grade 3 children (Reynolds et al. 1999). The proportion of variance in the frequency of consumption of food items with television time is consistent with the magnitude of effect size seen in the literature.

The current finding that television viewing in children is positively associated with energy-dense foods and drinks as well as fast foods and negatively associated with the consumption of fruits and vegetables has been shown consistently in the literature (Pearson and Biddle 2011). Previous work has shown high television viewing to be associated with higher consumption of sweets and soft drinks (Santaliestra-Pasías et al. 2012), fast food (French et al. 2001), meat, pizza, and salty snacks (Coon et al. 2001) and lower consumption of fruits and vegetables (Boynton-Jarrett et al. 2003; Santaliestra-Pasías et al. 2012; Vereecken et al. 2006). Intriguingly, the current study showed that the known associations between television viewing and food intake were maintained, even independent of covariates and total sedentary time. These results suggest that the type of sedentary behaviour in children is more important in predicting dietary patterns than is total sedentary time. Furthermore, the food items that were associated with television viewing were not associated with overall sedentary time. This is likely because sedentary time in children encompasses a variety of behaviours that may or may not be associated with the frequency of consumption of food items. This suggests

Table 3. Independent associations between television viewing time and food items in children (n = 523).

	Television viewing time								
	Model 1			Model 2			Model 3		
	β (95% CI)	R^2	p	β (95% CI)	R^2	p	β (95% CI)	R^2	p
Fruits	−0.21 (−0.29, −0.13)	0.05	<0.001	−0.18 (−0.27, −0.09)	0.14	<0.001	−0.18 (−0.27, −0.09)	0.14	<0.001
Vegetables	−0.16 (−0.25, −0.08)	0.02	<0.001	−0.10 (−0.20, −0.001)	0.07	0.047	−0.10 (−0.20, −0.001)	0.06	0.047
Green vegetables	−0.23 (−0.33, −0.13)	0.04	<0.001	−0.24 (−0.35, −0.12)	0.05	<0.001	−0.23 (−0.35, −0.12)	0.05	<0.001
Sweets	0.15 (0.07, 0.24)	0.02	0.001	0.24 (0.14, 0.34)	0.05	<.001	0.24 (0.14, 0.34)	0.05	<0.001
Soft drinks	0.17 (0.10, 0.24)	0.04	<0.001	0.09 (0.02, 0.17)	0.07	0.020	0.09 (0.01, 0.17)	0.07	0.026
Pastries	0.11 (0.04, 0.18)	0.02	0.001	0.10 (0.02, 0.18)	0.02	0.010	0.09 (0.02, 0.17)	0.02	0.015
Diet soft drinks	0.13 (0.07, 0.19)	0.03	<0.001	—	—	0.078	—	—	0.079
Potato chips	0.13 (0.07, 0.20)	0.03	<0.001	0.13 (0.06, 0.21)	0.05	<0.001	0.13 (0.05, 0.20)	0.06	0.001
French fries	0.12 (0.06, 0.17)	0.03	<0.001	0.09 (0.02, 0.15)	0.07	0.010	0.08 (0.01, 0.14)	0.09	0.021
Fruit juices	0.15 (0.04, 0.26)	0.01	0.009	—	—	0.062	—	—	0.09
Ice cream	0.18 (0.11, 0.25)	0.04	<0.001	0.18 (0.09, 0.26)	0.05	<0.001	0.17 (0.09, 0.25)	0.05	<0.001
Fried foods	0.15 (0.07, 0.23)	0.02	<0.001	0.10 (0.01, 0.19)	0.07	0.032	0.10 (0.01, 0.19)	0.07	0.036
Fast foods	0.16 (0.10, 0.22)	0.05	<0.001	0.15 (0.09, 0.22)	0.07	<0.001	0.15 (0.08, 0.22)	0.08	<0.001

Note: Model 1: unadjusted. Model 2: adjusted for age, gender, ethnicity, maturity offset, fat mass, income, education, total sleep period time, and moderate-to-vigorous physical activity. Model 3: additionally adjusted for total sedentary time (minutes/day). Only food items significantly associated with television viewing time are shown. R^2, adjusted R^2.

Table 4. Independent associations between total sedentary time and food items in children (n = 523).

	Sedentary time (min/d)					
	Model 1 (R^2 = 0.03)		Model 2 (R^2 = 0.15)		Model 3 (R^2 = 0.14)	
	β (95% CI)	p	β (95% CI)	p	β (95% CI)	p
Sport drinks	−0.004 (−0.006, −0.002)	<0.001	−0.003 (−0.005, 0.00007)	0.04	−0.03 (−0.005, −0.00008)	0.04

Note: Model 1: unadjusted. Model 2: adjusted for age, gender, ethnicity, maturity offset, fat mass, income, education, total sleep period time, and moderate-to-vigorous physical activity. Model 3: additionally adjusted for television time (hours/day). Only food items significantly associated with total sedentary time are shown. R^2, adjusted R^2.

Table 5. Combined associations of total sedentary time and television viewing time with food items (reported frequency of consumption in days per week) in children (n = 523).

Food items	Low sedentary–low television	Low sedentary–high television	High sedentary–low television	High sedentary–high television	F	p
Green vegetables	4 (3–6)*	3 (2–4)	4 (3–6)*	4 (2–5)	46.6	0.001
Sweets	4 (3–5)	4 (3–5)	3 (2–4)	4 (3–5)†,‡	34.2	0.001
Soft drinks	2 (1–3)	2 (2–3)†,‡	2 (1–3)	2 (2–4)‡	24.6	<0.001
Pastries	2 (2–3)	3 (2–4)†,‡	2 (2–3)	2 (2–3)	14.1	0.008
Diet soft drinks	1 (1–2)	2 (1–3)†	1 (1–2)	2 (1–3)‡	20.9	<0.001
Fruit juices	5 (3–6)	6 (3.25–7)‡	4 (3–6)	5 (3–6)	40.3	0.007
Ice cream	2 (2–3)	2 (2–4)	2 (2–3)	3 (2–4)‡	25.1	0.001
Fast foods	2 (2–3)	3 (2–3)†,‡	2 (2–3)	3 (2–3)‡	20.6	<0.001

Note: Data are presented as median (IQR). Adjusted for age, gender, ethnicity, maturity offset, and moderate-to-vigorous physical activity. Corrected model: F = 2.25, p < 0.001. F, Wilks' lambda. IQR, interquartile range. High–low sedentary time was defined as above or below the median (511 min per day). High–low television times were defined as >2 h and ≤2 h per day, respectively. Bonferroni post hoc tests were used to determine significant differences between groups. Only food items that were significantly different between groups of total sedentary time and television viewing time are shown.

*Significantly higher than low sedentary–high television.

†Significantly higher than low sedentary–low television.

‡Significantly higher than high sedentary–low television.

that the mixed findings seen in the literature with respect to sedentary time and childhood obesity may be explained by food intake. Furthermore, these results may explain why both total sedentary time and bouts of sedentary time are not associated with health risk in children (Colley et al. 2013). Future intervention studies that aim to reduce the health impact of sedentary behaviours in children should thus focus on reducing the amount of time spent in specific sedentary behaviours, such as television viewing, as opposed to overall sedentary time.

The finding that sedentary time is negatively associated with the frequency of consumption of sports drinks, even after adjustment for covariates (including MVPA), is somewhat contrary to our hypothesis. The increase in the proportion of variance in the frequency of consumption of sports drinks from 3% to 14% with the addition of covariates suggests that factors such as MVPA or socioeconomic status play an important role in this association. Each additional hour of sedentary time was associated with a reduction in the frequency of consumption of sports drinks of ~1–2 sports drinks per week. This is an interesting finding because sports drinks have been criticized for their high sugar content and their potential to increase a child's risk of obesity (Committee on Nutrition and the Council on Sports Medicine and Fitness 2011); that children consume these drinks more frequently the less time they spend sedentary is intriguing. Future research should examine how children who consume these drinks frequently displace their sedentary time (i.e., with sport participation, independent of MVPA) and should also examine the contexts within which sports drinks are consumed.

The strengths of this study include the large sample of Canadian children, the robust data quality assurance procedures

(Katzmarzyk et al. 2013), and the inclusion of many confounding variables. Unique to this analysis is the mutual adjustment of television viewing time and sedentary time as a means of comparing the associations between these 2 measures of sedentary behaviour and food intake patterns. Finally, the use of both self-report and objective measures of sedentary behaviour was an asset. The current analysis also has several limitations. First, the direction of causality cannot be determined from cross-sectional data. Second, although we used a large sample of Canadian children, this sample is not nationally representative and therefore the results may not be generalizable. Third, the FFQ is limited in its ability to assess food intake because it does not account for food quantity, although the finding that frequency alone may differ among groups of varying sedentary time–television time is intriguing. Fourth, as with all self-report measures, the FFQ and screen time questionnaire are subject to recall and social desirability biases; however, these measures maximize feasibility for studies with large sample sizes and reduce participant burden.

Conclusion

Television viewing was negatively associated with the frequency of consumption of healthy food items and positively associated with the frequency of consumption of unhealthy food items, independent of covariates, MVPA, and total sedentary time. Sedentary time was negatively associated with the consumption of sport drinks, independent of confounders, MVPA, and television viewing time. It is thought that the association between sedentary behaviours and obesity in children may be driven by variations in dietary patterns; this paper provides evidence to suggest that television viewing better explains the variation in dietary patterns than does total sedentary time. Future intervention research should focus on reductions in television time, independent of total sedentary time, as a means of improving dietary patterns and potentially reducing childhood obesity.

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References

Baranowski, T., Cullen, K.W., and Baranowski, J. 1999. Psychosocial correlates of dietary intake: advancing dietary intervention. Annu. Rev. Nutr. **19**: 17–40. doi:10.1146/annurev.nutr.19.1.17.

Barreira, T.V., Staiano, A.E., and Katzmarzyk, P.T. 2013. Validity assessment of a portable bioimpedance scale to estimate body fat percentage in white and African-American children and adolescents. Pediatr. Obes. **8**: e29–e32. doi:10.1111/j.2047-6310.2012.00122.x. PMID:23239610.

Borghese, M., and Chaput, J. 2013. Television viewing promoting obesity in children: Do we really know the mechanism? Bioenergetics, **2**: e113.

Boynton-Jarrett, R., Thomas, T.N., Peterson, K.E., Wiecha, J., Sobol, A.M., and Gortmaker, S.L. 2003. Impact of television viewing patterns on fruit and vegetable consumption among adolescents. Pediatrics, **112**: 1321–1326. doi:10.1542/peds.112.6.1321. PMID:14654604.

Cain, N., and Gradisar, M. 2010. Electronic media use and sleep in school-aged children and adolescents: a review. Sleep Med. **11**: 735–742. doi:10.1016/j.sleep.2010.02.006. PMID:20673649.

Chaput, J., Janssen, I., and Spence, J. 2012*a*. Time spent sedentary and active and cardiometabolic risk factors in children. JAMA, **307**: 2024–2025. PMID:22665091.

Chaput, J., Lambert, M., Mathieu, M., Tremblay, M., O'Loughlin, J., and Tremblay, A. 2012*b*. Physical activity vs. sedentary time: independent associations with adiposity in children. Pediatr. Obes. **7**: 251–258. doi:10.1111/j.2047-6310.2011.00028.x. PMID:22461356.

Chaput, J., Saunders, T.J., Mathieu, M.-È., Henderson, M., Tremblay, M.S., O'Loughlin, J., and Tremblay, A. 2013. Combined associations between moderate to vigorous physical activity and sedentary behaviour with cardiometabolic risk factors in children. Appl. Physiol. Nutr. Metab. **38**: 477–483. doi:10.1139/apnm-2012-0382. PMID:23668753.

Chen, X., Beydoun, M.A., and Wang, Y. 2008. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. Obesity, **16**: 265–274. doi:10.1038/oby.2007.63. PMID:18239632.

Cliff, D.P., Okely, A.D., Burrows, T.L., Jones, R.A., Morgan, P.J., Collins, C.E., and Baur, L.A. 2013. Objectively measured sedentary behavior, physical activity, and plasma lipids in overweight and obese children. Obesity, **21**: 382–385. doi:10.1002/oby.20005. PMID:23404925.

Colley, R.C., Garriguet, D., Janssen, I., Wong, S.L., Saunders, T.J., Carson, V., and Tremblay, M.S. 2013. The association between accelerometer-measured patterns of sedentary time and health risk in children and youth: results from the Canadian Health Measures Survey. BMC Public Health, **13**: 200. doi:10.1186/1471-2458-13-200. PMID:23497190.

Committee on Nutrition and the Council on Sports Medicine and Fitness. 2011. Sports drinks and energy drinks for children and adolescents: are they appropriate? Pediatrics, **127**: 1182–1189. doi:10.1542/peds.2011-0965. PMID:21624882.

Coon, K.A., Goldberg, J., Rogers, B.L., and Tucker, K.L. 2001. Relationships between use of television during meals and children's food consumption patterns. Pediatrics, **107**: e7. doi:10.1542/peds.107.1.e7. PMID:11134471.

Currie, C., Nic Gabhainn, S., Godeau, E., Roberts, C., Smith, R., Currie, D., Pickett, W., et al. 2008. Inequalities in children's health: HBSC International Report from the 2005/2006 Survey. World Health Organization, Geneva.

Dietz, W.H., and Gortmaker, S.L. 1985. Do we fatten our children at the television set? Obesity and television viewing in children and adolescents. Pediatrics, **75**: 807–812. PMID:3873060.

Ekelund, U., Luan, J., Sherar, L.B., Esliger, D.W., Griew, P., Cooper, A., and International Children's Accelerometry Database (ICAD) Collaborators. 2012. Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. JAMA, **307**: 704–712. doi:10.1001/jama.2012.156. PMID:22337681.

Epstein, L.H., Roemmich, J.N., Robinson, J.L., Paluch, R.A., Winiewicz, D.D., Fuerch, J.H., and Robinson, T.N. 2008. A randomized trial of the effects of reducing television viewing and computer use on body mass index in young children. Arch. Pediatr. Adolesc. Med. **162**: 239–245. doi:10.1001/archpediatrics.2007.45. PMID:18316661.

Evenson, K.R., Catellier, D.J., Gill, K., Ondrak, K.S., and McMurray, R.G. 2008. Calibration of two objective measures of physical activity for children. J. Sports Sci. **26**: 1557–1565. doi:10.1080/02640410802334196. PMID:18949660.

French, S.A., Story, M., Neumark-Sztainer, D., Fulkerson, J.A., and Hannan, P. 2001. Fast food restaurant use among adolescents: associations with nutrient intake, food choices and behavioral and psychosocial variables. Int. J. Obes. Relat. Metab. Disord. **25**: 1823–1833. doi:10.1038/sj.ijo.0801820. PMID:11781764.

Fuller-Tyszkiewicz, M., Skouteris, H., Hardy, L.L., and Halse, C. 2012. The associations between TV viewing, food intake, and BMI. A prospective analysis of data from the longitudinal study of Australian children. Appetite, **59**: 945–948. PMID:23000277.

Hart, C.N., Carskadon, M.A., Considine, R.V., Fava, J.L., Lawton, J., Raynor, H.A., Jelalian, E., et al. 2013. Changes in children's sleep duration on food intake, weight, and leptin. Pediatrics, **132**: e1473–1480. doi:10.1542/peds.2013-1274. PMID:24190680.

Herman, K.M., Paradis, G., Mathieu, M.-E., O'Loughlin, J., Tremblay, A., and Lambert, M. 2013. Association between accelerometer-measured physical activity intensities and sedentary time in 8–10 year old children. Pediatr. Exerc. Sci. **26**(1): 76–85. doi:10.1123/pes.2012-0128. PMID:24018974.

Katzmarzyk, P.T., Barreira, T., Broyles, S.T., Champagne, C., Chaput, J., Fogelholm, M., Hu, G., et al. 2013. The International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE): design and methods. BMC Public Health, **13**: 900. doi:10.1186/1471-2458-13-900. PMID:24079373.

Lubans, D.R., Hesketh, K., Cliff, D.P., Barnett, L.M., Salmon, J., Dollman, J., Morgan, P.J., et al. 2011. A systematic review of the validity and reliability of sedentary behaviour measures used with children and adolescents. Obes. Rev. **12**: 781–799. doi:10.1111/j.1467-789X.2011.00896.x. PMID:21676153.

Mirwald, R.L., Baxter-Jones, A.D.G., Bailey, D.A., and Beunen, G.P. 2002. An assessment of maturity from anthropometric measurements. Med. Sci. Sports Exerc. **34**: 689–694. doi:10.1097/00005768-200204000-00020. PMID:11932580.

Mitchell, J., Pate, R.R., Beets, M.W., and Nader, P.R. 2013*a*. Time spent in sedentary behavior and changes in childhood BMI: a longitudinal study from ages 9 to 15 years. Int. J. Obes. (Lond.), **37**: 54–60. doi:10.1038/ijo.2012.41.

Mitchell, J., Pate, R.R., and Liese, A.D. 2013*b*. Changes in cardiovascular disease risk factors from age 9 to 19 and the influence of television viewing. Obesity (Silver Spring), **21**: 386–393. doi:10.1002/oby.20014.

Neumark-Sztainer, D., Wall, M., Perry, C., and Story, M. 2003. Correlates of fruit and vegetable intake among adolescents. Findings from Project EAT. Preventive Medicine, **37**(3): 198–208.

Pearson, N., and Biddle, S.J.H. 2011. Sedentary behavior and dietary intake in children, adolescents, and adults. A systematic review. Am. J. Prev. Med. **41**: 178–188. doi:10.1016/j.amepre.2011.05.002.

Reynolds, K.D., Hinton, A.W., Shewchuk, R.M., and Hickey, C.A. 1999. Social cognitive model of fruit and vegetable consumption in elementary school

children. Journal of Nutrition Education and Behavior, **31**(1): 23–30. doi:10.1016/S0022-3182(99)70381-X.

Robinson, T.N. 2001. Television viewing and childhood obesity. Pediatric Clinics of North America, **48**: 1017–1025. doi:10.1016/S0031-3955(05)70354-0. PMID:11494635.

Rogol, A.D., Roemmich, J.N., and Clark, P.A. 2002. Growth at puberty. J. Adolesc. Health, **31**: 192–200. doi:10.1016/S1054-139X(02)00485-8.

Santaliestra-Pasías, A.M., Mouratidou, T., Verbestel, V., Huybrechts, I., Gottrand, F., Le Donne, C., Cuenca-García, M., et al. 2012. Food consumption and screen-based sedentary behaviors in European adolescents: the HELENA study. Arch. Pediatr. Adolesc. Med. **166**: 1010–1020. doi:10.1001/archpediatrics.2012.646. PMID:22945250.

Schmitz, K.H., Harnack, L., Fulton, J.E., Jacobs, D.R., Gao, S., Lytle, L.A., and Van Coevering, P. 2004. Reliability and validity of a brief questionnaire to assess television viewing and computer use by middle school children. J. School Health, **74**: 370–377. doi:10.1111/j.1746-1561.2004.tb06632.x. PMID:15656264.

Stang, J., and Story, M. 2005. Adolescent growth and development. *In* Guidelines for adolescent nutrition services. Center for Leadership, Education and Training in Maternal and Child Nutrition, University of Minnesota.

Statistics Canada. 2012. Focus on geography series, 2011 Census. Available from http://www12.statcan.ca/census-recensement/2011/as-sa/fogs-spg/Facts-cma-eng.cfm?LANG=Eng&GK=CMA&GC=505. [Accessed 10 February 2014.]

Tremblay, M.S., Colley, R.C., Saunders, T.J., Healy, G.N., and Owen, N. 2010. Physiological and health implications of a sedentary lifestyle. Appl. Physiol. Nutr. Metab. **35**: 725–740. doi:10.1139/H10-079. PMID:21164543.

Tremblay, M.S., Leblanc, A., Janssen, I., Kho, M., Hicks, A., Murumets, K., Colley, R., et al. 2011*a*. Canadian sedentary behaviour guidelines for children and youth. Appl. Physiol. Nutr. Metab. **36**: 59–64; 65–71. doi:10.1139/H11-012. PMID:21326378.

Tremblay, M.S., LeBlanc, A., Kho, M., Saunders, T., Larouche, R., Colley, R., Goldfield, G., et al. 2011*b*. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. Int. J. Behav. Nutr. Phys. Act. **8**: 98. doi:10.1186/1479-5868-8-98. PMID:21936895.

Tudor-Locke, C., Barreira, T.V., Schuna, J.M., Mire, E.F., and Katzmarzyk, P.T. 2014. Fully automated waist-worn accelerometer algorithm for detecting children's sleep-period time separate from 24-h physical activity or sedentary behaviors. Appl. Physiol. Nutr. Metab. **39**: 53–57. doi:10.1139/apnm-2013-0173. PMID:24383507.

US Youth Risk Behavior Surveillance System. 2011. Centers for Disease Control and Prevention - YRBSS - Youth Risk Behavior Surveillance System - Adolescent and School Health. Available from http://www.cdc.gov/HealthyYouth/yrbs/. [Accessed 10 July 2013.]

Vereecken, C.A., and Maes, L. 2003. A Belgian study on the reliability and relative validity of the health behaviour in school-aged children food-frequency questionnaire. Public Health Nutr. **6**: 581–588. doi:10.1079/PHN2003466. PMID:14690039.

Vereecken, C.A., Todd, J., Roberts, C., Mulvihill, C., and Maes, L. 2006. Television viewing behaviour and associations with food habits in different countries. Public Health Nutr. **9**: 244–250. doi:10.1079/PHN2005847. PMID:16571179.

Wiecha, J., Peterson, K.E., Ludwig, D., Kim, J., Sobol, A.M., and Gortmaker, S.L. 2006. When children eat what they watch: impact of television viewing on dietary intake in youth. Arch. Pediatr. Adolesc. Med. **160**: 436–442. doi:10.1001/archpedi.160.4.436. PMID:16585491.

Wong, S.L., Colley, R., Connor Gorber, S., and Tremblay, M. 2011. Actical accelerometer sedentary activity thresholds for adults. J. Phys. Act. Health, **8**: 587–591. PMID:21597132.