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Sedentary behavior and dietary intake in children, adolescents and adults: A systematic review.

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Sedentary Behavior and Dietary Intake in Children, Adolescents and Adults

A systematic review

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Context: Sedentary behavior is implicated in youth and adult overweight and obesity.

However, the relationship between sedentary behavior and weight status is often small or inconsistent with few studies controlling for confounding factors such as diet and physical activity. Diet has been hypothesized to co-vary with some sedentary behaviors. It is opportune, therefore, to review whether dietary intake is associated with sedentary behavior in young people and adults. This may allow for better interpretation of the diversity of findings concerning sedentary behavior and weight status.

Evidence acquisition: Published English language studies were located from computerized and manual searches in early 2010. Included studies were observational studies assessing an association between at least one sedentary behavior and at least one aspect of dietary intake in children (<11 years), and/or adolescents (12-18 years), and/or adults (>18 years).

Evidence synthesis: 53 studies (k), totaling 111 independent samples were eligible for this review. Sedentary behavior in children (k=19; independent samples=24), adolescents (k=26; independent samples=72), and adults (k=11; independent samples=14) appears to be clearly associated with elements of a less healthy diet including lower fruit and vegetable consumption, higher consumption of energy-dense snacks, drinks and fast foods, and higher total energy intake. Strength of associations were mainly in the range of small-to-moderate.

Conclusions: The association drawn mainly from cross-sectional studies is that sedentary behavior, usually assessed as screen time and predominantly TV viewing, is associated with unhealthy dietary behaviors in children, adolescents and adults. Interventions need to be developed that target reductions in sedentary time to test whether diet also changes.

Context

Sedentary behavior is rapidly emerging as an important issue in public health. Researchers are now investigating the role of sedentary behavior in diverse health outcomes. Typically, researchers have defined 'sedentary' as not meeting a criterion level of physical activity. However, by sedentary behavior we are referring to very low levels of energy expenditure through sitting and lying. Excessive sitting time is essentially the main concern for sedentary behavior researchers.^{1,2}

Studies are now showing associations between sedentary behavior (usually assessed as screen-based behaviors such as TV and computer use), and a range of health outcomes, including all-cause mortality and cardiovascular disease,^{3,4} adverse metabolic profile,⁵ and obesity.⁶ However, relationships are not always consistent across age, gender or health outcomes. For example, while there has been a longstanding assumption that TV viewing in youth is associated with overweight and obesity,⁷ a meta-analysis of mainly cross-sectional studies found that the strength of such an association was actually very small.⁸ Moreover, a review of sedentary behavior intervention studies showed inconsistent weight loss for young people.⁹ In addition, while cross-sectional data on screen time in 10-16 year olds from 34 countries showed higher degrees of overweight with increased TV viewing in 65% of the countries, this leaves more than one-third having no association.¹⁰ Overall, therefore, sedentary behavior in the form of screen time is implicated in youth overweight and obesity, but findings are less clear cut than some claim.

Prospective observational cohort studies in adults offer stronger evidence of an association between sedentary behavior and weight status in comparison to the cross-sectional studies typical in the literature on young people. For example, parent- and self-reported time spent watching television between 5 and 15 years in New Zealand was shown to predict BMI at 26 years of age. The Nurses Health Study of over 50,000 women¹¹ showed that those who were normal weight or overweight at baseline had a 23% increased risk of developing obesity during 6 years of follow-up for each 2-hour per day increment in time spent watching TV. In a study of over 18,000 women, Blanck et al¹² reported no significant prospective association between self-reported leisure sitting time and weight gain over 6 years. However, an elevated risk of weight gain was observed in those women who were normal weight at baseline and reporting more than 6 hours of leisure time sitting compared to those who reported less than 3 hours/day. For adults, therefore, associations between sedentary behavior and weight status are suggestive but mixed, although review level, mainly cross-sectional, data support a positive association.¹³ However, studies either do not control for confounding factors, such as diet or physical activity, or this is done inconsistently across studies. One variable that has been hypothesized to co-vary with some sedentary behaviors, and in particular TV viewing, is diet.

For adults and young people, during the time spent watching television, little energy is expended,¹⁴ and viewers are exposed to numerous advertisements that can influence the type of food desired and consumed.^{15, 16} Furthermore, TV may be a distraction resulting in a lack of awareness of actual food consumption or overlooking food cues, leading to overconsumption.¹⁷ It is opportune, therefore, to review whether dietary intake is associated with sedentary behavior in young people and adults. This may assist researchers in better interpreting the diversity of findings concerning sedentary behavior and weight status.

Evidence Acquisition

This study followed the procedures for a systematic review produced by the NHS Centre for Reviews and Dissemination.¹⁸

Search strategy

Search strategies were built around four groups of keywords: sedentary behavior, dietary behavior, study type, and sample type. Key terms for sedentary behaviors were used in combination with key terms for dietary behavior, study type and sample type to locate potentially relevant studies. Science Direct, PubMed, PsychINFO, and Web of Science databases were searched using the key terms in early 2010. In addition, manual searches of personal files were conducted along with screening of reference lists of primary studies and identified articles for titles that included the key terms.

Inclusion and exclusion criteria

For inclusion, studies were required to (i) include children aged ≤ 11 years, and/or adolescents aged 12–18 years, and/or adults aged >18 years (or a mean within these ranges) as subjects of study at baseline. Studies that did not state the mean age of participants were classified as pre-school children, school-aged children, adolescents or adults depending on the ages of the majority of the sample; (ii) have a point estimate (mean) of at least one aspect of dietary intake (or data showing prevalence) and have a point estimate (mean) of at least one sedentary behavior (or data showing prevalence); (iii) be observational and assess an association between at least one sedentary behavior and at least one aspect of dietary intake; (iv) be published in peer-reviewed journals in the English language; and (v) be published up

to and including January 2010. Experimental studies that manipulated a sedentary behavior and/or aspects of dietary intake were excluded.

Identification of relevant studies

Potentially relevant articles were selected by (i) screening the titles; (ii) screening the abstracts; and (iii) if abstracts were not available or did not provide sufficient data, the entire article was retrieved and screened to determine whether it met the inclusion criteria.

Data extraction

Data were extracted on standardized forms developed for this review between January and July 2010. This information is summarized in Tables 1 and 2. In addition, the reliability and validity of measures of sedentary behavior and dietary intake, and the response rates of each study were extracted (data not shown in tables).

Identified sedentary and dietary behaviors were tabulated to highlight the state of the literature for the associations between sedentary behavior and diet for children (Table 3), adolescents (Table 4), and adults (Table 5). A large number of dietary behaviors have been studied in association with sedentary behaviors (predominantly television viewing) (see Tables 1 and 2). 20% of the data extraction forms, containing data from the whole data extraction process, were double checked and discrepancies over the extracted data (n=7) were resolved through discussion.

Coding associations between sedentary behavior and diet

An independent sample was used as the unit of analysis and was defined as the smallest independent sub-sample for which relevant data were reported (e.g. boys/girls).¹⁹ The column 'number of samples' displays the number of samples that have been studied for each dietary behavior. The 'summary' column contains the number of samples, and references, finding positive (+), inverse (-) and no (0) associations between sedentary behavior and dietary behaviors.

Study quality

The quality of the studies included in the review was assessed. Studies were given scores (0-2) based on the sample size, sampling methods, response rates, their level of reporting the reliability and validity of measures used to assess sedentary behavior and dietary intake, and whether or not confounders had been included in analyses (full details available from corresponding author). Study quality scores could range from 0 to 16, with higher scores meaning higher quality studies.

In addition, the strength of association with reference to conventions (details and references available from first author) was assessed. Essentially, the strength of association was graded as 'none', 'small', 'medium', or 'large' for data using Pearson correlation (r), standardised regression coefficient (β), multiple regression (R , partial R , R^2 , partial R^2), Cohen's d effect size, and odds ratio.

Evidence Synthesis

The literature searches yielded 15,645 titles of potentially relevant articles and 53 (111 samples) were eligible for this review. Results are reported separately for children, adolescents, and adults.

Associations between sedentary behavior and diet in children

Nineteen studies (24 samples) of children were eligible for review (see Table 1). The majority of studies were conducted in the USA (n=13). Fifteen studies examined associations between sedentary behaviors and dietary outcomes for boys and girls combined, three examined associations separately for boys and girls, and one examined associations for girls only. The majority used a cross-sectional design (n=13), eight of the studies assessed sedentary behaviors through self-report, eight through parent report, and three using an interviewer, with a questionnaire being the most frequently used measure (n=17). Dietary behaviors were most commonly assessed through self-report (n=9), and parent report (n=8), with a food frequency questionnaire (FFQ) being the most used measure (n=12). The average sample size was 1184 (range 66–6235). Study quality scores for studies (K) including children ranged from 2/16 to 9/16, median=8 (scores: 9: K=3²⁰⁻²²; 8: K=6²³⁻²⁸; 7: K=2,^{29, 30} 6: K=3,³¹⁻³³ 5: K=2,^{34, 35} 4,³⁶ 3,³⁷ and 2³⁸; K=1 each).

Television viewing was the most commonly assessed sedentary behavior in association with dietary intake, studied in 19 samples (79%). Twenty-five dietary behaviors were identified, and for brevity dietary behaviors that were studied most often and dietary behaviors that are important in their contribution to the healthfulness of overall diet were tabulated (Table 3). Television viewing was inversely associated with fruit consumption in three out of three samples, and with vegetable consumption in three out of four samples. Sedentary behavior

(one study assessed screen time and two assessed TV viewing) was inversely associated with a composite measure of fruit and vegetable consumption (FV) in three out of three samples.

Television viewing was positively associated with energy-dense snack consumption in eleven samples, and not associated in four. Television viewing was positively associated with fast food consumption in seven samples and not associated in one. Television viewing was positively associated with energy-dense drinks in seven out of seven samples, positively associated with total energy intake in eight of eleven samples, and positively associated with percentage energy from fat in two out of two samples.

There were five longitudinal studies (nine independent samples) assessing the association between sedentary behavior and dietary intake in children;^{23, 26, 28, 33, 38} three out of these five studies scored higher than the median score for study quality (median =8/16), corroborating the results found from cross-sectional studies showing that TV viewing was inversely associated with fruit and vegetable consumption,²³ and positively associated with total energy intake,^{26, 28} energy-dense drinks, snacks and fast foods.²⁸ Overall, therefore, sedentary behavior in children appears to be clearly associated with elements of a less healthy diet.

Associations between sedentary behavior and diet in adolescents

Twenty-six studies (72 samples) of adolescents were eligible for review (see Table 1). Half of the studies were conducted in the USA (n=13). Fourteen studies examined associations between sedentary behaviors and dietary outcomes for boys and girls combined, 11 examined associations separately for boys and girls, and one examined associations for girls only. The majority used a cross-sectional design (n=21), all of the studies assessed sedentary behaviors through self-report, with a questionnaire being the most frequently used measure (n=25). All

of the studies assessed dietary behaviors through self-report, with a FFQ being the most frequently used measure (n=13). The average sample size was 8356 (range 60–14,407). Study quality scores for studies including adolescents ranged from 2/16 to 12/16, median=8 (scores: 12: K=3;³⁹⁻⁴¹ 11: K=1;⁴² 10: K=3;⁴³⁻⁴⁵ 9: K=; ²² 8: K=3;^{24, 27, 46} 7: K=2 ;^{47, 48} 6: K=7;⁴⁹⁻⁵⁵ 5: K=1;⁵⁶ 3: K=3;⁵⁷⁻⁵⁹ 2: K=2^{60, 61}).

Screen time was the most commonly assessed sedentary behavior in association with dietary intake, studied in 46 samples (64%). Twenty-seven dietary behaviors were identified, and for brevity dietary behaviors that were studied most often and are important in their contribution to the healthfulness of overall diet were tabulated (Table 4). Sedentary behavior was inversely associated with fruit consumption in 30 samples (23 assessed screen time and 7 assessed TV viewing), and not associated with fruit consumption in 18 samples (16 assessed screen time and 2 assessed TV viewing). Sedentary behavior was inversely associated with vegetable consumption in 26 samples (23 assessed screen time and 3 assessed TV viewing), and not associated in 18 samples (16 assessed screen time and 2 assessed TV viewing). Sedentary behavior was negatively associated with a composite measure of fruit and vegetable consumption (FV) in five samples (3 assessed screen time and 2 assessed TV viewing), and not associated in two.

Sedentary behavior was positively associated with energy-dense snack consumption in 42 samples (39 assessed screen time and 3 assessed TV viewing), and not associated in nine (2 assessed screen time and 7 assessed TV viewing). Sedentary behavior was positively associated with fast food consumption in five samples (1 assessed screen time and 4 assessed TV viewing) and not associated in five (1 assessed screen time and 4 assessed TV viewing).

Screen time was positively associated with fried food consumption in three samples, and not associated in one. Sedentary behavior was positively associated with energy-dense drinks in 42 samples (39 assessed screen time and 5 assessed TV viewing), and not associated in five (1 assessed screen time and 4 assessed TV viewing). Sedentary behavior was positively associated with total energy intake in three samples (3 assessed screen time), and not associated in six (4 assessed screen time and 2 assessed TV viewing). Sedentary behavior was positively associated with percentage energy from fat in five samples (5 assessed screen time), and not associated in five (3 assessed screen time and 2 assessed TV viewing). Sedentary behavior was positively associated with total fat in three samples (2 assessed screen time and 1 assessed TV viewing), and not associated in five (1 assessed screen time and 4 assessed TV viewing). Sedentary behavior was inversely associated with fibre in three samples (2 assessed screen time and 1 assessed TV viewing), and not associated in three (1 assessed screen time and 2 assessed TV viewing).

There were five longitudinal studies (ten independent samples) assessing the association between sedentary behavior and dietary intake in adolescents;^{39, 43, 44, 46, 54} four out of these five studies scored higher than the median score for study quality (median = 8/16), corroborating the results found from cross-sectional studies showing that TV viewing was inversely associated with fruit and vegetable consumption,^{43, 44, 46} and positively associated with energy-dense drinks.³⁹ Overall, therefore, sedentary behavior in adolescents appears to be clearly associated with elements of a less healthy diet, and in particular with higher consumption of energy-dense snacks and drinks and lower consumption of fruits and vegetables.

Associations between sedentary behavior and diet in adults

Eleven studies (14 samples) of adults were eligible for review (see Table 2). The majority of studies were conducted in the USA (n=8). Five studies examined associations between sedentary behaviors and dietary outcomes for men and women combined, two examined associations separately for men and women, three examined associations for women only, and one examined associations for men only. The majority used a cross-sectional design (n=7), and all of the studies assessed sedentary behaviors through self-report, with a questionnaire being the most frequently used measure (n=10). All but one of the studies assessed dietary behaviors through self-report, with a FFQ being the most used measure (n=7). The average sample size was 11,044 (range 74–50,277). Study quality scores for studies including adults ranged from 3/16 to 8/16, median=7.5 (scores: 8: K=4;⁶²⁻⁶⁵ 7: K=1;⁶⁶ 5: K=3;⁶⁷⁻⁶⁹ 4: K=2;^{70, 71} 3: K=1¹¹).

Television viewing was the most commonly assessed sedentary behavior in association with dietary intake, studied in 12 samples (86%). Twenty-two dietary behaviors were identified, and for brevity dietary behaviors that were studied most often and dietary behaviors that are important for the healthfulness of overall diet were tabulated (Table 5). Television viewing was inversely associated with fruit consumption in three samples, with vegetable consumption in three samples and with a composite measure of fruit and vegetable consumption (FV) in two samples.

Sedentary behavior was positively associated with energy-dense snack consumption in four out of four samples (1 assessed screen time and 3 assessed TV viewing), with fast food consumption in three out of three samples (3 assessed TV viewing), and with energy-dense drinks in two out of two samples (1 assessed screen time and 1 assessed TV viewing).

Sedentary behavior was positively associated with total energy intake in five samples (1 assessed screen time and 4 assessed TV viewing), and not associated in two. Sedentary behavior was positively associated with percentage energy from fat in one sample, and not associated in three (1 assessed screen time and 2 assessed TV viewing). Sedentary behavior was positively associated with total fat in three samples (1 assessed screen time and 2 assessed TV viewing), and not associated in one. Sedentary behavior was inversely associated with fibre in three out of three samples (1 assessed screen time and 2 assessed TV viewing).

There was one longitudinal study assessing the association between sedentary behavior and dietary intake in adults.⁶⁴ This study scored higher than the median score for study quality (median = 7.5/16), and corroborated the results found from cross-sectional studies showing that TV viewing was positively associated with consumption of energy-dense snacks.⁶⁴ Overall, therefore, sedentary behavior in adults appears to be clearly associated with elements of a less healthy diet.

Potential moderators

Age

Five studies examined age as a potential moderator of the association between sedentary behavior and diet.^{22, 24, 27, 35, 39} One study examined differences in the association between sedentary behavior and diet between two groups of pre-school children (aged 2-3.9 years and 4-5.9 years).³⁵ Three studies examined differences between groups of children (age ranged from 5-10 years or those in school grades 4-5) and adolescents (age 11+ or those in school grades 6-12).^{22, 24, 27} One study examined differences between two groups of adolescents (aged 12.8 years and 15.9 years).³⁹ Overall, there appears to be no clear pattern for age acting

as a moderator. However, the number of comparisons is quite small and the studies too diverse to draw meaningful conclusions.

Gender

Gender differences in the association between sedentary and eating behaviors were examined in three studies of children,^{26, 29, 31} 10 studies of adolescents,^{40, 42-44, 46, 51, 53-55, 59} and two studies of adults.^{65, 66} No gender differences were found in two out of the three studies that examined gender differences among children^{26, 31} and no gender difference were found in five out of the ten studies examining gender differences among adolescents.^{40, 44, 51, 53, 55} Gender differences were found in one of the two studies among adults.⁶⁶ Overall, there appear to be more consistent associations between sedentary behavior and diet for females than for males.

Discussion

The purpose of this systematic review was to assess whether patterns of dietary intake were associated with sedentary behavior. The relationship between sedentary behavior and weight status is often small or inconsistent^{8, 13, 72} and this may be explained by the moderating effect of diet, especially dietary intake during certain types of sedentary behaviors, such as TV viewing.

Results show a clear association, usually in the small-to-moderate range, between sedentary behavior and unhealthy dietary intake. This is reflected in higher consumption of energy dense snacks and less consumption of fruits and vegetables, and this is consistent across age groups studied.

For children, television viewing was consistently inversely associated with fruit and vegetable consumption and positively associated with consumption of energy-dense snacks and drinks, total energy intake, and fast foods. Sedentary behavior in adolescents is also clearly associated with elements of a less healthy diet, and in particular with higher consumption of energy-dense snacks and drinks and lower consumption of fruits and vegetables. Overall, therefore, diet and sedentary behavior in young people is coupled and may better explain associations between sedentary behavior and weight status than other behaviors, such as a displacement of physical activity. Review-level data shows the association between weight status and screen time in young people to be quite small⁸ and this could be explained by our findings. Given that physical activity can co-exist with screen time⁸, and dietary behaviors associated with sedentary time may not necessarily reflect consumption of food and drink at other times, the association between screen time and weight status is likely to exist but be small or inconsistent, notwithstanding the well known problems in the use of self-report measures for both exposure and outcome variables.

Of concern might be the early socializing of children into sedentary habits and the association with poor diet. Young people may associate television viewing with eating from a young age if, for example, parents place their children in front of the television with a snack or a meal while they do other household chores.⁷³ For some young people a significant proportion of their daily energy intake is consumed while watching television.⁷⁴ Experimental studies have shown that watching television while eating may cause a distraction resulting in a delay in normal mealtime satiation and a reduction in internal satiety signals,^{75, 76}. It is less likely that console computer games will have the same effect, although data are not able to clearly separate different screen behaviors. If more active computer games are undertaken in place of

seated games, sedentary time could be reduced, energy expenditure will rise,⁷⁷ and consumption of unhealthy foods and drinks may decrease. The role of other sedentary behaviors in dietary consumption of young people is much less clear, and warrants further research.

Evidence suggests that an important ‘window’ of opportunity to reduce sedentary behaviors and increase physical activity in young people is the period immediately after school.⁷⁸ If children and adolescents spend a high proportion of these hours sedentary in front of a screen, unhealthy dietary consumption will be more likely and physical activity less likely. This time of the day is thought to be important because it is one of the most obvious times for physical activity involvement, but more evidence is needed, including the role of diet⁷⁸

The association between sedentary behavior and diet in adults was similar to that of young people, although was slightly less pronounced. Influences will be different from that of young people, although there is little evidence on the key correlates of sedentary behavior in adults^{1, 79}. Overall sedentary time will be strongly influenced by work as well as leisure time factors, and family structures and rules regarding both sedentary and diet behaviors are more controllable for adults. However, adult behaviors are also associated with the behavior of their offspring, and a review of parental correlates of fruit and vegetable consumption in young people shows that intake of the parent is associated with that of their children.⁸⁰ Moreover, TV viewing habits of parents is associated with that of their children.⁸¹ Interventions may need to target adults and children together.⁸²

The limitations of this review include the over-reliance on cross-sectional studies and the use of self-report measures of sedentary and dietary behaviors that lack strong validity. Moreover, sedentary behavior is largely operationally defined as screen time, and this is

mainly TV viewing, making it difficult to draw any conclusions regarding non-screen time and dietary intake. Moreover, while 'screen time' can include TV and computer use, this does not help in identifying whether it is TV, computer use, or both, that is associated with unhealthy diets. More studies using objective measures of sedentary behaviors and more valid and reliable measures of dietary intake are required.

There is also a need to examine the longitudinal association between sedentary behavior and dietary intake, and the tracking of the clustering of specific sedentary behaviors and specific dietary behaviors. For example, it appears from the mainly cross-sectional evidence presented that TV viewing is associated with unhealthy dietary patterns. Much less is known about diet and either computer use or sedentary motorized transport. It is likely that the main associations will be with TV, but this needs testing. A focus on sedentary behaviors and dietary behaviors that 'share' determinants, as well as determinants of the clustering of sedentary and dietary behaviors will aid the development of targeted interventions to reduce sedentary behaviors and promote healthy eating.

In conclusion, the association drawn mainly from cross-sectional studies is that sedentary behavior, usually assessed as screen time and predominantly TV viewing, is associated with unhealthy dietary behaviors in children, adolescents and adults. Notwithstanding the methodological weaknesses of the evidence base, there is sufficient consistency to suggest that this is an important set of results. However, interventions need to be developed that target reductions in sedentary time to test whether diet also changes.

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Table 1. Characteristics of child and adolescent studies included in the review

Comment [BL1]: This table is very difficult to read, please revise.

	Children (<11 years)	No. of samples	Adolescents (12-18 years)	No. of samples
	References		References	
Sample size		24		72
<100	35 II, 36, 38 I	3	59 B/G, 60	3
100-199	33 G, 35 I, 38 II	3	42 B, 49, 51 B, 51 G, 54 B, 54 G	6
200-299	26 B, 26 G, 31 B, 31 G	4		
300-499			26, 50, 52, 57, 58 G	5
500-999	20, 21, 23, 28, 37	5	39 I, 41 VI, 43 B, 43 G, 44 B, 44 G, 46 B, 46 G, 61	9
1000-2999	22 I, 24 I, 25, 29 B, 29G, 30, 32, 34	8	22 II, 24 II, 24 III, 39 II, 40 B, 40 G, 41 XXII, 41 XXIII, 41 XXV, 41 XXVIII, 41 XXXI, 47	12
3000-4999			41 I-V, 41 VII-XV, 41 XVIII-XXI, 41 XXVII, 41 XXX, 41 XXXII-XXXV, 55 B, 55 G	26
>5000	27 I	1	27 II, 53 B, 53 G, 48, 56, 41 XVI, 41 XVII, 41 XXIV, 41 XXVI, 41 XXIX, 45	11
Gender				
Girls only	33	1	50	1
Boys and girls combined	20, 21, 22 I, 23, 24 I, 25, 27 I, 28, 30, 32, 34, 35 I II, 36, 37, 38 I II	17	22 II, 24 II III, 27 II, 39 I II, 41 I-XXXV, 45, 47, 48, 49, 52, 56, 57, 58, 60, 61	51
Boys and girls separately	26, 29, 31	6	40, 42, 43, 44, 46, 51, 53, 54, 55, 59	20
Study design				
Cross sectional	20, 21, 22 I, 24 I, 25, 27 I, 29 B/G,	15	22 II, 24 II III, 27 II, 40 ⁴ B/G, 41 ⁵ I-	62

	30, 32, 34, 35 I II, 36		XXXV, 42 B/G, 45 ⁵ , 47, 48, 49, 50, 51 B/G, 52, 53 B/G, 55 B/G, 56 ⁵ , 57, 58, 59 B/G, 60, 61	
Longitudinal	23 ³ , 26 ^{2,3} B/G, 28 ^{2,3} , 31 ¹ B/G, 33 G, 38 ¹ I II	9	39 ⁴ I II, 43 ⁴ B/G, 44 ⁴ B/G, 46 ⁴ B/G, 54 ² B/G	10
Sedentary behavior assessed				
TV viewing	20, 21, 22 I, 23, 25, 26 B/G, 27 I, 28, 29 B/G, 30, 32, 33 G, 34, 36, 37, 38 I II	19	22 II, 27 II, 42 B/G, 43 B/G, 44 B/G, 45, 46 B/G, 47, 48, 49, 50, 51 B/G, 53 B/G, 57, 58, 59 B/G	21
Screen time (TV + video + DVD)	24 I, 26 B/G, 31 B/G, 35 I II	7	24 II III, 39 I II, 40 B/G, 41 I-XXXV, 52, 55 B/G, 56, 60	46
Sedentary time (TV + video + DVD + sitting while talking on phone/listening to music)			54 B/G	2
Computer use	34	1	40 B/G	2
Inactivity (sum of sleeping, lying sitting or standing)	33 G	1		
Reading / doing homework	26 B/G	2	40 B/G, 60	3
Weekend screen time			60	1
Weekend homework			60	1
Sitting in a car (weekday)			60	1
Sitting in a car (weekend day)			60	1
High sedentary cluster (high TV, computer, sitting, homework and reading)			61	1
Assessment of sedentary behavior				
Self-report	21, 23, 24 I, 26 B/G, 27 I, 28, 33 G, 37	9	22 II, 24 II III, 27 II, 39 I II, 40 B/G, 41 I-XXXV, 42 B/G, 43 B/G, 44 B/G, 45, 46 B/G, 47, 48, 49, 50, 51 B/G, 52, 53 B/G, 54 B/G, 55 B/G, 56, 57, 58, 59 B/G, 60, 61	72

Parent report	20, 22 I, 25, 30, 32, 34, 35 I II, 38 I II	10		
Interviewer administered	29 B/G, 31 B/G, 36	5		
Measure of sedentary behavior				
Questionnaire	20, 21, 22 I, 23, 24 I, 25, 26 B/G, 27 I, 28, 29 B/G, 30, 32, 34, 35 I II, 36, 37, 38 I II	21	22 II, 24 II III, 27 II, 39 I II, 40 B/G, 41 I-XXXV, 42 B/G, 43 B/G, 44 B/G, 45, 46 B/G, 47, 48, 49, 50, 51 B/G, 52, 53 B/G, 54 B/G, 55 B/G, 56, 57, 58, 60, 61	70
24-hour recall	31 B/G, 33 G	3	59 B/G	2
Dietary behavior assessed				
Fruit	22 I, 30, 34	3	22 II, 39 I II, 40 B/G, 41 I-XXXV, 42 B/G, 44 B/G, 45, 48, 59 B/G	48
Vegetables	20, 22 I, 30, 34	4	22 II, 39 I II, 40 B/G, 41 I-XXXV, 44 B/G, 45, 48	44
Fruit and Vegetable (FV)	23, 24 I, 25	3	24 II III, 53 B/G, 54 B/G, 61	7
ED drinks / soft drinks	20, 22 I, 25, 28, 30, 34, 37	7	22 II, 39 I II, 40 B/G, 41 I-XXXV, 42 B/G, 48, 49, 51 B/G, 52, 57, 58	49
Light soft drinks	34	1		
Fruit juice	22 I, 25	2	22 II	1
Milk	22 I, 25	2	22 II	1
ED snacks	20, 22 I, 25, 27 I, 28, 30, 34, 38 I II	9	22 II, 27 II, 39 I II, 40 B/G, 41 I-XXXV, 48, 49, 51 B/G, 55 B/G,	47
% fat from ED snacks	38 I II	2		
% energy from ED foods	33 G	1		
Fast food	25, 22 I, 28, 30, 35 I II	6	22 II, 39 I II, 46 B/G, 48, 51 B/G	8
Fried foods	28	1	39 I II, 40 B/G	4
Red meat	25	1		
Total energy intake	20, 25, 26 B/G, 28, 29 B/G, 31 B/G, 32, 36	11	39 I II, 40 B/G, 54 B/G, 59 B/G, 60	9
Total fat			40 B/G, 42 B/G, 49, 59 B/G, 60	8
Total carbohydrate			59 B/G, 60	3

Total protein			59 B/G, 60	3
% energy from fat	25, 32	2	39 I II, 40 B/G, 54 B/G, 59 B/G, 60, 61	10
% carbohydrate	25, 32	2	52	1
% protein	25	1	52	1
% saturated fat	25, 32	2	39 I II	2
% trans fat	25	1	39 I II	2
% monosaturated	32	1		
% polysaturated fat	32	1		
Fiber	25	1	49, 54 B/G, 59 B/G, 61	6
Calcium	25	1	43 B/G	2
Vitamin C			59 B/G, 60	3
Calcium rich foods			39 I II	2
Junk food (sum of ED food and drinks)	21, 27 I, 33 G	3	27 II, 56	2
Whole grains			39 I II	2
Bread	34	1		
Healthy diet			47	1
Western dietary pattern			47	1
Frequency of breakfast			50	1
Assessment of dietary behavior				
Self-report	21, 23, 24 I, 26 B/G, 27 I, 28, 31 B/G, 33 G, 37	11	22 II, 24 II III, 27 II, 39 I II, 40 B/G, 41 I-XXXV, 42 B/G, 43 B/G, 44 B/G, 45, 46 B/G, 47, 48, 49, 50, 51 B/G, 52, 53 B/G, 54 B/G, 55 B/G, 56, 57, 58, 59 B/G, 60, 61	72
Parent report	20, 22 I, 25, 30, 34, 32, 36, 35 I II	9		
Self and Parent report	38 I II	2		
Home interview	29 B/G	2		

Measure of dietary behavior				
Food Frequency Questionnaire (FFQ)	20, 22 I, 23, 24 I, 25, 26 B/G, 28, 30, 31 B/G, 33 G, 34, 36	14	22 II, 24 II III, 39 I II, 40 B/G, 41 I-XXXV, 42 B/G, 43 B/G, 44 B/G, 45, 46 B/G, 47, 51 B/G, 56, 60	56
Other questionnaire	27 I, 29, 35 I II, 37	5	27 II, 48, 49, 50, 52, 53 B/G, 55 B/G, 57, 58	11
24-hour recall	29 B/G, 32, 38 I II	5	54 B/G, 61	3
Weighed food records	32	1	59 B/G	2
Country				
United States (US)	23, 24 I, 25, 26 B/G, 27 I, 28, 29 B/G, 31 B/G, 33 G, 35 I II, 36, 37, 38 I II	18	24 II III, 27 II, 39 I II, 40 B/G, 41, 43 B/G, 44 B/G, 46 B/G, 49, 53 B/G, 54 B/G, 58, 61	21
England			41, 50, 60	3
Australia	20, 21, 30	3	47, 48, 51 B/G	4
New Zealand	22 I	1	22 II	1
Canada			41	1
The Netherlands	34	1	40, 41, 52, 55 B/G, 57	6
Greece	32	1	41	1
Belgium			45	1
Spain			41, 59 B/G	3
Israel			41	1
Denmark			41	1
Finland			41	1
Greenland			41	1
Norway			41	1
Sweden			41	1
Croatia			41	1
Czech Republic			41	1
Estonia			41	1
Hungary			41	1
Latvia			41	1

Lithuania			41	1
Macedonia			41	1
Poland			41	1
Russia			41	1
Slovenia			41	1
Ukraine			41	1
Italy			41	1
Malta			41	1
Portugal			41	1
Austria			41	1
Belgium – Flemish			41, 42 B/G	3
Belgium – French			41	1
France			41	1
Germany			41	1
Ireland			41	1
Scotland			41	1
Switzerland			41	1
Wales			41	1

G, girls only; B, boys only; B/G, boys and girls analyzed separately. I/II, two independent samples.

¹Longitudinal study but only baseline cross-sectional data used in this review; ²Intervention studies, analyses for control group only used for this review; ³Studies from the larger Planet Health study; ⁴Studies from the larger Project EAT study; ⁵Studies from the larger HBSC study.

For reference 24: I= children in grades 4-5, II = adolescents in grades 6=8, III = adolescents in grades 9-12; for reference 38: I = children from overweight families, II = children from non-overweight families; for reference 35: I = children aged 2-3.9 years, II = children aged 4-5.9 years; for reference 22: I = children aged 5-10 years, II = adolescents aged 11-14 years; for reference 27: I = children in grade4, II = adolescents in

grade 8; for reference 39: I = younger cohort (mean age 12.8 years), II = older cohort (mean age 15.9 years); for reference 41: HBSC study examining associations between TV viewing and diet in 35 countries (each Country is an independent sample I-XXXV).

Reference numbers: see Reference list.

Table 2. Characteristics of adult studies included in the review.

Comment [BL2]: This table is very difficult to read, please revise.

	Adults (>18 years)	
	References	No. of samples
Sample size		14
<100	67 G	1
100-199	66 I	1
200-299	70	1
300-499	66 II	1
500-999	63 G, 66 III, 69	3
1000-2999	64	1
3000-4999		0
>5000	11 G, 62, 65 B, 65 G, 68 B, 71	6
Gender		
Girls only	11, 63, 67	3
Boys only	68	1
Boys and girls combined	62, 64, 69, 70, 71	5
Boys and girls separately	65, 66 I II III	5
Study design		
Cross sectional	62, 63 G, 66 I II III, 65 B/G, 67 G, 69, 71	10
Longitudinal	11 ¹ , 64, 68 ¹	3
Retrospective	70	1
Sedentary behavior assessed		
TV viewing	11 G, 63 G, 65 B/G, 66 I II III, 67 G, 68 B, 69, 70, 71	12

Screen time (TV + video + DVD)	62	1
Computer use	65 B/G	2
Total inactivity mins/day	64	1
Assessment of sedentary behavior		
Self-report	11 G, 62, 63 G, 64, 65 B/G, 66 I II III, 67 G, 68 B, 69, 70, 71	14
Measure of sedentary behavior		
Questionnaire	11 G, 62, 63 G, 65 B/G, 66 I II III, 67 G, 68 B, 69, 70, 71	13
IPAQ	64	1
Dietary behavior assessed		
Fruit	11 G, 64, 68 B	3
Vegetables	11 G, 64, 68 B	3
Fruit and Vegetable (FV)	65 B/G	2
ED drinks / soft drinks	62, 71	2
ED snacks	11 G, 62, 68 B, 69	4
Healthy snacks	69	1
Sweets/deserts	68 B	1
Fast food	11 G, 63 G, 68 B	3
Total energy intake	11 G, 62, 66 I II III, 67 G, 68 B	7
Total fat	11 G, 62, 67 G, 68 B	4
Total carbohydrate	62	1
Total protein	62	1
% fat	62, 66 I II III	4
% carbohydrate	62	1
% protein	62	1
% saturated fat	62	1
Fiber	11 G, 62, 68 B	3
Red meat	11 G, 64, 68 B	3
Fish	11 G, 64, 68 B	3
'Healthy dietary pattern'	70	1
'Unhealthy dietary pattern'	70	1

Grain mixtures	11 G, 62, 64, 68 B	4
Assessment of dietary behavior		
Self-report	11 G, 63 G, 64, 65 B/G, 66 I II III, 67 G, 68 B, 69, 70, 71	13
Interviewer administered	62	1
Measure of dietary behavior		
Food Frequency Questionnaire (FFQ)	11 G, 64, 66 I II III, 67 G, 68 B, 69, 70	9
Other questionnaire	63 G, 65 B/G, 71	4
24-hour recall	62	1
Country		
United States (US)	11 G, 62, 63 G, 66 I II III, 67 G, 68 B, 70, 71	10
Canada	65 B/G, 69	3
Greece	64	1

G, girls only; B, boys only; B/G, boys and girls analyzed separately. I/II, two independent samples.

For reference 66: I = men, II = low income women, III = high income women.

Reference numbers: see Reference list.

Table 3. Associations between sedentary behavior and diet in children (<12 years)

Dietary behavior	No. of samples	Summary		
		'Positive association (+)' n samples [references]	'Inverse association (-)' n samples [references]	'No association (0)' n samples [references]
Fruit	3	n=0	n=3 [22 I, 30, 34]	n=0
Vegetables	4	n=0	n=3 [20, 22, 34 I]	n=1 [30]
FV (composite measure of fruit and vegetables)	3	n=0	n=3 [23 ¹ , 24 ^s I, 25]	n=0
Energy dense snacks	10	n=11* [20 (savory snacks), 22 I (crisps, biscuits), 25, 27 I, 28 (baked sweet snacks, candy, salty snacks), 30 (savory snacks), 34, 38 I]	n=0	n=4* [20 (sweet snacks), 22 I (chocolate), 30 (sweet snacks), 38 II]
Fast foods	6	n=7* [22 I (hamburgers, French fries, fried chicken), 25, 28, 35 ^s I, 35 ^s II]	n=0	n=1* [30]
Energy dense drinks	7	n=7 [20, 22 I, 25, 28, 30, 34, 37]	n=0	n=0
Total energy intake	11	n=8 [23, 25, 26 ¹ B/G, 28, 29 G, 32, 36]	n=0	n=3 [29 B, 31 ^s B/G]
Percentage energy from fat	2	n=2 [25, 32]	n=0	n=0

G, girls only; B, boys only; B/G, boys and girls analyzed separately. ¹ = longitudinal study. [§] = all associations with dietary behaviors are for TV viewing unless otherwise stated. ^s = screen time (sum of TV viewing, video/DVD, computer use).

For reference 22: I = children aged 5-10 years; for reference 24: I = children in grades 4-5; for reference 35: I = children aged 2-3.9 years, II = children aged 4-5.9 years; for reference 38: I = children from overweight families, II = children from non-overweight families.

References numbers: see Reference list.

*If in one study, sedentary behavior is examined in relation to two types of energy-dense snack (e.g. crisps and chocolate) and the results differ for the dietary outcomes (e.g. a positive (+) association was found for crisps and no (0) association was found for chocolate), the study is counted once in the 'No. of samples' column, and twice in the 'Summary' column.

Table 4. Associations between sedentary behavior and diet in adolescents (12-18 years)

Dietary behavior	No. of samples	Summary		
		‘Positive association (+)’	‘Inverse association (-)’	‘No association (0)’
		n samples [references]	n samples [references]	n samples [references]
Fruit	48	n=0	n=30 [39 ^{1,s} I, 39 ^{1,s} II, 40 ^s B/G, 41 ^s I-II, 41 ^s IV-V, 41 ^s VII, 41 ^s X, 41 ^s XX-XXI, 41 ^s XXIII-XXIV, 41 ^s XXVI-XXXI, XXXIII-XXXV, 42 B/G, 44 ¹ B/G, 45, 48, 59 G]	n=18 [22 II, 41 ^s III, 41 ^s VI, 41 ^s VIII-IX, 41 ^s XI-XXX, 41 ^s XXII, 41 ^s XXV, 41 ^s XXXII, 59 B]
Vegetables	44	n=0	n=26 [39 ^{1,s} II, 40 ^s B/G, 41 ^s I-II, 41 ^s IV-V, 41 ^s VII, 41 ^s X, 41 ^s XIV, 41 ^s XVIII, 41 ^s XXI, 41 ^s XXIII, 41 ^s XXVI—XXXV, 44 ¹ B/G, 45]	n=18 [22 II, 39 ^{1,s} I, 41 ^s III, 41 ^s VI, 41 ^s VIII-IX, 41 ^s XI-XIII, 41 ^s XV-XVII, 41 ^s XIX-XX, 41 ^s XXII, 41 ^s XXIV-XXV, 48]
FV (composite measure of fruit and vegetables)	7	n=0	n=5 [24 ^s III, 53 B/G, 54 ^{1,d} G, 61 ^d]	n=2 [24 ^s II, 54 ^{1,d} B]
Energy dense snacks	47	n=42* [22 II (chocolate), 27 II, 39 ^{1,s} II, 40 ^s B/G, 41 ^s I-V, 41 ^s VII-XXXV, 48, 55 ^s B/G]	n=0	n=9* [22 II (crisps, biscuits), 39 ^{1,s} I, 41 ^s VI, 49, 51 B/G (sweet snacks, savory snacks)]
Fast foods	8	n=5* [22 II (hamburgers, French fries), 39 ^{1,s} II, 46 ¹ G, 48]	n=0	n=5* [22 II (fried chicken), 39 ^{1,s} I, 46 ¹ B, 51 B/G]
Fried foods	4	n=3 [39 ^{1,s} II, 40 ^s B/G]	n=0	n=1 [39 ^{1,s} I]
Energy dense drinks	49	n=44 [22 II, 39 ^{1,s} I, 39 ^{1,s} II, 40 ^s B/G, 41 ^s I-V, 41 ^s VII-XXXV, 42 B, 48, 52 ^s , 57, 58]	n=0	n=5 [41 ^s VI, 42 G, 49, 51 B/G]
Total energy intake	9	n=3 [39 ^{1,s} II, 40 ^s B/G]	n=0	n=6 [39 ^{1,s} I, 54 ^{1,d} B/G, 59 B/G, 60 ^s]

Percentage energy from fat	10	n=5 [39 ^{1, s} II, 40 ^s B/G, 60 ^s , 61 ^d]	n=0	n=5 [39 ^{1, s} I, 54 ^{1, d} B/G 59 B/G]
Total fat (grams)	8	n=3 [40 ^s B/G, 42 G]	n=0	n=5 [42 B, 49, 59 B/G, 60 ^s]
Fibre	6	n=0	n=3 [54 ^{1, d} G, 59 G, 61 ^d]	n=3 [49, 54 ^{1, d} B, 59 B]

G, girls only; B, boys only; B/G, boys and girls analyzed separately. ¹ = longitudinal study. ^s = all associations with dietary behaviors are for TV

viewing unless otherwise stated. ^s = screen time (sum of TV viewing, video/DVD, computer use); ^d = sedentary time (sum of TV viewing, video/DVD, sitting while talking/homework/reading).

For reference 22: II = adolescents aged 11-14 years; for reference 24: II = adolescents in grades 6=8, III = adolescents in grades 9-12; for reference 39: I = younger cohort (mean age 12.8 years), II = older cohort (mean age 15.9 years); for reference 41: HBSC study examining associations between TV viewing and diet in 35 countries. Each Country is an independent sample: I = Canada, II = USA, III = Israel, IV = Denmark, V = Finland, VI = Greenland, VII = Norway, VIII = Sweden, IX = Croatia, X = Czech Republic, XI = Estonia, XII = Hungary, XIII = Latvia, XIV = Lithuania, XV = Macedonia, XVI = Poland, XVII = Russia, XVIII = Slovenia, XIX = Ukraine, XX = Greece, XXI = Italy, XXII = Malta, XXIII = Portugal, XXIV = Spain, XXV = Austria, XXVI = Belgium – Flemish, XXVII = Belgium – French, XXVIII = England, XXIX = France, XXX = Germany, XXXI = Ireland, XXXII = Netherlands, XXXIII = Scotland, XXXIV = Switzerland, XXXV = Wales.

References: see Reference list.

*If in one study, sedentary behavior is examined in relation to two types of energy-dense snack (e.g. crisps and chocolate) and the results differ for the dietary outcomes (e.g. a positive (+) association was found for crisps and no (0) association was found for chocolate), the study is counted once in the ‘No. of samples’ column, and twice in the ‘Summary’ column.

Table 5. Associations between sedentary behavior and diet in adults (>18 years)

Dietary behavior	No. of samples	Summary		
		'Positive association (+)' n samples [references]	'Inverse association (-)' n samples [references]	'No association (0)' n samples [references]
Fruit	3	n=0	n=3 [11 G, 64 ¹ , 68 B]	n=0
Vegetables	3	n=0	n=3 [11 G, 64 ¹ , 68 B]	n=0
FV (composite measure of fruit and vegetables)	2	n=0	n=2 [65 B/G]	n=0
Energy dense snacks	4	n=4 [11 G, 62 ^s , 68 B, 69]	n=0	n=0
Fast foods	3	n=3 [11 G, 63 G, 68 B]	n=0	n=0
Energy dense drinks	2	n=2 [62 ^s , 71]	n=0	n=0
Total energy	7	n=5 [11 G, 62 ^s , 66 II, 66 III, 68 B]	n=0	n=2 [66 I, 67 G]
Percentage energy from fat	4	n=1 [66 II]	n=0	n=3 [62 ^s , 66 I, 66 III]
Total fat (grams)	4	n=3 [11 G, 62 ^s , 68 B]	n=0	n=1 [67 G]
Fibre	3	n=0	n=3 [11 G, 62 ^s , 68 B]	n=0

G, girls only; B, boys only; B/G, boys and girls analyzed separately. ¹= longitudinal study. ^s=all associations with dietary behaviors are for TV viewing unless otherwise stated. ^s= screen time (sum of TV viewing, video/DVD, reading and computer use).

For reference 66: I = men, II = low income women, III = high income women.

References numbers: see Reference list.