SEDENTARY BEHAVIOUR AND DIET ACROSS THE LIFESPAN: AN UPDATED SYSTEMATIC REVIEW

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ABSTRACT

Background: Sedentary behaviour and its association with dietary intake in young people and adults is an important topic and was systematically reviewed in 2011. There is a need to update this evidence given the changing nature of sedentary behaviour and continued interest in this field. This review aims to assist researchers in better interpreting the diversity of findings concerning sedentary behaviour and weight status.

Objective: To provide an update of the associations between sedentary behaviour and dietary intake across the lifespan.

Methods: Electronic databases searched were Medline, PsychInfo, Cochrane Library, Web of Science and Science Direct for publications between January 2010 and October 2013 thus updating a previous review. Included studies were observational studies assessing an association between at least one sedentary behaviour and at least one aspect of dietary intake in pre-school children (< 5 years), school-aged children (6-11 years), adolescents (12-18 years), and adults (> 18 years).

Results: 27 papers met inclusion criteria (pre-school k=3, school-aged children k=9; adolescents k=15; adults k=3). For all three groups of young people, trends were evident for higher levels of sedentary behaviour, especially TV viewing, to be associated with a less healthful diet, such as less fruit and vegetable and greater consumption of energy-dense snacks and sugar sweetened beverages. Data for the three studies with adults were less conclusive.

Conclusions: Sedentary behaviour continues to be associated with unhealthy diet in young people in mostly cross-sectional studies. More studies utilising a prospective design are needed to corroborate findings and more studies are needed with adults.

What are the new findings?

1. Sedentary time has been implicated in obesity yet this could be due to energy intake rather just low energy expenditure.
2. We provide review-level evidence linking sedentary time and various diet outcomes across the lifespan, including pre-school children for the first time
3. We build on a previous review by providing updated evidence linking sedentary behaviour and elements of an unhealthy diet at a time when sedentary behaviours are continually evolving

1.0 Introduction

Sedentary behaviour refers to sitting or lying tasks done in waking hours with low levels of energy expenditure.[1] Studies show associations between sedentary behaviour (usually assessed as screen-based behaviours such as TV and computer use) and a range of health outcomes, including all-cause mortality, cardiovascular disease,[2 3] poor cardio-metabolic health,[4] and obesity.[5]

In 2011, Pearson and Biddle[6] published the first systematic review to investigate associations between sedentary behaviours and dietary intake. This was predicated on the fact that not all associations between sedentary behaviour and health outcomes were consistent and some associations might be due to the influence of third variables, or co-existing health behaviours, such as diet.

In adults, prospective observational cohort studies show evidence of an association between sedentary behaviour and weight status. 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 [5]. The Nurses' Health Study of over 50,000 women[7] 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 another study of over 18,000 women, Blanck et al [8] showed an elevated risk of weight gain in

those 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 behaviour and weight status are suggestive of a positive association.[9] 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 behaviour, and in particular TV viewing, is diet.

For young people, there has been a longstanding assumption that TV viewing is associated with overweight and obesity.[10] However, a meta-analysis of mainly cross-sectional studies found that this association was very small.[11] Also, a review of sedentary behaviour intervention studies showed inconsistent weight loss for young people.[12] Overall, therefore, sedentary behaviour in the form of screen time is implicated in youth overweight and obesity, but findings are less clear cut than some claim.

For adults and young people, during the time spent watching television, little energy is expended,[13] and viewers are exposed to numerous advertisements that can influence the type of food desired and consumed.[14 15] Furthermore, eating in front of the TV may differ than when undertaken in other settings. For example, TV or snack commercials may be a distraction resulting in a lack of awareness of food consumption or overlooking food cues. This could disrupt habituation and lead to overconsumption.[16]

Dietary intake and its association with sedentary behaviour in young people and adults is an important topic that may assist researchers in better interpreting the diversity of findings concerning sedentary behaviour and weight status. However, it is recognised that sedentary pursuits using technology can change very quickly. Computer technology has become more mobile and will this change the way people use and interact with such devices. Moreover, TV channels have increased and the TV viewing experience has changed with greater access to

high definition screens and even 3D TV. To this end, it is important to update the review of studies on the association between sedentary behaviour and dietary behaviour. In addition, we feel it is important to differentiate studies with young people into pre-school, children, and adolescents. This systematic review, therefore, provides an update of the associations between sedentary behaviour and diet across the lifespan.

2.0 Methods

2.1 Search Strategy

A literature search was conducted using electronic databases, sedentary behaviour review papers, manual searches of existing reference lists and personal files. The electronic database searches used Medline, PsychInfo, Cochrane Library, Web of Science and Science Direct for publications between January 2010 and October 2013 thus updating the previous review.[6] To ensure a broad search, a comprehensive list of keywords was used to guide the search process that included the most common forms of sedentary behaviour and dietary intake.

2.2 Inclusion and Exclusion Criteria

To be included studies had to: (1) be observational in design; (2) report data on pre-school children (<5 years), school-aged children (6-11 years), adolescents (12-18 years) and adults (>18 years) (or a mean within these ranges) at baseline; (3) measure at least one domain of sedentary behaviour and one aspect of dietary intake; (4) assess an association between at least one sedentary behaviour and one aspect of dietary intake; (5) be published in English between January 2010 to October 2013. Studies that reported physical inactivity (low physical activity) as a measure of sedentary behaviour were excluded. Studies that manipulated a sedentary behaviour and/or aspects of dietary intake were excluded as were studies that did not involve healthy free living individuals were excluded (i.e. chronic illnesses preventing physical activity), although articles that reported risk factors were included.

2.3 Identification of relevant studies

Titles then abstracts of potentially relevant articles were screened independently by two authors. The full text of any relevant abstracts were then obtained and screened to determine

whether they met the full inclusion criteria. Any uncertainty was resolved by consulting a third author in order to determine whether to include the paper in the final sample upon reading the full text. Studies that did not meet the inclusion criteria at this stage were excluded.

2.4 Data Extraction

Two authors extracted the data from relevant articles in accordance with a standardised form developed for a previous review.[6] The following data were extracted from each paper: (1) author and year; (2) study design and duration of follow-up if prospective; (3) geographical location; (4) age group; (5) sample size and sub-groups; (6) sedentary behaviour outcome and primary measure; (7) dietary intake outcome and primary measure; (8) timing, reliability and validity of assessment methods; (8) the analysis and results of an association between sedentary behaviour and dietary intake. Authors were contacted when missing information prevented data extraction. All data extraction was completed by the researchers independently. Any differences or discrepancies (interpretation errors or factual errors, such as transposed information) were discussed and resolved. Finally, inter-rater reliability was calculated and reported for study quality and data extraction.

2.5 Coding Associations between Sedentary Behaviour and Dietary Intake

An independent sample was used as the unit of analysis and was defined as the smallest independent subsample for which relevant data was reported (i.e. boys and girls). The column "No. of samples" in Table 1 and 2 (supplementary material) shows the number of samples that have been studies for each dietary behaviour. The "Summary" column includes the number of samples, references, and the direction of association (i.e. positive (+), inverse (-), or no association (0)).

TABLE 1 & 2 (SUPPLEMENTARY DATA)

2.6 Study Quality

The quality of the studies included in this review was assessed using a previously used scale.[6] Studies were given a score based on sampling procedure, sample size, response rates, the validity and reliability of the measures used to assess sedentary behaviour and dietary intake and whether confounders had been considered in the analysis. Each included paper was given a score out of 16 with a higher score meaning higher study quality. Studies were categorised as high (scoring 12+), moderate (scoring 6-11), and poor (scoring 0-5) quality. There was good initial agreement for study quality (91% r = 0.98) between authors.

3.0 Results

3.1 Flow of studies included

The literature search identified 13,883 articles from which 209 were identified as potentially relevant upon reviewing the title. Following the screening of the full text of the article 27 were identified that sufficiently examined the association between sedentary behaviour and dietary intake. Figure 1 presents the flow of papers from citations retrieved. The results are reported separately for pre-school children, school-aged children, adolescents and adults.

INSERT FIGURE 1 AROUND HERE

3.2 Study Quality

Study quality for studies including children of pre-school age ranged from 2/16 to 6/16, median = 6 [individual scores 6: n=2[17 18]; 2: n=1[19]]. Study quality in studies including children ranged from 4/16 to 8/16, median = 6 [individual scores 6: n=4[17 18 20 21]; 7: n=2[22 23]; 8: n=1[24]; 4: n=1[25]; 5: n=1[26]].

Adolescent study quality ranged from 4/16 to 15/16, median=8 [scores 19: n= 1[27]; 10: n=4[28-31]; 8: n=2[32 33]; 7: n=1[34]; 6: n=5[18 35-38]; 5: n=1[39]; 4: n=1[40]. Study quality scores in adults for studies ranged from 5/16 to 7/16, median=6 [scores 7: n=1[41]; 6: n=1[18]; 5: n=1.[42]

3.3 Associations between Sedentary Behaviour and Diet in Pre-school Children

Three studies (three samples) including pre-school children were eligible for review (Table 3). Two studies were conducted in Australia and one in the USA. Two studies examined associations between sedentary behaviour and dietary outcomes for boys and girls combined, one study examined associations separately for boys and girls. The majority used a cross-

sectional research design (n=2), two of the studies assessed sedentary behaviour through parental report and one through self-report. Dietary behaviour was also assessed through parent report (n=2) and self-report (n=1). TV viewing was the most commonly assessed sedentary behaviour in association with dietary intake, studied in all three studies. In studies including children of pre-school age, five dietary behaviours were identified.

INSERT TABLE 3 HERE

Average weekday and weekend TV viewing, weekday and weekend non-commercial and weekday commercial TV viewing were inversely associated with fruit and vegetable consumption in one sample. However, weekday commercial TV viewing was positively associated with fruit and vegetable consumption in one sample. Finally, TV viewing was inversely associated with the healthy eating index in both boys and girls in one sample and with vegetable intake in one other sample.

TV viewing was positively associated with energy-dense food in two of two samples and positively associated with fast food in one sample. There was one longitudinal study[17] which scored well on study quality and had a large sample size (n=4983). This study corroborates the results from the limited cross sectional studies showing that TV viewing is positively associated with energy-dense food. Overall, sedentary behaviour in pre-school children seems to be trending towards an association with elements of an unhealthy diet, yet caution is required when interpreting results due to the paucity of studies. That said, these results are confirmed in a large high quality longitudinal study.

3.3 Associations between Sedentary Behaviour and Diet in Children

Nine studies (nine samples) of school-age children were eligible for review (Table 4). Three studies were conducted in Australia and two in Norway. The remaining four were carried out in Canada, Netherlands, USA and Belgium. Eight studies examined associations between sedentary behaviour and dietary outcomes for boys and girls combined whilst one study examined associations separately for boys and girls. The majority of studies used a cross-sectional design (n=6), six assessed sedentary behaviour through self-report and three by parental report. One used an objective measure of accelerometry yet specific methodological information on cut-points was withheld. Dietary behaviour was assessed through 24 hour recall (n=3), food diary (n=4) and questionnaire (n=3). TV viewing was the most commonly assessed sedentary behaviour in association with dietary intake (n=6). Nine dietary behaviours were identified and tabulated, the most common being energy-dense food.

INSERT TABLE 4 AROUND HERE

Sedentary behaviour was inversely associated with vegetable intake in two samples (one assessed TV viewing and the other both computer use and screen time), yet computer use was positively associated with vegetable intake in one sample. Sedentary behaviour was inversely associated with fruit intake in two samples (one assessed TV viewing and the other both computer use and screen time), yet computer use had no association with fruit intake in one sample. Finally, homework was positively associated with the healthy eating index (one sample) and TV viewing in boys and girls and computer use was inversely associated with the healthy eating index (two samples).

Sedentary behaviour was positively associated with energy-dense food in five samples (four assessed TV viewing and the other both screen time and computer use). However, computer use was inversely associated with energy-dense food in one sample. Sedentary behaviour was

positively associated with fat, sugar and total calorie intake in three samples (three used self-report and one study objectively assessed sedentary behaviour) and was positively associated with sugar sweetened beverage intake in two samples (one assessed screen time and computer use and the other assessed computer use and TV viewing). Finally, TV viewing was positively associated with diet quality based on fat and sugar intake (one sample).

Two longitudinal studies assessed the association between sedentary behaviour and diet in children.[17 24] Both scored at and above the median score on study quality and had moderate to large sample sizes (n=908 and n=4464). These studies corroborated findings from the cross-sectional evidence that various sedentary behaviours (TV viewing, screen time and computer use) are positively associated with consumption of energy-dense food and sugar sweetened beverages. Overall, sedentary behaviour in children again seems to be trending towards an association with elements of a less healthy diet. However, the number of comparisons is small, the studies are often diverse in the measurement methods adopted, and are often cross-sectional in design in both pre-school and children. This makes it difficult to draw meaningful conclusions. That said, two medium to large longitudinal studies of moderate to good quality did show associations between sedentary behaviour and unhealthy diet.

3.4 Associations between Sedentary Behaviour and Diet in Adolescents

All fifteen studies were cross-sectional in design. Data were reported separately for gender in eight studies. The remaining seven studies combined male and female data. Participants were aged between 11 and 19 years. Three studies reported data from the US and two presented combined data from Europe.

The majority of studies (60%) measured TV-viewing as the sedentary behaviour. Two of these also separately measured computer use and one also measured study time. A further two studies measured internet and video game use alongside TV-viewing, two additional studies measured computer use, internet for study, video games and study time alongside TV-viewing. One study measured screen time as one outcome (TV + video games + computer use + internet use), another also measured small screen recreation time (TV+/or video+/or DVDs + video games + computer games + computer not for homework) and sedentary education time (reading + homework). Sedentary behaviour was assessed by self-report in the majority of studies, one study used an interview administered technique. Sedentary behaviour was measured using questionnaires in all fifteen adolescent studies (Table 5).

INSERT TABLE 5 HERE

A total of eighteen dietary behaviours were assessed. Eleven studies assessed diet by self-report and the remaining study used a telephone interview technique. Diet was measured using unnamed questionnaires in eight studies, a web-based food behaviour questionnaire in another study, food frequency questionnaire in two studies, and using 24-hour recall methods in three studies. Finally, one study used a combination of a food frequency questionnaire and 24-hour recall.

Separate measures of TV-viewing and various categories of screen time were positively associated with sugar sweetened beverages in five of five samples and inversely associated in one sample. Separate measures of TV-viewing and various categories of screen time were also inversely associated with separate measures of fruit and vegetable consumption in three of three studies, and positively associated in another. Further, the inclusion of sedentary

behaviours such as ‘internet use for study’ and ‘studying’ evident in one study resulted in a positive association with a separate measure of fruit and vegetable consumption. TV-viewing and computer use were also inversely associated with a composite measure of fruit and vegetable consumption in one of one sample.

Overall, sedentary behaviour in adolescents appears to be associated with elements of an unhealthy diet. However, caution should be expressed when interpreting this association due to the low number of studies reporting the same sedentary and dietary behaviours.

3.5 Associations between Sedentary Behaviour and Diet in Adults

Characteristics of studies concerning adults are shown in Table 6. All three studies were cross-sectional in design. Male and female data were reported separately in two studies and one reported only female data. Studies were conducted in the US in two papers.

All three studies assessed self-reported TV-viewing as the sedentary behaviour using questionnaires. Dietary intake was measured using food-frequency questionnaires, 7-day weighed food records and a 24 hour recall. Two studies measured Healthy Eating Index Score, the other measured total energy intake. TV-viewing was marginally positively associated with total energy intake in adults and marginally inversely and positively associated with healthy food index scores. Again, caution should be headed when interpreting analyses with fewer than five studies, as estimates of an association may be imprecise.

Based on the lack of evidence, it is difficult to provide a clear conclusion on the association between TV-viewing and dietary behaviour in adults. Although limited, the available evidence tends to suggest that high TV-viewing is positively associated with total energy

intake and unhealthy diet quality. Similar to findings with adolescents, caution should be taken when interpreting associations regarding adults due the lack of research.

INSERT TABLE 6 HERE

4.0 Discussion

This systematic review builds on the published review by Pearson and Biddle.[6] An update was attempted because technology-based sedentary behaviours are likely to be changing quickly, and it is timely to examine new papers that were emerging but by differentiating pre-school children from children and adolescents. Adults were again included to allow for a lifespan approach.

For pre-school children, three new studies were found since early 2010. These showed a clear trend for greater time in sedentary behaviour (mainly TV viewing) to be associated with unhealthy eating. This showed in less fruit and vegetable consumption and lower scores on a healthy eating index, as well as higher levels of energy dense food and fast food. In the 2011 review, we combined this age group with older children. The present review, therefore, shows that the coupling of screen time and possibly commercial TV viewing time with an unhealthy diet starts at an early age and leads to the obvious conclusion that parental, family and other interventions are required with children in the first few years of life. However, caution is required at this stage due to the small number of studies. Clearly this is an important area of research development.

For children aged 5-11 years, results across nine studies showed a clear trend for sedentary behaviour to be associated with a less healthy diet. With 19 studies reported by Pearson and Biddle for pre-adolescent children, including pre-school children, this shows a continued interest in diet and sedentary behaviour in this age group. In the current review, sedentary

screen time, and mainly TV viewing, is associated with greater consumption of energy-dense food, fat, sugar, sugar sweetened beverages and total caloric intake. It is also associated with consumption of less fruit and vegetables.

Confidence in these trends in enhanced by two reasonably large longitudinal studies that show that screen time is associated energy-dense food and sugar sweetened beverage consumption. Sugar sweetened beverages have been implicated in weight gain [43] [44] and might be one mechanism linking screen time with obesity and account for the variable findings in this area. In other words, weight status may be as much to do with energy consumption as it is with low energy expenditure from sedentary time, thus accounting for inconsistency of findings when just investigating TV and weight status.[10] Studies are required that investigate further this association, including availability of food and drinks during different sedentary behaviours, and prompts or cues that encourage or discourage such consumption.

With 15 studies reported in the current review concerning associations between sedentary behaviour and diet in adolescents, this shows that researchers continue to view this topic and age group as important. In less than four years, this represents more than a 50% increase in the number of studies. However, while there is a trend for higher levels of sedentary behaviour to be associated with poorer diet, there are rather few studies assessing the same sedentary behaviour and same diet outcome variable. Future studies need to build on these associations by ensuring that similar measures are taken. It appears that TV and, to a certain extent computer screen time, are implicated in being associated with poorer diet. The dietary outcomes, therefore, need standardising by studies ensuring that they measure at least fruit and vegetable intake, energy-dense snacks, and sugar sweetened beverages. That way a more comprehensive picture will emerge for adolescents at an important time of change in this age group.

Data on adults have not expanded much since the last review. Only three studies were reviewed in the present paper, with 11 in 2011. With so few studies, firm conclusions are not possible, although similar trends noted elsewhere in this review are still evident. Future studies need more data on the context of sedentary behaviours and what might be cuing certain dietary behaviours in the presence of screen or other sitting behaviours.

Conclusion

In conclusion, sedentary behaviour, mainly in form of screen viewing and especially TV, is associated with indicators of unhealthy dietary intake in pre-school children, school-aged children and adolescents in predominantly cross-sectional studies. The results for adults are sparse and less clear. Findings largely confirm and extend the review published in 2011. We have added to knowledge by investigating pre-school children separately, and documenting the continued study of sedentary behaviour and diet in young people. Research on adults needs to develop. Future studies need to standard measures of diet, and include a wider variety of sedentary behaviours, as well as document the context that sedentary behaviour may be associated with dietary intake.

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Table 1. Characteristics of early years and child studies included in the review: sample size, gender, study design, nature of sedentary behaviour assessed, assessment and measurement of sedentary behaviour, type of dietary behaviours assessed, assessment and measurement of dietary behaviour and country of study.

	Early years (>2 x <5 years)		Children (≥5 x <11)	
	References	**No. of samples**	**References**	**No. of samples**
Sample size		**3**		**9**
<100	-	-	4	1
100-199	3	1	-	-
200-299	-	-	7	1
300-499	-	-	10	1
500-999	-	-	6, 8	2
1000-2999	1[n], 9[c]	2	1[o], 9[d]	2
3000-4999	-	-	2, 5	2
Gender				
Boys and girls combined	1[n], 3,	2	1[o], 2, 4, 5, 6, 7, 8, 10	8
Boys and girls separately	9[c]	1	9[d]	1
Study design				
Cross sectional	3, 9[c]	2	2, 4, 7, 8, 9[d], 10	6
Longitudinal	1[n]	1	1[o], 5, 6	3
Study quality				
Poor	3	1	5, 7	2
Moderate	1[n], 9[c]	2	1[o], 2, 4, 6, 8, 9[d], 10	7
High	-	-	-	-
Sedentary behaviour assessed				
TV viewing	1[n], 3, 9[c]	3	1[o], 2, 5, 7, 8, 9[d]	6
TV viewing non-commercial weekday	3	1	-	-
TV viewing commercial weekday	3	1	-	-
TV viewing non-commercial weekend	3	1	-	-
TV viewing non-commercial weekend	3	1	-	-
Sedentary activity	-	-	4[a], 4[b]	1
Computer (games or use)	-	-	6[i], 7	2
Screen time	-	-	6[n], 10	2
Homework	-	-	10	1
Assessment of sedentary behaviour				
Parent reported	1[n], 3	2	1[o], 2, 5	3
Accelerometer	-	-	4[a]	1
Self-report	9[c]	1	4[b], 6 7, 8, 9[d], 10	6
Measure of sedentary behaviour				
24 hour recall	1[n]	1	1[o], 2	2
Questionnaire	3, 9[c]	1	4[b], 5, 6, 7, 8, 9[d], 10	7
Accelerometer	-	-	4[a]	1
Dietary behaviour assessed				

Fruit and Vegetable (FV)	3	1	-	-
Energy-dense food	3, 1[n]	2	1[o], 2, 6, 7, 8	5
Vegetable	3	1	6[i], 6[n] 7	2
Fast food	3	1	-	-
Fat intake	-	-	4[a], 4[b]	1
Sugar intake	-	-	4[a], 4[b]	1
Total calorie intake	-	-	4[a], 4[b]	1
Diet quality (based on fat and sugar)	-	-	5	1
Fruit	-	-	6[i], 6[n] 7	2
Soft drinks	-	-	6[i], 6[n] 7	2
Healthy Eating Index	9[c]	1	9[d], 10	2
Assessment of dietary behaviour				
Parent reported	1[n], 3	2	1[o], 2, 5	3
Self-report	9[c]	1	4[a], 4[b], 6[i], 6[n] 7, 8, 9[d], 10	6
Measure of dietary behaviour				
24 hour recall	1[n], 3, 9[c]	3	1[o], 2, 9[d]	3
Food diary	-	-	4[a], 4[b], 10	2
Face to face interview	-	-	5	1
Questionnaire	-	-	6, 7, 8,	3
Country				
Australia	1[n], 3	2	1[o], 2, 5	3
Norway	-	-	4, 6	2
Canada	-	-	7,	1
Netherlands	-	-	8	1
USA	9[c]	1	9[d]	1
Belgium	-	-	10	1

For reference 4: [a]Objectively assessed sedentary activity using accelerometer, [b]Assessed using screen time questionnaire; for reference 9: [c]early years aged 2-5, [d]children aged 6-11 years of age; for reference 1: [n]early years aged 4-5, [o]children aged 6-7.

Note:
[e]non-commercial TV weekday, [f]non-commercial TV weekend day,
[g]commercial TV weekday, [h]commercial TV weekend day,
[i]TV weekday, [j]TV weekend.
[B], boys only; [G], girls only
[l]computer use (games or general use), [m]homework, [n]screen time

Reference numbers: (1) Brown et al. (2010); (2) Brown et al. (2011); (3) Cox et al. (2012); (4) Danielson et al. (2011); (5) Fuller et al. (2012); (6) Gebremariam et al. (2013); (7) McCormack et al. (2011); (8) Ouwens et al. (2012); (9) Sisson et al. (2012); (10) Seghers and Rutten (2010).

Table 2. Characteristics of adolescent and adults studies included in systematic review: sample size, gender, study design, nature of sedentary behaviour assessed, assessment and measurement of sedentary behaviour, type of dietary behaviours assessed, assessment and measurement of dietary behaviour, and country of study.

	Adolescents (12-18 years)		**Adults (18+ years)**	
	References	No. of samples	References	No. of samples
Sample size				
300-499	16	1	17	1
500-999	8	1	10	1
1000-2999	9, 6, 7, 3, 1, 2, 4, 5	9	-	-
3000-4999	14, 13	2	-	-
>5000	15, 11	2	14	1
Gender				
Female only	-	-	17	1
Male and female combined	9, 7, 13, 15, 2, 4	6	-	-
Male and female separately	14, 6, 12, 3, 16, 1, 11, 5, 8	9	14, 10	2
Study design				
Cross sectional	14, 9, 6, 7, 12, 3, 16, 13, 15, 1, 11, 2, 4, 5, 8	15	14, 10, 17	3
Sedentary behaviour assessed				
TV viewing	14, 9, 6, 7, 12, 3, 13, 15, 11, 8	10	14, 10, 17	3
Screen time (TV + video games + computer use + internet use)	1, 2, 4, 5	4	-	-
Computer use	12, 3, 13, 11, 8	5	-	-
Video use	11	1	-	-
Internet use	12	1	-	-
Internet for study	12, 5	2	-	-
Video games	12, 8	2	-	-
Studying	12, 3	2	-	-
Small screen recreation time (TV +/or video +/or DVDs + video games + computer games +computer not for homework)	16	1	-	-
Sedentary education time (reading + homework)	16	1	-	-
Assessment of sedentary behaviour				

Self-report	14, 9, 6, 7, 12, 3, 16, 15, 1, 11, 2, 4, 5, 8,	13	14, 10, 17	3
Interviewer administered	13	1	-	-
Measure of sedentary behaviour				
Questionnaire	14, 9, 6, 7, 12, 1, 2, 3, 16, 13, 15, 11, 4, 5, 8	15	14, 10, 17	3
Dietary behaviour assessed				
Fruit	7, 12, 15, 1, 2, 4	6		-
Vegetables	7, 12, 15, 1, 2, 4	6		-
Juices	12	1		-
Savoury snacks	12	1		-
Fast food	7, 13, 1	3		-
Fried foods	1	1		-
High-sugar foods	13, 2	2		-
Total energy intake	-	-	17	1
Western dietary pattern	6, 8	2		-
Frequency of breakfast consumption	1, 2, 5	3		-
Snacks	7, 4	2		-
Healthy food index score	14, 16	2	14	1
Food-frequency questionnaire	-	-	10	1
Mediterranean dietary pattern	6, 8	2		-
Korean dietary pattern		1		
Milk/dairy	12, 1, 2, 4	4		-
Cakes	9, 12, 1, 2	4		-
Energy drinks	1, 11, 2	3		-
Sweets	9, 1, 2, 4	4		-
Sugar sweetened beverages	12, 13, 1, 11, 2	5		-
Soda	11	1		-
Assessment of dietary behaviour				
Self-report	14, 9, 6, 7, 12, 3, 15, 11, 2, 4, 5, 8, 1	13	14, 10, 17	3
Telephone interview	13	1	-	-
Measure of dietary behaviour				
Food Frequency Questionnaire (FFQ)	6, 11, 8	3	10	1

Other questionnaire	9, 7, 3, 13, 15, 1, 2, 4	9		-
24-hour recall	14, 6, 12, 5	4	14	1
Weighed food records	-	-	17	1
Country/Region				
United States (US)	14, 13,11,	1	14, 10	2
Canada	4	1	-	-
Australia	16	1	-	-
Italy	15	1	-	-
Belgium – Flanders	15	1	-	-
Brazil	7	1	-	-
Balearic Islands	6	1	-	-
India	3	1	-	-
Saudi Arabia	1, 2	2	-	-
Kuwait	9	1	-	-
Korea	8	1	-	-
Europe	12, 5	2	-	-
Not stated	-	-	17	1

Note: For reference 7: 1=children and adolescents included in analysis (mean age M 13.8 years, F 13.9 years). For reference 15: study from the larger Health Behaviour in School-aged Children (HSBC) survey. For reference 1: 1= adolescent age range: 14-19 years, mean age: M 16.7 years, F 16.5 years; 2= study from the larger Arab Teens Lifestyle Study. For reference 17: 1= TV-viewing categories: infrequent, frequent, and moderate viewing behaviours.

Reference numbers: (1) Al-Hazzaa et al., 2011, (2) Al-Hazzaa et al., 2013 (3) Arora et al., 2012 (4) Ciccone et al., 2013 (5) Cuenca-Garcı´a et al., 2013 (6) del Mar Bibiloni et al., 2011 (7) Fernandes et al., 2011, (8) Lee et al., 2013 (9) Honkala et al., 2012 (10) Huffman et al., 2012 (11) Ranjit et al., 2010 (12) Santaliestra-Pasias et al., 2012 (13) Shi and Mao, 2010 (14) Sisson et al., 2012 (15) Verzeletti et al., 2010 (16) Williams and Mummery, 2012 (17) Tucker and Tucker, 2011

Table 3. Associations between sedentary behaviour and diet in pre-schoolchildren (aged <5 years)

Dietary behaviour	No. of samples	Summary (*n* samples [references])		
		Positive association (+)	Inverse association (-)	No association (0)
Fruit and Vegetable (FV)	1	1 [Cox et al. 2012[N]]	1 [Cox et al. 2012[L,M,O,P,Q]]	0
Energy-dense food	2	1, 3 [Brown et al. 2010, Cox et al. 2012[L,M,N,O,P,Q]]	0	0
Vegetable	1	0	1 [Cox et al. 2012[L,M,N,O,P,Q]]	0
Fast Food	1	1 [Cox et al. 2012[L,M,N,O,P,Q]]	0	0
Healthy Eating Index	1	0	1 [Sisson et al. 2012[C,B]]	0

For reference 4: [a]Objectively assessed sedentary activity using accelerometer, [b]Assessed using screen time questionnaire; for reference 9: [c]pre-school aged 2-5, [d]children aged 6-11 years of age; for reference 1: [n]pre-school aged 4-5, [o]children aged 6-7.

Note: All associations with dietary behaviours are with TV-viewing unless otherwise stated.
A. If in one study, dietary behaviour is examined in relation to two or more sedentary behaviours (e.g. a positive [+] association was found for studying and an inverse [-] association was found for TV and computer use), the study is counted once in the "No. of samples" column and twice in the "Summary" column.
B. Females only
C. Males only;
D. Males and females analysed separately,
E. Objectively assessed sedentary activity using accelerometer
F. Homework,
G. Separate measures of TV, computer use, internet use, internet for study, video games and studying.
H. Separate measures of TV and computer use
I. Separate measure of TV, computer use and video
J. Screen time (TV + DVD)
K. Screen time (TV + video games + computer use + internet)
L. Non-commercial TV weekday,
M. Non-commercial TV weekend day,
N. Commercial TV weekday,
O. Commercial TV weekend day,
P. TV weekday,
Q. TV weekend
R. Computer use (games or general use)

Table 4. Associations between sedentary behaviour and diet in school age children (aged ≥5 - 11 years)

Dietary behaviour	No. of samples	Summary (*n* samples [references])		
		Positive association (+)	Inverse association (-)	No association (0)
Energy-dense food	5	5 [Brown et al. 2010, Brown et al. 2011, Gebremariam et al. 2013[R,J], McCormack et al. 2011, Ouwens et al. 2012]	1 [McCormack et al. 2011[R]]	0
Vegetable	2	1 [McCormack et al. 2011[R]]	2 [Gebremariam et al. 2013[R,J], McCormack et al. 2011[J]]	0
Fat intake	1	1 [Danielson et al. 2011[a,b]]	0	0
Sugar intake	1	1 [Danielson et al. 2011[a,b]]	0	0
Total calorie intake	1	1 [Danielson et al. 2011[a,b]]	0	0
Diet quality (based on fat and sugar)	1	1 [Fuller et al. 2012]	0	0
Fruit	2	0	2 [Gebremariam et al. 2013[R,J], McCormack et al. 2011[J]]	1 [McCormack et al. 2011[R]]
Sugar sweetened beverages	2	2 [Gebremariam et al. 2013[R,J], McCormack et al. 2011[R,J]]	0	0
Healthy eating index	2	1 [Seghers and Rutten 2010[F]]	2 [Sisson et al. 2012[C,B], Seghers and Rutten 2010[R]]	0

For reference 4: [a]Objectively assessed sedentary activity using accelerometer, [b]Assessed using screen time questionnaire; for reference 9: [c]pre-school aged 2-5, [d]children aged 6-11 years of age; for reference 1: [n]pre-school aged 4-5, [o]children aged 6-7.

Note: All associations with dietary behaviours are with TV-viewing unless otherwise stated.
A. If in one study, dietary behaviour is examined in relation to two or more sedentary behaviours (e.g. a positive [+] association was found for studying and an inverse [-] association was found for TV and computer use), the study is counted once in the "No. of samples" column and twice in the "Summary" column.
B. Females only
C. Males only;
D. Males and females analysed separately,
E. Objectively assessed sedentary activity using accelerometer
F. Homework,
G. Separate measures of TV, computer use, internet use, internet for study, video games and studying.
H. Separate measures of TV and computer use
I. Separate measure of TV, computer use and video
J. Screen time (TV + DVD)
K. Screen time (TV + video games + computer use + internet)
L. Non-commercial TV weekday,
M. Non-commercial TV weekend day,
N. Commercial TV weekday,
O. Commercial TV weekend day,
P. TV weekday,
Q. TV weekend
R. Computer use (games or general use)

Table 5. Associations between sedentary behaviour and diet in adolescents (aged 12-18 years).

		Summary (*n* samples [references])		
Dietary behaviour	**No. of samples**	**Positive association (+)**	**Inverse association (-)**	**No association (0)**
Fruit	3	1[Santaliestra-Pasias [A,G,D]]	5[Santaliestra-Pasias [A,G,D], Verzeletti [S], Al-Hazza (2011) [H,S], Ciccone, Al-Hazzaa (2013)]	0
Vegetables	3	1[Santaliestra-Pasias [A,G,D]]	5[Santaliestra-Pasias [A,G,D], Verzeletti [S], Al-Hazza (2011) [H,S], Ciccone, Al-Hazzaa (2013)]	0
FV (composite measure of fruit and vegetables)	1	0	1[Shi [H,S]]	0
Juices	1	1[Santaliestra-Pasias [A,G,D]]	1[Santaliestra-Pasias [A,G,D]]	0
Savoury snacks	1	1 [Santaliestra-Pasias [A,G,D]]	1 [Santaliestra-Pasias [A,G,D]]	0
Fast food	4	[Shi [H,S] Al-Hazza (2011) [H,S] Lee, Al-Hazzaa(2013)]	0	0
Fried foods	2	2[Fernandes [S] Al-Hazza (2011) [H,S]]	0	0
High-sugar foods	1	1[Shi [H,S]]	0	0
Western dietary pattern	1	2[del Mar Bibiloni [D], Lee]	0	0
Mediterranean dietary pattern	1	0	1[del Mar Bibiloni [D]]	0
Breakfast consumption	2	1 [Arora [S,T]]	2[Al-Hazza (2011) [H,S], Cuenca-Garcia]	1 [Arora [A,H,S]]
Healthy food index score/Healthy nutrition behaviours	2	1[Williams [A,D,U]]	2 [Sisson [D], Williams [A,G,D]]	0
Milk/dairy	2	1[Santaliestra-Pasias [A,G,D]]	3[Sisson [A,G,D], Al-Hazza (2011) [H,S], Al-Hazzaa (2013)]	0
Desserts	1	1 [Santaliestra-Pasias [A,G,D]]	1 [Sisson [A,G,D]]	
Cakes	2	[Santaliestra-Pasias [A,G,D] Al-Hazza (2011) [H,S]]	1 [Sisson [A,G,D]]	0
Sweets	2	[Honkala [S], Al-Hazza (2011) [H,S]]		0
Energy drinks	2	[Al-Hazza (2011) [H,S], Al-Hazzaa(2013)]		0
Sugar sweetened beverages	6	5 [Honkala [S], Santaliestra-Pasias [A,G,D], Shi [H,S], Al-Hazzaa (2011) [H,S], Ranjit [D], Al-Hazzaa (2013)]	1 [Sisson [A,G,D]]	0
Korean health dietary pattern	1	Lee	0	

Note: All associations with dietary behaviours are with TV-viewing unless otherwise stated. For reference Honkala: younger cohort (mean age 13 years). For reference Fernandes: only 'TV-viewing (high frequency)' data given, mean age 13.8B and 13.9G. For reference Arora: adolescents in grades 8-10. For reference Shi: adolescents mean age 14.4. For reference Williams: adolescents in school years 9-12. For reference Verzeletti: adolescents aged 11-16 years, and part of the larger Health Behaviour in School-Aged Children study examining associations between TV-viewing and diet. For reference Ranjit: adolescents in grades 8 and 11. For reference Al-Hazza (2011): older cohort (age 14-19 years). For reference Santaliestra-Pasias: adolescents aged 12.5 - 17.5 years.

Table 6. Associations between sedentary behaviour and diet in adults (aged >18 years)

		Summary (*n* samples [references])		
Dietary behaviour	**No. of samples**	**Positive association (+)**	**Inverse association (-)**	**No association (0)**
Total energy intake	1	1 [Tucker [B]]	0	0
Healthy food index score	1	1 [Huffman [D]]	1 [Sisson [D]]	0

Note: All associations with dietary behaviours are with TV-viewing unless otherwise stated. For Tucker reference: TV-viewing categorised as infrequent, moderate, and frequent viewing. For Huffman reference: only 'high TV-viewing' data given.

A. If in one study, dietary behaviour is examined in relation to two or more sedentary behaviours (e.g. a positive [+] association was found for studying and an inverse [-] association was found for TV and computer use), the study is counted once in the "No. of samples" column and twice in the "Summary" column.
B. Females only
C. Males only;
D. Males and females analysed separately,
E. Objectively assessed sedentary activity using accelerometer
F. Homework,
G. Separate measures of TV, computer use, internet use, internet for study, video games and studying.
H. Separate measures of TV and computer use
I. Separate measure of TV, computer use and video
J. Screen time (TV + DVD)
K. Screen time (TV + video games + computer use + internet)
L. Non-commercial TV weekday,
M. Non-commercial TV weekend day,
N. Commercial TV weekday,
O. Commercial TV weekend day,
P. TV weekday,
Q. TV weekend
R. Computer use (games or general use)
S. Males and females analysed together
T. SB measure of studying for weekday and weekend.
U. Sedentary education time (reading + homework)