

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

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33

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36 **ABSTRACT**

37

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

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

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

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

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

60

61

62 **What are the new findings?**

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

70

71 **1.0 Introduction**

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

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

82 In adults, prospective observational cohort studies show evidence of an association between  
83 sedentary behaviour and weight status. For example, parent- and self-reported time spent  
84 watching television between 5 and 15 years in New Zealand was shown to predict BMI at 26  
85 years of age<sup>5</sup>. The Nurses' Health Study of over 50,000 women<sup>7</sup> showed that those who were  
86 normal weight or overweight at baseline had a 23% increased risk of developing obesity  
87 during 6 years of follow-up for each 2-hour per day increment in time spent watching TV. In  
88 another study of over 18,000 women, Blanck et al<sup>8</sup> showed an elevated risk of weight gain in

89 those who were normal weight at baseline and reporting more than 6 hours of leisure time  
90 sitting compared to those who reported less than 3 hours/day. For adults, therefore,  
91 associations between sedentary behaviour and weight status are suggestive of a positive  
92 association.<sup>9</sup> However, studies either do not control for confounding factors, such as diet or  
93 physical activity, or this is done inconsistently across studies. One variable that has been  
94 hypothesized to co-vary with some sedentary behaviours, and in particular TV viewing, is  
95 diet.

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

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

108 Dietary intake and its association with sedentary behaviour in young people and adults is an  
109 important topic that may assist researchers in better interpreting the diversity of findings  
110 concerning sedentary behaviour and weight status. However, it is recognised that sedentary  
111 pursuits using technology can change very quickly. Computer technology has become more  
112 mobile and will this change the way people use and interact with such devices. Moreover, TV

113 channels have increased and the TV viewing experience has changed with greater access to  
114 high definition screens and even 3D TV. To this end, it is important to update the review of  
115 studies on the association between sedentary behaviour and dietary behaviour. In addition, we  
116 feel it is important to differentiate studies with young people into pre-school, children, and  
117 adolescents. This systematic review, therefore, provides an update of the associations  
118 between sedentary behaviour and diet across the lifespan.

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119 **2.0 Methods**

120 *2.1 Search Strategy*

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

127

128 *2.2 Inclusion and Exclusion Criteria*

129 To be included studies had to: (1) be observational in design; (2) report data on pre-school  
130 children (<5 years), school-aged children (6-11 years), adolescents (12-18 years) and adults  
131 (>18 years) (or a mean within these ranges) at baseline; (3) measure at least one domain of  
132 sedentary behaviour and one aspect of dietary intake; (4) assess an association between at  
133 least one sedentary behaviour and one aspect of dietary intake; (5) be published in English  
134 between January 2010 to October 2013. Studies that reported physical inactivity (low  
135 physical activity) as a measure of sedentary behaviour were excluded. Studies that  
136 manipulated a sedentary behaviour and/or aspects of dietary intake were excluded as were  
137 studies that did not involve healthy free living individuals were excluded (i.e. chronic  
138 illnesses preventing physical activity), although articles that reported risk factors were  
139 included.

140

141 *2.3 Identification of relevant studies*

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

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

148

#### 149 *2.4 Data Extraction*

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

161 *TABLE 1 & 2 (SUPPLEMENTARY DATA)*

162

#### 163 *2.5 Study Quality*

164 The quality of the studies included in this review was assessed with a previously used scale.<sup>6</sup>  
165 Studies were given a score based on sampling procedure, sample size, response rates, the  
166 validity and reliability of the measures used to assess sedentary behaviour and dietary intake  
167 and whether confounders had been considered in the analysis. Each included paper was given  
168 a score out of 16 with a higher score meaning higher study quality. Studies were categorised

169 as high (scoring 12+), moderate (scoring 6-11), and poor (scoring 0-5) quality. There was  
170 good initial agreement for study quality (91%  $r = 0.98$ ) between authors.

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172 **3.0 Results**

173 *3.1 Flow of studies included*

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

179  
180 *INSERT FIGURE 1 AROUND HERE*

181  
182 *3.2 Study Quality*

183 Study quality for studies including children of pre-school age ranged from 2/16 to 6/16,  
184 median = 6 [individual scores 6: n=2<sup>17 18</sup>; 2: n=1<sup>19</sup>]. Study quality in studies including  
185 children ranged from 4/16 to 8/16, median = 6 [individual scores 6: n=4<sup>17 18 20 21</sup>; 7: n=2<sup>22 23</sup>;  
186 8: n=1<sup>24</sup>; 4: n=1<sup>25</sup>; 5: n=1<sup>26</sup>].

187  
188 Adolescent study quality ranged from 4/16 to 15/16, median=8 [scores 19: n= 1<sup>27</sup>; 10: n=4<sup>28-</sup>  
189 <sup>31</sup>; 8: n=2<sup>32 33</sup>; 7: n=1<sup>34</sup>; 6: n=5<sup>18 35-38</sup>; 5: n=1<sup>39</sup>; 4: n=1<sup>40</sup>]. Study quality scores in adults for  
190 studies ranged from 5/16 to 7/16, median=6 [scores 7: n=1<sup>41</sup>; 6: n=1<sup>18</sup>; 5: n=1.<sup>42</sup>

191  
192 *3.3 Associations between Sedentary Behaviour and Diet in Pre-school Children*

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

197 sectional research design (n=2), two of the studies assessed sedentary behaviour through  
198 parental report and one through interview. Dietary behaviour was also assessed through  
199 parental report (n=2) and interview (n=1). In this one instance, the dietary behaviour (based  
200 on the Healthy Eating Index (HEI) 2005) was collected from two, averaged interview-  
201 administered 24 hour dietary recalls. The sedentary behaviour information was also collected  
202 as part of this interview. TV viewing was the most commonly assessed sedentary behaviour  
203 in association with dietary intake, studied in all three studies. In studies including children of  
204 pre-school age, five dietary behaviours were identified.

205 INSERT TABLE 3 HERE

206

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

213

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

222

223 *3.3 Associations between Sedentary Behaviour and Diet in Children*

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

235 INSERT TABLE 4 AROUND HERE

236

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

245

246 Sedentary behaviour was positively associated with energy-dense food in five samples (four  
247 assessed TV viewing and the other both screen time and computer use). However, computer  
248 use was inversely associated with energy-dense food in one sample. Sedentary behaviour was  
249 positively associated with fat, sugar and total calorie intake in three samples (three used self-  
250 report and one study objectively assessed sedentary behaviour) and was positively associated  
251 with sugar sweetened beverage intake in two samples (one assessed screen time and  
252 computer use and the other assessed computer use and TV viewing). Finally, TV viewing was  
253 positively associated with diet quality based on fat and sugar intake (one sample).

254

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

266

#### 267 *3.4 Associations between Sedentary Behaviour and Diet in Adolescents*

268 All fifteen studies were cross-sectional in design. Data were reported separately for gender in  
269 eight studies. The remaining seven studies combined male and female data. Participants were

270 aged between 11 and 19 years. Three studies reported data from the US and two presented  
271 combined data from Europe.

272

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

283

284 INSERT TABLE 5 HERE

285

286 A total of eighteen dietary behaviours were assessed. Eleven studies assessed diet by self-  
287 report and the remaining study used a telephone interview technique. Diet was measured  
288 using unnamed questionnaires in eight studies, a web-based food behaviour questionnaire in  
289 another study, food frequency questionnaire in two studies, and using 24-hour recall methods  
290 in three studies. Finally, one study used a combination of a food frequency questionnaire and  
291 24-hour recall.

292

293 Separate measures of TV-viewing and various categories of screen time were positively  
294 associated with sugar sweetened beverages in five of five samples and inversely associated in

295 one sample. Separate measures of TV-viewing and various categories of screen time were  
296 also inversely associated with separate measures of fruit and vegetable consumption in three  
297 of three studies, and positively associated in another. Further, the inclusion of sedentary  
298 behaviours such as ‘internet use for study’ and ‘studying’ evident in one study resulted in a  
299 positive association with a separate measure of fruit and vegetable consumption. TV-viewing  
300 and computer use were also inversely associated with a composite measure of fruit and  
301 vegetable consumption in one of one sample.

302

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

306

### 307 *3.5 Associations between Sedentary Behaviour and Diet in Adults*

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

311

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

319

320 Based on the lack of evidence, it is difficult to provide a clear conclusion on the association  
321 between TV-viewing and dietary behaviour in adults. Although limited, the available  
322 evidence tends to suggest that high TV-viewing is positively associated with total energy  
323 intake and unhealthy diet quality. Similar to findings with adolescents, caution should be  
324 taken when interpreting associations regarding adults due the lack of research.

325 INSERT TABLE 6 HERE

326

#### 327 **4.0 Discussion**

328 This systematic review builds on the published review by Pearson and Biddle.<sup>6</sup> An update  
329 was attempted because technology-based sedentary behaviours are likely to be changing  
330 quickly, and it is timely to examine new papers that were emerging but by differentiating pre-  
331 school children from children and adolescents. Adults were again included to allow for a  
332 lifespan approach. However, studies are failing to provide contextual information about how  
333 TV is viewed, thus we were unable to further differentiate results on this basis. For example,  
334 we have shown that children multi-task while ‘watching’ TV.<sup>43</sup> Future research on diet and  
335 screen viewing needs to differentiate types of screen viewing as this will inevitably change  
336 with time.

337

338 For pre-school children, three new studies were found since early 2010. These showed a clear  
339 trend for greater time in sedentary behaviour (mainly TV viewing) to be associated with  
340 unhealthy eating. This showed in less fruit and vegetable consumption and lower scores on a  
341 healthy eating index, as well as higher levels of energy dense food and fast food. In the 2011  
342 review, we combined this age group with older children. The present review, therefore,  
343 shows that the coupling of screen time and possibly commercial TV viewing time with an  
344 unhealthy diet starts at an early age and leads to the obvious conclusion that parental, family

345 and other interventions are required with children in the first few years of life. However,  
346 caution is required at this stage due to the small number of studies and the difficulty of  
347 eliciting such information from young children or their carers. Clearly this is an important  
348 area of research development.

349 For children aged 5-11 years, results across nine studies showed a clear trend for sedentary  
350 behaviour to be associated with a less healthy diet. With 19 studies reported by Pearson and  
351 Biddle for pre-adolescent children, including pre-school children, this shows a continued  
352 interest in diet and sedentary behaviour in this age group. In the current review, sedentary  
353 screen time, and mainly TV viewing, is associated with greater consumption of energy-dense  
354 food, fat, sugar, sugar sweetened beverages and total caloric intake. It is also associated with  
355 consumption of less fruit and vegetables.

356 Confidence in these trends is enhanced by two reasonably large longitudinal studies that  
357 show that screen time is associated energy-dense food and sugar sweetened beverage  
358 consumption. Sugar sweetened beverages have been implicated in weight gain<sup>44 45</sup> and  
359 might be one mechanism linking screen time with obesity and account for the variable  
360 findings in this area. In other words, weight status may be as much to do with energy  
361 consumption as it is with low energy expenditure from sedentary time, thus accounting for  
362 inconsistency of findings when just investigating TV and weight status.<sup>10</sup> Studies are required  
363 that investigate further this association, including availability of food and drinks during  
364 different sedentary behaviours, and prompts or cues that encourage or discourage such  
365 consumption.

366 With 15 studies reported in the current review concerning associations between sedentary  
367 behaviour and diet in adolescents, this shows that researchers continue to view this topic and  
368 age group as important. In less than four years, this represents more than a 50% increase in



369 the number of studies. However, while there is a trend for higher levels of sedentary  
370 behaviour to be associated with poorer diet, there are rather few studies assessing the same  
371 sedentary behaviour and same diet outcome variable. Future studies need to build on these  
372 associations by ensuring that similar measures are taken. It appears that TV and, to a certain  
373 extent computer screen time, are implicated in being associated with poorer diet. The dietary  
374 outcomes, therefore, need standardising by studies ensuring that they measure at least fruit  
375 and vegetable intake, energy-dense snacks, and sugar sweetened beverages. That way a more  
376 comprehensive picture will emerge for adolescents at an important time of change in this age  
377 group.

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

### 383 **Conclusion**

384 In conclusion, sedentary behaviour, mainly in form of screen viewing and especially TV, is  
385 associated with indicators of unhealthy dietary intake in pre-school children, school-aged  
386 children and adolescents in predominantly cross-sectional studies. The results for adults are  
387 sparse and less clear. Findings largely confirm and extend the review published in 2011. We  
388 have added to knowledge by investigating pre-school children separately, and documenting  
389 the continued study of sedentary behaviour and diet in young people. Research on adults  
390 needs to develop. Future studies need to be longitudinal in design, use standard measures of  
391 diet, include a wider variety of sedentary behaviours, as well as document the context that  
392 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
<b>Sample size</b>		<b>3</b>		<b>9</b>
<100	-	-	4	1
100-199	3	1	-	-
200-299	-	-	7	1
300-499	-	-	10	1
500-999	-	-	6, 8	2
1000-2999	1 <sup>n</sup> , 9 <sup>c</sup>	2	1 <sup>o</sup> , 9 <sup>d</sup>	2
3000-4999	-	-	2, 5	2
<b>Gender</b>				
Boys and girls combined	1 <sup>n</sup> , 3,	2	1 <sup>o</sup> , 2, 4, 5, 6, 7, 8, 10	8
Boys and girls separately	9 <sup>c</sup>	1	9 <sup>d</sup>	1
<b>Study design</b>				
Cross sectional	3, 9 <sup>c</sup>	2	2, 4, 7, 8, 9 <sup>d</sup> , 10	6
Longitudinal	1 <sup>n</sup>	1	1 <sup>o</sup> , 5, 6	3
<b>Study quality</b>				
Poor	3	1	5, 7	2
Moderate	1 <sup>n</sup> , 9 <sup>c</sup>	2	1 <sup>o</sup> , 2, 4, 6, 8, 9 <sup>d</sup> , 10	7
High	-	-	-	-
<b>Sedentary behaviour assessed</b>				
TV viewing	1 <sup>n</sup> , 3, 9 <sup>c</sup>	3	1 <sup>o</sup> , 2, 5, 7, 8, 9 <sup>d</sup>	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 <sup>a</sup> , 4 <sup>b</sup>	1
Computer (games or use)	-	-	6 <sup>1</sup> , 7	2
Screen time	-	-	6 <sup>n</sup> , 10	2
Homework	-	-	10	1
<b>Assessment of sedentary behaviour</b>				
Parent reported	1 <sup>n</sup> , 3	2	1 <sup>o</sup> , 2, 5	3
Accelerometer	-	-	4 <sup>a</sup>	1
Self-report	9 <sup>c</sup>	1	4 <sup>b</sup> , 6, 7, 8, 9 <sup>d</sup> , 10	6
<b>Measure of sedentary behaviour</b>				
24 hour recall	1 <sup>n</sup>	1	1 <sup>o</sup> , 2	2
Questionnaire	3, 9 <sup>c</sup>	1	4 <sup>b</sup> , 5, 6, 7, 8, 9 <sup>d</sup> , 10	7
Accelerometer	-	-	4 <sup>a</sup>	1
<b>Dietary behaviour assessed</b>				

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

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

Note:

<sup>e</sup>non-commercial TV weekday, <sup>f</sup>non-commercial TV weekend day,

<sup>g</sup>commercial TV weekday, <sup>h</sup>commercial TV weekend day,

<sup>i</sup>TV weekday, <sup>j</sup>TV weekend.

<sup>B</sup>, boys only; <sup>G</sup>, girls only

<sup>l</sup>computer use (games or general use), <sup>m</sup>homework, <sup>n</sup>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
<b>Sample size</b>				
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
<b>Gender</b>				
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
<b>Study design</b>				
Cross sectional	14, 9, 6, 7, 12, 3, 16, 13, 15, 1, 11, 2, 4, 5, 8	15	14, 10, 17	3
<b>Sedentary behaviour assessed</b>				
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 +/- video +/- DVDs + video games + computer games +computer not for homework)	16	1	-	-
Sedentary education time (reading + homework)	16	1	-	-
<b>Assessment of sedentary behaviour</b>				



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	-	-
<b>Measure of sedentary behaviour</b>				
Questionnaire	14, 9, 6, 7, 12, 1, 2, 3, 16, 13, 15, 11, 4, 5, 8	15	14, 10, 17	3
<b>Dietary behaviour assessed</b>				
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		-
<b>Assessment of dietary behaviour</b>				
Self-report	14, 9, 6, 7, 12, 3, 15, 11, 2, 4, 5, 8,	13	14, 10, 17	3
Telephone interview	13	1	-	-
<b>Measure of dietary behaviour</b>				
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
<b>Country/Region</b>				
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-García 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 ( <i>n</i> samples [references])		
		Positive association (+)	Inverse association (-)	No association (0)
Fruit and Vegetable (FV)	1	1 [Cox et al. 2012 <sup>N</sup> ]	1 [Cox et al. 2012 <sup>L,M,O,P,Q</sup> ]	0
Energy-dense food	2	1, 3 [Brown et al. 2010, Cox et al. 2012 <sup>L,M,N,O,P,Q</sup> ]	0	0
Vegetable	1	0	1 [Cox et al. 2012 <sup>L,M,N,O,P,Q</sup> ]	0
Fast Food	1	1 [Cox et al. 2012 <sup>L,M,N,O,P,Q</sup> ]	0	0
Healthy Eating Index	1	0	1 [Sisson et al. 2012 <sup>C,B</sup> ]	0

For reference 4: <sup>a</sup>Objectively assessed sedentary activity using accelerometer, <sup>b</sup>Assessed using screen time questionnaire; for reference 9: <sup>c</sup>pre-school aged 2-5, <sup>d</sup>children aged 6-11 years of age; for reference 1: <sup>n</sup>pre-school aged 4-5, <sup>o</sup>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  $\geq 5$  - 11 years)

Dietary behaviour	No. of samples	Summary ( <i>n</i> 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 <sup>(R,J)</sup> , McCormack et al. 2011, Ouwens et al. 2012]	1 [McCormack et al. 2011 <sup>R</sup> ]	0
Vegetable	2	1 [McCormack et al. 2011 <sup>R</sup> ]	2 [Gebremariam et al. 2013 <sup>R,J</sup> , McCormack et al. 2011 <sup>J</sup> ]	0
Fat intake	1	1 [Danielson et al. 2011 <sup>a,b</sup> ]	0	0
Sugar intake	1	1 [Danielson et al. 2011 <sup>a,b</sup> ]	0	0
Total calorie intake	1	1 [Danielson et al. 2011 <sup>a,b</sup> ]	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 <sup>R,J</sup> , McCormack et al. 2011 <sup>J</sup> ]	1 [McCormack et al. 2011 <sup>R</sup> ]
Sugar sweetened beverages	2	2 [Gebremariam et al. 2013 <sup>R,J</sup> , McCormack et al. 2011 <sup>R,J</sup> ]	0	0
Healthy eating index	2	1 [Seghers and Rutten 2010 <sup>F</sup> ]	2 [Sisson et al. 2012 <sup>C,B</sup> , Seghers and Rutten 2010 <sup>R</sup> ]	0

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

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

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