

# Sedentary behaviour in youth

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## ABSTRACT

The purpose of this review is to describe the amount of time children spend in sedentary behaviour and to determine if there are specific factors that associate with sedentary behaviour in children. The following search terms were used to identify relevant articles: sedentary behaviour, inactivity, television, computer, video games, small screen, sitting, prevalence, patterns, correlates, factors and determinants. The databases used to conduct the search included PubMed, PsycINFO, ERIC (Education Resources Information Center) and Academic Search Premier. The studies reviewed were limited to those that sampled children (2–18 years), were written in English and used a measure of sedentary behaviour as the dependent variable. Several studies reported the time spent watching television or the proportion of children at or above a threshold for television viewing (eg,  $\geq 3$  h/day). Among the accelerometer studies included, the National Health and Nutrition Examination Survey is the largest and reported  $\sim 6.1$ , 7.5 and 8.0 h/day mean sedentary time in children 6–11, 12–15 and 16–19 years old, respectively. Taken together, the existing literature across the world indicates a slightly higher level of sedentary behaviour in older children. Higher levels of sedentary behaviour were also reported in non-white children, children from lower socioeconomic status background and children from households with more access to televisions/computers. Lower levels of sedentary behaviour were reported in children whose parents have rules/limitations on screen time.

## INTRODUCTION

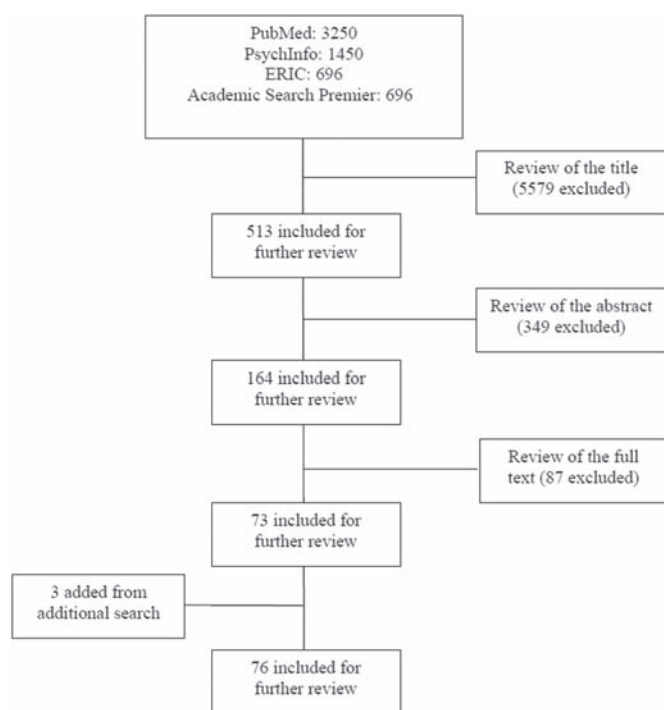
Recent decades have seen monumental changes in the developed societies of the world, and many of these changes have reduced the demand for physical activity. Among the most profound changes are the remarkable growth in the availability of electronic forms of entertainment, including television, the internet, mobile telephones and video games, and a reduced reliance on physically active forms of transportation, as well as reductions in physically demanding occupational tasks.

These societal changes in the availability of sedentary forms of entertainment and the demand for physical activity have profoundly influenced the behaviour of children and youth, as well as that of adults. Concurrent with these changes, the prevalence of overweight has increased rapidly in young people across the developed world,<sup>1</sup> and the same trend is now evident in some developing countries.<sup>2–3</sup> While changes in dietary behaviour may have contributed to these trends, it seems very likely that declining physical activity and increased time spent in sedentary behaviour are major factors underlying the worldwide childhood obesity epidemic.<sup>4–6</sup>

The major purpose of this review is to summarise the current state of knowledge regarding sedentary behaviour in children and adolescents. Two primary subtopics will be addressed. First, we will summarise the scientific literature that describes overall levels of sedentary behaviour and levels of specific forms of sedentary behaviour. Second, we will review the literature that addresses a wide range of factors that may be associated with sedentary behaviour in children and adolescents. Our goal is to contribute to an understanding of sedentary behaviour in children and youth so that effective interventions to reduce or limit sedentary time can be developed.

## METHODS

A search for relevant studies was conducted using the following electronic databases: PubMed, PsycINFO, ERIC (Education Resources Information Center) and Academic Search Premier. The searches were limited to children (2–18 years old), published between 1990 and 2010 and written in English. The following keywords were used to identify studies that measured sedentary behaviour: sedentary behaviour, inactivity, sitting, television, video games, computer and small screen. These were paired with the following keywords to identify descriptive sedentary behaviour papers and factors that associate with sedentary behaviour: prevalence, levels, pattern, factors, correlates and determinants. The initial searches identified 3250, 1450, 696 and 696 articles from PubMed, PsycINFO, ERIC and Academic Search Premier, respectively. We reviewed the titles and abstracts of the identified studies, and only those that used measures of sedentary behaviour as the dependent variable were considered for further review. The reference lists from past review articles were searched for additional articles of interest. For the purpose of this review, the identified studies were considered as descriptive or deterministic. Descriptive studies provide evidence of the time children spend in sedentary behaviour; deterministic studies provide evidence of the factors that influence time spent in sedentary behaviour. The process used to identify the studies included in this review is presented in figure 1. Past reviews have tended to focus only on screen-based sedentary behaviour<sup>7–8</sup> or have summarised the association between sedentary behaviour and health outcomes.<sup>9–11</sup> Our review will provide a contemporary summary of time spent in screen- and non-screen-based sedentary behaviour and will identify factors that associate with sedentary behaviour during childhood.



**Figure 1** Literature search flow chart.

## DEFINITIONS

Throughout this review, sedentary behaviour will be considered as a distinct construct from physical activity. In order to clarify this distinction, we give a brief definition of sedentary behaviour below. In addition, several studies used accelerometers to measure sedentary behaviour, and a brief summary of this measurement technique is provided below to help with the interpretation of the relevant studies.

## Sedentary behaviour

In terms of energy expenditure, sedentary behaviour represents a slight increase in expenditure above resting metabolic rate but below the expenditure seen with light-intensity physical activity (1.0–1.5 metabolic equivalents (METs)).<sup>12</sup> The most prevalent sedentary behaviours include television viewing, computer use, desk-based work and sitting while socialising; the fundamental characteristic of these behaviours is that sitting predominates. Importantly, we believe that sedentary behaviour should not be defined as failure to attain recommended levels of physical activity. An individual can spend a large proportion of time in sedentary behaviour and still meet guidelines for moderate to vigorous physical activity.<sup>12</sup> Sedentary behaviour and physical activity should be considered independent constructs.

## Accelerometry

Accelerometers are small unobtrusive devices, worn at the right hip by means of an elastic belt, that collect and store count data related to movement frequency and intensity. As a general rule, the higher the counts are, the more intense is the movement. In this review, the majority of accelerometers used a 1-min sampling period, and so, the count data are expressed as counts per minute (cpm). Cut points applied to the count data to define sedentary behaviour range from <100 to <1100 cpm.<sup>13 14</sup> Using the former cut point as an example, the

total time spent in sedentary behaviour reflects the sum of minutes in which 0–99 cpm are registered. A full description of accelerometry protocols is beyond the scope of this review, and further details can be found elsewhere.<sup>15</sup>

## RESULTS

### Time spent in sedentary behaviour

#### Screen-based sedentary behaviour

Television viewing is a common screen-based sedentary behaviour. From the studies identified, boys have reported watching television for 1.5–3.7 h/day, and girls, for 1.4–3.0 h/day.<sup>16–24</sup> The available data, while limited, suggest that viewing hours per day increased from early to mid childhood but declined from mid adolescence to late adolescence.<sup>18 21</sup>

Studies also have reported the proportion of children that exceed hourly thresholds of television viewing.<sup>22 25–33</sup> For example, the Youth Risk Behavior Survey and the National Health and Nutrition Examination Survey (NHANES) are two population-based studies in the USA that report such data. The Youth Risk Behavior Survey 2009 data showed that 35.2%, 34.7%, 30.8% and 29.7% of US children in the 9th, 10th, 11th and 12th grades, respectively, exceed 3 h of television viewing per day.<sup>33</sup> Using NHANES 2001–2006 data, Sisson *et al* reported that 35%, 49% and 56% of children aged 2–5, 6–11 and 12–15 years, respectively, watched two or more hours of television per day.<sup>30</sup>

#### Screen- and non-screen-based sedentary behaviour

Children also spend time in non-screen-based sedentary behaviours.<sup>25 34–37</sup> A cross-sectional study by Hardy *et al*, in Australia, reported the sum of time spent in screen-based sedentary behaviours, educational sedentary behaviours, motorised travel time, sedentary hobbies (eg, reading and musical instruments) and social sedentary behaviours (eg, sitting, talking).<sup>34</sup> The children were in the 6th, 8th and 10th grades. The total time spent in sedentary behaviour was 4.8, 6.0 and 6.5 h/day, respectively, for the boys, and 4.7, 5.8 and 6.4 h/day, respectively, for the girls.<sup>38</sup> Interestingly, Hardy *et al* also performed a longitudinal study involving a sample of Australian girls using a similar measure of sedentary behaviour; at 12 years, the girls spent 5.0 h/day in sedentary behaviour; the time increased to 6.9 h/day by 15 years.<sup>34</sup>

Similar findings were reported in a cross-sectional sample of US children aged 15–17 years, who were asked over the telephone to recall all their activities on the previous day. The sum of minutes spent in screen- and non-screen-based sedentary behaviour was 7.6 and 8.0 h/day for the boys and girls, respectively.<sup>35</sup>

Adopting a different methodology, studies in the UK and Hungary used self-report diaries to determine the time children (12–18 years) spent in sedentary behaviour while not in school.<sup>39 40</sup> The children were instructed to make a diary entry every 15 min, and the time spent watching television, using a computer, playing video games, sitting and talking, doing homework, reading, talking on the phone and using motorised transportation was determined.<sup>39 40</sup> The boys and girls in the UK were sedentary for 4.1 and 3.0 h/day, respectively.<sup>39</sup> The data from Hungary showed that the children were sedentary for 4.9 h/day on weekdays and 6.7 h/day on weekends.<sup>40</sup>

Gorely *et al* also used self-report diaries to determine time spent in sedentary behaviour.<sup>41</sup> Interestingly, this study identified clusters of children based on their most prominent reported sedentary behaviour.<sup>41</sup> Depending on the cluster a child belonged to, the total time spent in sedentary behaviour

(computer use (boys only), working (girls only), socialising, television/video and homework) ranged from 3.7 to 5.8 h/day for the boys and from 3.7 to 5.3 h/day for the girls.<sup>41</sup>

### Sedentary behaviour measured by accelerometry

Accelerometers can provide an objective measure of sedentary behaviour during waking hours. A large sample of US children (6–19 years) who participated in the NHANES 2003–2004 wore accelerometers for 1 week.<sup>14 42</sup> The sum of minutes at <100 cpm was used to define time spent in sedentary behaviour.<sup>14</sup> Boys aged 6–11, 12–15 and 16–19 years spent 6.0, 7.4 and 7.9 h/day, respectively, in sedentary behaviour. Girls in the same age groups spent 6.1, 7.7 and 8.1 h/day, respectively, in sedentary behaviour.<sup>14</sup>

Using the same definition of sedentary behaviour (<100 cpm), Steele *et al* found that 10-year-old boys and girls in the UK spent 7.5 and 7.7 h/day, respectively, in sedentary behaviour.<sup>43</sup> Nilsson *et al* found that 9- and 15-year olds in Denmark, Portugal, Estonia and Norway were sedentary for 4.0–5.7 and 5.5–7.8 h/day, respectively.<sup>44</sup> The times spent in sedentary behaviour from the three studies using <100 cpm as the definition of sedentary behaviour are shown in figure 2.

Nilsson *et al* also reported the proportion of time children from Denmark, Portugal and Estonia were sedentary. Boys aged 9 years and 15 years spent 41% and 55% of their waking time, respectively, in sedentary behaviour, while girls aged 9 and 15 years spent 43% and 60% of their waking time, respectively, in sedentary behaviour.<sup>45</sup> Van Sluijs *et al* defined sedentary behaviour as the time spent in 10-min blocks at <200 cpm in children from Denmark, Portugal, Estonia and

Norway.<sup>46</sup> They found that the 9-year olds spent 3.6 h/day and the 15-year olds spent 5.6 h/day in sedentary behaviour.<sup>46</sup>

Janz *et al* defined sedentary behaviour as the time spent at <800 cpm in a sample of US children. They found that children aged 5 and 8 years spent 4.1 and 5.3 h/day, respectively, in sedentary behaviour.<sup>19</sup> Two additional studies reported time spent in sedentary behaviour using an accelerometer count cut point of ≤1100 cpm to define sedentary behaviour,<sup>13 47</sup> although this cut point appears to provide an inflated estimate of the time children spend in sedentary behaviour. Guinhouya *et al* determined that a small sample of French boys and girls, aged 8–11 years, spent 11.7 h/day and 12.1 h/day in sedentary behaviour, respectively.<sup>47</sup> King *et al* determined that the median percentage of time spent in sedentary behaviour in a small sample of UK children, aged 7 years, was 77.8%.<sup>13</sup> The average child wore the accelerometer for 11.1 h/day, and the children spent approximately 8.6 h/day in sedentary behaviour.<sup>13</sup>

### Correlates of sedentary behaviour

The deterministic studies we identified hypothesised a wide range of factors to be associated with sedentary behaviour. For the purpose of this review, the factors will be categorised into five groups: (1) Demographic, (2) Biological, (3) Psychosocial, (4) Behavioural and (5) Environmental. In addition, within each group, distinctions regarding the measure of sedentary behaviour will be made.

#### Demographic variables

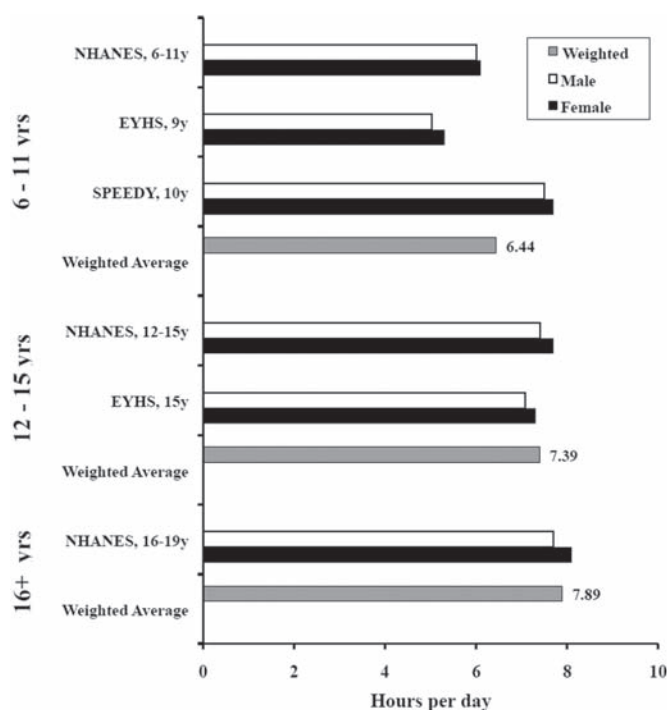
Associations between identified demographic variables and measures of sedentary behaviour are described in table 1. Thirteen studies investigated age, and seven of these found that older children spent more time in screen-based sedentary behaviour. In addition, two studies found that time spent in sedentary behaviour, as measured by accelerometry, was higher in older children.<sup>45 46</sup>

Race/ethnicity was investigated in 12 studies, all of which were conducted in the USA or the UK (table 1). Most studies found that non-white children spent more time in screen-based sedentary behaviour.<sup>23 24 48–55</sup> No studies investigated the association between race/ethnicity and accelerometer-measured sedentary behaviour; however, these findings regarding screen-based sedentary behaviours support the descriptive accelerometry data described by Matthews *et al*.<sup>14</sup>

The associations between gender and measures of sedentary behaviour are presented in table 1. The majority of studies used screen-based sedentary behaviour as the dependent variables, and the results were mixed. However, of the three studies that used accelerometers to measure sedentary behaviour, two found that girls spent more time in sedentary behaviour.<sup>13 45</sup>

Three studies investigated the association between measures of sedentary behaviour and parents' age and reported mixed results<sup>13 56 57</sup> (table 1). The one study that used accelerometry to investigate the association between sedentary behaviour and parental age found that the children with an older mother spent more time in sedentary behaviour.<sup>13</sup>

Measures of socioeconomic status (SES) were consistently associated with screen-based sedentary behaviour (table 1). Specifically, children tended to spend more time in screen-based sedentary behaviours if they were from low SES backgrounds, defined as a family with a lower income, a lower level of parental education or a lower level of parental employment.<sup>49–52 57–65</sup> One study, however, showed that children from higher SES backgrounds spent more time in academic sedentary behaviours (ie, reading, studying and doing



**Figure 2** Time spent in sedentary behaviour as measured by accelerometry by gender and age group, using time spent at <100 cpm to define sedentary behaviour. NHANES, National Health and Nutrition Examination Survey<sup>9</sup>; SPEEDY, Sports, Physical activity and Eating behaviour: Environmental Determinants in Young people<sup>38</sup>; EYHS, European Youth Heart Study.<sup>39</sup>

homework) than children from lower SES backgrounds.<sup>52</sup> Interestingly, two studies assessed the relationship between accelerometry-measured sedentary behaviour and SES. One study found that children from lower SES backgrounds spent

more time in sedentary behaviour,<sup>13</sup> while the other found a null association between SES backgrounds and objectively measured sedentary behaviour.<sup>46</sup>

### Biological variables

The associations between measures of sedentary behaviour and four biological factors are presented in table 2. A total of 18 studies investigated the influence that a child's body mass index (BMI) has on measures of sedentary behaviour; half of these found null associations.<sup>13 19 48 54 63 64 66 67</sup> In contrast, two studies that used accelerometry to measure sedentary behaviour found that having a higher BMI was associated with more time spent in sedentary behaviour.<sup>13 19</sup> However, studies by Steele *et al* and van Sluijs *et al* found that time spent in sedentary behaviour, measured by accelerometry, did not differ by BMI status.<sup>43 46</sup>

Three studies that assessed the relationship between pubertal stage and measures of sedentary behaviour were identified<sup>48 60 63</sup> (table 2). One study found that more mature children spent more time in screen-based sedentary behaviour<sup>49</sup>; a second found that more mature children spent more time in non-screen-based sedentary behaviour.<sup>68</sup> No studies have used accelerometry to assess the relationship between sedentary behaviour and pubertal stage.

### Psychosocial variables

The associations between 11 psychosocial factors and measures of sedentary behaviour are presented in table 3. These factors have only been investigated in single studies, making a review of the data difficult. Nonetheless, there is evidence that parents who limited screen time and enforced screen time rules had children who spent less time engaged in screen-based sedentary behaviours.<sup>23 52 63 69</sup> One accelerometry-based study found that children with more interest in physical activity spent less time in sedentary behaviour.<sup>13</sup> Another found that children with parents who were concerned about the safety of outdoor play (ie, not allowed to play outside) spent more time in sedentary behaviour.<sup>46</sup>

### Behavioural variables

Studies that examined the associations between behavioural factors and measures of sedentary behaviour are presented in table 4. Seven studies found null associations between children's physical activity levels and screen-based sedentary behaviour, supporting the concept that sedentary behaviour is distinct from low levels of physical activity. However, one study found that communication-based sedentary behaviour (ie, talking on the phone, texting or messaging) was negatively associated with physical activity levels.<sup>70</sup> Previous studies also found null associations between parents' physical activity levels and time spent in screen-based sedentary behaviour<sup>54</sup> and sedentary behaviour measured by accelerometry.<sup>13 46</sup>

Two studies used accelerometry to investigate the association between sedentary behaviour and active transport to school. One of these studies found that children who actively travelled to school spent less time in sedentary behaviour.<sup>13</sup>

Regarding parents' screen time, four studies found that a child's screen-based sedentary behaviour was higher if his or her parent reported more screen time (table 4).<sup>54 57 63 64</sup> Interestingly, one study that used accelerometers to measure sedentary behaviour found a null association between parents' screen time and time spent in sedentary behaviour.<sup>13</sup>

Three studies investigated whether children who ate meals while watching television spent more time in screen-based sedentary behaviour (table 4). Two of these studies found that children who ate while watching television reported more

**Table 1** Sociodemographic correlates of sedentary behaviour

Variables	Sedentary behaviour					
	Screen-based*		Non-screen-based†		Accelerometry-based	
	Assoc.	Studies	Assoc.	Studies	Assoc.	Studies
Child's age	+	17, 48, 49, 52, 59, 64, 68	+		+	45, 46
	o	57, 58, 63, 71	o		o	
Parent's age	+		+		+	13
	—	57	—		—	
	o	56	o		o	
Gender						
Female	+	48, 59, 67	+	70	+	13, 45
Male	+	23, 52, 56, 62, 63, 71	+	17	+	
	o	24, 51, 53–55, 58, 64, 65, 73–75	o		o	46
Race/ethnicity						
Non-white	+	23, 24, 48–55	+		+	
African American	—	52, 75	—		—	
SES‡	+	56	+	52	+	
	—	49–52, 57–65	—		—	13
	o	64, 74, 76	o		o	46

\*Includes TV/video viewing, playing PC/video games and using computer.

†Includes texting, talking on the phone, listening to music, reading, studying and doing homework.

‡SES was determined based on family income, parental education and parental employment.

+, positive association; —, negative association; o, null association.

SES, socioeconomic status.

**Table 2** Biological correlates of sedentary behaviour

Variables	Sedentary behaviour					
	Screen-based*		Non-screen-based†		Accelerometry-based	
	Assoc.	Studies	Assoc.	Studies	Assoc.	Studies
Child's BMI	+	27, 49, 59, 62, 68, 71, 77	+		+	13, 19
	o	48, 54, 63, 64, 66, 67	o	71	o	43, 46
Parent's BMI	+	60	+		+	
	o	48, 63	o		o	13, 46
Birth weight	o	59	o		o	
Pubertal stage	+	49	+	69	+	
	o	53	o		o	

\*Includes TV/video viewing, playing PC/video games and using computer.

†Includes texting, talking on the phone, listening to music, reading, studying and doing homework.

+, positive association; —, negative association; o, null association.

BMI, body mass index.



**Table 3** Psychosocial correlates of sedentary behaviour

Variables	Sedentary behaviour					
	Screen-based*		Non-screen-based†		Accelerometry-based	
	Assoc.	Studies	Assoc.	Studies	Assoc.	Studies
Confidence to reduce TV time	—	69	—		—	
Future expectations to school achievement	—	55	—		—	
Importance place on general health	—	55	—		—	
	o	49	o		o	
Spiritual/religious belief on health behaviour	—	55, 78	—		—	
Family support for encourage PA/discourage SED	+	54, 69	+		+	
	o		o	70	o	
Parent limit/rules on screen time	—	23, 52, 63, 69	—		—	
					o	
Parental perceptions						
Importance of child PA	—	54, 79	—		—	
Child interest in PA	—		—		—	13
Safety concern	+		+		+	46
Concerns for excess TV	o	16	o		o	
Their own fitness	—	54	—		—	
No. of active friend	—		—	70	—	

\*Includes TV/video viewing, playing PC/video games and using computer.

†Includes texting, talking on the phone, listening to music, reading, studying and doing homework.

+, positive association; —, negative association; o, null association.

PA, physical activity.

**Table 4** Behavioural correlates of sedentary behaviour

Variables	Sedentary behaviour					
	Screen-based*		Non-screen-based†		Accelerometry-based	
	Assoc.	Studies	Assoc.	Studies	Assoc.	Studies
Child PA level	—		—	70	—	13
	o	27, 49, 51, 53, 54, 64, 66	o		o	46
Parent's PA level	o	54	o		o	13, 46
Parent screen time	+	54, 57, 63, 64	+		+	
	—	54	—		—	
	o		o		o	13
Eat while watching TV	+	16, 71	+		+	
	o	80	o		o	
Sleep time	o	57				

\*Includes TV/video viewing, playing PC/video games and using computer.

†Includes texting, talking on the phone, listening to music, reading, studying and doing homework.

+, positive association; —, negative association; o, null association.

PA, physical activity.

time in screen-based sedentary behaviour.<sup>16 71</sup> No studies have assessed this relationship using accelerometry to measure sedentary behaviour.

#### Environmental variables

The studies that examined the association between environmental factors and measures of sedentary behaviour are presented in table 5. Studies found that the household environment was important in terms of screen-based sedentary behaviour. Specifically, the number of televisions and computers in

a household was associated with more screen-based sedentary behaviour.<sup>17 56 63 65 67 71</sup> In addition, children who had a television in their bedroom spent more time in screen-based sedentary behaviour.<sup>16 23 63 71</sup> No studies have used accelerometry to investigate the association between these household characteristics and sedentary behaviour.

Additional studies also investigated the associations between measures of sedentary behaviour and the following environmental factors: season, region, community environment and school environment (table 5). These studies found mixed associations between the environmental factors and screen-based sedentary behaviour. One study that used accelerometry found that children spent less time in sedentary behaviour in the summer.

## DISCUSSION

### Time spent in sedentary behaviour

The total time children spend in sedentary behaviour reflects the minutes accumulated in daily behaviours that require low energy expenditure (1.0–1.5 METs). Based on this review of the literature, self-reported time spent in screen-based and non-screen-based sedentary behaviours ranged from 4.7 to 8.0 h/day in children. In comparison, sedentary behaviour measured by accelerometry ranged from 3.6 h to 8.1 h/day in children. It is encouraging that the estimated times spent in sedentary behaviour are similar between self-reported and accelerometry-based studies. However, the former methodology assumes that children are sedentary (1.0–1.5 METs) during their reported screen- and non-screen-based behaviours and that recall abilities are similar for all children. Accelerometers do not require children to recall their activities, and the cutpoints to define sedentary behaviour are based on calibration studies involving estimated energy expenditure (1.0–1.5 METs).<sup>72</sup>

**Table 5** Environmental correlates of sedentary behaviour

Variables	Sedentary behaviour					
	Screen-based*		Non-screen-based†		Accelerometry-based	
	Assoc.	Studies	Assoc.	Studies	Assoc.	Studies
Season/temperature	+	17 (Fall)	+		+	
	—	49 (Temp)	—		—	13 (Summer)
	o	20, 51	o		o	
Region (urban)	+	16, 64	+		+	
	o	20, 51	o		o	
Community environment						
Availability of PA/recreation facilities	o	49, 67, 69	o		o	13
Sidewalk/street connectivity	o	67, 69				
Cohesiveness	—	50, 52				
Residential stability	—	81				
Crime safety	—	50, 52	—		—	
	o	51, 69	o		o	
Hills in the neighborhood	+	69				
School type						
Public (vs private)	+	17	+		+	
More affluent (vs less affluent)	—	49	—		—	
Household environment						
No. of TVs/computers	+	17, 56, 63, 65, 67, 71	+		+	
	o	57, 80	o		o	
TV/computer in child's bedroom	+	16, 23, 63, 71	+		+	
	o	80				

\*Includes TV/video viewing, playing PC/video games and using computer.

†Includes texting, talking on the phone, listening to music, reading, studying and doing homework.

+, positive association; —, negative association; o, null association.

PA, physical activity; SED, sedentary behaviour.

However, the cut points do vary between studies, resulting in different estimated times spent in sedentary behaviour.

Despite these methodological limitations, the estimates from both self-report (screen and non-screen based) and accelerometry consistently showed that older children spent more time in sedentary behaviour. Interestingly, while boys and girls provide similar estimates of time spent in sedentary behaviour, the accumulation of sedentary time has been shown to vary by gender and within gender from self-reported data.<sup>41</sup>

### Factors associated with sedentary behaviour

In agreement with the descriptive studies, older children and non-white children spent more time in sedentary behaviour. The finding that sedentary behaviour increases with age needs to be confirmed through longitudinal studies. Nonetheless, the existing evidence supports the need to target reductions in sedentary behaviour in early childhood.

Of interest were the findings involving the association between SES and measures of sedentary behaviour. Children from lower SES backgrounds consistently spent more time in screen-based sedentary behaviour. However, in studies that used accelerometers to measure sedentary behaviour, the associations between SES background and time spent in sedentary behaviour were mixed.<sup>13 46</sup> These findings suggest that screen-based sedentary behaviour could be targeted by interventions to reduce overall sedentary behaviour in children from low SES backgrounds.

Regarding associations between biological factors and sedentary behaviour, mixed associations between child's

BMI and screen-based sedentary behaviour were reported. Of the limited studies that assessed this association using accelerometry, the results were mixed. Longitudinal studies are needed to determine whether BMI influences sedentary behaviour.

Two studies found that more mature children spent more time in sedentary behaviour.<sup>49 68</sup> These findings complement those that studied chronological age, and it is likely that maturation is acting as a marker for age and not a biological factor that influences the time spent in sedentary behaviour.

The consistent null associations found between measures of sedentary behaviour and physical activity variables confirm that spending time in sedentary behaviour is not the same as having low levels of physical activity. From a public health standpoint, this suggests that a specific guideline for the time spent in sedentary behaviour is needed, in addition to physical activity guidelines.

Several studies found that parental rules and limitations on screen time were associated with less time spent in screen-based sedentary behaviour.<sup>23 52 63 69</sup> It is unknown if having such rules/limitations lowers overall sedentary behaviour, and accelerometer-based studies would advance understanding in this area. Further, it would be of interest for longitudinal studies to investigate if the expected age increase in sedentary behaviour is lower if parents set screen time rules early in childhood.

Studies consistently found that homes with more televisions and computers and those with televisions in the child's bedroom were associated with more screen-based sedentary

behaviour. Future studies should determine if these findings are independent of parental rules/limitations; it is possible that parental screen time rules/limitations operate by reducing the number of televisions in the house or removing televisions from bedrooms. Finally, further studies using accelerometry to measure sedentary behaviour are needed to determine if these household characteristics influence overall sedentary behaviour.

## CONCLUSIONS

In summary, children spend a large proportion of their day in sedentary behaviour, and there is strong evidence that children spend more time in sedentary behaviour with increasing age. Other demographic factors that were associated with more time spent in sedentary behaviour included having low SES background and being non-white. Further, accessibility to televisions and computers in the home was associated with more screen-based sedentary behaviour. Additional studies that use accelerometry to measure sedentary behaviour are needed to confirm these findings.

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