



Review Article

Sedentary behaviour across the primary-secondary school transition: A systematic review



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ABSTRACT

The transition from primary/middle school to secondary/high school is likely to be a key period in children's development, characterised by significant changes in their social and physical environment. However, little is known about the changes in sedentary behaviour that accompany this transition. This review aimed to identify, critically appraise and summarise the evidence on changes in sedentary behaviour across the primary – secondary school transition. Published English language studies were located from computerised and manual searches in 2015. Inclusion criteria specified a longitudinal design, baseline assessment when children were in primary/middle school with at least one follow-up during secondary/high school and a measure of sedentary behaviour at both (or all) points of assessment. Based on data from 11 articles (19 independent samples), tracking coefficients were typically in the range of 0.3 to 0.5 and relatively consistent across the different sedentary behaviours examined and durations of follow-up. Both screen-based sedentary behaviour and overall sedentary time increased during the school transition. Overall there was an increase of approximately 10–20 min per day per year in accelerometer-assessed sedentary time. Consistent with the broader age-related changes in behaviour observed during this period, sedentary behaviour increases during the transition from primary/middle to secondary/high school. Investigating features of the social and physical environment that might exacerbate or attenuate this trend would be a valuable next step.

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1. Introduction

An emerging body of evidence indicates that sedentary (or sitting) behaviours may be adversely associated with metabolic and mental health across the life course (Marshall and Ramirez, 2011). In adults, certain sedentary behaviours have been associated with chronic disease morbidity and mortality, whilst associations with obesity and clustered metabolic risk have been identified in children and adolescents (Ford and Caspersen, 2012; Grontved and Hu, 2011; Michell and Byun, 2014; Tremblay et al., 2011). It is noteworthy that the evidence base in children is dominated by cross-sectional observational studies, though research utilising longitudinal or experimental designs is now accumulating (Saunders et al., 2013; van Ekris et al., 2016). A key challenge for the field lies in establishing whether associations observed between sedentary behaviour and adverse health are independent or co-dependent on engagement in other health behaviours, such as physical activity and sleep (Chastin et al., 2015; Page et al., 2015). Despite the evolving nature of evidence on this topic, public health guidelines in the UK and other countries recommend that overall sedentary time or time spent in specific sedentary activities should be limited in young people and adults (American Academy of Pediatrics et al., 2011; Chief Medical Officer Department of Health, 2011).

Sedentary behaviours are highly prevalent in young people. Sitting for screen-time (alternatively labelled as technology use, electronic media use, screen-viewing), defined as time spent watching television, using computers, tablets, smartphones, and playing on games consoles or any other screen-based technology, is the most prevalent leisure time sedentary behaviour and has been studied extensively. Surveillance data indicate that a substantial proportion of young people exceed the frequently applied guideline of two hours per day of screen-time (i.e. television viewing and/or computer use) (Atkin et al., 2014; Foley et al., 2011; Rideout et al., 2010). Despite its prominent place in the lives of young people, screen-time is only weakly associated with overall sedentary time (Klitsie et al., 2013; Verloigne et al., 2013). In a nationally representative sample of UK children age 7 years, overall sedentary time, measured by accelerometry, exceeded an average of 6 h per day (Griffiths et al., 2013). In order to develop behaviour change interventions capable of reducing the prevalence of sedentary behaviour in this population, it is necessary to identify the modifiable and non-modifiable determinants of these behaviours (Sallis and Owen, 1999). Environmental influences on behaviour are well recognised (World Health Organization, 1986). Given that young people spend half of their waking hours at school, there is good reason to believe that the school environment may be a critical influence on their health behaviour patterns (Bonell et al., 2014; Morton et al., 2016a; van Sluijs et al., 2011). Of particular interest is the transition from primary/middle school to secondary/high school, which may be a key period in children's development and is likely to be characterised by significant changes in their social and physical environment (Morton et al., 2016b). To our knowledge, no previous review has documented the changes in children's sedentary behaviour that accompany this key life transition. Understanding how sedentary behaviour changes across this transition, and whether this varies by gender will help to inform the design of intervention programmes. Therefore, the aim of this study was to identify, critically appraise and summarise the evidence on changes in sedentary behaviour across the primary – secondary school transition.

2. Methods

The review protocol was registered with the International Prospective Register for Systematic Reviews ((PROSPERO) CRD42015023599), and reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Liberati et al., 2009).

2.1. Search strategy

Search strategies were built around four groups of keywords: sedentary behaviour, transitions, study type, and sample type. Key terms for sedentary behaviours were used in combination with key terms for transitions, study type, and sample type to locate potentially relevant studies. An example of the search strategies used can be provided on request. Science Direct, PubMed, PsycINFO, Web of Science and Cochrane databases were searched using the key terms. In addition, manual searches of personal files were conducted along with screening reference lists of primary studies and identified articles for titles that included the key terms.

2.2. Inclusion and exclusion criteria

For inclusion, studies were required to (1) use a longitudinal observational design with at least two points of assessment; (2) include children in primary/middle school at baseline (or time 1) as participants; (3) include children in secondary/high school at follow-up (or time 2); (4) include a measure of sedentary behaviour at both (or all) points of assessment; (5) have measured the same group of children at these two time points; (6) be published in a peer-reviewed journal in the English language; and (7) be published up to and including October 2015. Experimental studies were excluded.

2.3. Identification of relevant studies

Potentially relevant articles were selected by (1) screening the titles; (2) screening the abstracts; and (3) if abstracts were not available or did not provide sufficient data, the entire article was retrieved and screened to determine whether it met the inclusion criteria.

2.4. Data extraction

Data were extracted on standardised forms developed for this review. Extracted data included: author, date of publication and country of study, characteristics of the participants (sample age at baseline and follow-up, sample size and gender), length of follow-up, sedentary behaviour outcome, and method of sedentary behaviour measurement. This information is summarised in Table 1.

2.5. Sedentary behaviours over the primary-secondary school transition

Data on sedentary behaviour tracking and/or changes over the primary-secondary school transition were extracted from the included articles by NP and AJA, and summarised in Tables 2 and 3 respectively. In public health and epidemiological literature, tracking is used to describe the (relative) stability of a certain characteristic over time (Twisk, 2003), and typically describes the consistency of the relative position of a person in a distribution at two or more points in time, and can identify high risk groups. At the population level, prevalence and frequencies of behaviour over time reflect overall trends (e.g. changes) and behaviour patterns in the population, but mask individual changes.

Tracking coefficients (r) were extracted from included articles, and were classified as small (0.10–0.29), moderate (0.30–0.49) or large (≥ 0.5) according to strength of association cut-off points described by (Cohen, 1988). Tracking coefficients are displayed according to sedentary behaviour outcome and length of follow up (Table 2). Data on change in sedentary behaviours (mean, standard deviations and mean differences, where possible) were extracted and change was coded as ++ to indicate significant increases in sedentary behaviour; + to indicate increases in sedentary behaviour which were non-significant or where statistical significance data were not provided by authors; – to indicate decreases in sedentary behaviour which were non-significant or where statistical significance data were not provided by authors. An independent sample was used as the unit of analysis and was defined

Table 1
Study characteristics.

Author, date and country	Baseline age* (years) School grade* (*where reported)	Follow-up age* (years) School grade* (*where reported)	Length of follow-up (years)	Sex	Sample size	Sedentary behaviour		Analysis	Study quality score (%)
						Outcome	Method		
Janz et al. (2000) USA	10.8 B 10.3 G	14.6 B 14.2 G	5 (in 1-year assessments)	B/G	61 B 62 G	ST	Questionnaire (self)	Tracking	7/9 (77%)
Pate et al. (1999) USA	10.7 5th grade	7th grade	3	B/G	82 B 99 G	ST	Questionnaire (self)	Tracking	8/9 (88%)
Marks et al. (2015) Australia	12.2 6th grade	12.8 7th grade	1	BG	152	ST	Questionnaire (self)	Change	8/10 (80%)
Mitchell et al. (2013) USA	9	11 12 15	2, 3, 6	B/G	391 B 407 G	SedT	Accelerometer	Change	10/10 (100%)
Pearson et al. (2011) Australia	11.1 B 11.1 G 5–6th grade	15–17 11–12th grade	5	B/G	62 B 59 G	TV	Questionnaire (parent)	Tracking	8/9 (88%)
Rutten et al. (2014, 2015) Belgium	10.9 6th grade	12.9 8th grade	2	B/G	162 B 17 OWB 202 G 23 OWG	TV C ST	Questionnaire (self)	Change	8/9 (88%)
Arundell et al. (2013) Australia	10–12 5–6th grade	13–17 11–12th grade	3, 5	B/G	656 B 789 G	SedT	Accelerometer	Change	9/10 (90%)
Atkin et al. (2013) UK	10.3 5th grade	13/14 8th grade	4	B/G	767 B 978 G	ST	Questionnaire (self)	Change	10/10 (100%)
Corder et al. (2015) UK	10.3 5th grade	13/14 8th grade	4	B/G	877 B 1187 G	SedT	Accelerometer	Change	10/10 (100%)
Francis et al. (2011) USA	11	13	2	B/G	152 B 180 G	TV VG	Questionnaire (parent and self)	Tracking and change	8/9 (88%)

SedT = sedentary time (as assessed by accelerometry), screen time (ST) = sum of time spent watching TV and electronic games/computer use, TV = time spent watching television, VG = time spent playing electronic games, C = computer use. BG = boys and girls assessed together, B/G = boys and girls assessed separately, G = girls, B = boys, OWB = overweight boys, OWG = overweight girls.

as the smallest independent sub-sample for which relevant data were reported (e.g. boys/girls) (Cooper, 1998).

2.6. Methodological quality assessment

Included articles were assessed for methodological quality using a 9- or 10-item quality assessment scale. One item pertaining to appropriate reporting of the cut-point used to define sedentary time was used in studies that measured behaviour using accelerometry. This scale was selected as it has been previously used in reviews of observational longitudinal behavioural research (Jones et al., 2013) (Tanaka et al., 2014). Four dimensions of methodological quality were assessed: (i) study population and participation rate (2 items); (ii) study attrition (3 items); (iii) data collection (3 items); and (iv) data analysis (1/2 items). For each article, two reviewers (NP and AJA) independently assessed whether the article scored positively (+) or negatively (-) for each item. The scores were then summed and converted to a percentage to indicate the overall quality of the article.

3. Results

The literature search yielded 47,614 titles of potentially relevant articles (see Fig. 1), of which 11 articles (n = 10 studies and 19 samples) were considered eligible for this review (see Table 1). Studies were conducted in the USA (n = 4), Australia (n = 3), the UK (n = 2), and Belgium (n = 1). Most studies (n = 9) reported sedentary behaviours for boys and girls separately, one reported sedentary behaviour for boys and girls combined. In all studies, the first point of assessment was in the last one or two years of primary/elementary/middle school (aged 9–11 years). Follow-up periods ranged from one to five years, with participants aged 11–17 years. The majority of studies (n = 7) utilised self-report measures to assess television viewing (TV), video games use (VG), computer use (C), or screen-time (ST, a combination of some or all of the individual behaviours listed previously). Three studies used accelerometers to assess total sedentary time (SedT). Four studies assessed tracking of sedentary behaviour across the primary-secondary school transition and seven assessed changes over time. Study quality scores were high for all eligible papers and ranged from

Table 2
Sedentary behaviour tracking coefficients, by length of follow-up and behaviours assessed.

Sedentary behaviour assessed	Length of follow up							
	1 year		2 years		3 years		5 years	
	Janz et al. (2000)	Francis et al. (2011)	Janz et al. (2000)	Pate et al. (1999)	Janz et al. (2000)	Janz et al. (2000)	Pearson et al. (2011)	
Screen time	B = 0.56* G = 0.59*		B = 0.65* G = 0.16ns	BG = 0.41*** B = 0.42*** G = 0.39***	B = 0.40* G = 0.26ns	B = 0.48* G = 0.16ns		
Television viewing		B = 0.29*** G = 0.25***					B = 0.72*** G = 0.65***	
Video games use		B = 0.15* G = 0.27***						

BG = boys and girls assessed together, B/G = boys and girls assessed separately, G = girls, B = boys.

*** p < 0.001

** p < 0.01

* p < 0.05

Table 3
Change in sedentary behaviour across the primary-secondary school transition.

Authors	Length of follow-up	Sedentary behaviour assessed (mean(SD) unless stated otherwise)	Time 1	Time 2	Time 3	Time 4	Mean difference (where stated)	Summary code
Marks et al. (2015) ^a	1 year	SedT (obj) minutes	476 (69)	492 (86)			16 (76)*	++
		Weekday leisure ST minutes	135(111)	152 (114)			17 (126)*	++
		Weekend leisure ST minutes	143 (121)	158 (160)			16 (164)	+
		Weekday homework ST minutes	36 (49)	61 (64)			25 (67)*	++
		Weekend homework ST minutes	19 (32)	31 (45)			12 (48)*	++
Atkin et al. (2013)	4 years	ST h/week (B) (median (IQR))	8.1	15.2			ns	+
			(3.3–16.6)	(8.9–25.5)				
		ST h/week (G) (median (IQR))	6.1	15.0			ns	+
			(2.6–13.2)	(8.3–26.0)				
Corder et al. (2015)	4 years	SedT (obj) mins/day (B)	451.3 (53.3)	ns			45.2 (73.5)***	++
Rutten et al. (2014, 2015)	2 years	SedT (obj) mins/day (G)	467.4 (53.3)	ns			37.4 (67.8)***	++
		ST h/week (B)	21.48	23.76			ns	++
			(14.48)	(12.99)				
		ST h/week (OWB)	21.91	29.76			ns	++
			(12.86)	(15.23)				
		ST h/week (G)	17.72	20.79			ns	++
			(11.84)	(13.60)				
		ST h/week (OWG)	19.28	22.96			ns	++
			(10.46)	(12.48)				
		TV h/week (B)	13.09 (8.77)	13.19 (7.11)			ns	No change
		TV h/week (OWB)	15.24	14.91 (8.19)			ns	–
			(10.21)					
		TV h/week (G)	12.68 (8.59)	12.09 (7.31)			ns	–
		TV h/week (OWG)	13.61 (7.48)	14.37 (9.30)			ns	+
		C h/week (B)	8.39 (8.45)	10.57 (8.26)			ns	++
		C h/week (OWB)	6.68 (7.75)	14.85			ns	++
				(10.76)				
		C h/week (G)	5.04 (5.47)	8.70 (8.54)			ns	++
		C h/week (OWG)	5.67 (5.51)	8.59 (8.92)			ns	++
		Homework h/week (B)	7.51 (4.66)	9.19 (4.11)			ns	+
		Homework h/week (OWB)	8.18 (5.37)	7.62 (4.18)			ns	–
		Homework h/week (G)	8.35 (5.12)	12.10 (4.97)			ns	+
		Homework h/week (OWG)	9.28 (6.24)	11.26 (5.43)			ns	+
Arundell et al. (2013)	3 years and 5 years	SedT (obj) (% of time) (B)	42.7 (10.49)	Not stated	Not stated		3 year change = 9.34 (6.57, 12.12)***	++
							5 year change = 15.40 (12.88, 17.92)***	++
		SedT (obj) (% of time) (G)	44.91 (10.57)	ns	ns		3 year change = 10.73 (9.04, 12.42)***	++
							5 year change = 15.61 (13.98, 17.24)***	++
Francis et al. (2011)	2 years (aged 11–13 years)	TV, % exceeding 2 h/day (B)	63	64				++
		VG, % exceeding 1 h/day (B)	60	66				+
		TV, % exceeding 2 h/day (G)	50	52				+
		VG, % exceeding 1 h/day (G)	32	34				++
Mitchell et al. (2013)	2 years, 3 years, and 6 years	SedT (obj) mins/day (B) (median (IQR))	309.1 (263.7, 364.6)	342.0 (290.1, 402.0)	352.6 (294.9, 427.4)	464.4 (384.6, 535.7)		++
		SedT (obj) mins/day (G) (median (IQR))	312.0 (275.1, 360.4)	349.9 (300.9, 404.4)	368.9 (314.0, 428.6)	467.3 (401.4, 554.3)		++

SedT = sedentary time (as assessed by accelerometry), Screen time (ST) = sum of time spent watching TV and electronic games/computer use, TV = time spent watching television, VG = time spent playing electronic games, C = computer use. BG = boys and girls assessed together, B/G = boys and girls assessed separately, G = girls, B = boys, OWB = overweight boys, OWG = overweight girls. ns = data not given/stated; IQR = inter-quartile range. ++ = significant increases in sedentary behaviour; + = increases in sedentary behaviour but non-significant or statistical significance data has not been provided by authors; – = decreases in sedentary behaviour but non-significant or statistical significance data has not been provided by authors.

^a Marks et al. (2015) also showed a 42* minute and 46* minute difference in change in weekday leisure ST and weekend leisure ST respectively among those pupils in year 6 who changed to a different institution for year 7 compared to those who stayed at the same institution.

*** p < 0.001.

** p < 0.01.

* p < 0.05.

7/9 to 10/10, with a median score of 8. Individual study quality scores are presented in Table 1.

3.1. Tracking of sedentary behaviour across the primary-secondary school transition

Table 2 summarises findings from the four studies that reported tracking coefficients for sedentary behaviour across the primary-secondary school transition. Two studies assessed tracking of screen-time. Janz et al. (2000) examined tracking of ST over 5 years in American

children. In girls, year 5 ST tracked only with year 4 (1-year tracking – representing the transition from elementary to high school), whereas ST tracking coefficients were moderate-to-large for boys at all time points ($r = 0.65–0.40$). Pate et al. (1999) found that ST tracked moderately well in boys and girls over a 3-year period that represents that transition from elementary to high school ($r = 0.42$ and $r = 0.39$ respectively).

Two studies assessed tracking of TV viewing. Francis et al. (2011) found small tracking coefficients for TV viewing in boys and girls between ages 11 and 13 years representing the transition from middle

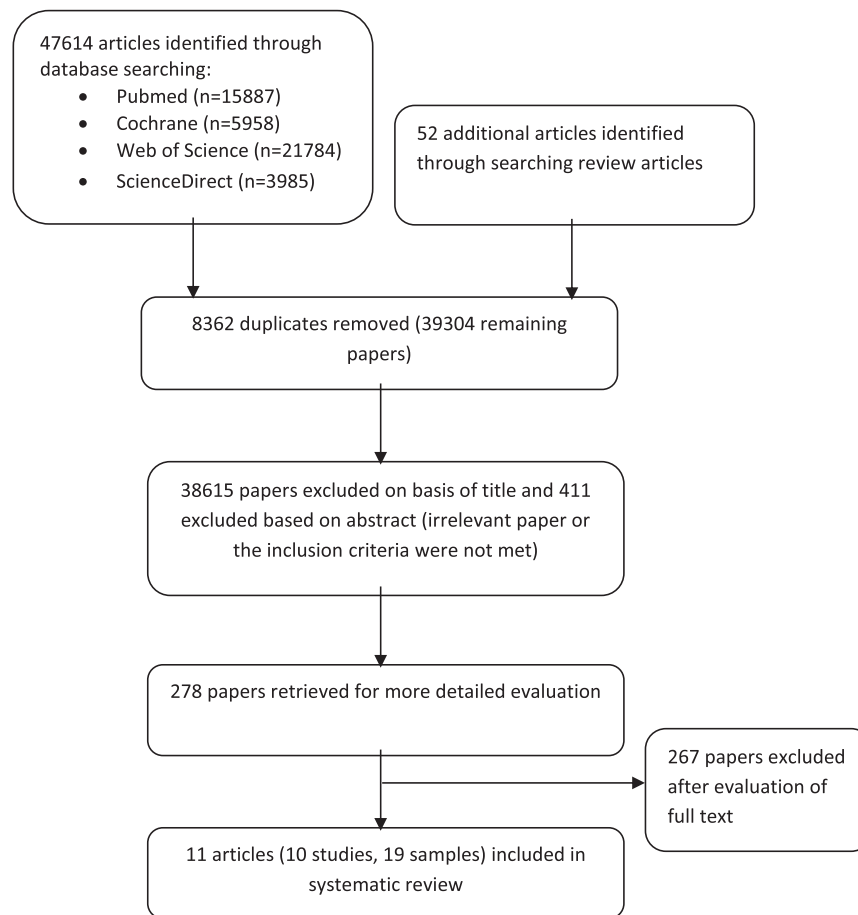


Fig. 1. Flow of information through different phases of the systematic review.

to high school in the US. Pearson et al. (2011) found large 5-year tracking coefficients for TV viewing in Australian boys and girls from Grade 5 and 6 of primary school (10–12 years).

One study assessed tracking of VG use. Francis et al. (2011) found small tracking coefficients for VG use in boys and girls between ages 11 and 13 years representing the transition from middle to high school in the US.

3.2. Changes in sedentary behaviour across the primary-secondary school transition

Table 3 summarises the seven studies reporting changes in sedentary behaviours across the primary-secondary school transition. The overall trend was for sedentary behaviour to increase during the primary-secondary school transition. Changes in sedentary behaviour were assessed objectively in seven samples (Arundell et al., 2013; Corder et al., 2015; Marks et al., 2015; Mitchell et al., 2013). In all seven samples, sedentary behaviour increased significantly across the transition from primary to secondary school, with a range of 16 to 45 min increase in studies assessing sedentary behaviour at two time points (Corder et al., 2015; Marks et al., 2015). In the studies with three or more time points, the changes in sedentary behaviour appeared to be linear and similar for both boys and girls (Arundell et al., 2013; Mitchell et al., 2013).

Changes in ST were assessed in six samples (Atkin et al., 2013; Marks et al., 2015; Rutten et al., 2014, 2015), all of which showed an increase over time with no differences between subgroups. Changes in TV viewing were assessed in six samples (Francis et al., 2011; Rutten et al., 2014, 2015) with clear increases found in two samples (Francis et al., 2011). Within one study, with four sub-samples, the results were mixed

(Rutten et al., 2014, 2015). Decreases in TV viewing were found among overweight boys and normal weight girls, increases were found in overweight girls, and there was no change in TV viewing among normal weight boys (Rutten et al., 2014, 2015).

Changes in VG use were assessed in two samples (Francis et al., 2011), both of which showed an increase over time. Changes in computer use and homework time were both assessed in four samples within one study (Rutten et al., 2014, 2015). Computer use increased significantly over time in the four samples, whereas homework increased in all samples apart from among overweight boys who showed a decrease.

4. Discussion

This is the first study to identify, critically appraise and summarise the evidence on changes in sedentary behaviour during the primary-secondary school transition. Across the 11 articles that met the inclusion criteria, findings were consistent in demonstrating an increase in both individual and overall sedentary behaviour during this period, though the magnitude of change varied substantially between behaviours in some cases. Tracking coefficients were mostly in the moderate to large range, and change scores were positive and mostly significant (where data was available), as might be expected given the relatively short duration of follow-up. The evidence appears sufficiently robust to warrant further research to examine how and why specific sedentary behaviours change over the transition from primary to secondary school. Such knowledge could inform the development of targeted interventions to prevent the increases in sedentary behaviour over this time period.

Tracking coefficients were typically in the range of 0.3 to 0.5 and relatively consistent across the different behaviours examined and durations of follow-up. These data suggest that, whilst sedentary

behaviour appears to increase during the school transition (see discussion below), the direction and magnitude of change appears to be relatively consistent within each study population. In addition, because the behaviours that have been examined to date (mainly screen-based such as TV viewing, video game use) occur predominantly outside of school hours they may not be influenced by the changes in social or physical environments that accompany the school transition. We did not identify any studies that examined the tracking of overall or school-time sedentary behaviour across the primary-secondary transition and it is possible that these data would show something different. This would be a worthy topic for future analyses. Additionally, it would be valuable to examine how features of the school environment influence children's engagement in sedentary behaviour, as this has been under-studied to date (Morton et al., 2016a).

The evidence on changes in sedentary behaviour indicates that screen-based sedentary behaviour and overall sedentary time increase during the transition from primary to secondary school. Although direct comparison of results is hindered by the different durations of follow-up, studies that assessed changes in sedentary time by accelerometry reported remarkably similar findings. This was typically an increase of approximately 10–20 min per day per year. The overall trend was similar for studies that measured self- or proxy-reported sedentary behaviours, though there was much less consistency in the estimated magnitude of change. This may be due to true variation in the degree of change in individual behaviours and between populations or the generally lower reliability of self-report measures. Further observational studies that seek to identify factors that predict changes in behaviour over the school transition will help to inform intervention design. Preliminary evidence indicates that height-adjustable desks may be a route to reducing sedentary behaviour in school but high quality evaluations are lacking and much of the existing research has been based in primary schools (Sherry et al., 2016). Factors such as break duration and the availability of facilities for physical activity may also influence sedentary time in secondary schools and are worthy of further exploration as targets for intervention (Morton et al., 2016b).

Findings of the current review should be viewed within the context of broader changes in sedentary time that occur during the transition from childhood to adolescence (Cooper et al., 2015) and the extent to which these changes are attributable to the school transition per se is largely unknown. A recent study sought to elicit whether changing school environments (i.e. moving from primary/middle school to a completely new school for secondary/high school) had a greater or lesser impact on physical activity and sedentary behaviour compared to transitioning year groups within the same school environment (Marks et al., 2015). All students showed declines in physical activity, and increases in sedentary behaviour and screen time. Interestingly, compared to students who remained in the same school environment, students who changed school reported a greater reduction in PA, were less likely to cycle to/from school, and showed a greater increase in both weekday and weekend leisure screen time (Marks et al., 2015). The findings of this study suggest that the transition from one school to another plays a role in the increase in certain sedentary behaviours. Of note is the increase in leisure screen-time but no significant difference in accelerometer assessed sedentary time suggesting that whilst screen-time may be increasing, other sedentary behaviours may decline proportionally. This is supported by the increased use of tablets and mobile phones by children who have just transitioned to secondary/high school (Ofcom, 2014; Soubhi and Potvin, 2004) and aligns with the increase in independence that accompanies this transition. These findings indicate that a change in school appears to have an impact upon behaviour that is distinct from that associated with a within-school change in year group. This may be due to differences in the social and physical environment of primary and secondary schools (Morton et al., 2016b). In order to disentangle the impact of school transition on sedentary behaviour from the broader age-related change, it may be beneficial to move beyond the day-level examination of variations in behaviour over time

to a more nuanced approach that focusses on particular segments of the day or the frequency and duration of sedentary bouts (Brooke et al., 2014; Carson and Janssen, 2011). Previous research has highlighted temporal differences in the way that more or less active children accumulate their physical activity, with notable differences both inside and outside of school hours, and the same may apply to sedentary behaviour (Belton et al., 2016). This may highlight changes in the pattern of accumulation of sedentary behaviour during the school transition, contributing to the identification of periods of the day that may be suitable for targeted interventions.

The findings of the present review suggest that both tracking and change in sedentary behaviour across the primary-secondary school transition is similar for boys and girls (with the exception of tracking ST data from Janz et al. showing that boys ST tracks at a moderate and significant level each year over 5 years, whereas for girls tracking ST was only evident at 1 year follow up (Janz et al., 2000)). Such findings are in line with the results from a recent systematic review of tracking of sedentary behaviour across the lifespan (Biddle et al., 2010) where little evidence was found of gender differences. These results are however in contrast to the wealth of literature showing gender differences in changes in physical activity through childhood and adolescence (Dumith et al., 2011). It is typical that boys report more physical activity and more sedentary behaviour than girls, but there is a trend for a steeper average decline in physical activity for girls compared to boys (Brodersen et al., 2007; Metcalf et al., 2015). Trends for an increase in sedentary behaviour appear to be comparable in size for both boys and girls (Brodersen et al., 2007), supported by data from the present review.

On initial inspection, our findings for 'tracking' and 'change' in sedentary behaviour during the primary-secondary transition appear somewhat contradictory, with the results of the tracking studies indicating relative stability and the results of the studies examining change in sedentary behaviour demonstrating notable changes over time. However, the statistical techniques used to estimate tracking (e.g. by a correlation coefficient between subsequent measurements or by the proportion of subjects staying in a certain 'risk' group at a follow-up measurement) typically focus upon the relative position (rank) of individuals within the distribution, rather than the absolute value of the outcome. Thus, a degree of tracking may still be observed if changes in behaviour are uniform in direction and magnitude throughout the population. Such results are similar to findings in relation to physical activity and food choice in this age group (although these behaviours haven't been examined over the same specific time period that the present review is focused on), where there is evidence both for strong tracking and mean changes over time (Kelder et al., 1994).

4.1. Strengths and limitations

Strengths of this review include the comprehensive search strategy, which drew from five electronic databases without publication date restrictions, and the duplication of title/abstract screening and quality assessment. The review is registered with the PROSPERO database and reported in accordance with PRISMA guidelines (Liberati et al., 2009). The inclusion of articles published in English only is recognised as a limitation. The use of meta-analysis would have enabled the quantification of changes in sedentary behaviour during the school transition and exploration of effect modifiers; however, we felt that this was not appropriate due to the considerable heterogeneity of methodology and reporting between studies.

4.2. Conclusion

Understanding of how children's sedentary behaviour changes over time is informative for the design and evaluation of behaviour change programmes. This systematic review shows that, consistent with the broader age-related changes in behaviour observed during this period,

overall sedentary time and individual sedentary behaviours increase during the transition from primary/middle to secondary/high school. In light of the substantial changes in physical and social environment that accompany the school transition, this may be a key period for the delivery of interventions to attenuate or reverse this trend.

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Conflicts of interest

None.

Transparency document

The Transparency document associated with this article can be found, in online version.

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