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Children's and adolescents' sedentary behaviour in relation to socioeconomic position

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ABSTRACT

Background Sedentary behaviour is an emerging cardiometabolic risk factor in young people. Little is known about how socioeconomic position (SEP) and sedentary behaviour are associated in children and adolescents. This study examines associations between SEP and sedentary behaviour in school-age children and adolescents.

Methods The core sample comprised 3822 Health Survey for England 2008 participants aged 5–15 years with complete information on SEP (household income, head of household occupational social class and area deprivation) and self-reported sedentary time (television viewing and other sitting during non-school times). Accelerometer-measured total sedentary time was measured in a subsample (N=587). We examined multivariable associations between SEP (including a composite SEP score) and sedentary time using generalised linear models, adjusting for age, sex, body mass index, physical activity, accelerometer wear time and mutually adjusting for the other SEP indicators.

Results Participants in the highest SEP category spent 16 min/day less (95% CI 6 to 25, $p=0.003$) watching TV than participants in the lowest SEP category; yet they spent 7 (2 to 16, $p=0.010$) and 17 (5 to 29, $p<0.000$) min/day more in non-TV sitting and total (accelerometry-measured) sedentary time, respectively. Associations across individual SEP components varied in strength. Area deprivation was not associated with sedentary time.

Conclusions Low SEP is linked with higher television times but with lower total (accelerometer-measured) sedentary time, and non-TV sitting during non-school time in children and adolescents. Associations between sedentary time and SEP differ by type of sedentary behaviour. TV viewing is not a good proxy for total sedentary time in children.

INTRODUCTION

Sedentary behaviour (as characterised by activities involving sitting) is high among British children. Objective data show that English children aged 4–15 years spend approximately 7–8 h a day being sedentary on average.¹ In recent years, sedentary behaviour, which is characterised by activities with an energy expenditure rate between 1 and 1.5 metabolic equivalents such as sitting, has received increasing attention as a potential risk factor for adverse health outcomes in its own right, over and above the lack of physical activity (PA).² Sedentary time (ST) that involves screen time and TV viewing in particular is consistently associated with obesity and other cardiometabolic risk markers in children and adolescents.^{3,4} Although evidence is mixed, with some studies reporting that total (accelerometry-estimated) ST is not associated with obesity⁵ and other cardiometabolic risk factors³ independently of moderate-to-

vigorous physical activity (MVPA), other studies have found interventions targeting ST to be effective in reducing childhood obesity.^{6,7} Despite this mixed evidence, recent public health guidelines highlight the importance of minimising time spent sitting in young populations.⁸

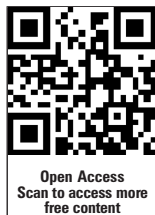
Up to now, research suggests an inverse socioeconomic gradient in both childhood adiposity^{9,10} and indicators of ST such as television viewing and other screen time^{11–17}: children at the lower end of the socioeconomic spectrum tend to spend more time watching TV and are more likely to be obese than children in more affluent households. Although most of the above studies assume that television viewing is a good indicator of total ST, more recent studies refute this idea,^{3,18} and therefore our understanding on how household socioeconomic position (SEP) influences overall ST is incomplete because most of the aforementioned studies used only a screen time-related indicator.^{11–17} Objective measures of ST, such as accelerometers or inclinometers, quantify overall ST. Only a few studies have used objective ST methodologies to look at its associations with SEP and the results have been mixed. A European study found positive associations between children's accelerometry-measured ST and SEP in Portugal and Estonia, but not Denmark or Norway.¹⁹ Similarly, a positive association between objectively measured total ST and maternal education was reported for children from the South West of England.²⁰ However, in contrast, the Gateshead Millennium study in North East England found an inverse association between area deprivation and maternal education with children's objectively measured ST that was mediated by other factors (time spent in after-school sports clubs, birth weight and birth order).²¹ In addition, many of the studies examining associations between SEP and ST in children have been limited to only one^{11,13,17,22} or two^{14,21} socioeconomic indicators. SEP is a complex concept that cannot be fully described by any single measure. Socioeconomic differences in ST may be driven by a combination of financial circumstances, parental occupation or education effects and area characteristics that cannot be fully reflected by any single SEP marker.

To address these research gaps, the aim of this study was to examine the associations between multiple indicators of SEP and self-reported as well as objectively assessed ST in a population sample of children and adolescents living in England.

METHODS

Sample

The Health Survey for England (HSE) is a nationally representative survey of individuals living in



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private households in England, conducted annually. The 2008 HSE included a boost sample of children aged 2–15 years and focused on PA and ST. Data were collected using self-report and (for a randomly selected subsample) accelerometry. A multistage-stratified sample design was used, and addresses were randomly selected within specified postcode sectors. Up to two children were randomly selected in each household. In total, 5587 children aged 5–15 took part in the 2008 HSE. Of these, 1516 children aged 5–15 were included in the boost sample and asked to wear an accelerometer for 7 days, with 779 (54%) providing valid accelerometer data for at least 1 day. Of the children selected for accelerometry who did not provide data, around 15% refused to wear the accelerometer, around 2% were ineligible, and a fault rendered over 20% of the data unusable (in a non-systematic manner), with the rest missing due to incomplete wear time.¹ Ethical approval was obtained from the Oxford Research Ethics Committee (reference number 07/H0604/102). Informed consent was obtained from participants and the research followed the World Medical Association's Declaration of Helsinki. More details of the sample design are available elsewhere.²³ The household response rate was 64% for the main sample and 73% for the accelerometer subsample.

Measurements

Self-reported ST and PA

Self-reported ST was assessed by parental proxy interview for children aged 5–12, and by interview for children aged 13–15. Children (or their parents) were asked to report the average number of minutes spent watching TV or DVDs/videos, and non-TV sitting time per week day and weekend day, outside of school time. Examples given for non-TV sitting time included homework, drawing, time at a computer or playing video games. Information was also collected on average daily PA time, including active transport to and from school (weekdays only), sport or other informal activities.

Objective ST and PA

The accelerometer used was the Actigraph GT1M (ActiGraph, Pensacola, USA), a uniaxial accelerometer that captures vertical movement. Actilife (V2, ActiGraph, Pensacola, USA) was used to initialise the GT1M and upload the data. Participants were requested to wear the accelerometer on a belt around the waist during waking hours for seven consecutive days, apart from when showering or swimming. Some children also removed the accelerometer when engaged in contact sports. Non-wear time was defined as 60 min or more of consecutive zero counts. Children with at least one valid day of accelerometer wear were included in the analysis: to be classed as a valid day, at least 600 min of wear time were required. A 1 min epoch was used. Like in previous similar studies in young people,¹⁹ accelerometer-measured ST was defined as less than 200 counts per minute (CPM) and accelerometer-measured MVPA (2802 or more CPM).²³ Data were analysed using custom analysis software (Kinesoft, V3.3.19).

SEP variables

Two measures of SEP were collected by the survey interviewers: equivalised household income (annual income adjusted for family composition) and occupational social class of the head of household (unskilled manual; semiskilled manual; skilled manual; skilled non-manual; managerial or technical; professional). In addition to individual SEP indicators, area-level Index of Multiple Deprivation 2007 quintiles were derived from the residential address. This index incorporates

37 indicators of deprivation including income, education, employment and health. Further details of how this index was calculated are available elsewhere.²⁴

Demographic and contextual variables

Self-reported information on participant age, sex, weight (kg), height (m) and limiting long-standing illness was also collected by the survey interviewers.

Data handling

Social class comprised six categories, and household income and area deprivation were categorised into quintiles. A composite SEP score was derived from the household income, area deprivation and social class variables. The lowest category of each component variable (the lowest two categories for social class) was assigned an SEP score of 0, the second lowest category was given an SEP score of 1, and so on, with the highest category (the highest two categories for social class) given an SEP score of 4. This resulted in an SEP score ranging from 0 to 12. Owing to the small numbers of observations, particularly at the high and low ends of the score, the SEP score was collapsed into five categories (0 to 3=SEP1; 4 and 5=SEP2; 6 and 7=SEP3; 8 and 9=SEP4; 10 to 12=SEP5), with SEP1 representing the lowest SEP, and SEP5 the highest.

Owing to a small number of observations in the highest and lowest social class categories, social class was recoded from six to four categories, by merging the bottom two (unskilled manual, semiskilled manual) and the top two categories (managerial or technical, professional). Body mass index (BMI) was calculated by dividing weight (kg) by height² (m).

Statistical analyses

The associations between each of the socioeconomic indicators (household income, social class, area deprivation and SEP score) and each individual ST indicator (TV time, non-TV sitting time, accelerometer-measured ST) were examined using generalised linear models, and multiple linear regression was used to determine linear trend *p* values. Results are presented for the whole week, and the weekday/weekend day-specific results can be found in the appendix tables. For all multivariate analyses, we used the complex samples generalised linear models (CSGLM) procedure to take into account the complex survey design. Analyses were weighted for non-response to enable inference to the general population. SPSS V18 was used for all analyses.

Casewise deletion of missing data was used, excluding between 21.6% and 27.8% of cases, depending on the outcome variable. Outliers outside 3 SDs of the mean for all continuous variables apart from age were removed from the analyses to improve the normality of the residuals that are required for linear regression. This excluded a further 4–5.3% of cases from the analyses. The sample size after deletions was 587 for accelerometer-measured ST models, 3822 for TV time models, and 3820 for non-TV ST models.

All statistical models were run for each combination of dependent variables (household income, social class, area deprivation and SEP score) and main exposure (TV time, non-TV sitting time and accelerometer-measured ST). Different models were adjusted: (1) for age and sex; (2) additionally for BMI, limiting long-standing illness and other socioeconomic indicators (household income, social class, area deprivation); (3) additionally for time spent in active transportation to and from school (weekday models only), time spent in sporting or informal activities (on week or weekend days) and total MVPA time (accelerometer models only, on week or weekend days).

Models with accelerometer-measured ST as the outcome were also adjusted for accelerometer wear time. There was no evidence of collinearity in the multivariate model as no variance inflation factor value was higher than 2.9, with most values around 1. Residual statistics and plots for each model were checked for normality, independence of observations, homoscedasticity and influential outliers.

CSGLM coefficients indicate mean differences in ST (in minutes) between the reference category and each of the other SEP categories. The lowest SEP category (<£10 671 for household income, unskilled/semiskilled manual for social class, most deprived quintile for area deprivation, SEP1 for SEP score) is the reference category for the mean difference in the outcome (and associated CI for the difference) in all CSGLMs.

RESULTS

Sample characteristics

The mean age of children aged 5–15 in the TV time sample was 10.1 (SD 3.1). Of these, 2463 were aged 5–12, and 1359 were aged 12–15, and 50.1% were male. Table 1 presents characteristics of the TV-time sample by SEP score. Compared with children in SEP scores 4 and 5 (least deprived), children in SEP scores 1 and 2 (most deprived) were more likely to report a long-standing illness, have a higher BMI and spend more time watching TV but less sedentary time overall. Children in SEP scores 1 and 2 also spent more time in active transport and in sports and other informal activities.

See online supplementary appendix table S1 tests for differences between individuals included and excluded from the analyses. For the accelerometer sample, excluded individuals were less likely to be in the highest household income quintile, more likely to have a higher BMI, spend more time sedentary (accelerometer-measured) and more time in sporting and informal activities. Similar associations were found between individuals included and excluded from the TV and the non-TV sitting samples: those excluded were additionally less likely to be in the most affluent area deprivation quintile, more likely to be older and spend more time in non-TV sitting.

Accelerometer-measured ST was weakly (positively) correlated with both self-report TV time (Spearman rho=0.11; p=0.011)

and non-TV sitting time; r=0.36; p<0.000). We found very little evidence for differences in the sample characteristics between the accelerometer and self-reported samples of children used in our analyses (see online supplementary appendix table S2).

SEP score

Online supplementary appendix table S2 shows the results from the models with SEP score as the main exposure. SEP score was inversely associated with TV viewing, but directly associated with accelerometer-measured ST and non-TV sitting time. These associations were observed in all models. On average, children in the lowest SEP group spent 15.7 fewer minutes a day watching TV, yet 17.1 more minutes sedentary overall and 7.1 more minutes in non-TV sitting than children in the most deprived SEP score. Figure 1 displays the fully adjusted marginal means of the three ST indicators by SEP score. Linear relationships were observed for associations between SEP score and accelerometer-measured ST (direct) and TV time (indirect), with apparent deviations for SEP2 for TV time, which did not follow the linear pattern. A curvilinear association was observed between SEP and non-TV sitting time.

Household income, social class and area deprivation

Tables 2–4 present results from models with household income, social class and area deprivation as the main exposures. Household income and social class were inversely associated with TV viewing. No other associations were observed in the fully adjusted models.

Weekday and weekend day comparison

Online supplementary appendix tables S4–S8 present results split by weekday/weekend day. Similar associations are seen for weekdays and weekend days, with a few exceptions. Accelerometer-measured ST is positively associated with SEP score on weekdays, but not weekend days, while non-TV sitting is positively associated with household income on weekend days but not weekdays.

Table 1 Sample characteristics by socioeconomic position (SEP) score for self-reported TV-time models

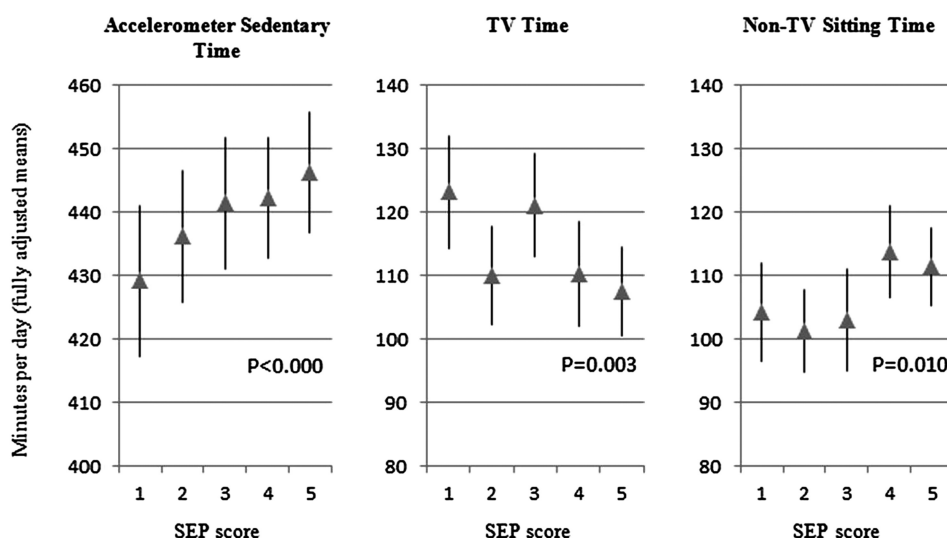
Categorical variables†	SEP score			p Value
	1 (lowest) and 2 (N=1406)*	3 (N=733)*	4 and 5 (highest) (N=1683)*	
	Per cent	Per cent	Per cent	
Sex (% male)	49.36	51.67	50	0.622
Limiting long-standing illness (% with LLI)	11.17	6.55	6	<0.001
Continuous variables‡	M (SD)	M (SD)	M (SD)	p Value
Age	9.97 (3.09)	9.98 (3.07)	10.05 (3.12)	0.755
BMI	19.01 (3.67)	18.79 (3.43)	18.61 (3.27)	0.006
Sedentary time (Accel) (min/day)	430.16 (99.69)	452.11 (107.32)	452.62 (96.88)	0.032
TV time (min/day)	118.25 (64.9)	115.44 (66.24)	108.06 (58.92)	<0.000
Non-TV sitting time (min/day)	108.74 (70.04)	109.52 (71.47)	113.74 (70.25)	0.116
Active transportation to and from School (min/day)	13.36 (15.7)	12.53 (15.09)	10.78 (14.45)	<0.000
Sporting and informal activities (min/day)	62.85 (57.45)	54.7 (50.78)	49.75 (46.23)	<0.000
MVPA time (Accel) (min/day)	70.43 (40.76)	66.05 (40.23)	66.24 (39.8)	0.463

*Sample size for accelerometer variables 229 for SEP 1 and 2; 103 for SEP 3; 247 for SEP 4 and 5.

† χ^2 was used to test significance of association between categorical variables and SEP score.

‡ANOVA was used to test significance of association between continuous variables and SEP score.

ANOVA, analysis of variance; BMI, body mass index; MVPA, moderate-to-vigorous physical activity.



^a SEP score is derived from household income, household social class, and area deprivation. SEP 1 is the least deprived, SEP 5 is the most deprived.
^b Adjusted for age, sex, BMI, limiting long term illness, time spent in active transportation to and from school, self-reported MVPA, and accelerometer-measured MVPA (accelerometer models only). Accelerometer models also adjusted for average accelerometer wear time on valid days.

Figure 1 Difference in sedentary time by socioeconomic position (SEP) score, fully adjusted model, 95% CI.

DISCUSSION

This study supports the findings of other studies that lower SEP is associated with higher levels of TV viewing.¹¹⁻¹⁷ This study is the first to highlight that there may be differential patterns of the SEP-ST associations for accelerometer-measured total sitting and self-reported TV ST. We found that children from higher SEP households are spending more time sedentary but less time

watching TV than those from lower SEP households. Interventions to reduce sedentary behaviour in young people need to take into account the conflicting demands of ST spent in activities that a child’s parents and school will be encouraging such as homework, musical instrument practice and computer-based learning, against activities such as TV, computer/video games and social media networking, which might be more open

Table 2 Multivariable-adjusted associations between equivalised household income and sedentary time in children

Household income quintiles	Model 1* coefficient† (95% CI)	Model 2* coefficient† (95% CI)	Model 3* coefficient† (95% CI)
Accelerometer sedentary time (min/day) (N=587)			
<£10 671 (reference)			
£10 671–£17 788	-11.64 (-27.17 to 3.88)	-12.33 (-27.81 to 3.13)	-8.76 (-21.6 to 4.07)
£17 789–£27 316	-0.19 (-14.38 to 13.99)	-3.05 (-18 to 11.88)	-7.78 (-21.05 to 5.49)
£27 317–£44 199	15.82 (1.12 to 30.53)	8.49 (-8.19 to 25.18)	7.31 (-7.25 to 21.88)
>£44 199	15.02 (-1.77 to 31.82)	1.2 (-16.94 to 19.35)	-1.3 (-16.2 to 13.59)
Trend p	0.001	0.382	0.592
TV time (min/day) (N=3822)			
<£10 671 (reference)			
£10 671–£17 788	-9.65 (-19.86 to 0.56)	-7.98 (-18.17 to 2.19)	-8.3 (-18.4 to 1.78)
£17 789–£27 316	-10.87 (-20.84 to -0.9)	-7.75 (-18.56 to 3.06)	-9.17 (-19.87 to 1.53)
£27 317–£44 199	-10.51 (-20.58 to -0.44)	-4.06 (-15.55 to 7.42)	-5.92 (-17.29 to 5.44)
>£44 199	-21.51 (-31.34 to -11.69)	-14.38 (-26.27 to -2.49)	-17.13 (-29.14 to -5.12)
Trend p	0.001	0.069	0.020
Non-TV sitting time (min/day) (N=3820)			
<£10 671 (reference)			
£10 671–£17 788	4.47 (-4.22 to 13.16)	5.08 (-3.57 to 13.73)	4.57 (-4.01 to 13.16)
£17 789–£27 316	11.45 (2.1 to 20.79)	11.65 (1.71 to 21.58)	9.86 (0 to 19.72)
£27 317–£44 199	13.32 (4.39 to 22.25)	12.37 (2.59 to 22.15)	10.18 (0.43 to 19.92)
>£44 199	10.08 (0.79 to 19.36)	9.32 (-1.32 to 19.98)	6.03 (-4.73 to 16.79)
Trend p	0.004	0.128	0.375

*Model 1: adjusted for age and sex; model 2: further adjustments for body mass index, limiting long-term illness, social class and area deprivation; model 3: further adjustments for time spent in active transportation to and from school, time spent in sporting or informal activities and moderate-to-vigorous physical activity time. Models with accelerometer sedentary time as the outcome were also adjusted for average accelerometer wear time on valid days.
 †Generalised linear model coefficients; coefficients indicate mean differences (in daily sedentary time) between the reference category (>£39 000) and each of the other household income quartiles, for example, a value of five indicates that a specific category had an average daily sedentary time that is 5 min higher than the referent group.

Table 3 Multivariable-adjusted associations between social class and sedentary time in children

Social class of head of household	Model 1* coefficient† (95% CI)	Model 2* coefficient† (95% CI)	Model 3* coefficient† (95% CI)
Accelerometer sedentary time (min/day) (N=587)			
Unskilled and semiskilled manual (reference)			
Skilled manual	-12.2 (-26.37 to 1.97)	-12.85 (-27.29 to 1.58)	-9.92 (-21.93 to 2.08)
Skilled non-manual	9.97 (-7.79 to 27.75)	6.89 (-11.13 to 24.93)	2.3 (-11.51 to 16.12)
Managerial technical and professional	16.22 (4.13 to 28.31)	6.4 (-6.6 to 19.42)	2.19 (-9.28 to 13.66)
Trend p	0.000	0.020	0.082
TV time (min/day) (N=3822)			
Unskilled and semiskilled manual (reference)			
Skilled manual	-5.29 (-15.7 to 5.1)	-4.98 (-15.7 to 5.72)	-4.63 (-15.27 to 6)
Skilled non-manual	-6.28 (-16.89 to 4.32)	-5.95 (-16.72 to 4.81)	-5.25 (-16 to 5.49)
Managerial technical and professional	-15.69 (-24.18 to -7.2)	-14.17 (-24.11 to -4.23)	-14.46 (-24.32 to -4.6)
Trend p	0.000	0.005	0.004
Non-TV sitting time (min/day) (N=3820)			
Unskilled and semiskilled manual (reference)			
Skilled manual	-4.2 (-12.86 to 4.45)	-7.41 (-16.67 to 1.84)	-6.81 (-16.07 to 2.44)
Skilled non-manual	10.82 (1 to 20.65)	8.67 (-1.37 to 18.72)	9.44 (-0.56 to 19.44)
Managerial technical and professional	5.8 (-2.08 to 13.69)	-1.82 (-11.17 to 7.53)	-1.94 (-11.18 to 7.29)
Trend p value	0.021	0.430	0.468

*Model 1: adjusted for age and sex; model 2: further adjustments for body mass index, limiting long-standing illness, household income and area deprivation; model 3: further adjustments for time spent in active transportation to and from school, time spent in sporting or informal activities and moderate-to-vigorous physical activity time (accelerometer models only). Models with accelerometer sedentary time as the outcome were also adjusted for average accelerometer wear time on valid days.
 †Generalised linear model coefficients; coefficients indicate mean differences (in social class) between the reference category (non-manual) and manual category; for example, a value of five indicates that the manual category had an average daily sedentary time that is 5 min higher than the referent group.

to parental but possibly not children's support for reduction. For example, increasing active transport and reduction of travelling as a car passenger would be a possible area for intervention

to reduce overall ST: while we controlled for active school-related transport, higher SEP children may have greater access to car transportation at other times which could be a driver

Table 4 Multivariable-adjusted associations between area deprivation and sedentary time in children

Index of multiple deprivation quintiles	Model 1* coefficient† (95% CI)	Model 2* coefficient† (95% CI)	Model 3* coefficient† (95% CI)
Accelerometer sedentary time (min/day) (N=587)			
Q1 (least deprived) (reference)			
Q2	8.15 (-7 to 23.3)	6.85 (-7.97 to 21.69)	1.22 (-12.15 to 14.6)
Q3	4.61 (-10.52 to 19.74)	0.29 (-15.18 to 15.77)	0.58 (-12.5 to 13.67)
Q4	19.24 (4.21 to 34.26)	14.97 (-0.04 to 30)	9.1 (-3.89 to 22.11)
Q5 (most deprived)	23.8 (10.62 to 36.99)	16.39 (2.47 to 30.32)	5.88 (-6.61 to 18.38)
Trend p	<0.000	0.037	0.331
TV time (min/day) (N=3822)			
Q1 (least deprived) (reference)			
Q2	-2.16 (-12.71 to 8.38)	-1.22 (-11.69 to 9.24)	-1.43 (-11.77 to 8.9)
Q3	-6.82 (-16.62 to 2.97)	-2.15 (-12.06 to 7.74)	-2.53 (-12.34 to 7.26)
Q4	-3.5 (-13.51 to 6.5)	4.02 (-6.38 to 14.43)	3.51 (-6.73 to 13.76)
Q5 (most deprived)	-2.46 (-12.36 to 7.43)	5.84 (-4.73 to 16.42)	6.09 (-4.36 to 16.55)
Trend p	0.573	0.151	0.143
Non-TV sitting time (min/day) (N=3820)			
Q1 (least deprived) (reference)			
Q2	-4 (-13.04 to 5.03)	-5.48 (-14.65 to 3.69)	-5.48 (-14.62 to 3.66)
Q3	0.89 (-8.4 to 10.19)	-1.94 (-11.23 to 7.34)	-2.23 (-11.47 to 6.99)
Q4	8.89 (-0.28 to 18.07)	5.3 (-4.29 to 14.9)	4.93 (-4.58 to 14.45)
Q5 (most deprived)	6.84 (-2.05 to 15.73)	3.31 (-5.98 to 12.61)	3.65 (-5.65 to 12.97)
Trend p	0.011	0.193	0.179

*Model 1: adjusted for age and sex; model 2: further adjustments for body mass index, limiting long-standing illness, household income and social class; model 3: further adjustments for time spent in active transportation to and from school, time spent in sporting or informal activities and moderate-to-vigorous physical activity time (accelerometer models only). Models with accelerometer sedentary time as the outcome were also adjusted for average accelerometer wear time on valid days.
 †Generalised linear model coefficients; coefficients indicate mean differences (in daily sedentary time) between the reference category (quintile 1) and each of the other deprivation quintiles; for example, a value of five indicates that a specific category had an average daily sedentary time that is 5 min higher than the referent group.

behind the positive association between SEP and total (accelerometer-measured) ST. In contrast, TV time is inversely associated with SEP in children. This may be because other sedentary and non-sedentary/physically active pastimes are not available to children in lower SEP groups due to financial constraints. Overall, our results suggest that TV time is a poor indicator of overall ST and that TV time should not be used as a proxy for total ST, supporting other studies.^{3 18}

One implication of TV sitting time being used as a proxy for total sitting time is that higher SEP children may not be targeted for interventions to reduce sitting time, despite their total sitting time being greater than those in lower SEP groups. There is an apparent paradox that low-SEP children have higher BMI¹⁰ and poorer health indicators and outcomes,²⁵ yet they spend less time sedentary overall. This raises questions as to whether the type of sedentary behaviour is more important than the overall time spent sedentary. We previously found that TV time (but not other types of self-reported ST) was associated with adiposity²⁶ and cardiometabolic⁴ outcomes in Portuguese children, independently of time spent physically active. While we found that non-TV sitting time has the least consistent results (non-linear) with SEP, it may also have the most measurement error. The question is non-specific in that it asks about 'everything else' apart from TV, which has unknown validity. TV sitting time may be more strongly associated with SEP because it is easier to quantify.

Our time of the week-specific analyses showed that the positive associations between SEP and accelerometer-measured ST were more consistent for weekdays. Since neither the direction of the association nor the magnitude of the coefficients differ substantially between weekdays and weekend days in the fully adjusted models (see online supplementary appendix table S3), we cannot rule out the possibility that this is a statistical artefact resulting from the relatively broad 95% CIs of the coefficients. Assuming that the weaker associations we observed for weekend days were not artefactual, possible explanations include higher sports participation at school among lower SEP children; more time spent sedentary while travelling to and from school among high SEP children and more time spent in structured sedentary activities such as homework and musical instrument practice on school nights among higher SEP children. This raises questions about what types of sitting activities occur on weekdays and how their type and timing vary by SEP. As discussed above, we have limited type-specific sitting time information and require further research to identify associations between type-specific sedentary behaviour and health outcomes.

The strengths of this study include the large population sample for the analyses of the self-reported outcomes, the use of multiple indicators of one objective and two subjective measures of ST, and the availability of a broad range of potential confounders, including BMI and detailed information about PA.

Limitations include the use of proxy parental reports of self-reported ST for children aged 5–12.

Although it would be intuitive to assume that the different results we found for the accelerometer and self-report outcomes might partially be due to the different samples used, we found very few differences in the key characteristics of the two samples (see online supplementary appendix table S2). Another potential area for bias is the case-wise deletion of missing data. An examination of the characteristics of children with missing data shows that the association between low SEP and higher TV time (but lower total ST) may have been partly influenced by response bias: the children who were excluded due to missing data tended to have lower household income,

but had higher overall ST than children without missing data (see online supplementary appendix table S1). If they had been included in the analyses, the association between low SEP and low total ST might have been diluted to some extent. However, the ST association was borderline ($p=0.05$), with overlapping 95% CIs for children included and excluded due to missing data; thus, we consider the effect of this potential bias to be marginal.

CONCLUSION

There is a socioeconomic gradient in sedentary behaviour among children, but the direction of the gradient differs by the type of sedentary behaviour indicator and the measurement (objective vs self-reported). Lower SEP is associated with higher levels of TV viewing, but with lower levels of overall ST and non-TV sitting during non-school time. Time spent watching TV is not a good indicator of overall ST in children.

What is already known on this subject

- ▶ Sedentary behaviour is an emerging cardiometabolic risk factor in young people. There is an inverse socioeconomic gradient in both obesity and sedentary behaviour (particularly TV and other screen time) in children and adolescents.

What this study adds

- ▶ The association between socioeconomic position and sedentary time (ST) differs by type of sedentary behaviour: indirect association for TV viewing, direct for total (accelerometer) and non-TV sitting. TV time is not a good indicator of total ST.

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REFERENCES

- 1 Joint Health Surveys Unit. *The Health Survey for England 2008. Chapter 6: Accelerometry in children*. Leeds: The Health and Social Care Information Centre, 2010.
- 2 Pate RR, O'Neil JR, Lobelo F. The evolving definition of "sedentary". *Exerc Sport Sci Rev* 2008;36:173–8.
- 3 Martinez-Gomez D, Eisenmann JC, Healy GN, et al. Sedentary behaviors and emerging cardiometabolic biomarkers in adolescents. *J Pediatr* 2012;160:104–.e2–10.e2.
- 4 Stamatakis E, Coombs N, Jago R, et al. Type-specific screen time associations with cardiovascular risk markers in children. *Am J Prev Med* 2013;44:481–8.
- 5 Mitchell JA, Mattocks C, Ness AR, et al. Sedentary behavior and obesity in a large cohort of children. *Obesity* 2009;17:1596–602.
- 6 Leung MM, Agaronov A, Grytzenko K, et al. Intervening to reduce sedentary behaviors and childhood obesity among school-age youth: a systematic review of randomized trials. *J Obes* 2012;2012:Article ID 685430.
- 7 van Grieken A, Ezendam NPM, Paulis WD, et al. Primary prevention of overweight in children and adolescents: a meta-analysis of the effectiveness of interventions aiming to decrease sedentary behaviour. *Int J Behav Nutr Phys Act* 2011;9:61.
- 8 English Department of Health. *Start active, stay active: a report on physical activity from the four home countries' Chief Medical Officers*. London: Crown, 2011.
- 9 Shrewsbury V, Wardle J. Socioeconomic status and adiposity in childhood: a systematic review of cross-sectional studies 1990–2005. *Obesity* 2008;16:275–84.
- 10 Stamatakis E, Wardle J, Cole TJ. Childhood obesity and overweight prevalence trends in England: evidence for growing socioeconomic disparities. *Int J Obesity* 2010;34:41–7.
- 11 Brodersen NH, Steptoe A, Boniface DR, et al. Trends in physical activity and sedentary behaviour in adolescence: ethnic and socioeconomic differences. *Br J Sports Med* 2007;41:140–4.
- 12 Cillero IH, Jago R. Sociodemographic and home environment predictors of screen viewing among Spanish school children. *J Public Health* 2010;33:392–402.
- 13 Drenowatz C, Eisenmann JC, Pfeiffer KA, et al. Influence of socio-economic status on habitual physical activity and sedentary behavior in 8- to 11-year old children. *BMC Public Health* 2010;20:214.
- 14 Fairclough SJ, Boddy LM, Hackett AF, et al. Associations between children's socioeconomic status, weight status, and sex, with screen-based sedentary behaviours and sport participation. *Int J Pediatr Obes* 2009;4:299–305.
- 15 Gorely T, Marshall SJ, Biddle SJH. Couch kids: correlates of television viewing among youth. *Int J Behav Med* 2004;11:152–63.
- 16 Hanson MD, Chen E. Socioeconomic status, race, and body mass index: the mediating role of physical activity and sedentary behaviors during adolescence. *J Pediatr Psychol* 2007;32:250–9.
- 17 Lioret S, Maire B, Volatier JL, et al. Child overweight in France and its relationship with physical activity, sedentary behaviour and socioeconomic status. *Eur J Clin Nutr* 2007;61:509–16.
- 18 Biddle SJH, King J, Yates T. TV viewing, but not total sedentary behaviour, is associated with adverse cardiometabolic biomarkers in adolescents. *Evid Based Nurs* 2012;15:113–4.
- 19 van Sluijs EMF, Page A, Ommundsen Y, et al. Behavioural and social correlates of sedentary time in young people. *Br J Sport Med* 2008;747–55.
- 20 Mitchell JA, Pate RR, Dowda M, et al. A prospective study of sedentary behavior in a Large Cohort of Youth. *Med Sci Sports Exerc* 2012;44:1081–7.
- 21 Pearce MS, Basterfield L, Mann KD, et al. Early predictors of objectively measured physical activity and sedentary behaviour in 8–10 year old children: the Gateshead Millennium Study. *PLoS ONE* 2012;7:e37975.
- 22 Ball K, Cleland VJ, Timperio AF, et al. Socioeconomic position and children's physical activity and sedentary behaviors: longitudinal findings from the CLAN Study. *J Phys Act Health* 2009;6:289–98.
- 23 Craig R, Mindell J, Hirani V. *Health Survey for England 2008. Volume 1 Physical activity and fitness*. The Health and Social Care Information Centre, 2009.
- 24 Communities and Local Government. *Using the English Indices of Deprivation 2007: Guidance*. 2007.
- 25 Starfield B, Riley AW, Witt WP, et al. Social class gradients in health during adolescence. *J Epidemiol Community Health* 2002;56:354–61.
- 26 Stamatakis E, Coombs N, Jago R, et al. Associations between indicators of screen time and adiposity indices in Portuguese children. *Prev Med* 2013;56:299–303.