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Title: Displacement of bedtime by screen time in schoolchildren: the importance of area deprivation.

Running title: Children, late bedtime, screen time and deprivation.

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Abstract

Background: Sleep duration is an important predictor of obesity and health. We aim to evaluate the association between late bedtime with screen time and the role of geographical deprivation in English schoolchildren.

Methods: We collected Sleeping & waking times, screen time, socio-demographic data and measured body mass index in a cross-section of 1,332 (45.7% females) 11-15 year old schoolchildren participating in the East of England healthy heart study. Logistic regressions were used to determine the likelihood of late bedtimes in schoolchildren with different screen time and from a different geographic location. Mean differences were assessed either by ANOVA or t-test.

Results: About 42% of males go to bed late at night compared with 37% females. When compared to those with <2hours of daily screen time, schoolchildren who spend 2-4 hours on screen time were more likely 1.50(1.07 to 2.09) to sleep late at night while those with > 4hours of daily screen time were most likely 1.97(1.34 to 2.89) to sleep late at night. Late bedtimes were associated with deprivation in schoolchildren.

Conclusions: High screen time and deprivation may explain lateness in bedtime in English schoolchildren. This explanation may vary according to area deprivation and geographic location. Family centred interventions and parental support is important to reducing screen time, late bedtimes and sleep duration.

Keywords: Bedtime; screen time; deprivation; geographic location; children.

Introduction

The average sleep duration of schoolchildren has declined greatly [1], a common behavioural issue brought to the attention of paediatricians [2]. Recent evidence suggests that adequate sleep is important health behaviour, following the identification of potential mechanistic pathways linking sleep with obesity [3, 4]. There is evidence that insufficient amount of sleep (short sleep duration or sleep deprivation) is an independent risk factor for excessive weight gain [5], obesity [4] and cardiometabolic risk [6]. Although causative inferences cannot be made between sleep and health outcomes, the decline in average sleep duration has been concurrent with increases in screen time and obesity pandemic.

Screen time, a high prevalent behaviour among schoolchildren, is not encouraged in children under two years of age [7], and should be limited to not more than two hours per day in older children [7, 8]. Recent study suggests that one in three English schoolchildren may be exposed to over two hours of screen time in a day [9]. In children age 3-5 years, evening (after 7pm) media use is associated with sleep problem [10]. A study on schoolchildren from a different population, New Zealand, shows that screen time shortly before bedtime delay onset of sleep [11]. There is evidence also that screen time in adults [12] and in children [13] are associated with deprivation. Despite these studies, evidence on differing screen time in English children living in varying location, and that have late bedtimes is lacking. As a result therefore, we aim to assess the association of late bedtime, as opposed to sleep duration, with screen time in schoolchildren and whether geographical location was related to late bedtime. We also assessed the importance of deprivation on the association between screen time and late bedtimes.

Methods

The study participants came from the ongoing East of England Healthy Hearts Study. Following approval by the University Ethical Review Committee, data were gathered from 1332 (45.7% females) 11-15 year olds attending three state-run, comprehensive schools, with differing area deprivation levels. One School (school 1 here-in) was from a less deprived location, school 2 was from the less deprived rural location, while school 3 was a deliberate booster sample to include schoolchildren from a highly deprived location. All data collection occurred in the summer months of 2010 and 2011. We sent letters to schools in the East of England region inviting them to participate in this study, and then purposefully selected a representative mix of volunteer schools to take part in the study, a detail methodology has been described previously [9].

Assessment of Bedtime

Participants self-reported bedtimes by answering the following question: 'What time do you usually go to bed on school nights'. These questions were adapted from the general sleep questionnaire and have been validated for use in this age group previously [14]. Schools' 2 and 3 have are the same opening time, while school 1 opens five minutes later. Since school opening times may have an effect on the bedtime the previous night, we assumed that a five minutes difference in the opening time should not have a significant effect on the bedtimes. Participant's bedtimes were classified as either early- or late-bed, using median splits for age- and sex-adjusted bedtimes on a school day. This method is much preferred and has been used previously [15] than choosing an arbitrary bedtimes. Bedtimes on weekdays (school nights') were used because it is likely to be more constant than bedtimes on weekends.

Screen time

Participants self-reported daily screen time by answering the following question: 'How much time do you spend on average each day watching television, watching DVDs or videos, using a computer or games console'. Answers were given on a 0–5 point scale with the following answers: none, 0–30 min, 30–60 min, 1–2, 2–4 and .4 h. Participants were grouped according to whether they reported <2 h screen time as recommended[7, 8], 2–4 or >4 h. The latter value is proposed as another important threshold representing heavy use [16].

Body composition

Participants' mass and stature were measured, to the nearest 0.1 kg and 0.1 cm, respectively, wearing light clothing (T-shirts and shorts) and without shoes. Body mass index (BMI) was calculated (kg/m^2) and *z*-scores generated using the UK 1990 Growth Reference which adjusts for age, sex and skewness [17]. We categorized BMI in two ways to determine the potential effects of our method of categorization. Schoolchildren BMI were categorized according to the International Obesity Task force (IOTF) criteria [18].

Area-level Deprivation

We obtained an area-level measure of deprivation for each participant using their home postcode as detailed previously [9]. Briefly, The English Index of Multiple Deprivation 2007 (IMD 2007) is measured based on the small area geographical units known as Lower Super Output Areas (LSOAs); each LSOA contains between 1,000 and 3,000 inhabitants with an average population of 1,500 people allowing identification of small pockets of deprivation by area [19]. In IMD 2007, there are a total of 38 indicators, distributed across the seven domains of deprivation (income, employment, health and disability, education, skills and training, barriers to housing and services, living environment, crime) [19].A low IMD score indicates affluence, and a high score suggests an area of deprivation.

Statistical analyses

Binary logistic regression analysis was used to assess the relationship between bedtime (dichotomous bedtime early-bed versus late-bed) was the outcome variable with categorical screen time (<2h, 2-4h and >4h) as the determinant. A univariate model was initially produced followed by a multivariate model controlling for: sex, age, school, BMI and deprivation. The differences in area deprivation between schools were carried out using analysis of variance (ANOVA) with as the *post hoc* (Bonferroni) tests for multiple comparisons. Statistical analyses were performed using IBM SPSS 19.0 for windows (SPSS Inc.: an IBM Company, Chicago, IL, USA).

Results

The sample included 9.7% and 22.1% obese and overweight schoolchildren respectively. The proportion of those who reported 2 - 4 hours screen time daily was 19.7%, with 15.3% reporting >4 hours.

Table 1 shows the demographic characteristics of schoolchildren according to whether they reported going to bed early or late. Overall, 42.2% of males reported going to bed late compared with 37.3% females. Prevalence of late-bed increased with higher reported screen time; 51.5% schoolchildren who spent >4 hours engaged in screen-time were classed as late-bed, compared with those that spend between 2-4 hours (45.8%) or less than 2hours (35.1%) screen time.

There was a significant difference in IMD scores between early-bed and late-bed groups (mean difference in IMD score = -2.89, 95%CI: -4.80 to -0.97, p= 0.003) as shown in table 2. There was no significant difference (p>0.05) in the mean BMI *z*-score between early-bed and late-bed groups (mean difference= -0.74, 95%CI:-0.22 to 0.07, p=0.32).

Analysis of variance showed that there was a significant main effects for IMD score among the three schools (F=499.7, p< 0.001). The mean IMD score in the third school (34.9±14.2) was significantly different from the other two schools (p<0.05). Mean IMD score was not different (p>0.05) between the first (13.3±7.59) and second school (12.8±5.89).

Adjusted and unadjusted likelihood of late bedtime

Adjusted for age, sex, school, deprivation and weight status, the odds ratios for late night sleeping (i.e., > bedtimes greater than median splits for age- and sex-adjusted bedtimes) were 1.00 for screen time <2 hours (reference category), 1.50(1.07 to 2.09) for 2-4 hours screen time and 1.97(1.34 to 2.89) for over 4 hours of daily screen time. The unadjusted odds ratios for screen time were very similar to these values (table 3).

Late bedtime may be common in schoolchildren from a more deprived location according to IMD. Where school 1 was the reference category, the unadjusted odds ratios for late bedtime were 2.30(1.59 to 3.32) in school 3 (in a more deprived location) and 1.31(0.89 to 1.94) in school 2. When we adjusted for age, sex, school, deprivation and weight status, the odds ratios for late-bed were 1.66(0.96 to 2.85) and 1.12(0.73 to 1.74) in school 3 and school 1 respectively. Age was associated with late night sleeping, but not in a linear manner. Compared to11 years old, 12 years old schoolchildren were over 2 times (2.19(1.46 to 3.27)) more likely to go to bed late at night; while the adjusted odds ratio was in 1.58(0.93 to 2.71) in the 15 years old.

Influence of deprivation

When accounting for school (already an area-level factor), adjusting for deprivation had very little influence on the association between late sleeping and screen time. Deprivation, using IMD 2007, seemed not to be a significant determinant of sleep time in schoolchildren (table 3). However, school location may be an important determinant of late sleeping in schoolchildren. These schools in our study have different levels of deprivation. Schoolchildren in the most deprived school were more likely (1.64(1.07 to 2.52)) to go to bed late at night than a less deprived reference category school.

Discussion

This study shows that late bedtime habits are associated with shorter total sleep duration in children, especially during schooldays. This is the first study comparing bedtimes in English schoolchildren of different deprivation categories. Screen time displaces physical activity and may also displace bedtime; both factors are important determinants of weight status and obesity as shown in figure 1. Schoolchildren who report >2 hours daily screen time were more likely to go to bed at a time deemed late at night. Those who live in deprived area were twice as likely to report late bedtimes. In order to improve sleep duration, screen time (evening screen time) should be reduced. Bed times also are different in schoolchildren living in different geographic locations and areas with different levels of deprivation. The proportion of children reporting late bedtime may be as high as 45% in more deprived schools, more common than in more affluent ones. Sleep duration has been linked with childhood obesity in previous studies [20, 21], but the present study found that obese and overweight schoolchildren were no more likely to report late bedtimes than those of normal weight.

There are multiple reasons for insufficient sleep, including: insomnia (a sleep disorder), stressors such as preparation for examinations as well as excessive screen time. These reasons in adults may differ from that of children. But addressing the behavioural reasons/causes for sleep deprivation, not insomnia, may be important in combating obesity pandemic.

Few studies have examined the association between screen time and late bedtime in schoolchildren. In fact there is little data on English schoolchildren with high screen time [9]. Those that have examined the association between obesity and screen time have done so either in adults[22], indirectly[23] or in populations [24, 25] likely to accumulate lower daily screen time than the present population. The only one of these studies that examined the influence of socioeconomic status or deprivation, did so in a population with high socioeconomic status [25].

In 4 to 13 year old Dutch children [25] short sleep duration was associated with being overweight. Short sleep duration was determined by late bedtimes and was strongly associated with higher screen-time. We understand that late bedtime and sleep duration are different constructs; and that late sleeping may be associated with sleep duration especially on a school weekday [25]. More recent findings also show that, the bedtimes of schoolchildren may be important in addition to total sleep duration [15]. Though this sample of their study is of a different population with a low study response rate [15] compared to that of our study, sleeping pattern was associated with physical activity levels, screen time and weight status in schoolchildren.

Previously we observed that, Age-specific prevalence for >2 h daily screen time increased at around 13 years of age[9].

The proportion of schoolchildren with daily screen time >2 h rises sharply at 13 years of age, while the duration of sleep start falling during this age. There are other studies that have reported a similar increase in screen time[9] or late bedtime[26] at this age, possibly due to an increase in computer use for educational purposes at this age. Such increases may, however, also be associated with 13 years being the lower age limit for registration on a number of the world's most popular social networking websites including Facebook™.

Inequality may be central to the screen time – sleep time relationship. Prior studies have shown that both low sleep duration and socioeconomic status were predictors of obesity in schoolchildren[27]. Also, screen time is shown to relate to obesity, and previous studies in schoolchildren did not find any significant trend between deprivation categories and screen time [9] even though socioeconomic status is related to high screen time in adults, or deprived adults (defined using area deprivation) engage in high screen time [12]. Deprived children are more likely to go to be late at night. Our result suggests that socio economic status may be an important determinant of sleep time. Parents of low socioeconomic status may be indulging in of high screen time in the evening and may lack the control of reducing high or late night screen time in their children. There is need for parents' guidance on the best ways of preventing late bedtime and associated high levels of screen time.

Increased television viewing is associated with shorter sleep duration [20, 28, 29]. After adjusting for television viewing, these studies did not find television viewing to be independently associated with either sleep duration or obesity. The obesity-sleep duration relationship may be one thing and screen time-sleep duration is another and may be independent. Based on the current findings, it seems that the relationship between bedtimes and screen time in schoolchildren are independent of weight status. Of note, is that we have measured screen time in our study with television viewing inclusive among other devices and we only studied bedtimes (not sleep duration).

The present study suggests that area-level deprivation may be associated with late bedtime in schoolchildren. Previous studies in schoolchildren have mainly used family structure indicator such as living with a single parent and the presence of other siblings, low level of parental education, or unemployment [4, 30]; maternal education, maternal work and family income[30]. Direct associations between socioeconomic status/deprivation, bedtimes and screen time in adults may be visceral, but the association in schoolchildren may be indirect.

Parents face difficulties in making their children go to bed early, and may have to undertake interactive routines [30]such as reading, storytelling, singing prayer, and putting off the lights. Difficulty can arise because they are unsure of the appropriate time to send them to bed or late night working by the parents or they sleep earlier than their children. Sleeping in lounge are not uncommon in schoolchildren especially sleeping with television or computer game still on. It may be difficult for parent to identify the right time to send schoolchildren to sleep as some may want to study or be preparing for an examination.

Previous suggestions [4, 5] favour the development and the testing behavioural interventions that will improve sleeping habits. Interventions to reduce screen time in schoolchildren especially in the evening and before bed are important. Family regulations to reduce television viewing or other screen based devices use at a particular time, to give schoolchildren ample time for sleeping may be beneficial. Paediatric health professionals working with schoolchildren should also consider asking about bedtime in addition to their sleep duration.

Study strengths

Our study is an improvement over studies that have used parental-reported bedtime of schoolchildren. In this age group, self-reported may be better than parental-reported bedtime. The relatively large sample size provides a robust support for our findings presented here.

Deprivation or socioeconomic status is difficult to measure in some parts of the population. An example is schoolchildren. However, area deprivation may be a better indicator for schoolchildren than socioeconomic status. Both area-level deprivations with 37 indicators measured through children postcode were used here and we also compared three schools, which can act as a cluster, in this study that varies in location and built.

Study limitations

We have not identified or separated children who may be suffering from insomnia from our study; self-imposed sleep deprivation was our aim.

Self-reported sleep/wake and screen time habits was used and we recognised that bedtimes may vary between by days, weeks and seasons. Therefore to minimise the bias this might bring we have not included bedtimes on weekends with is highly varied and irregular. We have used a less costly and a less stressful measure on participants. We understand the possibility of social desirability and satisficing in our study do to the use of questionnaire. Due to the cross sectional nature of our study, no conclusions can be drawn regarding causal links or causality.

Reverse causality is also possible, may be English schoolchildren are generally late bed goers, and found themselves exposed to screen as a result of that habit/behaviour rather than the other way round. Randomised controlled trials and cohort studies are needed to confirm a temporal relationship between screen time and bedtimes in schoolchildren.

High screen time may be a factor preventing English schoolchildren from going to bed early or sleeping for an adequate duration. However, some of the participants may sleep late due to other factors (e.g. reading) and not due to screen based activity. Future studies on sleep-obesity relationship should not only evaluate the association between intermediate factors like physical activity levels and sleep duration[4], but in schoolchildren, studies should consider closely the association between sleep duration and mode of transport to school (figure 1). Objective measures of what schoolchildren do after school and during the time before they go to bed need to be investigated more closely. Randomised controlled trials promoting earlier bed times and increases sleep duration may also be effective in establishing that screen based activities (rather than reading) is what is depriving English schoolchildren of adequate sleeping time. Implication of switching off television and other screen based devices in the home at a particular time, say 9.00pm, and how this would affect sleeping time, sleep duration, late night eating and weight status would be interesting to explore. Future studies should also evaluate the association between built environment and screen time; especially after school hours screen time. Safer places with brilliant outdoor facilities may have different screen time-bedtime pattern compared to other places.

In agreement with previous research [15] that the emphasis has been on sleep duration, but that the importance of bed time may have been neglected in relation to child health to date.

Schoolchildren's activities in the evening may be important in potential public health interventions as this is the period they are likely to engage in screen based activities or become sedentary. What a high sedentary time would it have been for schoolchildren that sleep at midnight? Interventions that are aimed at reducing sedentary behaviours or late sleeping time in schoolchildren may be tailored to evenings after schools when they are at home engaging in screen/media use and are not in parks or on bed.

Conclusion

Previous studies have shown that short sleep duration is associated with physical inactivity[31] and high caloric intake[5]. The findings from this study suggest that high screen time and deprivation may explain lateness in bedtime in schoolchildren and possibly in turn sleep duration on schooldays. Interventions that support family rules and support for parents may be effective in combating high screen time, late bedtime, short sleep duration and obesity in English schoolchildren.

It is intuitive to suggest that sleep deprivation or duration may be improved by reducing evening screen time in schoolchildren. Interventions trying to improve sleep duration in schoolchildren that targets bed times should target screen times as well. Just like previous study[25], interventions should also focus on improving parenting skills and encouraging rules to govern the home. Limiting screen time may reduce late bedtimes and in turn improve weight status via increase in sleep duration of school children.

There are still many questions that remain unanswered. Future studies methodology should see how geospatial technologies such as GIS (Geographic Information Systems) / GPS (Global Positioning System) could be used. Also, can the association between screen time and BMI be mediated by sleep duration? Since short sleep duration is associated with high screen time.

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Authors' contributions:
A.A.O., Dr. C.V., and Dr. G.R.S., conceptualized the study, designed the protocol and were involved in data collection in the schools. A.A.O. performed the regression analysis, and wrote parts of the Introduction and Results sections of the manuscript. Dr. G.R.S. proofread and wrote the Discussion section of the manuscript. Dr. CV. edited, proofread and reviewed the manuscript.

References

1 Matricciani L, Olds T, Petkov J. In search of lost sleep: secular trends in the sleep time of school-aged children and adolescents. *Sleep Med Rev*. 2012; **16**: 203-11.

2 Owens JA. The practice of pediatric sleep medicine: results of a community survey. *Pediatrics*. 2001; **108**: E51.

3 Spiegel K, Leproult R, L'Hermite-Baleriaux M, Copinschi G, Penev PD, Van Cauter E. Leptin levels are dependent on sleep duration: relationships with sympathovagal balance, carbohydrate regulation, cortisol, and thyrotropin. *J Clin Endocrinol Metab*. 2004; **89**: 5762-71.

4 Patel SR, Hu BF. Sleep deprivation and Obesity. In: Frank H (ed.). *Obesity Epidemiology*. Oxford University Press, New York, 2008a; 320-41.

5 Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. *Obesity (Silver Spring)*. 2008b; **16**: 643-53.

6 Knutson KL. Sleep duration and cardiometabolic risk: a review of the epidemiologic evidence. *Best Pract Res Clin Endocrinol Metab*. 2010; **24**: 731-43.

7 American Academy of Pediatrics.Committee on Public Education. American Academy of Pediatrics: Children, adolescents, and television. *Pediatrics*. 2001; **107**: 423-6.

8 Tremblay MS, Leblanc AG, Janssen I, Kho ME, Hicks A, Murumets K, *et al.* Canadian sedentary behaviour guidelines for children and youth. *Appl Physiol Nutr Metab*. 2011; **36**: 59-64; 65-71.

9 Ogunleye AA, Voss C, Sandercock GR. Prevalence of high screen time in English youth: association with deprivation and physical activity. *J Public Health (Oxf)*. 2012; **34**: 46-53.

10 Garrison MM, Liekweg K, Christakis DA. Media use and child sleep: the impact of content, timing, and environment. *Pediatrics*. 2011; **128**: 29-35.

11 Foley LS, Maddison R, Jiang Y, Marsh S, Olds T, Ridley K. Presleep activities and time of sleep onset in children. *Pediatrics*. 2013; **131**: 276-82.

12 Stamatakis E, Hillsdon M, Mishra G, Hamer M, Marmot M. Television viewing and other screen-based entertainment in relation to multiple socioeconomic status indicators and area deprivation: the Scottish Health Survey 2003. *J Epidemiol Community Health*. 2009; **63**: 734-40.

13 Sisson SB, Church TS, Martin CK, Tudor-Locke C, Smith SR, Bouchard C*, et al.* Profiles of sedentary behavior in children and adolescents: the US National Health and Nutrition Examination Survey, 2001-2006. *Int J Pediatr Obes*. 2009; **4**: 353-9.

14 Owens JA, Spirito A, McGuinn M. The Children's Sleep Habits Questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. *Sleep*. 2000; **23**: 1043-51.

15 Olds TS, Maher CA, Matricciani L. Sleep duration or bedtime? Exploring the relationship between sleep habits and weight status and activity patterns. *Sleep*. 2011; **34**: 1299-307.

16 Tammelin T, Ekelund U, Remes J, Nayha S. Physical activity and sedentary behaviors among finnish youth. *Med Sci Sport Exer*. 2007; **39**: 1067-74.

17 Cole TJ, Freeman JV, Preece MA. Body mass index reference curves for the UK, 1990. *Arch Dis Child*. 1995; **73**: 25-9.

18 Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *Bmj*. 2000; **320**: 1240-3.

19 Department of Communities and Local Governments. English Indices of Deprivation. Assessed 3rd of August, 2012. Vol. 2012. London, 2007.

20 Reilly JJ, Armstrong J, Dorosty AR, Emmett PM, Ness A, Rogers I, *et al.* Early life risk factors for obesity in childhood: cohort study. *Bmj*. 2005; **330**: 1357.

21 Locard E, Mamelle N, Munoz F, Miginiac M, Billette A, Rey S. [Life style of children and obesity in a population of 5-year-old children]. *Rev Epidemiol Sante Publique*. 1992; **40**: 460-6.

22 Custers K, Van den Bulck J. Television viewing, internet use, and self-reported bedtime and rise time in adults: implications for sleep hygiene recommendations from an exploratory cross-sectional study. *Behav Sleep Med*. 2012; **10**: 96-105.

23 Taylor AW, Winefield H, Kettler L, Roberts R, Gill TK. A population study of 5 to 15 year olds: full time maternal employment not associated with high BMI. The importance of screen-based activity, reading for pleasure and sleep duration in children's BMI. *Matern Child Health J*. 2012; **16**: 587-99.

24 Van den Bulck J. Television viewing, computer game playing, and Internet use and self-reported time to bed and time out of bed in secondary-school children. *Sleep*. 2004; **27**: 101-4.

25 de Jong E, Stocks T, Visscher TL, Hirasing RA, Seidell JC, Renders CM. Association between sleep duration and overweight: the importance of parenting. *Int J Obes (Lond)*. 2012.
26 Olds T, Maher C, Blunden S, Matricciani L. Normative data on the sleep habits of Australian children and adolescents. *Sleep*. 2010; **33**: 1381-8.
27 O'Dea JA, Dibley MJ, Rankin NM. Low sleep and low socioeconomic status predict high body mass index: a 4-year longitudinal study of Australian schoolchildren. *Pediatr Obes*.
28 Locard E, Mamelle N, Billette A, Miginiac M, Munoz F, Rey S. Risk factors of obesity in a five year old population. Parental versus environmental factors. *Int J Obes Relat Metab Disord*. 1992a; **16**: 721-9.
29 Chaput JP, Brunet M, Tremblay A. Relationship between short sleeping hours and childhood overweight/obesity: results from the 'Quebec en Forme' Project. *Int J Obes (Lond)*. 2006; **30**: 1080-5.
30 Hale L, Berger LM, LeBourgeois MK, Brooks-Gunn J. Social and demographic predictors of preschoolers' bedtime routines. *J Dev Behav Pediatr*. 2009; **30**: 394-402.
31 Taheri S, Lin L, Austin D, Young T, Mignot E. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. *PLoS Med*. 2004; **1**: e62.

Figure 1: Flowchart showing the potential mechanism in the association between screen time, sleep deprivation, intermediate factors and obesity (Note: arrows on represent associations and not causal links).

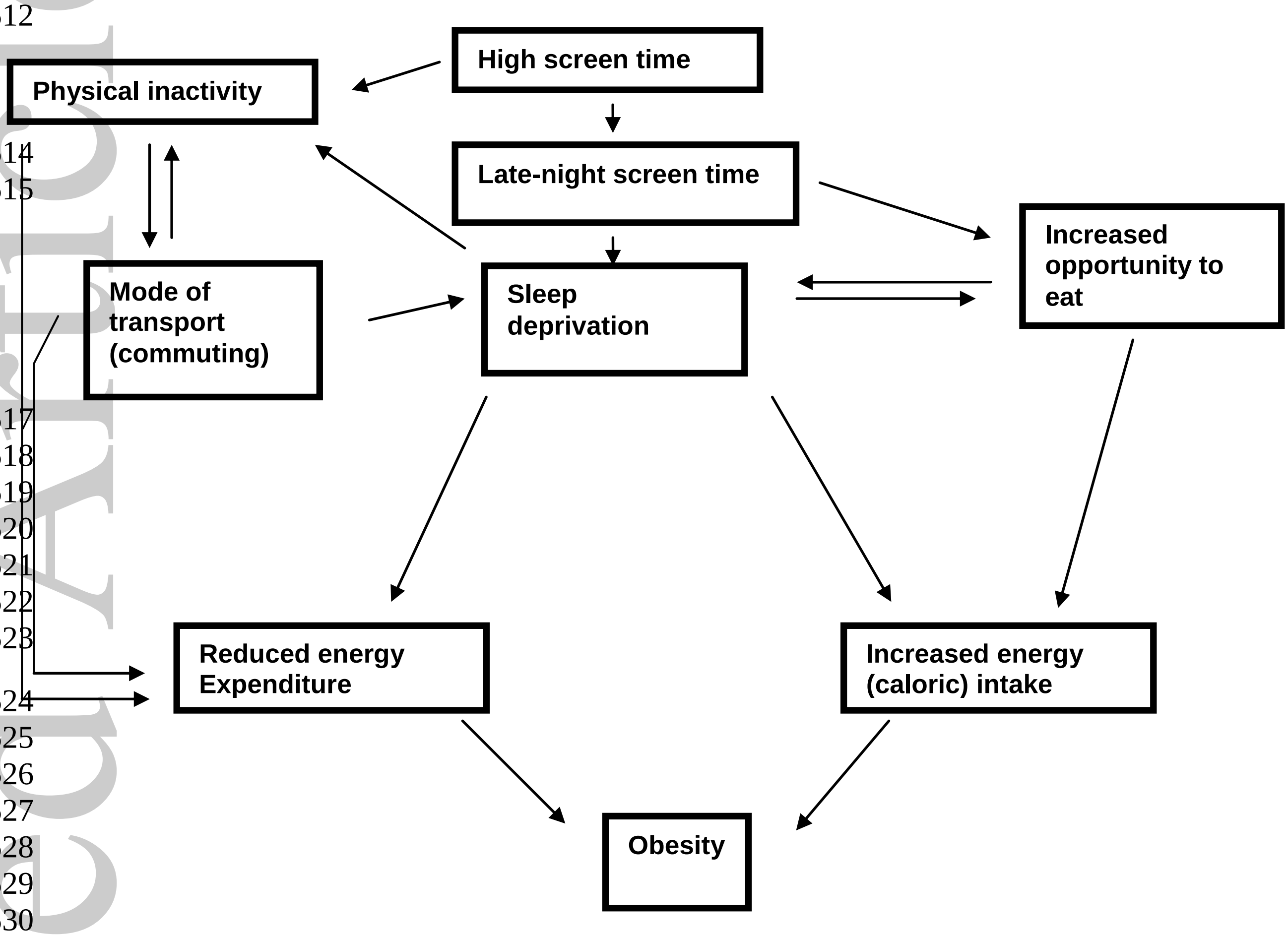

Table 1: Demographic and descriptive characteristics of study participants.

	Early bed: n(%)	*Late bed:n(%)*
Sex		
Female	382(62.73)	227(37.27)
Male	418(57.81)	305(42.19)
Age (years)		
11	475(67.19)	232(32.81)
12	89(41.59)	125(58.41)
13	117(75.48)	38(24.51)
14	69(48.59)	73(51.41)
15	50(43.86)	64(56.14)
*BMI *Z* score	0.66(±1.32)	0.73(±1.25)
BMI categories		
Normal	520(59.56)	353(40.44)
Overweight	181(64.07)	106(35.93)
Obese	75(58.14)	54(41.86)
Screen time		
<2hours	556(64.95)	300(35.05)
2-4 hours	141(54.23)	119(45.77)
>4hours	99(48.53)	105(51.47)
*Deprivation	22.82(±15.36)	25.71(±15.82)
‡Schools		
1	298(66.52)	150(33.48)
2	120(72.29)	46(27.71)
3	382(53.20)	336(46.80)

Data shown are n(%) or *Mean (±SD)

BMI: body mass index

‡School 1 was from a less deprived location; school 2 was from the least deprived rural location, while school 3 was from the most deprived location.

Table 2: Bonferroni tests for multiple comparisons of mean differences and 95% Confidence intervals of index of multiple deprivation (IMD) scores.

Multiple comparisons	***Mean difference in IMD score (95% CI)***	*p-values*
‡Schools:		
School 1 compared to school 2	0.49(-2.17 to 3.16)	1.00
School 1 compared to school 3	-21.63(-23.42 to -19.85)	<0.001
School 2 compared to school 3	-22.13(-24.71 to -19.55)	<0.001
Bedtimes:		
Early-bed compared to Late- bed	-2.89(-4.80 to -0.97)	0.003
Screen time:		
<2hours compared to 2-4 hours	-1.69(-4.63 to 1.25)	0.505
<2hours compared to 4 hours	-5.73(-9.11 to -2.35)	<0.001
2-4hours compared to 4 hours	-4.04(-8.04 to -0.04)	0.047

‡School 1 was from a less deprived location; school 2 was from the least deprived rural location, while school 3 was from the most deprived location.

Table 3: Adjusted and unadjusted odds ratio (95% confidence intervals) of late bedtimes in English schoolchildren.

	Unadjusted OR (95%CI)	*Adjusted OR (95%CI)*	*Adjusted OR (95%CI) without deprivation*
Screen time			
>4hours	1.97(1.44 to 2.68)	1.97(1.34 to 2.89)	1.70(1.22 to 2.36)
2-4 hours	1.56(1.18 to 2.07)	1.50(1.07 to 2.09)	1.43(1.06 to 1.39)
<2hours	1.00	1.00	1.00
Sex			
Males	1.23(0.99 to1.53)	1.16(0.88 to 1.51)	1.20(0.95 to 1.53)
Females	1.00	1.00	1.00
Age			
15	2.62(1.75 to 3.92)	1.58(0.93 to 2.71)	1.77(1.11 to 2.84)
14	2.17(1.50 to 3.12)	1.65(0.99 to 2.77)	1.50(0.96 to 2.34)
13	0.67(0.45 to 0.99)	0.54(0.33 to 0.87)	0.55(0.36 to 0.84)
12	2.88(2.10 to 3.94)	2.19(1.46 to 3.27)	2.35(1.65 to 3.33)
11	1.00	1.00	1.00
BMI			
Obese	1.06(0.73 to 1.54)	1.01(0.65 to1.59)	0.93(0.63 to 1.39)
Overweight	0.83(0.63 to 1.09)	0.87(0.63 to 1.20)	0.84(0.63 to 1.11)
Normal weight	1.00	1.00	1.00
Deprivation	1.01(1.00 to 1.02)	1.00(0.99 to 1.01)	-
Schools (different Geographical location)			
3	2.30(1.59 to 3.32)	1.66(0.96 to 2.85)	1.64(1.07 to 2.52)
2	1.31(0.89 to 1.94)	1.12(0.73 to 1.74)	1.28(0.85 to 1.93)
1	1.00	1.00	1.00