PUBLISHED VERSION

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BMJ Open, 2013; 3(8):e003402-1-e003402-11

http://hdl.handle.net/2440/98352

BMJ open

Characteristics associated with requested and required accelerometer wear in children

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ABSTRACT

Objective: To investigate characteristics associated with wearing an accelerometer for the required and requested time among 8-year-old to 10-year-old children.

Design: Cross-sectional.

Setting: 60 Bristol and North Somerset primary schools taking part in the 'Active for Life Year 5' randomised controlled trial (RCT) in 2011.

Participants: 2048 children, aged 8–10 years, invited to wear an accelerometer for 5 days of recording.

Primary outcome measure: Numbers meeting required wear-time for inclusion in main RCT analysis (≥8 h/day ≥3 days) and numbers meeting requested wear-time (≥8 h/day for all 5 days).

Results: 817 (40%) of the children wore the accelerometer for the requested time and 1629 (80%) for the required time. In adjusted multivariable analyses the odds of wearing the accelerometer for the required time were greater in females as compared with males (OR 1.76 (1.42–2.18)), those with higher scores for reporting their mother restricted time on sedentary behaviours (1.26 (1.04–1.52) per increase of 1 on a 1–4 scale) and in children from schools with larger year group sizes (1.01 (1.00–1.02) per additional child). Living in a neighbourhood with higher levels of deprivation (0.49 (0.33–0.72) comparing highest to lowest third of the deprivation score) or reporting higher levels of weekday outdoor play (0.97 (0.94, 1.00) per 30 min more) were associated with reduced odds of meeting required time. Results were essentially the same for requested wear-time. Other characteristics, including child body mass index, were not associated with required or requested wear-time.

Conclusions: Only 40% of children wore the accelerometer for the requested time but 80% fulfilled the required criteria to be included in the main study analyses. Knowing which characteristics are associated with accelerometer wear could help target interventions to increase wear-time.

BACKGROUND

Being able to accurately assess physical activity in children is important for public health research. Children who are more physically

ARTICLE SUMMARY

Article focus
- This article investigates the child and school-based characteristics associated with wearing an accelerometer for the number of days requested and for the minimum number of days required to be included in analyses for children taking part in a large school-based randomised controlled trial in the South West of England.

Key messages
- Females, those who perceived their mother restricted their sedentary behaviours and those from larger school-year groups were more likely to provide the required wear-time (3 days of 8 h/day).
- Those living in areas of higher deprivation and those reporting more time spent playing outdoors on weekdays were less likely to provide required wear-time.
- Results were similar for requested wear-time (5 days of 8 h/day).

Strengths and limitations of this study
- This study adds to the limited research in the field and looks at a wide variety of child and school characteristics and their association with accelerometer wear; many of which have not been looked at previously.
- The findings of this study may not be generalisable to different age groups, or to studies that operate outside the school setting.

active have lower fat mass and lower levels of associated cardiometabolic risk factors.[1–3] Higher levels of physical activity have also been associated with better skeletal health, lower levels of anxiety and improved academic performance.[2] Whether these associations are causal or explained by bias or confounding is unclear. One source of potential bias is recall bias in self-repot or parental-report of physical activity, which might be related to key outcomes such as weight and hence bias association studies.[4]

Accelerometry has become one of the most commonly used objective methods to assess

physical activity in free-living individuals.[5][6] However, bias in the results of trials (or observational studies) that use accelerometers to measure physical activity and sedentary behaviour may be introduced by selective non-wearing, or not wearing the accelerometer for a sufficient amount of time to obtain the required data.[7] Understanding the characteristics that are related to wearing an accelerometer for the required amount of time is key to understand the likelihood of bias resulting from not providing adequate wear-time and also for developing study protocols that might maximise the provision of adequate data by all participants. To date relatively few studies have examined characteristics associated with accelerometer wear-time in children.[7][8]

In a US study of 282 children aged 11–14 years, 255 (90%) accelerometers were returned and contained downloadable data, but only 128 (50% of those with downloadable data; 45% of those included in the study) children had worn them for the requested 7 days.[9] Children who were overweight were more likely to comply with requested wear-time than their normal weight counterparts, but gender, race and age were not related to wear-time. Similarly in a second small US study (N=87) of 15-year-olds to 18-year-olds, gender and race were not associated with complying with requested accelerometer wear-time, but younger participants were more likely to wear the accelerometer for the requested time than older participants.[10] In a UK study of 11-year-olds, 2217 (36%) of 6086 who provided downloadable data had worn their accelerometer for the 7 days requested and a further 3378 (56%) provided 3–6 days of data.[11] Girls, and children who were younger, had a lower body mass index (BMI), were at a more advanced stage of puberty and had a mother with a higher level of education were more likely to provide sufficient days of accelerometer data. Lastly, a recently published UK study investigated characteristics associated with returning reliable accelerometer data in 7-year-old to 8-year-old children using postal methods to distribute and collect the accelerometers. In total 6675 (53%) of the 12 625 children who consented and were sent accelerometers returned adequate days of data (defined as ≥2 days).[12] That study found that males, those who were overweight/obese, non-white, mixed or of 'other' ethnicity, from a disadvantaged area or reporting exercising once or less a week, were less likely to provide adequate days of accelerometer data.

Some of these studies have examined characteristics associated with adherence to the requested wear-time, but studies usually include participants in final effectiveness/association analyses if they have worn the accelerometer for fewer days.[13] For example, in the Active for Life randomised controlled trial (RCT),[14] which is used in this paper, any child who has worn the accelerometer for at least 8 h on at least 3 days will be included in the final effectiveness analyses, even though participants were asked to wear the accelerometer for 5 days.

The aim of this study was to add to scant evidence to date in this area by examining the characteristics

associated with 8-year-old to 10-year-old participants in a school-based RCT wearing an accelerometer for the pre-specified required time to be included in the trial analysis (≥8 h for ≥3 days). In addition, we have examined characteristics associated with the requested wear-time of 5 days.

METHODS
Study population and design
Active for Life Year 5 is a school-based cluster RCT of a complex primary school-based intervention designed to increase levels of physical activity, decrease sedentary behaviour and improve diet.[14] Sixty schools in Bristol and North Somerset in the South West of England were recruited to the study between March and July 2011. All 2236 pupils in year 4 (academic year 2010/2011) were invited to participate. Of these, 31 children left the school prior to baseline data collection and for 74 their parents declined consent to participate, leaving 2131 eligible participants.

Baseline data collection was conducted in schools by trained research fieldworkers between May 2011 and November 2011, starting 2 months after school recruitment began. A standard school visit took place in 1 day, consisting of a questionnaire administered aloud to the class and completed individually by each child, followed by individual measurements in a private measuring space (height, weight and waist) and the distribution of an accelerometer (Actigraph GT3X+, Actigraph LLC, Pensacola, Florida, USA). Children were asked to give assent and were given the option to opt in or out of any or all of the measurements. In cases where children were absent on the day of the school visit, efforts were made to catch the children up at a later date.

The study was approved by the University of Bristol Faculty of Medicine and Dentistry Research Ethics Committee (reference number: 101115).

Accelerometers
Children were instructed to wear the accelerometer as much as possible for the following 5 days, bringing it back into school for collection on the sixth day. They were instructed to remove the monitor only when sleeping, getting wet (washing, swimming, etc) and playing very rough sport (examples included karate and rugby). A poster was left in the classroom to remind the children to wear the accelerometers and to bring it back on the named collection day and a note was sent home with the child to inform the parents how and when the accelerometer should be worn. Children were given a certificate and a small bouncy ball on return of the accelerometer.

Accelerometers were collected from schools 6 days after they were distributed and were downloaded using Actilife software V.5. Accelerometers were set to record in 'raw' mode from 5:00 on the day after distribution until 23:59 on the fifth day after distribution; the results were then integrated into 10 s epochs at download. If

the monitor recorded zero counts for 60 consecutive minutes, this time was discounted and considered non-wear-time. In accordance with our prespecified RCT analysis plan, a child will be considered to have provided required data for inclusion in the main trial analysis if the accelerometer was worn for at least 8 h (excluding periods of consistent zero activity for 60 min or more) on at least 3 days. These criteria were consistent with the aims of the main trial and agreed with our trial steering committee, they are also consistent with most other published studies.[13] For the main analyses presented here we present characteristics associated with wearing the accelerometer for this minimum time required to be included in the RCT analysis (referred to as 'required' wear-time). In addition we repeated all analyses with the outcome being wearing the accelerometer for the full-requested 5 days, again with ≥8 h/day taken as a valid day of wear-time (referred to as 'requested' wear-time).

Characteristics associated with accelerometer wear-time

On the basis of the previous studies described in the introduction,[9–12] characteristics measured in our main RCT[14] and characteristics that we agreed a priori to be plausibly related to child accelerometer wear-time, we examined the association of the following school and child level characteristics with accelerometer wear-time.

Child characteristics

▶ Gender
▶ BMI (as a continuous variable and also classified as normal/overweight/obese)
▶ Waist circumference
▶ Self-report screen time (two variables: total time spent on screen-viewing on a typical weekday and on a Saturday)
▶ Self-report recreation (four variables, time spent on: weekday outdoor play; weekday classes/clubs; Saturday outdoor play; Saturday classes/clubs)
▶ Self-efficacy for physical activity
▶ Perceived physical environment
▶ Child-reported maternal support (three variables: modelling physical activity; logistic support for physical activity; limitation of sedentary activities)
▶ Child-reported paternal support (three variables: modelling physical activity; logistic support for physical activity; limitation of sedentary activities)
▶ Child's home neighbourhood area deprivation score

School level characteristics

▶ School's neighbourhood area deprivation
▶ School's involvement with health-promoting activities
▶ Year group size

Age was not included in the main analysis despite other studies finding an association with age.[10 11] In this study all participants were members of the same school-year group and all measurements took place within a 6-month period (age range 8 years 9 months to 10 years 4 months). With such little variation we would not expect age to be related to wear-time and confirmed this to be the case (OR of wearing the accelerometer for the required 3 days/1 month greater age 1.02 (0.98–1.06), p=0.3).

Assessment of child characteristics

Gender and home postcode were provided by the school. Home postcode was linked to lower super output areas, which were then linked to index of multiple deprivation (IMD). IMD combines a number of indicators covering a range of economic, social and housing issues into a single deprivation score for each small area (approximately 1600 population) in England.[15] Higher IMD scores indicate greater levels of area deprivation. Participants were ranked by IMD and divided into thirds; low-deprivation (least deprived) IMD 1.43–13.79, mid-deprivation IMD 13.80–32.06 and high-deprivation (most deprived) IMD 32.07–70.36.

Anthropometric measures were completed on school visits, in private rooms with two Criminal Record Bureau (CRB) checked trained fieldworkers present. Height was measured—to the nearest 0.1 cm—without shoes, using a portable Harpenden stadiometer. Weight was measured without shoes or heavy clothing to the nearest 0.1 kg, using a Seca digital scale. Waist circumference was measured to the nearest 0.1 cm at the midpoint between the lower ribs and the pelvic bone with a flexible tape. BMI was calculated from height and weight. BMI and age were used to classify children into categories of normal, overweight and obese according to the International Obesity Task Force cut points.[16]

Child-reported time spent screen viewing and in recreational activity was measured using an updated version of a validated questionnaire as previously described.[14 17] Responses to the 18 different questions are grouped and summed to provide total time (in minutes) spent on different activities on different days (weekday or Saturday).

Physical activity self-efficacy was assessed using a validated questionnaire that consists of 19 items each of which is answered by the child indicating their level of agreement on a five-point scale (scored 1–5).[18 19] Of all the children completing this questionnaire (2038), 1745 (86%) completed all 19 items, 206 completed 18 items (10%) and a further 79 answered between 15 and 17 items (4%). Owing to the high item response we included all 2038 children who had attempted the questionnaire in the analysis and took account of missing data by calculating an average score based on the number of questions each child had answered. Thus, this measure of self-efficacy takes a value between 1 and 5.

The child's perception of their environment was assessed using a seven-item scale used previously.[20] The scale is divided into two subscales; three items relate to positive perception of environment and four relate to negative perception of environment, both of which are answered by a child's level of agreement on a five-point scale (1–5). 2032 answered some questions relating to positive environment, with 1951 (96%) answering all

three. In total, 2031 participants answered some questions relating to negative environment, with 1919 (94%) answered all four. We included all children that attempted the subsections of the questionnaire in the analysis and took account of the missing data by creating an average score for each scale based on the number of questions each child had answered, thus creating scores of 1–5.

Parental support for physical activity was assessed using a validated 24-item scale, which provides information on modelling of parental physical activity behaviours, logistical support and parental support for reduction of screen viewing.[21] [22] Each question is scored between 1 and 4 and means were derived separately for paternal and maternal scores for three subscales; modelling (five items), logistic support (three items) and limitation of sedentary behaviours (four items). As for the scores above, the item response rate was high (for each subsection ≥89% of those answering questionnaire had complete data), so the small amount of missing data were dealt with by using the number of questions each child had answered in that specific section to create the subscore mean between 1 and 4.

Assessment of school level characteristics

Size of year group was provided by the school. Deprivation was measured by IMD, which was provided by the two Local Authorities in the areas where the schools were based. Schools were ranked by IMD and divided into three quantiles; low-deprivation IMD 6.00–16.96 (least deprived), mid-deprivation IMD 16.97–33.16 and high-deprivation IMD 33.17–58.85 (most deprived). School engagement in other health-related activities was assessed through the school consent form which was completed by a member of school management. On the consent form the school was asked to indicate their involvement in any initiatives to promote healthy eating or physical activity and reduce sedentary behaviours. The answers from all schools were judged by one member of the study team and divided into two strata: high level and low level of engagement in other health-related initiatives/policies.

Analysis

Self-report screen time and self-report outdoor play time were positively (right) skewed and for these variables we have used medians and IQRs when describing their distributions. The majority of children reported zero time spent attending recreational classes/clubs on weekdays or Saturdays and so for these we generated a binary variable of some versus no time. We calculated the mean (SD) days of at least 8 h wear-time and the percentage of children who provided this level of data for the requested 5 days and also the required at least 3 days. To examine how child and school level characteristics were associated with providing required and requested wear-time we present distributions of these (numbers (%), mean (SD), median (IQR)) for children with required

wear-time versus not, and similarly for requested wear-time versus not. We used logistic regression to estimate the unadjusted OR (95% CI) and p value comparing odds of providing required (or requested) wear-time, by category or unit of child and school level characteristics. We then used multivariable logistic regression to determine the independent association of characteristics. Owing to the large number of variables examined in the univariable analyses we a priori decided that we would only examine variables in the multivariable model that had a strong magnitude of association (defined as a OR of 20% or more per category for categorical exposures and 10% or more per unit for continuously measured exposures and/or a small p value (defined as ≤0.1)) in univariable analyses. To ensure that we were appropriately comparing univariable with multivariable associations on the same participants in these final analyses we only included participants who provided completed data for all selected variables and repeated the univariable analyses on this complete data subset. In the regression association studies for the exposure time spent screen viewing and in different recreational activities we scaled the exposures so that we were examining the odds of outcome per 30 min (half an hour) as results per 1 min would not be easy to report or interpret. However, these variables are summarised in the original (minute) units in the descriptive statistics. We took account of clustering (non-independence of pupils within schools) using the 'vce(cluster)' stata option in these logistic regression models. This produces a robust SE that allows for intra-school correlations. All analyses were completed using Stata V.12.

RESULTS

A total of 2048 children had parental consent (ie, were not opted out) and child assent to participate in the accelerometer baseline data collection; their characteristics are displayed in table 1. The mean age of the participants was 9.5 years (113.6 months) and the mean BMI was 17.7 kg/m² (16% of participants were overweight and a further 5% were obese). Of the 2048 participants, 817 (40%) wore their accelerometer for ≥8 h/day for all of the requested 5 days and 1629 (80%) for ≥8 h/day for ≥3 days (ie, the required wear-time). Sixty schools participated in the study and the average year group size was 37 pupils, with 70% of the schools reporting high levels of involvement with other health promoting activities (table 2).`

The unadjusted association of child and school characteristics with wearing the accelerometer for the required wear-time is shown in tables 3 and 4, respectively. Children who wore their accelerometer for this amount of time were more likely to be female, report higher self-efficacy for physical activity, have a more positive perception of their environment, spend some time in recreational classes/clubs on weekdays, have a higher level of perceived paternal and maternal support in terms of modelling

Table 1 Study children characteristics, N=2048 children

Characteristic	Unit or category	Number with data	N (%); mean (SD) or median (IQR)
Required accelerometer data provided (3 days)		2048	
	n (%) yes		1629 (79.5)
	n (%) no		419 (20.5)
Requested accelerometer data provided (5 days)		2048	
	n (%) yes		817 (39.9)
	n (%) no		1231 (60.1)
Accelerometer returned		2048	
	n (%) yes		2016 (98.4)
	n (%) no		32 (1.6)
Number of days of valid data	Mean (SD) days	2048	3.7 (1.5)
Gender		2048	
	n (%) male		999 (48.8)
	n (%) female		1049 (51.2)
Age	Mean (SD) months	2047	113.6 (4.0)
Deprivation (individual level)		2042	
	n (%) low deprivation		687 (33.6)
	n (%) mid deprivation		681 (33.4)
	n (%) high deprivation		674 (33.0)
BMI	Mean (SD) kg/m^2	1787	17.7 (2.9)
Overweight/obese		1786	
	n (%) normal weight		1418 (79.4)
	n (%) overweight		277 (15.5)
	n (%) obese		91 (5.1)
Waist circumference	Mean (SD) cm	1905	62.1 (8.0)
Self-report screen time per day			
Weekday all screen	Median (IQR) min	2038	105 (45–225)
Saturday all screen	Median (IQR) min	2032	105 (30–240)
Self-report recreation time per day			
Weekday outdoor play	Median (IQR) min	2039	30 (0–90)
Weekday classes/clubs	n (%) some time	2039	704 (35)
Saturday outdoor play	Median (IQR) min	2032	60 (15–120)
Saturday classes/clubs	n (%) some time	2032	450 (22)
Self-efficacy for physical activity	Mean (SD) mean score on scale 1–5*	2038	3.9 (0.7)
Perceived physical environment			
Positive environment	Mean (SD) mean score on scale 1–5*	2032	4.0 (0.9)
Negative environment	Mean (SD) mean score on scale 1–5*	2031	2.2 (1.1)
Paternal factors			
Modelling physical activity	Mean (SD) mean score on scale 1–4†	1887	3.0 (0.8)
Logistic support for physical activity	Mean (SD) mean score on scale 1–4†	1877	3.0 (0.8)
Limitation of sedentary activities	Mean (SD) mean score on scale 1–4†	1877	2.6 (0.9)
Maternal factors			
Modelling physical activity	Mean (SD) mean score on scale 1–4†	1999	2.9 (0.8)
Logistic support for physical activity	Mean (SD) mean score on scale 1–4†	1993	3.1 (0.8)
Limitation of sedentary activities	Mean (SD) mean score on scale 1–4†	1995	2.8 (0.9)

*Scale 1–5 where 1=low, 5=high.
†Scale 1–4 where 1=low, 4=high.
BMI, body mass index.

physical activity and limitation of sedentary activities, and a higher level of perceived maternal support in terms of logistic support, than those children who did not meet the required wear-time. Children from areas of higher deprivation, those who reported spending more time participating in screen viewing activities on a weekday or a day on the weekend, and those that reported spending more time playing outdoors on weekdays, were less likely to provide accelerometer data for the required 3 days. BMI, proportion overweight/obese, waist circumference, self-report attendance at classes/clubs on a Saturday, self-report Saturday outdoor play, negative perception of physical environment and paternal logistic support for physical activity, were not associated with providing required data.

Table 2 Study school characteristics, N=60 schools

Characteristic	Unit or category	Number with data	N (%); mean (SD) or median (IQR)
Size of year group	Mean (SD) children	60	37 (18.2)
Deprivation (school level)		60	
	n (%) low deprivation		20 (33.3)
	n (%) mid deprivation		20 (33.3)
	n (%) high deprivation		20 (33.3)
School engagement in other health related initiatives/policies		60	
	n (%) low		18 (30.0)
	n (%) high		42 (70.0)

Children who provided the required accelerometer data were more likely to attend schools that had a larger year group size, whereas children attending schools in areas of high deprivation were less likely to provide the required data. School engagement in other health promoting initiatives was not associated with likelihood of providing the required wear-time.

Table 5 shows the unadjusted and mutually adjusted associations of child and school-based characteristics in those with complete data on all characteristics included in this multivariable analysis. The unadjusted associations in this subset of 1837 (90%) children were virtually identical to the equivalent associations in the maximum samples for each variable shown in tables 3 and 4. With mutual adjustment, the association of several characteristics attenuated, in particular child's report of TV/screen viewing and child's perception of physical environment, modelling for physical activity (maternal and paternal) and maternal logistical support; school area deprivation also attenuated to the null. Gender, own area deprivation, self-report weekday outdoor play, perceived maternal limitation of sedentary behaviour and school-year group size remained associated with providing accelerometer data for the required number of days. The positive association of time spent in recreational classes/clubs on weekdays did not attenuate with mutual adjustment, but this was imprecisely estimated with the 95% confidence including the null value both in the unadjusted and adjusted model.

Own and school area deprivation were correlated (Pearsons correlation coefficient=0.66) and the attenuation of school deprivation was due entirely to adjustment for own home area deprivation. However, there was no strong evidence of multicollinearity in the final model that included both of these with SEs for coefficients only increasing slightly compared with no mutual adjustment for both. Coefficients for all other exposures were essentially the same whether one or other or both of these two deprivation measures were included in the final mutually adjusted model.

Online supplementary web tables 1–3 show results of univariable and multivariable analysis of associations of child and school-based characteristics with requested wear-time. The results are very similar to those for required wear-time. The only difference was for maternal limitation of sedentary behaviour which was more weakly associated with requested than required time; though the overlapping CIs show that these two associations cannot be said to be statistically different to each other with confidence and p values comparing them (derived using 1000 bootstrap replications to estimate SEs of the difference between the two estimates and then using the SE to calculate the p value based on a normal approximation for the sampling distribution) confirmed the lack of evidence for a statistical difference; p=0.3 for both unadjusted and adjusted comparisons.

DISCUSSION

Forty per cent of 8-year-old to 10-year-old participants in a school-based RCT wore their accelerometer for ≥ 8 h/day for the total 5 days that they were requested to do so. Like most research studies, participants can be included in the analyses even if they wear their accelerometer for fewer days than the total requested. For this trial we have specified in our analysis plan that for accelerometer-based outcomes participants would be included in the main trial analyses if they wear their accelerometer for ≥ 8 h/day for ≥ 3 days, and we found that 80% met these criteria. Females, those who perceived that their mothers restricted their sedentary behaviour and those from larger school-year groups were on average more likely to provide the required wear-time and those who were from more deprived areas and who reported higher levels of weekday outdoor play were less likely to provide required wear-time data, with similar results for requested wear-time.

We found a slightly lower proportion of children provided the required wear-time of at least 3 days than two previously published studies, in which over 90% of children provide this level of data.[9][11] Both of those studies were completed in older children and it is possible that younger children find it harder to wear accelerometers. In addition, they both requested that children wear the accelerometer for 7 days, rather than 5 days, and it is possible children are more likely to reach 3 days if they have been requested to wear the monitor for longer. A large UK study that distributed accelerometers by post

Table 3 Association of child characteristics with the child providing accelerometer data for the required number of days (3 days)

Variable (unit change for OR)	Provided required data, N=1629; n (%), mean (SD) or median (IQR)	Did not provide required data, N=419; n (%), mean (SD) or median (IQR)	OR (95% CI) per category or unit for scores/continuous variables	p Value
Gender *				
Male	748 (74.9)	251 (25.1)	ref (1)	<0.001
Female	881 (84.0)	168 (16.0)	1.76 (1.43 to 2.16)	
Deprivation (home postcode)*				
Low (least deprived)	599 (87.2)	88 (12.8)	ref (1)	<0.001
Mid	550 (80.8)	131 (19.2)	0.62 (0.42 to 0.90)	
High (most deprived)	476 (70.6)	198 (29.4)	0.35 (0.24 to 0.51)	
BMI (kg/m^2) †	17.7 (2.9) (n=1432)	17.7 (3.0) (n=355)	0.99 (0.96 to 1.03)	0.6
Overweight/obese*				
Normal weight	1134 (80.0)	284 (20.0)	ref (1)	0.6
Overweight	227 (82.0)	50 (18.0)	1.14 (0.82 to 1.58)	
Obese	70 (76.9)	21 (23.1)	0.83 (0.51 to 1.35)	
Waist circumference†	62.1 (8.1) (n=1519)	62.0 (7.7) (n=386)	1.00 (0.99 to 1.02)	0.8
Self-report screen time (half hour unit; OR per half hour) ‡				
Weekday all screen	3.0 (1.5–7.0) (n=1625)	5.0 (2.0–10.0) (n=413)	0.97 (0.96 to 0.98)	<0.001
Saturday all screen	3.0 (1.0–7.0) (n=1620)	4.0 (1.5–9.5) (n=412)	0.97 (0.96 to 0.99)	<0.001
Self-report recreation				
Weekday outdoor play (half hour units; OR per half hour) ‡	1.0 (0.0–2.5) (n=1625)	1.0 (0.5–4.0) (n=414)	0.95 (0.93 to 0.98)	<0.001
Weekday classes/clubs				
None	1050 (65)	285 (69)	Ref (1)	0.1
Some	575 (35)	129 (31)	1.21 (0.96 to 1.53)	
Saturday outdoor play (half hour units; OR per half hour) ‡	2.0 (0.5–4.0) (n=1620)	2.0 (0.5–6.0) (n=412)	0.99 (0.96 to 1.01)	0.3
Saturday classes/clubs				
None	1257 (78)	325 (79)	Ref (1)	0.6
Some	363 (22)	87 (21)	1.08 (0.83 to 1.40)	
Self-efficacy for PA (mean score on scale 1–5; OR per 1 of score)†	4.0 (0.7) (n=1624)	3.8 (0.8) (n=414)	1.25 (1.10 to 1.43)	<0.001
Perceived physical environment (mean score on scale 1–5; OR per 1 of score)†				
Positive environment	4.1 (0.9) (n=1623)	4.0 (1.0) (n=409)	1.13 (1.01 to 1.27)	0.03
Negative environment	2.2 (1.0) (n=1622)	2.2 (1.1) (n=409)	0.95 (0.87 to 1.04)	0.3
Paternal factors (mean score on scale 1–4; OR per 1 of score)†				
Modelling physical activity	3.0 (0.7) (n=1522)	3.0 (0.8) (n=365)	1.14 (0.99 to 1.31)	0.08
Logistic support for physical activity	3.0 (0.8) (n=1516)	2.9 (0.9) (n=361)	1.05 (0.91 to 1.21)	0.5
Limitation of sedentary activities	2.7 (0.9) (n=1515)	2.6 (0.9) (n=362)	1.10 (0.95 to 1.26)	0.2
Maternal factors (mean score on scale 1–4; OR per 1 of score)†				
Modelling physical activity	2.9 (0.8) (n=1596)	2.8 (0.8) (n=403)	1.22 (1.05 to 1.41)	0.008
Logistic support for physical activity	3.1 (0.8) (n=1594)	2.9 (0.9) (n=399)	1.21 (1.05 to 1.39)	0.007
Limitation of sedentary activities	2.8 (0.9) (n=1594)	2.6 (0.9) (n=401)	1.33 (1.17 to 1.51)	<0.001

*Number (%).
†Mean (SD).
‡Median (IQR).
BMI, body mass index; PA, physical activity.

to 7-year-old to 8-year-old children found that just 50% of children provided at least 3 days of valid data.[12]

Three of the previous studies which examined characteristics associated with wear-time explored a smaller range of potential characteristics than we have here,[9–11] the other examined a wide range of characteristics several of which differed to ours.[12] Consistent with our findings both UK studies found gender and socioeconomic status to be associated with providing accelerometer data, with females and those from higher socioeconomic backgrounds being more likely to provide required wear-time as in our study.[11 12] By

Table 4 Association of school characteristics with the child providing accelerometer data for the required number of days (3 days)

Variable	Provided required data, N=1629, mean (SD) (number)	Did not provide required data, N=419, mean (SD) (number)	OR (95% CI)	p Value
Size of year group (number pupils; OR per increase of 1 pupil)*	46 (19.9) (n=1629)	42 (18.8) (n=419)	1.01 (1.00 to 1.02)	0.009
Deprivation (school postcode) †				
Low (least deprived)	623 (86.4)	98 (13.6)	ref (1)	<0.001
Mid	527 (80.1)	131 (19.9)	0.63 (0.38 to 1.06)	
High (most deprived)	479 (71.6)	190 (28.4)	0.40 (0.27 to 0.59)	
School engagement in other health related initiatives/policies†				
Low	514 (79.6)	132 (20.4)	ref (1)	0.9
High	1115 (79.5)	287 (20.5)	1.00 (0.63 to 1.59)	

*Mean (SD).
†Number (%).

Table 5 Multivariable association of child and school level characteristics with the child providing accelerometer data for required number of days

Variable	Unadjusted OR (95% CI)	p Value	Mutually adjusted* OR (95% CI)	p Value
Child characteristics				
Gender				
Male	ref (1)	<0.001	ref (1)	<0.001
Female	1.81 (1.43 to 2.29)		1.76 (1.42 to 2.18)	
Deprivation (home postcode)				
Low (least deprived)	ref (1)	<0.001	ref (1)	<0.001
Mid	0.63 (0.44 to 0.91)		0.73 (0.49 to 1.10)	
High (most deprived)	0.36 (0.25 to 0.52)		0.49 (0.33 to 0.72)	
Self-report screen time (per half hour unit; median IQR)				
Weekday all screen	0.97 (0.95 to 0.98)	<0.001	0.99 (0.97 to 1.00)	0.1
Saturday all screen	0.97 (0.95 to 0.99)	<0.001	1.00 (0.98 to 1.02)	0.8
Self-report recreation				
Weekday outdoor play (per half hour units; median IQR)	0.95 (0.92 to 0.98)	<0.001	0.97 (0.94 to 1.00)	0.08
Weekday classes/clubs				
None	ref (1)	0.1	ref (1)	0.1
Some	1.18 (0.95 to 1.47)		1.17 (0.96 to 1.44)	
Self-efficacy for PA (per increase of 1 on score 1–5)	1.19 (1.03 to 1.37)	0.02	1.15 (0.95 to 1.41)	0.2
Perceived physical environment (per increase of 1 on score 1–5)				
Positive environment	1.12 (1.00 to 1.26)	0.06	0.99 (0.87 to 1.13)	0.9
Paternal factors (per increase of 1 on score 1–4)				
Modelling physical activity	1.14 (0.99 to 1.31)	0.08	1.03 (0.84 to 1.27)	0.8
Limitation of sedentary activities	1.13 (0.98 to 1.29)	0.09	0.89 (0.73 to 1.09)	0.3
Maternal factors (per increase of 1 on score 1–4)				
Modelling physical activity	1.18 (1.02 to 1.37)	0.03	1.01 (0.84 to 1.21)	0.9
Logistic support	1.17 (1.02 to 1.35)	0.02	0.94 (0.77 to 1.13)	0.5
Limitation of sedentary activities	1.29 (1.11 to 1.49)	<0.001	1.26 (1.04 to 1.52)	0.02
School characteristics				
Size of year group (per increase of 1 pupil)	1.01 (1.00 to 1.02)	0.02	1.01 (1.00 to 1.02)	0.1
Deprivation (school postcode)				
Low (least deprived)	ref (1)	<0.001	ref (1)	0.4
Mid	0.61 (0.36 to 1.04)		0.84 (0.49 to 1.45)	
High (most deprived)	0.40 (0.27 to 0.60)		0.74 (0.48 to 1.14)	

N=1837 pupils with complete data on variables examined.
*Mutually adjusted for gender, home area deprivation, self-report screen time (weekday all screen, Saturday all screen), self-report recreation (weekday outdoor play), self-efficacy for physical activity, perceived positive physical environment, paternal factors (modelling of physical activity, limitation of sedentary activities), maternal factors (modelling of physical activity, logistic support, limitation of sedentary activities), size of school-year group, school area deprivation.
PA, physical activity.

contrast both US-based studies found no association of gender with wear-time.[9] [10] Variation between studies in relation to gender may be related to country-specific cultural differences. Differences between studies in the relationship of BMI with accelerometer wear-time are notable. Two previous UK studies, one of children aged 11 and the second of children aged 7–8, found that greater BMI or being overweight/obese was associated with less likelihood of wearing the accelerometer for the required time.[11] [12] The large US study found the opposite (those classed as overweight were more likely to wear their accelerometer for the required time)[9] and we find no evidence of an association of BMI with required wear-time, whether BMI was treated as a continuous variable or comparing those who were overweight or obese to those who were normal weight. Nor did we find any association of waist circumference with wear-time. Thus, these differences could reflect chance variation around a true null association, though with just four studies looking at this, further research is required.

The differences found between the studies might reflect different ways that 'adequate' wear-time is defined in different studies, with the two US studies defining this as no more than 3 h of continuous zeros between 8:00 and 21:00 on a weekday and 12:00 and 21:00 on a weekend, for seven consecutive days[9] and ≥10 h/day for ≥4 days,[10] the first UK study as ≥10 h/day for ≥3 days,[11] the UK postal study defining it as ≥10 h/day for ≥2 days[12] and in our study we define it as ≥8 h/day for ≥3 days in the main analyses. That said, we found no differences in associations, including those for BMI, overweight/obesity or waist circumference, with accelerometer wear-time whether this was defined as ≥8 h/day for the requested 5 days or the required 3 days, suggesting that within a given study population how the outcome is defined may not necessarily be a major determinant of how the characteristics relate to accelerometer wear-time. As so few studies to date have examined the association of characteristics with accelerometer wear-time in children or adolescents it is difficult to be definitive about what might explain differences between results from different studies.

To our knowledge, the associations of self-report weekday outdoor play, perceived maternal restriction of sedentary behaviour and school-year group size that we found here to be associated with accelerometer wear-time have not been previously examined and so need further replication before it can be concluded that they are important. Importantly, what this and previous studies[9–12] illustrate is that wearing accelerometers for the requested number of days or the required number of days to be included in analyses is related to participant characteristics. While these may vary by study population and study type, this work suggests that by identifying these characteristics during pilot and feasibility work, they could then be used to promote better wear-time in the main study.

Furthermore, these findings suggest that the results from research studies measuring physical activity using accelerometers may be influenced by selection bias due to differential wear-time by exposure categories. If the likelihood of wearing the accelerometer for the required time in a study is related to the actual physical activity levels of the child and characteristics related to wear-time are also related to activity levels, selecting participants based on their wear-time will generate an association between those characteristics related to wear-time and activity and hence bias the exposure-activity association.[23] It might be possible to minimise this bias by controlling for characteristics associated with wear-time, and this further emphasises the importance of exploring these associations within studies. Such selection bias could also occur in RCTs, though is less likely if these are well conducted, with valid and concealed randomisation, and where there is little loss to follow-up.

Study strengths and limitations
This study has added to the otherwise very limited research in this area to date. We used a large sample size and included children from a wide range of levels of neighbourhood deprivation. A wide variety of characteristics were investigated to see if they were associated with accelerometer wear-time, including many characteristics that had not been investigated in previous studies. This study is limited in that the population was all between the ages of 8 and 10 years and from the metropolitan area around a single UK city, therefore the results may not be generalisable to younger children or adolescents, or to other settings. Several of the characteristics investigated relied on child self-report and therefore may not truly reflect reality, for instance self-report screen time and recreation time, and perception of parental support may be different if they were reported by parents or teachers or observed directly. However, the child's perception of these characteristics is also likely to be important even if this is not an accurate measure—that is, if a child perceives that his/her mother restricts his/her sedentary behaviour, this rather than the actual level of restriction she enforces, might be what influences the child's enthusiasm for wearing the accelerometer (eg, to prove that they are not sedentary). We did not have any measure of teacher support, which would be useful considering that the study took place through schools and much of the accelerometer wear would have taken place in the school day. It is also important to acknowledge that debate remains within the field about the minimum number of days and the minimum number of hours within those days that are needed to provide an indication of habitual physical activity, as well as the minutes of zero counts that are required for that time to be considered 'non-wear' time. Results might differ if any of these criteria are different to what were used in our study.

CONCLUSIONS AND IMPLICATIONS
We have demonstrated that there are several characteristics associated with accelerometer wear in 8-year-old to 10-year-old children. In well-designed RCTs it is not

necessarily the case that having differences between children who provide required wear-time and those who do not will lead to bias in the main study results. For example, in this RCT,[14] we think it unlikely that accelerometer wear-time at baseline or follow-up will vary by randomised group (although we will test that). Randomisation has been conducted accurately, the geographical confines of the study have made it possible to keep loss to follow-up to a minimum, and the intervention (16 lessons and 10 homeworks that fit into the national curriculum for these pupils) is unlikely to directly influence follow-up accelerometer wear-time. If this is correct, then the main study outcome results will not be biased. However, we will examine whether wear-time varies by randomised group.

As noted above selection bias may occur in relation to differential wear-time, particularly in observational studies. Even if selection bias is not thought to be a major problem within a study, loss of participants because of not wearing the accelerometer for the required time could have importance for statistical efficiency and may reduce the potential for studies to make definitive conclusions because of lack of statistical power. Identifying characteristics that are related to accelerometer wear-time is therefore important for considering incentives that could be targeted at those groups who are less likely to wear their accelerometer for the required time. Given the differences between the studies to date, we would recommend that future trials examine characteristics that might be related to wear-time during the trial feasibility/pilot phase and use that information to develop methods for maximising wear-time in the main study and/or in the power calculation for the main study. We would also recommend that in main studies characteristics associated with wear-time are further explored and their likely impact on the validity of results assessed through appropriate sensitivity analyses. That is considering a range of plausible ways in which associations might differ in those who are excluded because of not wearing their accelerometer for the required time and testing these with informed imputation and/or simulation.

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Characteristics associated with requested and required accelerometer wear in children

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