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School level correlates with adiposity in 9-10 year old children

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Abstract

We examined the associations between the physical, social and policy environments of schools and adiposity in 9-10 year old children in Norfolk, UK. The relationships between 56 school-level variables and Fat Mass Index (FMI; fat mass (kg)/height(m)²) were investigated among 1724 well characterised children from 92 schools in this cross-sectional study. After stepwise removal of variables from multilevel linear regression models stratified by gender, only three variables were significantly associated with FMI. Among girls, attending a school with more pupils in the year group was associated with lower FMI, and attending a school with better cycle provision was associated with higher FMI. In boys being allowed to eat any food at break-time was associated with higher FMI. There was some evidence of moderation of the relationship between cycle provision and FMI by urban-rural location. These data suggest that few school factors are associated with FMI, and provide limited pointers to inform potential future school-based interventions to reduce obesity.

Keywords

Obesity; Britain; School; Environment; Fat Mass

Introduction

The prevalence of childhood obesity in the developed world has increased dramatically in recent years (Wang and Lobstein, 2006). The direct health impacts of excess body fat in childhood are mainly psychosocial, with obese children suffering discrimination and stigmatisation (Dietz, 1998). However, obese children are also more likely to exhibit physical conditions such as hypertension, dislipidemia, insulin resistance and asthma, which may have severe health consequences (Reilly, 2005). Adiposity has been shown to track

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from childhood into adulthood (Freedman et al., 2005) where it increases risks of, among others, type 2 diabetes, and coronary heart disease (Maffeis and Tato, 2001).

There has long been an interest in the impact schools can have on child health in general and, more recently, on obesity in particular. The appeal of schools as a vehicle for health promotion stems from the significant role they play in most children's lives, with the majority of English children spending around six hours a day at school on roughly 190 days of the year. The provision of meals, the availability of physical activity facilities, and the design of the learning environment give schools unequalled opportunities to promote good weight management via healthy eating and increased physical activity (Peterson and Fox, 2007, Story, 1999).

Despite a growing number of studies examining the relationship between children's adiposity and elements of the school environment, it remains unclear as to which aspects of the environment are most important. Various aspects of the physical, social and policy environment at school may impact on both food consumption and physical activity. Past cross-sectional work has tended to focus on individual elements of the school environment such as PE requirements (Cawley et al., 2007) and the use of school canteens (Finch et al., 2006), or on school classifications such as state funded vs. private (Ramos and Barros, 2007), and the ethnicity and parental education of the student body (O'Malley et al., 2007).

These studies have reported rather few associations with children's weight status, although a limited number of factors have been associated with increased risk of overweight or obesity, including, menus offering french fries and/or desserts at least once a week (Fox et al., 2009), school practices that offer more opportunities for the consumption of food (Kubik et al., 2005), and lower average socio-economic status (SES) of the student body as measured by parental education (O'Malley et al., 2007), and household income (Richmond and Subramanian, 2008). Increased participation in school sponsored sports (Elkins et al., 2004), participation in school breakfast programs (Gleason and Dodd, 2009), and strict healthy eating promotion policies (Veugelers and Fitzgerald, 2005) have been associated with a decreased risk of overweight and obesity. Most of these studies used BMI-based outcome measures as a substitute for direct measures of adiposity and excess body fat. Yet BMI-based measures have a variable association with adiposity among children (Freedman et al., 2004), whereas body fat mass determined from bioelectrical impedance correlates better with dual-energy X-ray absorptiometry measures of body composition (Tyrrell et al., 2001).

This cross-sectional study tests the hypothesis that certain aspects of the school environment (size, grounds, facilities, policy and provision) are associated with adiposity. It builds on previous work by jointly examining their relative importance, and additionally establishes how these associations vary by urban-rural location, and family socio-economic status. The study utilises a well characterised sample of children attending a group of environmentally heterogeneous schools in the county of Norfolk, UK.

Methods

Study methods and recruitment

The SPEEDY study (Sport, Physical activity and Eating behaviour: Environmental Determinants in Young people) was set up to investigate individual and collective correlates of diet and physical activity behaviour of Year 5 (aged 9-10) children across the county of Norfolk, UK. The study's methods are described in detail elsewhere (van Sluijs et al., 2008) and so are only briefly recounted here.

State and independent schools across Norfolk with at least 12 Year 5 pupils on role were invited to participate in SPEEDY. Schools were sampled according to a stratification by urban/rural status (being classed as either Urban, Town & Fringe (semi-urban) or Village, Hamlet & Isolated Dwelling (Rural)) (Bibby and Shepherd, 2004), as defined by the census area (lower super output area) each school fell within. Rural schools were somewhat over sampled to ensure sufficient numbers of participants in these areas. Invitations to participate were sent at random to 157 of the 227 eligible schools, of which 92 agreed to take part in the study. Teams of two research assistants visited participating schools before the planned measurement date to introduce the study to all Year 5 children. Children were given an information pack containing a leaflet for themselves, a letter for their parents/guardians, and a consent form. Only children with a completed consent form (signed by both a parent/guardian and the child) on the day of measurement were included in the study. In total 2064 children were recruited into SPEEDY.

Ethical approval for the SPEEDY study was obtained from the University of East Anglia local research ethics committee.

Child measurement

Schools were visited by trained research assistants, and a range of anthropometric measurements were taken. Height was recorded to the nearest millimetre using a Leicester height measure using standardized procedures, with children with bare feet and headwear removed where possible. Non-segmental Tanita scales (type TBF-300A) were used to measure weight and foot-to-foot bioelectrical impedance. Children were not asked to fast prior to measurement and impedance readings were taken only once. Fat mass (FM) was derived from impedance values using previously validated equations (Tyrrell et al., 2001). Fat Mass Index ($FMI = FM(kg)/height(m)^2$), was calculated for each child for whom height and impedance data were available. FMI was used as the outcome as it provides a good measure of body fat regardless of stature (VanItallie et al., 1990), and was shown to correlate better with physical activity than other adiposity measures among this sample (Steele et al., 2009). Nevertheless, Body Mass Index ($BMI; weight(kg)/height(m)^2$) was also calculated so that obesity status of the sample could be determined based on international age- and gender-specific cut-points (Cole et al., 2000).

Measurement of the school environment

Variables measuring the school environment were derived from a questionnaire completed by the head teacher, an audit of the school grounds undertaken by a trained assessor, and from additional information supplied by Norfolk County Council.

The head teacher questionnaire was designed especially for this study, and included questions around five themes. These covered the physical activity opportunities at school (access to and quality of physical activity facilities, hours of PE and swimming lessons, and provision of extracurricular physical activity), food-related learning opportunities (facilities and time provision), school rules and attitudes (on the promotion of physical activity and healthy eating, break-time policies, active travel facilities and policies, and additional health education), food provision and catering (facilities, child choice, packed lunch rules and policies), and the physical environment around the school, as perceived by the head teacher.

The audit tool was developed based on previously validated tools (Cardon et al., 2008, Hillsdon et al., 2006), and was designed to measure how suitable the grounds of the school were for physical activity. A draft of the audit tool was circulated to three experts for comment, and after resulting edits the final version was piloted in two schools. A comprehensive user manual was developed to ensure consistency between auditors and

schools. The tool comprised 44 items which measured the location of school access points and the transport infrastructure around them, the presence and quality of various facilities, the suitability of grounds for sports, informal games and general play, and the presence or absence of various aesthetic indicators. Composite scores for each school were derived from the audit outcomes describing cycling provision, walking provision, sports and play facility provision, other facility provision, design of school grounds, aesthetics, and overall physical activity provision (Jones et al., 2010).

Norfolk County Council provided general information on all state schools in the sample including number of children at the school, number of pupils in our target year group, percentage eligible for free school meals (FSM), the ethnic composition of schools, and whether the school participated in the Healthy Schools programme (a UK government programme to promote a 'whole school' approach to health, with an aim to, among others, help children develop healthy behaviours (Department of Health and Department for Children Schools and Families, 2007)). Similar information for independent schools was provided by the Independent Schools Council, and by the schools themselves.

A full list of the school level variables considered in these analyses, along with information on the range of each, is given in the online supplementary material associated with this paper.

Child, parental, family, and home co-variates

Each child's gender and date of birth were recorded at the anthropometric measurement visit. On the same day, participating children were asked to complete a questionnaire about their home, physical activity, and eating habits. This was completed in a classroom under the supervision of the researchers and their teachers. Questionnaires were checked for completeness and children were asked to address any missed questions. Children were also given a pack to take home which included a questionnaire for their parents or carers to complete and return to the school.

Participants' mothers (the biological parent if they lived in the household or their step-parent/guardian otherwise) were asked to report their height and weight, from which BMI (kg/m²) was calculated. Three SES indicators were derived from the parent and child questionnaires; the age the parent left full-time education (this questions were asked of the adult completing the questionnaire, which was the mother on 84% of occasions), and the tenure of the home (rented or owner-occupied), both from the parent questionnaire, and household access to cars from the child questionnaire.

Statistical analysis

All statistical analyses were performed in Stata IC version 11 (StataCorp, 2009). The outcome variable, FMI, was log transformed as its distribution was skewed. To take account of the hierarchical nature of the dataset (children nested within schools) all random coefficients regression models were run with schools as the level two unit, and participants at level one. As gender differences have been observed in physiological and environmental determinants of adiposity (Wisniewski and Chernausek, 2009), and several studies have observed differences in the impacts of school interventions on obesity (Thomas, 2006), all analyses were undertaken separately for girls and boys.

Variables from the school questionnaire and grounds audit were grouped according to the domain they measured; school size, grounds, physical activity opportunities, food learning opportunities, rules & attitudes, and food provision. As many of the variables with continuous outcomes were not normally distributed, or had limited ranges, they were banded into tertiles and analysed as categorical variables, with a test for trend. Within each domain,

all variables were added to a model that also included the co-variables age, mothers' BMI, age parent left full-time education, household access to cars, home tenure, and school urban/rural status. Variables were removed using a backwards stepwise procedure so that only those statistically significant at $p < 0.1$ remained. Remaining variables from all domains were then added to a final model, adjusted for the same co-variables, and were removed until only those statistically significant at $p < 0.05$ remained. Once final models were reached, the moderating effect of school urban-rural location and family SES were investigated by entering interaction terms between these factors (using age parent left full-time education to model the household SES interaction) and each school level variable present in the final model. Where interaction terms were associated at $p < 0.1$, they were further investigated in stratified models.

Results

Amongst the 2064 children who agreed to take part and were included in the SPEEDY study, valid height and impedance data were available for 2047 of the participants. However, a further 323 were excluded from these analyses as data on mother's BMI was not available, resulting in a final sample of 1724 children; 84% of the SPEEDY participants, 48% of Year 5 pupils at participating schools and 20% of Year 5 pupils at all eligible schools. Some data on SES were missing for 38 participants, and to prevent loss of further cases we imputed these variables to the mode. There was no significant difference in FMI between those included and excluded.

Summaries of the characteristics of the pupils included in these analyses are shown in Table 1. More girls than boys were included (56% girls) and girls had higher weight and FMI than boys (difference statistically significant at $p < 0.05$). Among this sample FMI and BMI were highly correlated ($r = 0.945$ for log transformed variables) and overall 16.8% of children were overweight (not including obese) and 5.2% were obese. Boys were found to be more heterogeneous than girls in their FMI; the mean (standard deviation) log-transformed FMI was 1.53 (0.41) for boys and 1.76 (0.38) for girls.

Table 2 shows the school level variables that were associated at $p < 0.1$ with FMI after stepwise removal of variables within domain groups. Of the 56 school variables investigated, four showed a statistically significant association with FMI for girls, and five for boys. Some of these associations were not in the expected directions; among girls, better cycling provision was associated with increased FMI, and among boys better school design scores, and a greater number of activities allowed at break time were also associated with increased FMI.

Multivariable adjusted models

Table 3 shows the results of the final multivariable regression models. In the girls' model two school level variables remained; having more pupils in the year group was associated with a lower FMI (equating to a difference of 17.8% in predicted FMI between the top and bottom tertiles, holding co-variables at the mean), and higher cycle provision scores were associated with higher FMI (a difference of 8.2% in predicted FMI between top and bottom tertiles). Among boys, being allowed to eat any food they liked at break-time was the only factor that remained in the model, being associated with higher FMI. Predicted FMI was 10.3% higher among those allowed to eat any food compared with those with restricted break-time food choices.

The proportion of the variation that occurred at the school level in these models was low. For girls the intraclass correlation (ICC) was less than 0.01% in the null and final models. For boys it ranged from 0.17% in the null model to 0.81% when the co-variables were added.

Moderation by School Urban/Rural location and Household SES

The only school-level variable to show an interaction with school urban/rural location at $p < 0.1$ was the cycle provision score among girls. Stratified analysis showed better provision was associated with higher FMI in urban schools (for trend across tertiles $B = 0.066$, $p = 0.004$), and was associated with lower FMI in rural schools ($B = -0.119$, $p = 0.024$). There was no significant association in semi-urban schools ($B = 0.042$, $p = 0.145$). No significant moderation of any of the relationships between school level variables and FMI by household SES was observed.

Discussion

We investigated a total of 56 variables describing the physical, social, and policy environments of schools relating to both physical activity and food, and their association with 10-yr old children's FMI. While we had prior hypotheses as to why all the school related measures in our final models might be associated with FMI, it is of particular note that so few of the original set of measures generated showed statistically significant relationships with FMI after adjustment for individual and family correlates. Indeed, only two of the school variables analysed showed a statistically significant associations with FMI among girls, and among boys only one, different, school variable remained in the final model.

Among girls we found significantly lower FMI in those attending schools with more pupils in their age group. Dietz and Gortmaker (2001) suggest that physical activity is likely to be higher among children with access to other children to play with, and physical activity with peers has been seen to make a significant contribution to overall physical activity (Voorhees et al., 2005). It could therefore be the case that larger year groups offer more potential playmates, encouraging physical activity and therefore reducing FMI, although we have found no other evidence for this mechanism and previous work has suggested that large physical education class sizes are actually associated with reduced physical activity (Pate et al., 2006). It should be noted however that the measure used in this analysis represents the number of children within a year group, not class size, and where the year group is large they may be divided into two or more classes.

Also among girls, higher cycle provision scores were associated with higher FMI. This is not the direction we would expect this score to operate in. It could be that schools with pupils with higher FMI are more likely to improve their cycle provision in an attempt to encourage healthy behaviours, although it is not possible to determine if this is so based on cross sectional analysis. After stratification this association persisted in urban schools, but in rural schools the direction of the association changed, with higher scores associated with lower FMI. There is some evidence that active travel to school contributes a greater amount to overall physical activity the further children travel (van Sluijs et al., 2009). In this sample girls attending rural schools typically have further to travel than those at urban or semi-urban schools (mean of length of route to school was 3.3km for rural schools and 2.4km in urban and semi-urban schools, $p < 0.05$), so rural cyclists may be more active, and therefore have lower FMI. However, few girls in our sample report cycling to school (just 7.9% in rural schools and 3.9% at urban schools) and the relationship was not observed for boys, so more investigation is needed into how school cycle provision may impact on adiposity.

Attending a school that reported allowing pupils to eat any food at break-time, rather than no food or only healthy foods, was associated with a statistically significant increase in FMI for boys. Past studies have shown that some school-wide food policies are associated with overweight and obesity. For example, Veugelers and Fitzgerald (2005) found that schools participating in a co-ordinated healthy eating programme had lower rates of overweight and

obesity among their pupils, while Kubik et al. (2005) found the more opportunities for the consumption of unhealthy food a school allowed, the higher the BMI of its students.

Some aspects of the school environment which have been previously associated with the behavioural determinants of adiposity did not show significant associations here. For example, larger school grounds size (Cradock et al., 2007), greater numbers of physical activity facilities (Haug et al., 2010) and playground markings (Stratton and Mullan, 2005) have all been associated with higher levels of physical activity, however, none of these measures were associated with FMI in these analyses.

Our paucity of statistically significant associations may be due to a number of reasons. We would expect many of the environmental characteristics measured here to affect adiposity via their impact on physical activity. However our school level variables generally pertained to the presence or absence of facilities or to policies, rather than actual facility use, which is likely to be an important factor. No information was available with which to access the use of facilities or application of policies within this sample, but validation of the grounds audit tool found that children spent significantly longer in moderate-to-vigorous physical activity (MVPA) at schools with grounds audited to be the most suitable for physical activity (Jones et al., 2010). That this pattern is not clearly seen in FMI may be due to an attenuation of the impact of physical activity on adiposity by other behavioural factors. Alternatively it may be that small differences seen in activity levels may take a long time to produce significant differences in weight status.

While the SPEEDY study was designed to maximise environmental heterogeneity, our schools were all located in the same county and the majority were run by the same education authority, possibly reducing the variability of some exposures. In particular almost all schools reported having play equipment for use at break-time (89 schools of the 92 participating), sports equipment for PE lessons (91/92), and between 1.5-2.5 hours of physical education per week (87/92). It is noteworthy that the food environments of schools in the USA have been seen to become more varied as children age (Finkelstein et al., 2008), and some aspects of the school food environment which have previously been associated with less healthy diets and adiposity, for example vending machines (Kubik et al., 2003, Wiecha et al., 2006), are completely absent from Norfolk primary schools.

Whilst we included measures of the school environment which previously have been, or hypothesised to be, associated with adiposity or its behavioural determinants, it may be that they were inadequately measured or are not relevant to the adiposity of Year 5 pupils in Norfolk. The associations we did observe were different for girls and boys, and one association was moderated by school urban-rural location. Gender differences in school level associations with diet, physical activity and adiposity have been noted by others (e.g. Haerens et al., 2006, Haug et al., 2010), and are potentially a result of genuine differences in the factors driving girls' and boys' behaviour. Our sample did contain more girls than boys, although boys were more heterogeneous than girls in their weight status.

This study has a number of strengths and weaknesses. In terms of strengths, we were able to recruit a large sample of schools and pupils, and collected detailed anthropometric measurements using standardised procedures. Anthropometry included bioelectrical impedance allowing the use of an outcome measure that has been shown to be better correlated with body fat in children than those based on weight. While past studies have focused on urban areas (Dummer et al., 2005, Elkins et al., 2004, Kubik et al., 2005, Moffat et al., 2005, Proctor et al., 2008), we included many more rural schools than commonly studied. We also recorded a wide range of school environment variables from teachers and independent assessors, as well as detailed individual and household data for all participants.

Study weaknesses include the cross-sectional design, which means that causality cannot be determined from the associations observed. Whilst the inclusion of a comprehensive set of individual-level correlates reduced the possibility that associations were seen with school level variables as a result of confounding with individual characteristics, the large number of tests we performed means that some associations were likely to be observed by chance. While foot-to-foot bioelectrical impedance measures of body fat have been shown to correlate well with those derived from dual-energy X-ray absorptiometry (Tyrrell et al., 2001), the procedure does not measure the composition of the upper body. In addition, due to the logistics of testing a large number of children at many different schools, children were not asked to fast prior to impedance measurements, which were performed only once per child and were conducted at different times of day at each school. As a consequence, limitations related to impedance measures, such as hydration status, recent exercise, and meal intake should be considered when interpreting the results of this study (Kushner et al., 1996). Nevertheless, we did test the sensitivity of the findings to different outcome measures by substituting FMI with BMI and waist circumference, and we obtained broadly similar results (not presented).

A further limitation of our study is the fact that we banded categorical school-level variables into tertiles as many were skewed and/or had limited ranges, and there is little prior work to show more meaningful cut-points. Although the 40.5% of eligible Norfolk schools that took part in the study have been previously shown not to differ from the broader population of schools, our participants had lower prevalence of obesity than the eligible population (van Sluijs et al., 2008), potentially limiting our ability to detect significant associations. It is also noteworthy that schools in Norfolk, and consequently our sample, have a low proportion of non-white pupils, which limits the generalisability of our findings to more diverse populations.

In conclusion, this study found that rather few school related factors were associated with adiposity in 9-10 year old children. Further investigative work is required to establish whether the associations found here could be used to develop into successful interventions to reduce obesity among 9-10 year old children.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1
Characteristics of pupils in the sample

		Count(%), or Mean, SD unless otherwise stated		
		All	Girls	Boys
Number of cases		1724	959	765
Age (years)		10.25, 0.31	10.25, 0.31	10.24, 0.31
Height (cm)		140.85, 6.66	140.86, 6.78	140.82, 6.51
Weight (kg) ^a		36.28, 8.26	36.75, 8.65	35.70, 7.12
Number overweight		289 (16.8%)	173 (18.0%)	116 (15.2%)
Number obese		90 (5.2%)	58 (6.0%)	32 (4.2%)
Fat Mass Index (Median, IQR) ^a		5.13, 3.96 - 6.90	5.53, 4.49 - 7.42	4.44, 3.45 - 6.16
Mother's BMI (Median, IQR)		23.97, 21.68 - 27.34	23.96, 21.68 - 27.49	24.07, 21.67 - 27.13
Age parent left full-time education	<16 years	802 (46.5%)	451 (47.0%)	351 (45.9%)
	16-18 years	575 (33.4%)	315 (32.8%)	260 (34.0%)
	>18 years	347 (20.1%)	193 (20.1%)	154 (20.1%)
Number of cars accessible to household	None	73 (4.2%)	39 (4.1%)	34 (4.4%)
	One	616 (35.7%)	342 (35.7%)	274 (35.8%)
	Two or more	1035 (60.0%)	578 (60.3%)	457 (59.7%)
Home tenure	Renting	428 (24.8%)	241 (25.1%)	187 (24.4%)
	House owner	1296 (75.2%)	718 (74.9%)	578 (75.6%)
School location	Rural	440 (25.5%)	236 (24.6%)	204 (26.7%)
	Semi-urban	583 (33.8%)	342 (35.7%)	241 (31.5%)
	Urban	701 (40.7%)	381 (39.7%)	320 (41.8%)

^a difference between girls and boys significant $p < 0.05$

Table 2
School level variables associated with log-transformed FMI ($p<0.1$) after stepwise removal of variables within domains.

Original measure	Summarised as	Girls	Boys	Direction of association ^a
School society (characteristics of the student body)				
Number of year 4 pupils at the school in the 2005-2006 academic year				
	bottom tertile: ≤ 20 pupils			
	middle tertile: 21-46 pupils	--		
	top tertile: ≥ 47 pupils	--	<i>b</i>	
School grounds				
From the school grounds audit				
Cycle lanes ^e , Pavements ^e , Marked pedestrian crossings ^e , Traffic calming ^e , School warning signs for road users ^e , Road safety signs ^e , Route signs for cyclists ^e , Cycle parking ^f	bottom tertile: <4 ^c middle tertile: 4 top tertile: ≥ 5	ns	<i>b</i>	
Presence of dog dirt ^g , School grounds on a split site ^g , Sloped school grounds ^g , Suitability for sport ^h , Suitability for informal games ^h , Suitability for general play ^h	below median: ≤ 9 ^c above median: >9		++	
Physical activity opportunities				
Does your school have access to:				
A specific hall for gym or sports (indoors)?	Indoor sports facilities			
A shared facility used for sports activities (indoors)?	has shared facility only ^c has specific hall only has both	-	ns	
Food-related learning opportunities				
Do children have cookery lessons as part of the planned curriculum for Key Stage 2 in years 3, 4 or 5?				
If yes, total number of hours over school year (to nearest 1/2 hour)	bottom tertile: <2 hours ^c middle tertile: 2-5 hours top tertile: >5 hours	ns	<i>b</i>	
School rules and attitudes				
Are the children in year 5 allowed to do the following during breaks?				
Use the school's sports equipment	Number of physical activities	0 ^c		
Play a ball game indoors	1		ns	

Original measure	Summarised as	Direction of association ^a	
		Girls	Boys
Play a running game indoors	2		ns
Play ball games outdoors	3 or 4		++
Does your school have/offer the following?			
A 'Park and Stride' ^d	No ^c		
	Yes	-	
Does your school have a policy to promote...			
Physical activity (PA) among the children?	has neither HE nor PA policy ^c		
Healthy eating (HE) among the children?	has HE policy only	-	
	has PA policy only	ns	
	has both HE and PA policy	ns	
Food provision			
With regard to food at break times, which of the following is true of your school?			
Children are not allowed to eat during break times	No food/only healthy foods allowed ^c		
Children may only bring in healthy foods (fruit/veg) to eat at break times			
Children may bring in any food to eat at break times	Any food allowed		++

^a --- = negative association $p < 0.05$, - = negative association $p < 0.1$, ++ = positive association $p < 0.05$, + = positive association $p < 0.1$, ns = $p > 0.1$

^b significant ($p < 0.1$) trend across tertiles/categories

^c reference category

^d A 'Park and Stride' is a place where parents park their cars or stop and drop children off away from the school so that children walk the remainder of the journey.

Coding of school grounds items:

^e Visible from school entrance - Yes/No;

^f Quantity provided - Bands (None, up to mean + 1 Standard Deviation, above) ;

^g Presence - Yes/No;

^h Suitability - Very, somewhat, not at all

Table 3
Results from multiple regression models of log-transformed FMI for girls and boys

	Girls				Boys			
	B	lower	upper	p	B	lower	upper	p
Individual, family and neighbourhood co-variables								
Age	0.056	-0.017	0.130	0.134	0.051	-0.041	0.143	0.278
Mother's BMI	0.024	0.019	0.028	0.000	**	0.021	0.015	0.026
Age parent left full-time education ^a	-0.010	-0.062	0.042	0.714	0.002	-0.062	0.066	0.948
	-0.048	-0.110	0.015	0.134	-0.009	-0.086	0.068	0.818
Number of cars accessible to household ^b	0.117	-0.001	0.235	0.052	0.051	-0.093	0.196	0.488
	0.056	-0.064	0.176	0.363	0.020	-0.125	0.166	0.783
Home tenure ^c	-0.042	-0.098	0.014	0.141	-0.021	-0.091	0.050	0.563
School location ^d	0.136	0.043	0.229	0.004	**	-0.056	-0.131	0.141
	0.091	-0.002	0.185	0.055	-0.040	-0.112	0.031	0.270
School Factors								
Number of year 4 pupils in 2006 ^e	-0.126	-0.215	-0.037	0.006	**			
	-0.196	-0.300	-0.093	0.000	**			
Cycle provision score ^e	0.026	-0.033	0.084	0.387				
	0.079	0.013	0.145	0.019	*			
Can children eat any food they like at break-time? ^f					0.098	0.029	0.166	0.005

** = p<0.01,

* = p<0.05

Reference categories for categorical variables:

^a ≤16 years old,

^b no cars,

^c renting,

^d Rural,

e bottom tertile,

f not allowed to eat at break/only allowed healthy foods