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Neighbourhood, route and school environments and children's active commuting

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Abstract

Objective—To assess whether objectively-measured characteristics of the neighbourhood, route and school environments are associated with active commuting to school among children. We also explore whether distance acts as a moderator in this association.

Methods—A cross sectional study of 2012 children (899 boys and 1113 girls) aged 9-10 years attending 92 schools in the county of Norfolk, UK. During the summer of 2007 questionnaires were completed by children and parents. Attributes around the home and route to school were assessed using a Geographical Information System. School environments were assessed using a newly developed school audit and via questionnaires completed by head teachers. Data were analysed in 2008.

Results—Almost half of the children usually walked or cycled to school. Children who lived in a more deprived area and whose route to school was direct were less likely to walk or cycle to school, whilst those who had a higher density of roads in their neighbourhood were more likely to walk. Furthermore, children whose routes had a high density of streetlights were less likely to cycle to school. Distance did not moderate the observed associations.

Discussion—Objectively measured neighbourhood and route factors are associated with walking and cycling to school. However, distance did not moderate the associations found here. Creating environments which are safe, through improving urban design may influence children's commuting behaviour. Intervention studies are needed to confirm the findings from this observational cross-sectional study.

Introduction

Physical activity provides a number of important benefits for children, including improved physical[1] and mental health.[2] Walking and cycling to school (or 'active commuting') is one way in which children can integrate physical activity into their everyday lives and has previously been identified as a possible target for increasing physical activity levels in children.[3] Research suggests that children and adolescents who actively commute to school

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tend to be more active than those who do not[4] and this may contribute significantly to children's overall physical activity.[5]

According to the socio-ecological model of health behaviour,[6] a variety of contextual influences are likely to be important in determining health behaviour. A recent review highlighted that in addition to individual factors such as age and gender, a broad range of environmental factors may influence children's active commuting.[7] Several authors, including Moudon and Lee,[8] have suggested that three environmental components should be considered as possible influences on active commuting; the neighbourhood around the home, the route between home and school, and the environment of the school itself.

Studies that have examined one or more of these components have used either self-reported perceptions of the environment from participants or objective measures generated using geographical information systems (GIS) or street audits. Current research using objective methods suggests that the presence of pavements and mixed land use around the school is associated with a higher prevalence of walking or cycling to school,[9, 10] whilst having to cross a busy road on route to school or having less route options have been negatively associated with children's active commuting.[11]

There are four main limitations of work to date. Distance is an important determinant of travel behaviour[7] and may moderate the association between environmental factors and active commuting,[12] yet there is a lack of studies examining this in the context of travel to school. Secondly, many studies fail to separate walking and cycling. As the characteristics of environments encouraging walking among children may be very different to those supporting cycling, failure to consider the behaviours separately may mean that study outcomes and environmental exposures are not appropriately matched.[13] Thirdly, the environmental measures commonly studied are often based on those developed to assess the supportiveness of the environment for walking among adults. Our understanding of how these factors are associated with cycling behaviour or how associations may differ in children is limited. Finally, the majority of studies to date have been conducted in urban areas in the USA and Australia, both countries with typical urban layouts that are not commonly found in regions such as Europe. Hence there is a need to examine how the environment might be associated with children's active commuting in different environmental settings.

In order to address these limitations we quantified a range of associations between objectively measured environmental characteristics and walking and cycling to school in a large sample of British schoolchildren selected from urban and rural neighbourhoods. We also explored the hypothesis that the associations between environmental factors and children's active commuting behaviours are moderated by the distance travelled to school.

Methods

Study design and setting

Children included in this analysis participated in the SPEEDY study (Sport, Physical activity and Eating behaviour: Environmental Determinants in Young people). The methods of recruitment, sampling and overall sample representativeness of the study have been described in detail elsewhere.[14] Briefly, children were sampled through schools in the county of Norfolk, Eastern England. Ethical approval for the study was obtained from the University of East Anglia local research ethics committee and informed consent was provided by participating children and their parents. 2064 children aged 9-10 years from 92 schools across the county were recruited to the study. During summer 2007, a team of trained field workers visited each school to distribute questionnaires for children and their parents or guardians, and measure each child's height and weight according to standard operating procedures. Body mass index (BMI) was calculated in kg/m^2 and used to classify children into categories as described by Cole and colleagues.[15]

Children reported their usual travel mode to school ('by car', 'by bus or train', 'on foot' and 'by bike') via questionnaires. Responses were collapsed into three categories; 'motorised travel to school', 'cycle to school' and 'walk to school'. Parents or guardians provided information on their access to or ownership of a car, mode of travel to work and educational qualifications by questionnaire. Based on the highest qualification reported, parents were assigned to one of three educational attainment categories; low (high school or less), medium (vocational qualifications above high school) and high (university education or above).

Neighbourhood delineation and environmental measures

Objective assessments of neighbourhood environmental factors were computed using a GIS (ESRI ArcGIS 9.2). Children's home addresses were converted into a map location using the Ordnance Survey Address Layer 2 product, a dataset that identifies precise locations for all registered addresses in Great Britain.[16] The neighbourhood of each child was defined using the street network (Ordnance Survey Integrated Transport Network) as the area within an approximate 10 minute walk (corresponding to 800m) of their home. The network included publicly accessible roads and pedestrianised streets, and public footpaths were added from maps supplied by local authorities.

Thirteen measures were chosen to reflect a variety of characteristics within the neighbourhood which might support walking and cycling or act as barriers (Table 1). These capture detailed characteristics of the area such as traffic safety, the provision of pavements for walking and street connectivity, as well as general indicators such as socioeconomic deprivation. These measures have either been hypothesised to be associated with adult's walking or cycling[17] or have been associated with active commuting in empirical work.[7] Table 1 also provides an overview of the methods, data sources and classifications used. Classifications were based on those previously used in published studies, or where no prior method was available continuous data were collapsed into quartiles, and categorical data were simplified into two or three categories as appropriate.

Route identification and environmental measures

To enable the delineation of a route between the home and school location for each child, the locations of all access points, such as gates and driveways, at each school were noted by researchers by on-foot survey. Assuming that children would use their nearest access point, the shortest route between each child's home and school was identified in the GIS using the modified street network and route lengths were calculated. Each route was then buffered by a distance of 100m, as this was felt to be an appropriate distance of the environment proximal to the road, and seven measures of the environment of the route falling within this zone were computed.

School environment characteristics

A team of trained fieldworkers conducted audits of the school grounds and assessed three components of the school environment; facility provision for walking and cycling in the area surrounding the school and in the school grounds, as well as school policy towards walking and cycling. Further details of the tool developed for this purpose are available from the authors. All head teachers also completed a questionnaire which included seven items that allowed school policy towards active commuting to be determined.

Data Analysis

Analyses were undertaken in 2008 using SPSS version 16 (SPSS Inc). Cross tabulations were generated to compare the number of children reporting the use of different travel modes across personal and demographic groups. Differences in neighbourhood, route, and school categorical measures between those children who lived more or less than 1km from school were tested using chi-squared tests. To identify predictors of children's travel mode, multilevel statistical models were fitted using the MLWin version 2.10 package.[18] A two-level structure of children (level 1) nested within schools (level 2) was applied in order to account for clustering of children's characteristics, including behaviours, within schools. Multinomial outcomes were specified in the models with a three category outcome of 'motorised travel', 'walking', or 'cycling', with motorised travel as the reference category. Analysis was stratified by two route length categories; less than or equal to 1km (n= 760 children), and greater than 1km (n= 1252 children). These cut-offs were chosen to ensure adequate statistical power to detect associations in each strata.

Two sets of models were created. The first, partially adjusted, examined the effects of the factors of interest listed in Table 1 separately, whilst adjusting for the hypothesised confounding effect of age, gender, child BMI, household car access, within category variation in route length, and maternal travel mode to work. Maternal, rather than paternal, travel mode to work was chosen as weaker associations were found with the latter measure. The second set of 'best fit' models fully adjusted for all predictors included in the model. Variables were retained in models based on the goodness of fit (a statistical significance of $\alpha \leq 0.05$), and if the direction of effect was expected and consistent between partially and fully adjusted models. If variables showed strong correlations with each other, the one which was most strongly associated with active commuting behaviour was selected for multivariate analysis. Strong associations ($r>0.75$) were seen between neighbourhood building density and streetlight density, as well as road density, junction density and urban rural status (all between $r=0.72$ and $r=0.84$). Of the route measures, associations were seen between road traffic accidents per km and whether the route included a primary or secondary road ($r=0.54$) as well as whether the route included a primary road and whether the route included a primary or secondary road $r=0.75$). For the school environment, only measures of school pedestrian training and school walking initiatives were strongly associated ($r=0.68$). In order to investigate any moderating effects of distance on associations, an interaction term (distance × predictor) was added to the models.

Results

Sample Characteristics

From the sample of 2064 children who participated in the SPEEDY study, 52 participants (2.5%) were excluded; 41 failed to provide an address which could be located and 11 gave no information on travel mode to school. No significant differences were noted between participants excluded from analysis and the main sample.

The sample contained more girls than boys (55.3% versus 44.7%), mean age (± SD) was 10.25 (± 0.3) years. Forty percent of children reported usually walking to school, 9% usually cycled and the remainder used a motorised form of travel. 77% of children were normal weight and 40% lived in an urban area. Most parents had access to or ownership of a car (95%), usually travelled to work using motorised travel (60.6 % of mothers) and were in the low (39.0%) or middle educational attainment categories (41.0%).

Neighbourhood, route and school based environmental factors

The two rightmost pairs of columns in Table 1 present the prevalence of neighbourhood, route, and school categorical measures according to the distance to school. Overall, 77% of children lived in neighbourhoods which were deemed to have high connectivity and over half of children had a route to school which was completely within an urban area, although the prevalence of many of the environmental measures varied by distance to school. The majority of schools reported having policies which would promote active commuting, with most children attending schools with a school travel plan (84%).

Correlates of active commuting behaviour

Table 2 shows the direction and statistical significance of associations from the partially adjusted models for both walking and cycling behaviours, stratified by distance. In the overall sample many of the variables, including those from neighbourhood, route and school environments, were significantly associated with walking or cycling behaviours. The results are generally inconsistent. Nevertheless, there is some evidence that school policies to promote walking and cycling are associated with more active commuting behaviour. In addition, the presence of cycling infrastructure was associated with more cycling. The table shows no evidence that these effects are modified by distance.

Fully adjusted models are shown in Table 3. These results indicate that children who lived in a more deprived area were less likely to walk or cycle to school. Those who had a higher density of roads in their neighbourhood were more likely to walk, whilst children whose route was direct were less likely to walk. Furthermore, children whose routes had a high density of streetlights were less likely to cycle to school. When the moderating effects of distance on the associations between environmental factors and active commuting were tested, none of the interaction terms were statistically significant ($\alpha \leq 0.05$).

Discussion

This is one of the first studies to examine the association between objectively measured characteristics of neighbourhoods, routes, and schools and children's reported active commuting in the UK, and to consider the moderating effects of distance required to travel to school. We found evidence that children who lived in highly connected, more deprived neighbourhoods, with routes to school which were short, direct and included a busy road were less likely to walk or cycle to school. These associations were not moderated by distance required to travel to school.

Even though levels of active commuting are higher than those reported in many similar studies conducted in the US[19], the findings are generally similar to those reported here; that busy roads[11, 20] and direct routes[11] are barriers to active commuting in children. Although direct routes may be associated with more walking in adults, Timperio and colleagues[11] have suggested that the contrary finding in children may be because high route directness is often associated with greater traffic flow, and busy roads may be particularly avoided by children, although we found the association was independent of the presence of a main road en-route in our sample.

In contrast to much of the literature which reports a positive association between deprivation and active commuting (for example, Harten and Olds[21]), we found that children from more deprived neighbourhoods were less likely to walk or cycle to school, even after controlling for distance travelled and car ownership. Whilst this is somewhat counter-intuitive, the same finding was reported by Timperio and colleagues[11] although the effect of deprivation disappeared in that work after controlling for maternal education. The reason for our finding is not apparent, although it is possible that unmeasured factors influencing child travel

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behaviour are socially patterned in a way that is associated with area deprivation. For example, we have shown that parental perceptions of neighbourhood safety are predictors of children's travel mode[22] and it could be that more positive perceptions in more affluent areas are acting to encourage active travel amongst children.

We hypothesised that distance from school would act as a moderator in the relationship between environmental factors and active commuting. Not surprisingly children living closer to school were more likely to walk or cycle, but there was no evidence that distance moderated any other associations. We found that the environmental correlates for both walking and cycling behaviours were similar, although the structure of the pedestrian network was found to be more strongly associated with walking. Findings from the US[10] which suggest that urban form is an important driver of children's active commuting, are supported here. However, in our study children were more likely to walk to school if they lived in neighbourhoods with low network connectivity but high density. Taken together these results suggest that environments with a high number of route choices but with less connected, and hence quieter, streets are particularly supportive of walking for children.

Although we examined the effects of the school environment, no school related measures proved to be statistically significant predictors of behaviour in our fully adjusted models. While this may be related to a lack of heterogeneity for these variables, our findings suggest that interventions within neighbourhood environments may be more successful in encouraging children's active commuting. Indeed, our view that addressing components of road safety and urban design will be central to interventions to increase children's active commuting is supported by recent UK National Institute for Clinical Excellence recommendations.[23] Nevertheless, given the pivotal role that parents play in determining children's travel behaviour,[12] it is unlikely that environmental modifications alone will be sufficient unless they also gain parental support.

Our study has a number of strengths and limitations. Data were collected in a large, population-based study incorporating sampling to generate significant variation in environments. We also used objective methods to measure the characteristics of neighbourhoods and routes which might influence the decision to walk or cycle. However, our data are cross-sectional and hence we cannot infer causality to the observed relationships. Furthermore, we purposefully sampled children from a narrow age range to obtain a homogenous study population, however this limits the generalisability of our findings to children of other ages. Our sample consisted of predominantly white children so we were not able to examine how our findings might be influenced by ethnicity. Whilst we used a modified version of the street network to delineate neighbourhoods and routes, we did not have information on informal cut-throughs. Our modelled routes were also based on the assumption that children would choose the shortest distance, and may not exactly match with the actual routes used.[11] As we assessed usual travel mode to school, we were unable to assess the importance of weather on children's active commuting, although the climate in Norfolk is relatively benign and weather may be less important in this setting than other authors have observed. We acknowledge that parents perceptions of the environment are important influences on children's active commuting patterns, and have previously reported on these associations[22]. The aim of the current paper was to study this influence of objectively measured characteristics only.

Further work, using large sample sizes in heterogeneous environments would confirm the findings reported here. As the environment in which children travel to school can often change markedly, for example during the transition from primary to secondary school, we believe that there is particular potential for studies that utilise longitudinal designs to examine the impact of changes on active commuting behaviours.

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Conclusion

A combination of objectively measured neighbourhood and route characteristics were associated with children's active commuting behaviour. We found no evidence that these associations varied according to the distance to school, or that differences in the school environment were important. Creating neighbourhoods that provide safe and quiet routes to school may increase participation in active commuting

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Table 1

Description and distribution of objectively measured environmental variables by distance to school

Variables	Description	Data source	Classification	Percentage prevalence (n) Distance <1km	Percentage prevalence (n) Distance >1km	P value
Neighbourhood (Area within 800m around child's home)						
Road outside child's home	A major or minor road adjacent to the child's home	A	A/B/Minor	30.5 (232)	31.0 (388)	n.s
			Local & private	69.5 (528)	69.0 (864)	
Road density	Total road lengths divided by neighbourhood area	A	Lowest road density	13.2 (100)	32.0 (401)	0.001
			Second quartile	30.5 (232)	21.8 (273)	
			Third quartile	28.4 (216)	22.9 (287)	
			Highest road density	27.9 (212)	23.2 (291)	
Proportion of primary (A)	Length of A roads divided by total road length	A	No A roads	56.8 (432)	58.1 (728)	n.s
roads			Some A roads	43.2 (328)	41.9 (524)	
Building density	Total area of buildings divided by neighbourhood area	B & C	Lowest building density	13.2 (100)	32.2 (403)	0.001
			Second quartile	29.5 (224)	22.3 (279)	
			Third quartile	29.2 (222)	22.4 (281)	
			Highest building density	28.2 (214)	23.0 (289)	
Streetlight density	Number of streetlights divided by total road length	D	Lowest streetlight density	17.0 (129)	31.9 (399)	0.001
			Second quartile	33.9 (258)	17.6 (220)	
			Third quartile	22.8 (173)	26.4 (330)	
			Highest streetlight density	26.3 (200)	26.4 (303)	
Traffic accidents per km	Number of fatal or serious road traffic accidents between	E	None	30.8 (234)	41.2 (516)	0.001
	2002-2005 divided by total road length		Any	69.2 (526)	58.8 (736)	
Pavement density	Area of pavements divided by total road length	B	Lowest pavement density	13.2 (100)	32.1 (402)	0.001
			Second quartile	25.9 (197)	24.6 (308)	
			Third quartile	29.2 (222)	19.6 (246)	
			Highest pavement density	31.7 (241)	23.6 (296)	
Effective walkable area	Total neighbourhood area (the area that can be reached via	A	Lowest EFA	23.2 (176)	26.1 (327)	0.001
(EFA)	the street network within 800m from the home) divided by		Second quartile	28.5 (216)	22.8 (285)	
	the potential walkable area (the area generated using a		Third quartile	28.3 (215)	23.0 (288)	

Variables	Description	Data source	Classification	Percentage prevalence (n) Distance <1km	Distance >1km	P value
	circular buffer with a radius of 800m from the home).		Highest EFA	20.0 (152)	28.1 (351)	
Connected node ratio	Number of junctions divided by number of junctions and cul-	A	<0.7 Low connectivity	13.2 (89)	8.3 (169)	0.001
(CNR)	de-sacs		>0.7 High connectivity[1]	88.2 (671)	91.7 (1083)	
Junction density	Number of junctions divided by total neighbourhood area	A	Lowest junction density	24.2 (184)	26.0 (326)	0.001
			Second quartile	32.5 (247)	20.2 (253)	
			Third quartile	30.9 (235)	21.2 (265)	
			Highest junction density	12.4 (94)	32.6 (408)	
Land use mix	Proportion of each land use[2] squared and summed	C & F	Highest land use mix	27.9 (212)	23.2 (291)	0.001
			Second quartile	29.1 (221)	22.5 (282)	
			Third quartile	29.9 (227)	22.0 (276)	
			Lowest land use mix	13.2 (100)	32.2 (403)	
Socioeconomic deprivation	Population weighted scores for neighbourhood G Least deprived	G	Least deprived	25.9 (197)	24.4 (305)	0.004
			Second quartile	21.4 (163)	27.2 (341)	
			Third quartile	24.1 (183)	25.6 (320)	
			Most deprived	28.6 (217)	22.8 (286)	
Urban-rural status	Urban-rural classification of child's home address	H	Urban	43.4 (330)	37.1 (795)	0.001
			Town and Fringe	34.7 (264)	24.6 (308)	
			Village	21.8 (166)	38.3 (479)	
Route (Area within a 100m buffer of the shortest route to school)						
Streetlight density	Number of streetlights within 100m of route divided by	D	Lowest streetlight density	46.2 (351)	26.2 (328)	0.001
	route length		Second quartile	6.8 (52)	22.0 (276)	
			Third quartile	18.6 (141)	28.8 (361)	
			Highest streetlight density	28.4 (216)	22.9 (287)	
Traffic accidents per km	Number of fatal or serious road traffic accidents between	E	None	72.8 (553)	30.5 (380)	0.001
	2002-2005 within 100m of route divided by route length		Any	27.2 (207)	69.5 (866)	
Main road en route	Presence of primary (A) road as part of route	A	No	86.8 (660)	49.1 (615)	0.001
			Yes	13.2 (100)	50.9 (737)	

Variables	Description	Data source	Classification	Percentage prevalence (n)		P value
				Distance <1km	Distance >1km	
Main or Secondary road en	Presence of primary (A) or secondary (B) road as part of	A	No	77.1 (586)	33.2 (416)	0.001
route	route		Yes	22.9 (174)	66.8 (836)	
Route length ratio	Route length divided by the straight line distance between	A	≤1.6 Low directness	26.6 (202)	26.4 (330)	n.s
	the home and school		<1.6 High[3]	73.4 (558)	73.6 (922)	
Percentage of route to	Proportion of route which passes through urban area	H	<100% urban	11.7 (89)	59.3 (742)	0.001
school within an urban area			100% urban	88.3 (671)	40.7 (510)	
Land use mix	Proportion of each land use[2] within 100m of route squared	C & F Highest land use mix	Highest land use mix	27.9 (212)	23.2 (291)	0.001
	and summed		Second quartile	29.1 (221)	22.5 (282)	
			Third quartile	29.9 (227)	22.0 (276)	
			Lowest land use mix	13.2 (100)	32.2 (403)	
School						
Travel plan	Presence of school has a travel plan (a formal document,	I	No	15.0 (114)	16.5 (206)	n.s
	which identifies ways to encourage walking, cycling or use		Yes	85.0 (646)	83.5 (1046)	
	of public transport to school)					
Walking bus	Presence of walking bus (where a group of children walk to	I	No	95.8 (728)	95.8 (1200)	n.s
	school along a route accompanied by adults, picking up		Yes	4.2 (32)	4.2 (52)	
'Walk to School' initiative	The school has a walk to school initiative (period during	I	No	31.3 (238)	27.9 (347)	n.s
	which children are encouraged to walk to school)		Yes	68.7 (522)	72.3 (905)	
Pedestrian training	The school offers pedestrian training	I	No	59.2 (450)	55.6 (696)	n.s
			Yes	39.8 (302)	44.4 (547)	
Entrance for	The school has separate entrance(s) for pedestrians and	I	No	26.6 (202)	25.9 (324)	n.s
pedestrians/cyclists	cyclists		Yes	72.1 (548)	72.4 (906)	
Lollypop person	The school has a lollypop person (road crossing guard/school	I	No	54.2 (412)	63.3 (793)	0.001
	crossing supervisor/ school road patrol)		Yes	43.4 (330)	35.5 (445)	

Variables	Description	Data source	Classification	Percentage prevalence (n)		P value
				Distance <1km	Distance >1km	
Cycle racks	The school has cycle racks for use by children	J	No	10.8 (82)	12.3 (154)	n.s
			Yes	89.2 (678)	87.7 (1098)	
Land use mix around the	Single or mixed land use surrounding school	J	Single land use	70.4 (535)	70.1 (878)	n.s
school			Mixed land use	29.6 (225)	29.9 (374)	
Pavements	Pavements (sidewalks) visible from the school entrance	J	None/On one side	86.0 (653)	65.4 (819)	0.001
			On both sides	14.1 (107)	34.6 (433)	
On road/shared cycle paths	Cycle paths visible from the school entrance	J	No	87.6 (666)	92.1 (1153)	0.004
			Yes	12.3 (94)	7.9 (99)	
Traffic calming	Traffic calming measures visible from the school entrance	J	No	58.9 (448)	69.9 (872)	0.001
			Yes	41.1 (312)	30.4 (380)	
Pedestrian crossing	Pedestrian crossing visible from the school entrance	J	No	89.6 (681)	93.7 (1173)	0.001
			Yes	10.4 (79)	6.3 (79)	

A OS Integrated Transport Network, B OS Mastermap, C Address Layer 2, D Local Authority, E Norfolk & Suffolk Constabulary, F Land Cover 2000, G Index of Multiple Deprivation, H Urban-rural classification, I Teacher Questionnaire, J School grounds audit.

n.s not significant. P values indicate the differences in neighbourhood, route, and school categorical measures between those children who lived more or less than 1km from school.

[1] Connectivity; Classification previously used by Schlossberg et al., (2005).

[2] Seventeen different land uses were classified: farmland, woodland, grassland, uncultivated land, other urban, beach, marshland, sea, small settlement, private gardens, parks, residential, commercial, multiple use buildings, other buildings, unclassified buildings and roads. This score is also known as the Herfindahl-Hirschman Index developed by Rodriguez and Song (2005)

[3] Route length ratio; Classification previously used by Dill (2004)

Table 2

Direction of association between neighbourhood, route and school variables and active travel, stratified by distance to school

Environmental attributes	Overall sample: Cycle to school n=186 Direction	Overall sample: Walk to school n=805 Direction	Distance to school <1km: Cycle to school n=89 Direction	Distance to school <1km: Walk to school n=533 Direction	Distance to school >1km: Cycle to school n=97 Direction	Distance to school >1km: Walk to school n=272 Direction
Neighbourhood characteristics						
Road outside child's home (A/B/minor= referent)	− n.s	+ n.s	+ n.s	+ n.s	− n.s	+ n.s
Road density (lowest density=referent)	− n.s	+ *	− n.s	+ n.s	− *	+ *
Proportion of primary (A) roads (lowest proportion= referent)	n.s	− **	− *	− n.s	− n.s	− n.s
Building density (lowest density=referent)	− n.s	+ n.s	− *	+ n.s	− **	+ **
Streetlight density (lowest density=referent)	− **	+ n.s	− **	− n.s	− n.s	+ **
Traffic accidents per km of roads (none =referent)	− n.s	− n.s	+ n.s	+ n.s	− n.s	+ n.s
Pavement density (lowest density =referent)	− n.s	+ n.s	− n.s	+ n.s	+ n.s	− n.s
Effective walkable area (lowest connectivity=referent)	+ n.s	+ *	− n.s	+ n.s	+ n.s	+ **
Connected node ratio (low connectivity=referent)	− n.s	− **	− n.s	− n.s	− **	− **
Junction density (lowest density= referent)	+ n.s	− *	+ n.s	+ n.s	+ n.s	− **
Land use mix (highest mix= referent)	+ *	− n.s	+ n.s	− n.s	+ n.s	− n.s
Socioeconomic deprivation (least deprived= referent)	− **	− **	− **	− n.s	− n.s	− *
Urban-rural status (urban= referent)	− n.s	− **	+ *	− n.s	− **	− **
Route characteristics						
Streetlight density(lowest density=referent)	− *	+ n.s	− n.s	− n.s	− n.s	+ **
Traffic accidents per km of route (none =referent)	− n.s	−n.s	+ n.s	− n.s	− n.s	− n.s
Main road en route (no =referent)	− n.s	− **	− n.s	+ n.s	− n.s	+ n.s
Main or Secondary road en route (no =referent)	− n.s	− n.s	− n.s	− n.s	− n.s	+ n.s
Route length ratio (low directness=referent)	− n.s	− **	+ n.s	+ **	− n.s	− **
Percentage of route within an urban area (<100%= referent)	+ n.s	+ **	− n.s	− n.s	+ n.s	+ n.s
Land use mix (highest mix= referent)	+ *	− n.s	+ n.s	− n.s	+ n.s	− n.s
School characteristics						
Travel plan (no=referent)	+ **	+ **	+ n.s	+ **	− n.s	− *
Walking bus (no= referent)	+ n.s	− n.s	+ n.s	+ n.s	+ n.s	− n.s
'Walk to school' initiative (no=referent)	+ n.s	+ **	+ **	+ **	+ n.s	− n.s
Pedestrian training (no=referent)	− n.s	+ n.s	+ n.s	− n.s	− n.s	+ *

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Environmental attributes	Overall sample		Distance to school <1km		Distance to school >1km	
	Cycle to school n=186 Direction	Walk to school n=805 Direction	Cycle to school n=89 Direction	Walk to school n=533 Direction	Cycle to school n=97 Direction	Walk to school n=272 Direction
Entrances for pedestrians/cyclists (No= referent)	− *	− n.s	+ n.s	+ n.s	− n.s	+ *
Lollypop person (no=referent)	+ n.s	− n.s	+ n.s	−n.s	+ n.s	−n.s
Land use mix around the school (Single land use =referent)	− n.s	− n.s	+ n.s	+ n.s	− n.s	+ **
Pavements (none = referent)	− n.s	− *	− n.s	+ n.s	+ n.s	− n.s
On road /shared cyclepaths (no=referent)	+ **	− n.s	+ n.s	+ n.s	+ n.s	− n.s
Traffic calming (no=referent)	+ n.s	− n.s	− n.s	+ n.s	− n.s	+ *
Pedestrian crossing (no=referent)	− n.s	+ n.s	− n.s	+ n.s	+ n.s	+ **

Direction indicates direction of association (+ = positive association, − = negative association) when variables tested for trend, n.s.= not statistically significant

All associations are adjusted for child age, gender, BMI, parental car access, maternal travel mode to work and journey length.

* =p<0.05

** =p<0.01

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Table 3

Fully adjusted associations (best-fit model) between neighbourhood, route and school variables and active travel

Characteristic	Cycle to school OR (95%CI)	Walk to school OR (95%CI)
Neighbourhood characteristics		
Connected node ratio (low connectivity = referent)	0.96 (0.50-1.84)	0.49 (0.31-0.76) **
Road density (lowest density=referent)		
Second quartile	1.39 (0.86- 2.27)	1.94 (1.33-2.82) **
Third quartile	1.53 (0.90-2.54)	2.74 (1.85-4.07) **
Highest density	1.31 (0.72-2.36)	3.22 (2.09-4.94) **
Socioeconomic deprivation (least deprived=referent)		
Second quartile	0.59 (0.35-0.97) *	0.85 (0.59-1.22)
Third quartile	0.72 (0.43-1.20)	0.55 (0.37-0.81) **
Most deprived	0.47 (0.26-0.85) *	0.45 (0.29-0.70) **
Route characteristics		
Distance to school >1km (<1km =referent)	0.27 (0.18-0.39) **	0.10 (0.06-0.11) **
Route length ratio (low directness= referent)	0.62 (0.43-0.90) *	0.47 (0.36-0.61) **
Main road en route (no= referent)	0.50 (0.32-0.78) **	0.65 (0.48-0.89) **

All associations are adjusted for child age, gender, BMI, parental car access, maternal travel mode to work and journey length

* =p<0.05

** =p<0.01