
Personal, Family, Social, and Environmental Correlates of Active Commuting to School

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Background: Active commuting to school may be an important opportunity for children to accumulate adequate physical activity for improved cardiovascular risk factors, enhanced bone health, and psychosocial well-being. The purpose of this study was to examine personal, family, social, and environmental correlates of active commuting to school among children.

Methods: Cross-sectional study of 235 children aged 5 to 6 years and 677 children aged 10 to 12 years from 19 elementary schools in Melbourne, Australia. Self-administered questionnaires were completed by parents, and the older children. The shortest possible routes to school were examined using a geographic information system.

Results: Among both age groups, negative correlates of active commuting to school included parental perception of few other children in the neighborhood and no lights or crossings for their child to use, and an objectively assessed busy road barrier en route to school. In younger children, an objectively assessed steep incline en route to school was negatively associated with walking or cycling to school. Good connectivity en route to school was negatively associated with walking or cycling to school among older children. Among both age groups, children were more likely to actively commute to school if their route was <800 meters. There were no associations with perceived energy levels or enjoyment of physical activity, weight status, or family factors.

Conclusions: For children, creating child-friendly communities and providing skills to safely negotiate the environment may be important. Environmental correlates of active transport in children and adults may differ and warrant further investigation.

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Introduction

Physical inactivity is a major contributor to the burden of disease.¹ Among children, physical activity is associated with improved cardiovascular risk factors, enhanced bone health, and psychosocial well-being.^{2–4} There is growing interest in active commuting as a means of increasing children's physical activity.⁵ Children who walk to school have higher energy expenditure,⁶ perform more physical activity,⁷ and are more likely to meet physical activity guidelines⁸ than children who travel to school by motorized transport, although one study found no impact on total activity among children aged 5 years.⁹ Nevertheless, the

proportion of children actively commuting to school has decreased in many nations.^{10–13}

Consistent with social ecology theory,¹⁴ personal, family, social, and physical environment factors are likely to influence children's travel behavior. However, few studies have examined multiple influences concurrently. Existing research suggests that car ownership and attending private schools are associated with lower odds of walking^{15,16} and a higher likelihood of car travel¹⁷ to school. Other studies have found that children who report that their parents are worried about abduction/molestation or traffic danger and who do not allow them to go out without an adult are more likely than others to be driven to school,¹⁷ while adolescents who report that there is never an adult at home after school, are more likely to walk/cycle to school.¹⁸ Further, parental perceptions of the need to cross several roads to reach play areas, and lack of traffic lights or crossings are negatively associated with children regularly walking or cycling to local destinations, including school.¹⁹ While population density, street connectivity, and mixed land use are associated with walking for transportation among adults,²⁰ in

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one of few studies that targeted children and included objective measures, active commuting to school was positively associated with population density, not associated with connectivity, and negatively associated school size.²¹ Further, objectively measured terrain has not been examined among children despite its association with recreational walking among adults.²²

Current efforts to support active school journeys require data on correlates of active commuting to school to inform program development. Existing data mainly examine self- or proxy-reported personal correlates. The influences on children's mode of travel to school are likely to be broader, also encompassing the social and physical environment. The present study examined personal, family, social, and environmental correlates of children's active commuting to school using self-report and objective measures.

Methods

Data were collected from families of 5- to 6-year-old and 10- to 12-year-old children, representing elementary school entry and exit ages, and thus potentially the least and most independent children. The protocol was approved by the Deakin University Ethics Committee and the Department of Education and Training Victoria.

Sample Selection

Families were recruited from 19 public elementary schools in high ($n=10$) and low ($n=9$) socioeconomic status (SES) areas in Melbourne, Australia. Schools were selected using stratified random sampling proportionate to school size, based on the Australian Bureau of Statistics' Socioeconomic Indices for Areas.²³ Schools whose principal declined access to students ($n=5$) were replaced with the next school on the randomly generated list within the same SES stratum. All students within the preparatory grade and grades 5 and 6 in participating schools were invited; however, only families who returned a signed consent form were eligible to participate. Data are presented for a subset of participants for whom residential address data were available.

Measures

Questionnaires were completed by parents of both age groups at home, and by older children at school, between July and December 2001 (questionnaires were not administered to younger children). Older children answered questions about the local neighborhood only. Other measures included anthropometry, area-level SES, and objective measures of the physical environment. Two-week test-retest reliability of items measuring walking/cycling to school was performed among parents of 5- to 6-year-old ($n=58$) and 10- to 12-year-old ($n=111$) children. Two-week test-retest reliability of other items was tested among 97 parents of 5- to 6-year-olds and 156 parents of 10- to 12-year-olds.

Walking and Cycling to School

Parents reported whether their child usually traveled by walking to school during a typical week since the start of the school year (not including school holidays) and how frequently (to and from school equalled two times). These questions were repeated for cycling to school. Frequency of usual walking and cycling to/from school were collapsed into three categories: never; infrequent/occasional (one to four times per week); frequent (five or more times per week). Percent agreement (reliability) was $\geq 73.0\%$ for each item.

Personal Factors

Weight status was calculated from measured height and weight (taken privately in light clothing and no shoes at school using digital scales and a portable stadiometer). International age- and gender-specific cut-points were applied to body mass index (kilograms/square meters) to define overweight and obesity.²⁴ Parents indicated how much they agreed or disagreed with the following statements about reasons that their child was not more physically active: "My child doesn't have enough energy" (intraclass correlation coefficient [ICC]=0.70–0.86); and "My child just doesn't enjoy being physically active" (ICC=0.79–0.86). Response categories were strongly agree, agree, neither, disagree, strongly disagree, and don't know.

Family Factors

Marital status, number of children aged <18 years (collapsed into two categories: only child and siblings), and number of cars in the household were requested in the parent questionnaire. Children whose parents reported no demographic information about their partner (who lives with them) were coded as having a single-(versus dual-) parent family. Parents indicated how much they agreed or disagreed with the statement, "There are no adults at home during daylight hours after school to supervise my child in active play outside" (response categories: strongly agree, agree, neither, disagree, strongly disagree, don't know [ICC=0.70–0.73]). Included as a covariate, highest level of maternal education (a proxy for SES),^{25,26} was collapsed into three categories: low (some high school or less); medium (high school, technical certificate, or apprenticeship); high (university/tertiary qualification).

Area-Level Socioeconomic Status

Using the Australian Bureau of Statistics' Index of Relative Socio-Economic Advantage/Disadvantage,²⁷ an area-based score for SES was assigned to each participant (based on residential postcode), and collapsed into tertiles for each age group. Higher scores indicate greater advantage.

Perceived Social and Physical Neighborhood Environment

Parents and older children indicated how much they agreed or disagreed with six statements about their local neighborhood; these items and their reliability have been reported previously.^{19,25} In addition, parents indicated how much they agreed or disagreed with the statement, "There are not many other children around for my child to play with" (ICC=0.63–

0.84). Response categories were strongly agree, agree, neither, disagree, strongly disagree, and don't know.

Objective Physical Environment

Objective measures of the potential route to school were determined in 2004 using the geographic information systems (GIS) software package, ArcView, version 3.3 (Environmental Systems Research Institute, Redlands CA, 2002), and spatial data supplied by the State of Victoria (cadastral data, address points, road and road attribute information, and a digital elevation model). Residential and school locations were geocoded.

Distance to school. Using the ArcView 3.X extension, Network Analyst V1.0b, distance to school was calculated based on the shortest route possible along the road network, and collapsed into two categories: <800 m and ≥800 m (consistent with parents' reports of 1.5 to 1.6 km [round trip] as an appropriate walking distance for their child).¹⁹

Busy-road barrier. Types of roads that intersected each route to school were extracted (i.e., types of roads to be crossed). These road types included (in hierarchical order): freeway, highway, arterial, subarterial, collector, and local. A busy-road barrier was defined as a freeway, highway, or arterial road.

Route along busy road. A route **along** a busy road was defined as a route that included a freeway, highway, or arterial road along any section.

Pedestrian route directness. This is a measure of connectivity or directness of a route along a road network. The pedestrian route directness (PRD) en route to school was calculated by dividing the distance to school along the road network (as described above) by the "straight line" or "crow-fly" distance.²⁸ The PRD was collapsed into two categories: <1.6 (direct) and ≥1.6 (indirect/poor connectivity).²⁸

Steep incline en route to school. A TIN (triangulated irregular network) file was created from the digital elevation model. Surface analysis was undertaken along each route to determine the presence of a steep incline (≥5.7 degrees [≥10%] slope²² along any segment, using Surface Tools, version 1.5 (Jenness Enterprises, Flagstaff AZ, 2004).

Data Analysis

Data were analyzed in 2004. Survey items with response categories ranging from strongly agree to strongly disagree were collapsed into two categories: (1) "strongly agree" and "agree;" (2) "neither"/"don't know," "disagree," and "strongly disagree." Using SPSS for Windows, version 11.5 (SPSS Inc., Chicago, 2003), frequency of walking or cycling to school was compared between age groups, and by gender within each age group, using Student's independent *t*-tests (continuous data) and Pearson's chi-square (categorical data). As there were few gender differences, boys and girls were combined for subsequent analyses. The distribution of predictor variables was compared by age group using Pearson's chi-square. Using Stata software, version 8.0 (Stata Corp, College Station TX, 2003), each independent variable was entered into bivariate logistic regression analysis that predicted walking or cycling to school at least once per week. Variables with a statistically significant relationship in bivariate

Table 1. Sample characteristics^a

Sample characteristic	Age group, %	
	5–6 years	10–12 years
Gender (n)	(235)	(677)
Boys	50.6	46.7
Maternal education (n)	(229)	(652)
Low	22.7	29.4
Medium	34.9	35.9
High	42.2	34.7
Usually speak English at home (n)	(234)	(672)
Parental marital status (n)	(232)	(664)
Married/de facto	87.1	82.4
Separated/divorced/widowed	9.1	15.4
Never married	3.9	2.3
Maternal employment (n)	(235)	(677)
Part-time	35.3	42.5
Full-time	15.3	22.6**
SES of school (n)	(235)	(677)
Low SES	46.0	36.0
Child weight status (n)	(229)	(639)
Overweight	17.9	21.3
Obese	4.4	6.6*

^aCharacteristics of participants for whom residential address details were known (all analyses were based on this subset of participants).

p* < 0.01; *p* ≤ 0.01, Pearson chi-square test of significance between age groups (all bolded).

SES, socioeconomic status.

ate analyses were included in a multiple regression model, controlling for gender and maternal education. All regression analyses were performed separately for each age group and controlled for the clustering of participants according to school.

Results

Sample Characteristics

In total, 291 families of younger (27% response rate) and 919 families of older (44% response rate) children participated. On average, response rates were higher among schools in high SES areas compared to low SES areas (53% vs 38%, respectively). Residential address data were available for 81% of younger (*n* = 235) and 74% of older (*n* = 677) children. There were few differences between this subset and other participants. In general, the subset contained a slightly higher proportion of children who usually spoke English at home, and younger children with married parents, and a lower proportion of older children whose mother was employed full-time. A profile of the subset is presented in Table 1.

Active Commuting to School

Table 2 presents the prevalence and frequency of active commuting to school in both age groups. There were no gender differences among younger children. Among older children, a greater proportion of boys usually cycled to school compared to girls (9.2% vs

Table 2. Prevalence and frequency of walking and cycling to school by age group

	Age group, %	
	5–6 years	10–12 years
Mode of travel (n)	(229)	(656)
Walk	47.8	60.4**
Cycle	6.6	6.3
Either walk or cycle	48.9	62.0**
Frequency/week (n)	(232)	(662)
<i>Either walk or cycle, times/week (SD)</i>	2.7 (3.7)	3.5 (3.8)***
Never	53.0	40.3
1–4 times/week	19.8	21.1
≥5 times/week	27.2	38.5*

* $p < 0.01$; ** $p \leq 0.001$, Pearson chi-square test of significance between age groups; *** $p < 0.01$, student's independent t -test between age groups (all bolded).
SD, standard deviation.

3.7%, $p = 0.004$), and boys cycled to school more frequently than girls (0.3 [standard deviation {SD}=1.4] vs 0.1 [SD=0.7] times per week, $p = 0.009$).

Personal and Family Factors and the Social and Physical Neighborhood

Table 3 shows the distribution of personal, family, social, and physical neighborhood factors. There was heterogeneity in the environments studied (area-based SES score: mean=1041.3 [SD=67.2]; distance to school: mean=2.3 [SD=3.1 km]; PRD: mean=1.6 [SD=0.6]).

Associations with Active Commuting to School

Children in both age groups were less likely to actively commute to school if their parents reported that there were few other children in the neighborhood for their child to play with, and no lights or crossings for their child to use (Table 4). In both age groups, children whose route to school was <800 m were more likely to actively commute, and those with a busy-road barrier en route to school less likely. Younger children with a steep incline en route to school, and older children with a direct route, were less likely to walk or cycle to school compared with other children.

Discussion

This study found that aspects of the social and physical neighborhood environment may influence children's active commuting to school. The consistency of most findings across both age groups confirms the importance of these issues, and highlights that having other children nearby and improving urban design may be important strategies for increasing active commuting to school. While the personal and family factors included in this study were not related to active school journeys,

Table 3. Distribution of personal, family, social, and physical neighborhood variables by age group

Variables	Age group (%)	
	5–6 years	10–12 years
Personal factors		
Child has no energy	1.8	4.7
Doesn't enjoy physical activity	3.0	6.5*
Overweight or obese	22.3	27.9
Family factors		
Mother's employment		
No employment	49.4	34.9
Part-time	35.3	42.5
Full-time	15.3	22.6***
Single-parent family	11.6	16.4
No siblings	8.6	10.8
No adult at home after school	9.8	10.4
Family owns >1 car	74.0	75.2
Area-level SES		
Low	37.9	31.2
Medium	31.9	38.7
High	30.9	30.1
Parent-perceived social/physical neighborhood		
Heavy local traffic	67.5	60.3
Strong concern about strangers	91.5	81.7***
Strong concern about road safety	86.3	78.0**
No lights/crossings	57.4	47.4**
Need to cross several roads	55.8	42.4***
Limited public transport	35.2	39.2
Not many other children in neighborhood	27.9	25.3
Child-perceived social/physical neighborhood		
Heavy local traffic	—	45.4
Perceives parents believe there is heavy local traffic	—	55.5
Worried about strangers	—	67.1
Perceives parents worried about strangers	—	84.0
Roads not safe	—	57.0
Perceives parents believe roads not safe	—	71.3
Objective measures of route to school		
School route <800 m	27.7	23.6
Busy road barrier along school route	39.8	42.4
School route along busy road	38.3	41.4
Direct route to school	71.9	68.4
Steep road barrier en route to school	26.9	24.9

* $p < 0.05$; ** $p < 0.01$; *** $p \leq 0.001$, Pearson's chi-square test of significance between age groups (all bolded).
SES, socioeconomic status.

this may be because only a limited range of these factors was assessed. Constructs such as self-efficacy, cognitive capacity, behavioral skills, parental modeling and support, and rules and restrictions may also be relevant.²⁹

Consistent with a study in adolescent girls,³⁰ children whose parents perceived few other children in the

Table 4. Odds of walking or cycling to school among 5–6- and 10–12-year-old children

Variables	Age group			
	5–6 years		10–12 years	
	Unadjusted ^a OR (95% CI)	Adjusted ^b OR (95% CI)	Unadjusted ^a OR (95% CI)	Adjusted ^b OR (95% CI)
Personal factors				
Child has no energy (referent=disagree)	2.9 (1.1–8.0)*	2.9 (0.8–10.8)	0.8 (0.4–2.0)	—
Doesn't enjoy physical activity (referent=disagree)	6.5 (0.7–59.4)	—	1.4 (0.7–2.6)	—
Overweight or obese (referent=healthy weight)	1.2 (0.7–2.0)	—	1.1 (0.8–1.6)	—
Family factors				
Mother's employment				
No employment (referent)	1.0	—	1.0	—
Part-time	1.8 (0.8–4.2)	—	1.1 (0.7–1.6)	—
Full-time	1.9 (0.9–4.2)	—	1.0 (0.7–1.3)	—
Single-parent family (referent=dual parent)	0.6 (0.3–1.4)	—	1.3 (0.8–2.0)	—
Only child (referent=siblings)	0.5 (0.2–1.3)	—	1.3 (0.9–1.9)	—
No adult at home after school (referent=disagree)	0.5 (0.2–1.2)	—	1.1 (0.8–1.6)	—
Own >1 car (referent= $\leq$ 1 car)	0.5 (0.3–0.8)**	0.7 (0.3–1.7)	0.9 (0.6–1.5)	—
Area-level SES (advantage/disadvantage)				
Low (referent)	1.0	—	1.0	1.0
Medium	1.8 (0.7–4.5)	—	1.9 (1.1–3.1)*	1.3 (0.8–2.1)
High	1.4 (0.7–3.0)	—	2.5 (1.4–4.3)***	1.5 (0.8–3.0)
Parent-perceived social/physical neighborhood (referent=disagree)				
Heavy local traffic	1.6 (1.0–2.6)*	1.7 (0.8–3.9)	0.9 (0.6–1.3)	—
Strong concern about strangers	1.0 (0.3–2.6)	—	1.0 (0.6–1.7)	—
Strong concern about road safety	1.7 (0.7–4.2)	—	1.1 (0.7–1.8)	—
No lights/crossings	0.4 (0.2–0.7)**	0.4 (0.1–0.9)*	0.5 (0.3–0.7)***	0.6 (0.3–0.9)*
Need to cross several roads	0.8 (0.4–1.4)	—	0.8 (0.6–1.0)	—
Limited public transport	0.7 (0.3–1.3)	—	0.6 (0.4–0.99)*	0.7 (0.4–1.3)
Not many other children around	0.3 (0.2–0.6)***	0.3 (0.1–0.8)*	0.5 (0.3–0.8)***	0.6 (0.4–0.99)*
Child-perceived social/physical neighborhood (referent=disagree)				
Heavy local traffic	—	—	0.7 (0.5–1.0)	—
Parents perceive heavy local traffic	—	—	0.7 (0.5–0.9)**	0.9 (0.6–1.6)
Worried about strangers	—	—	1.1 (0.8–1.5)	—
Parents worried about strangers	—	—	1.0 (0.7–1.6)	—
Roads not safe	—	—	0.7 (0.5–0.9)**	1.0 (0.7–1.5)
Parents perceive roads as not safe	—	—	0.7 (0.6–0.9)**	0.8 (0.5–1.4)
Objective measures of route to school				
School route <800m (referent= $\geq$ 800m)	13.9 (7.3–26.4)***	5.2 (2.2–12.3)***	15.5 (9.0–26.5)***	10.2 (5.9–17.6)***
Busy road barrier along school route (referent=no)	0.3 (0.1–0.6)***	0.1 (0.0–0.5)***	0.3 (0.2–0.5)***	0.3 (0.1–0.9)*
School route along busy road (referent=no)	0.3 (0.2–0.7)**	2.5 (0.7–8.9)	0.3 (0.2–0.5)***	1.2 (0.4–3.6)
Direct route to school (referent=indirect)	0.7 (0.4–1.2)	—	0.6 (0.4–0.8)***	0.7 (0.5–0.98)*
Steep road barrier en route to school (referent=no)	0.2 (0.1–0.4)***	0.3 (0.1–0.8)*	0.4 (0.2–0.7)**	0.6 (0.3–1.2)

^aAdjusted for clustering of children by school only.^bAdjusted for gender and maternal education (covariates), clustering of children by school, and variables that were significantly related to the dependent variable in unadjusted analyses.* $p < 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$ (all bolded).

CI, confidence interval; OR, odds ratio; SES, socioeconomic status.

neighborhood for their child to play with were less likely to actively commute to school. Children who live in neighborhoods with many children may have more opportunities to walk to school in the company of others or along a route walked or cycled by other

children. Given the negative association between active commuting and the need to cross busy roads, parents may feel more comfortable if other children used the same route. These findings highlight the importance of initiatives such as “walking school buses,” which provide

social support and safety to facilitate active journeys to school.³¹

Urban design and the pedestrian environment may also have an impact on children's active commuting. The present study found that longer distance to school, a need to cross busy roads, and poor access to lights and crossings were negatively associated with walking/cycling to school. These results provide support for the Safer Routes to School initiative,³² and suggest that school location in relation to residential areas and major traffic routes is an important factor that should be considered in planning for new communities and when school zoning decisions are made. Given that one in two parents reported that there were no lights or crossings for their child to use, greater attention should be given to infrastructure to aid safe walking and cycling, including the presence of traffic wardens to assist children to cross busy streets. While the cost of installing traffic lights may be prohibitive for many schools and local authorities, other types of pedestrian crossings and traffic-calming devices³³ may be feasible. Speed restrictions within school zones may also be helpful; however, children may still need to negotiate heavy traffic close to home. The findings also highlight the need to provide children with skills to manage and negotiate an unsupportive environment (e.g., children could be taught safe crossing practices and shown appropriate and safe routes and areas of high danger).

In contrast to the findings of Braza et al.²¹ and studies of adults,²⁰ older children in this study were less likely to actively commute to school if their route to school was direct. This counter-intuitive finding requires further study, but may reflect different antecedents to behavior among adults and children. While adult commuting may be strongly influenced by travel time (well-connected streets reduce travel time),^{20,28} children's travel may be more strongly influenced by traffic safety concerns. Neighborhoods with poorly connected street networks and cul-de-sacs may carry less traffic and have fewer busy roads, providing routes that are less exposed to traffic. This is consistent with the finding that children are less likely to actively commute if they need to cross busy roads. Although few studies with children have considered connectivity, these findings suggest that environmental correlates of active transport in adults and children may differ.

This study is novel in its inclusion of both perceived and objective measures of the environment. However, the use of a GIS is not without limitations. For example, the shortest route between home and school may not be the route that would be taken. In addition, in some cases the distance to school may be over-estimated because the algorithm uses the point on the road closest to the centroid of the school as the end point, which may be farther than the actual access point. The methods also assume that participants cross a road at all intersections, including T-intersections. Other limita-

What This Study Adds . . .

Despite increasing interest in promoting active journeys to school, few studies have comprehensively examined influences on this behavior.

This article reports on a study that examined personal, family, social, and environmental correlates of children's active commuting to school.

Findings suggest that distance, busy intersections, poor access to lights/crossings, and more direct and hilly routes prohibit children's active commuting.

To increase children's active commuting to school, it may be important to create child-friendly communities, and provide skills to safely negotiate the environment.

tions of the study include its cross-sectional design, modest response rate (particularly for the younger children), and missing residential addresses for some participants.

Promoting active commuting to school may be a promising means of increasing children's physical activity. The findings suggest that distance to school, the need to cross busy intersections, poor access to lights and crossings, and more direct and hilly routes prohibit children's active commuting, and have important implications for the creation of safer walking environments and child-friendly urban design. They also highlight the need for education programs aimed at helping children safely navigate the built environment. Future research should include rural communities and a wider range of personal, family, and social factors.

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