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ORIGINAL ARTICLE

Are the correlates of active school transport context-specific?

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OBJECTIVES: Previous research consistently indicates that children who engage in active school transport (AST) are more active than their peers who use motorized modes (car or bus). However, studies of the correlates of AST have been conducted predominantly in high-income countries and have yielded mixed findings. Using data from a heterogeneous sample of 12 country sites across the world, we investigated the correlates of AST in 9–11-year olds.
METHODS: The analytical sample comprised 6555 children (53.8% girls), who reported their main travel mode to school and the duration of their school trip. Potential individual and neighborhood correlates of AST were assessed with a parent questionnaire adapted from previously validated instruments. Multilevel generalized linear mixed models (GLMM) were used to examine the associations between individual and neighborhood variables and the odds of engaging in AST while controlling for the child's school. Site moderated the relationship of seven of these variables with AST; therefore we present analyses stratified by site.
RESULTS: The prevalence of AST varied from 5.2 to 79.4% across sites and the school-level intra-class correlation ranged from 0.00 to 0.56. For each site, the final GLMM included a different set of correlates of AST. Longer trip duration (that is, $\geqslant$16 min versus $\leqslant$15 min) was associated with lower odds of AST in eight sites. Other individual and neighborhood factors were associated with AST in three sites or less.
CONCLUSIONS: Our results indicate wide variability in the prevalence and correlates of AST in a large sample of children from twelve geographically, economically and culturally diverse country sites. This suggests that AST interventions should not adopt a 'one size fits all' approach. Future research should also explore the association between psychosocial factors and AST in different countries.

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INTRODUCTION

The majority of children and youth worldwide fail to meet current physical activity (PA) guidelines.[1,2] The promotion of active school transport (AST) may be part of a multifaceted strategy to address the current physical inactivity crisis. There is consistent evidence showing that children who engage in AST are more active than those using motorized travel modes.[3,4] Recent research also suggests that children engaging in AST may accrue psychosocial benefits such as improved well-being[5] and better cognitive performance.[6] At the population level, a switch from motorized travel to AST could substantially reduce greenhouse gas emissions associated with the school trip.[7]

Despite the reported benefits, the prevalence of AST has decreased markedly during the last few decades in several middle-[8-10,] and high-income countries.[11–14] Onywera *et al.*[15] also reported that Kenyan children are less likely to engage in AST than their parents were at the same age. Furthermore, Kenyan children living in urban areas were much more likely to use motorized travel modes than their rural counterparts.[15,16] While these studies were limited by a small sample size, they provide preliminary evidence that AST may also be decreasing in low-income countries as a result of the PA transition.[17] Therefore, a better understanding of the correlates of AST is warranted to inform future interventions aiming to reverse these trends and improve children's health.

While previous research has consistently shown that a greater distance between home and school is strongly associated with motorized travel, the literature is less consistent regarding the influence of other environmental factors on children's travel behavior.[18–20] Almost all of the studies included in these reviews have been conducted in high-income countries, and often in a single city. Limited variability in environmental characteristics may partly explain lack of significant associations reported in many single-site studies.[21] Furthermore, it is unclear if associations observed in high-income countries can be generalized to low and middle income countries in which little is known about the correlates of AST.[22] The heterogeneity in the measurement of environmental attributes also makes comparison of results across studies difficult.[20,23] Hence, there is a clear need for studies examining the correlates of AST using a consistent methodology in environmentally diverse countries.

Therefore, our study had two primary objectives. First, we aimed to describe school travel behavior in a large sample of 9–11-year olds from 12 different countries who participated in the International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE).[24] Of particular interest, the ISCOLE was

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conducted using standardized methods in geographically, economically and culturally diverse country sites. Second, we investigated the individual and environmental correlates of AST among those participants using multilevel models.

MATERIALS AND METHODS

Setting

The ISCOLE investigated the influence of behavioral settings and the physical, social, and policy environments on the observed relationship between lifestyle and weight status among 9–11-year-old children living in the following 12 country sites: Australia (Adelaide), Brazil (São Paulo), Canada (Ottawa), China (Tianjin), Colombia (Bogota), Finland (Helsinki, Espoo and Vantaa), India (Bangalore), Kenya (Nairobi), Portugal (Porto), South Africa (Cape Town), the United Kingdom (Bath and North East Somerset) and the United States (Baton Rouge).[24] These countries represent five major geographic regions of the world and include low-, middle- and high-income countries. Ethical approval was obtained at the coordinating center (Pennington Biomedical Research Center) and from relevant research ethics boards in each site. Written informed consent was obtained from parents (or legal guardians), and child assent was also obtained before participation in the study. Data were collected from September 2011 through December 2013.

Participants

On the basis of *a priori* sample size calculations, recruitment targeted a sex-balanced stratified sample of 500 children in each site with minimal variability around 10 years of age.[24] To maximize variability within site, participating schools were selected in areas that differed in socioeconomic status and level of urbanization (urban and suburban). Further details about the sampling strategy are available elsewhere.[24]

Of the 7372 children enrolled in ISCOLE, 6872 remained in the analytical data set after exclusion of participants for whom information on school travel mode ($n=70$), school travel time ($n=2$), parent education ($n=389$) and motor vehicle ownership ($n=39$) was not available. Descriptive analyses were conducted with this analytical data set ($n=6872$). However, because our intent was to examine the within-school differences between active and motorized travelers, we also excluded schools in which either 0% or 100% of children engaged in AST ($k=22$ schools; $n=317$ children). Therefore, the analytical sample for all regression analyses consisted of 6555 children. Included participants were slightly younger (10.5 versus 10.4 years; $P<0.001$), and had lower scores on the land use mix–diversity subscale (2.8 versus 3.0; $P<0.001$) described below. χ^2 tests identified differences between included and excluded participants for parental education ($P<0.001$), as well as for seven single items related to parental neighborhood perceptions (see Supplementary Table 1 for more details). However, effect sizes for all these differences are trivial (Cohen's $d \leqslant 0.19$ and Cramer's $V \leqslant 0.052$).

Measure of travel mode

Trained study staff administered a child questionnaire in schools.[24] Travel mode was assessed with one item ('in the last week you were in school, the MAIN part of your journey to school was by'). Response options were: (i) walking; (ii) bicycle, rollerblade, skateboard, scooter; (iii) bus, train, tram, underground or boat; (iv) car, motorcycle or moped; (v) other. Children also reported the time that it usually took them to travel to school. Categories were: (i) <5 min; (ii) 5–15 min; (iii) 16–30 min; (iv) 31 min to 1 h; (v) >1 h. These questions were adapted from the Health Behavior in School-aged Children study.[25]

Individual factors

Socio-demographic variables were obtained through a parent questionnaire.[24] Parents reported the mother's and father's highest level of education (six levels), the number of functioning motorized vehicles (five levels), and the child's gender. Parental social support for their child's PA was examined with 4 items which were averaged to create a social support scale (Cronbach $\alpha=0.71$; Table 1).

Neighborhood factors

Parents completed a home and neighborhood environment questionnaire available elsewhere.[24] The questionnaire included items related to social capital, the food environment, the PA environment, and the built environment and it was adapted from the Neighborhood Impact on Kids study[26] and other validated questionnaires.[27–29] Following Sampson *et al.*,[29] collective efficacy was assessed as the sum of two 5-item subscales, specifically neighborhood cohesion (Cronbach $\alpha=0.75$) and neighborhood response ($\alpha=0.75$). To reduce the number of independent variables, items that were identical (or very similar) to those used in the Neighborhood Environment Walkability Scale for Youth (NEWS-Y)[27] were assigned to the corresponding subscale of the NEWS-Y. Items were scored as recommended by the NEWS-Y developers (http://www.drjamessallis.sdsu.edu/Documents/NEWS-Yscoring.pdf) and reverse coded when necessary to ensure that higher scores indicate greater walkability/safety. Subscales were used as potential correlates of AST provided that they had satisfactory internal consistency (for example, $\alpha>0.70$) in the overall sample and in the majority of countries. Three subscales satisfied this criterion: land use mix–diversity (4 items; $\alpha=0.81$), neighborhood recreation facilities (9 items; $\alpha=0.85$), and crime safety (5 items; $\alpha=0.86$). The remaining 12 items were analyzed individually because principal component analysis failed to reveal components with acceptable internal consistency.

Data treatment

Children's travel mode was dichotomized as active (walk, bicycle, and so on) versus motorized (car, bus, and so on). Socioeconomic variables were recoded based on the observed frequency distributions. Mothers' and fathers' education was categorized as less than high school, high school/college, or university. Then the highest level of education in the household was used in analyses. Motorized vehicle ownership was categorized as 0, 1 and $\geqslant 2$. School travel time was dichotomized as $\leqslant 15$ min versus $\geqslant 16$ min. The 12 single items were recoded as 'agree' or 'disagree'.

Statistical analyses

We used multilevel generalized linear mixed models with a binomial distribution and logit link to examine the individual and environmental correlates of children's travel mode.[30] We intended to explore the within-school differences between active and motorized travelers. To produce unbiased estimates of the within-school effects and to control for endogeneity (that is, correlation between school random effects and the covariates included in the model), we treated schools as fixed effects and limited our analysis to students from schools with variation in travel behavior. The Hausman test supported a fixed-effects specification ($P<0.001$). Prior to pooling data across sites, we verified whether country-site moderated the relationships between the potential correlates of AST and children's travel mode by fitting a site by correlate interaction term in generalized linear mixed models adjusted for gender, school travel time and the school within site interaction. Interactions were considered significant if $P<0.10$, owing to the reduced statistical power. We found significant interactions with the following 7 variables: school travel time ($P<0.001$), motorized vehicle ownership ($P=0.043$), and the single items 'there is a bus, subway or train stop within easy walking distance' ($P=0.085$) 'there are many places to go within easy walking distance' ($P=0.033$), 'there are sidewalks on most streets' ($P=0.077$), 'most drivers go faster than the posted speed limit' ($P=0.008$), and 'traffic makes it difficult or unpleasant for my child to walk' ($P=0.094$). Therefore, we present site-specific models wherein school, gender, parental education and school travel time were mandatory variables.

To reduce the likelihood of excluding variables that may achieve statistical significance at $P<0.05$, but only after adjustment for other covariates, we used a liberal $P<0.20$ threshold for inclusion of variables in the site-specific multivariable model.[25] Then, a backward selection approach was used to remove non-significant variables ($P>0.05$). As a result of the backward selection process, the final site-specific models include a different set of variables in each site. An alternative analytical strategy would have been to force all variables that have achieved statistical significance in at least one site into the models. However, the latter strategy resulted in poor-fitting models with frequent problems of quasi-complete separation, probably due to the sparse distribution of some of the parent-perceived variables. Therefore, the backward selection approach was preferred. Analyses were conducted with IBM SPSS version 22 (IBM, Armonk, NY, USA). Degrees of freedom were calculated with Satterthwaite's[31] method.

Table 1. Internal consistency and descriptive statistics for the neighborhood scales used in the ISCOLE ($n = 6\ 555$)

Title and number of items	*Items*	α	*Mean (s.d.)*
Neighborhood cohesion (5 items assessed as 5-point Likert scale)[a]	'People around my neighborhood are willing to help their neighbors' 'This is a close-knit neighborhood' 'People in my neighborhood can be trusted' 'People in my neighborhood generally don't get along with each other' (reverse coded) 'People in my neighborhood do not share the same values, attitudes or beliefs'(reverse coded)	0.75	3.47 (0.84)
Neighborhood response (5 items assessed as 5-point Likert scale)[a]	Stem: how likely is it that your neighbors would do something about it? 'If a group of neighborhood children were skipping school and hanging out on a street corner' 'If some children were spray-painting graffiti on a local building' 'If a child was showing disrespect to an adult' 'If there was a fight in front of your house and someone was being beaten or threatened' 'Suppose that because of budget cuts the fire station closest to your home was going to be closed down by the city'	0.75	3.57 (0.86)
Crime safety (5 items assessed as 4-point Likert scale)[b]	'I'm afraid of my child being taken or hurt by a stranger on local streets' 'I'm afraid of my child being taken or hurt by a stranger in my yard, driveway, or common area' 'I'm afraid of my child being taken or hurt by a stranger in a local park' 'I'm afraid of my child being taken or hurt by a known "bad" person (adult or child) in my neighborhood' 'There is a high crime rate'	0.86	2.41 (0.87)
Land use mix–diversity (4 items assessed as 5-point Likert scale)[b]	Stem: About how long would it take you to walk from your home to the nearest places listed below? 'Convenience/corner store/small grocery store/bodega' 'Supermarket' 'Fast food restaurant' 'Non-fast food restaurant'	0.81	2.75 (1.03)
Neighborhood recreation facilities scale (9 items assessed as 5-point Likert scale)[b]	Stem: About how long would it take you to walk from your home to the nearest places listed below? 'Indoor recreation or exercise facility (public or private)' 'Beach, lake, river, or creek' 'Bike/hiking/walking trails, paths' 'Basketball court (including half-court)' 'Other playing fields/courts' 'Small public park' 'Large public park' 'Public playground with equipment' 'School with recreation facilities open to the public'	0.85	3.46 (0.94)
Social support scale (4 items assessed as 5-point Likert scale)	Stem: during a typical week, how often do you or another adult in the household: 'Watch your child participate in physical activity or sports?' 'Encourage your child to do sports or physical activity' 'Provide transport to a place where your child can do physical activity or play sports' 'Do a physical activity or play sports with your child'	0.71	2.60 (0.92)

Abbreviations: *a*, Cronbach's alpha; ISCOLE, International Study of Childhood Obesity, Lifestyle and the Environment. [a]The scores for these two subscales were added to obtain a collective efficacy score (Sampson *et al.*[29]). [b]For these subscales, questionnaire items that were conceptually similar to those used in the Neighborhood Environment Walkability Scale for Youth (NEWS-Y; Rosenberg *et al.*[27]) were assigned to the corresponding NEWS-Y subscale. Then, the internal consistency of the resulting subscales was assessed for the overall analytical sample ($n = 6{,}555$) and the analytical samples of each country site.

RESULTS

Socio-demographic characteristics of the participants are shown in Table 2. A total of 6872 participants (3701 girls and 3171 boys aged 10.4 ± 0.6 years) were included in analyses. There were large differences between sites in site-level socio-demographic indicators and in household motorized vehicle ownership and parental education. Overall, 42.1% of children reported engaging in AST with large differences between sites in travel mode and trip duration (Figures 1 and 2). The highest rates of AST were observed in Finland (79.4%) and Colombia (73.8%), and the lowest in India (5.2%) and the United States (10.8%). The highest proportion of trips made by bus/train/van was noted in India (61.8%) while the highest percentage of trips made by car was noted in Australia (63.8%). Conversely, the highest proportion of cycling was found in Finland (24.4%) whereas the highest proportion of walking was noted in Colombia (71.6%) The school-level intra-class correlation coefficient ranged from 0.00 in India to 0.56 in Colombia. Regardless of travel mode, school trips were generally quicker in high-income countries. Among active travelers, the proportion of children reporting trips $\geqslant 16$ min ranged from 11.8% in Canada to 33.6% in Kenya. The majority of motorized travelers reported trips $\leqslant 15$ min in all countries except India, Colombia and Kenya.

Descriptive characteristics for the environmental variables are shown in Table 3. In general, high-income countries had better crime safety and collective efficacy scores than low-income countries, but this pattern was not apparent for other subscales. A greater proportion of parents expressed concerns about traffic safety aspects than about walkability aspects (i.e., street connectivity, presence of sidewalks, etc.). The neighborhood

Table 2. Descriptive characteristics of participants stratified by study site in the International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE)

	Australia (Adelaide)	*Brazil (São Paulo)*	*Canada (Ottawa)*	*China (Tianjin)*	*Colombia (Bogota)*	*Finland (Helsinki, Espoo and Vantaa)*	*India (Bangalore)*	*Kenya (Nairobi)*	*Portugal (Porto)*	*South Africa (Cape Town)*	*UK (Bath and North East Somerset)*	*USA (Baton Rouge)*	*Total*
	n = *512*	n = *498*	n = *559*	n = *544*	n = *911*	n = *496*	n = *600*	n = *552*	n = *672*	n = *437*	n = *469*	n = *622*	n = *6872*
Socio-demographic characteristics													
World bank classification[a]	High income	Upper-middle income	High income	Upper-middle income	Upper-middle income	High income	Lower-middle income	Low income	High income	Upper-middle income	High income	High income	NA
Gini index[b]	35.2 (1994)	54.7 (2009)	32.6 (2000)	42.6 (2002)	55.9 (2010)	26.9 (2000)	33.4 (2005)	47.7 (2005)	38.5 (1997)	63.1 (2009)	36.0 (1999)	40.8 (2000)	NA
Motor vehicles per 1000 inhabitants[c]	687	198	605	37	58	534	15	21	509	159	526	809	NA
Estimated road traffic death rate per 100 000 inhabitants[d]	6.1	22.5	6.8	20.5	15.6	5.1	18.9	20.9	11.8	31.9	3.7	11.4	NA
Age[e]	10.8 (0.4)	10.5 (0.5)	10.5 (0.4)	9.9 (0.5)	10.4 (0.6)	10.4 (0.4)	10.4 (0.5)	10.2 (0.7)	10.4 (0.3)	10.2 (0.7)	10.9 (0.5)	10.0 (0.6)	10.4 (0.6)
Gender													
Male	45.9	48.0	41.9	53.1	49.3	46.8	47.0	46.4	44.0	42.3	43.9	43.1	46.1
Female	54.1	52.0	58.1	46.9	50.7	53.2	53.0	53.6	56.0	57.7	56.1	56.9	53.9
Highest parent education													
< High School	11.3	24.3	2.0	32.9	31.5	2.8	4.7	14.1	46.6	47.1	2.8	8.5	19.8
Complete high school or some college	47.9	53.2	27.7	44.7	50.9	55.2	21.8	45.1	32.9	39.8	51.8	44.1	42.8
⩾ Bachelor degree	40.8	22.5	70.3	22.4	17.6	41.9	73.5	40.8	20.5	13.0	45.4	47.4	37.4
Motorized vehicle ownership													
None	2.3	30.1	3.8	9.7	75.5	9.9	4.3	44.2	10.7	47.6	4.3	8.4	23.2
1	22.5	47.8	38.3	44.1	21.6	45.0	32.5	33.3	42.4	27	36.2	32.0	34.6
2 or more	75.2	22.1	58.0	46.1	2.9	45.2	63.2	22.5	46.9	25.4	59.5	59.6	42.2
Number of siblings													
None	6.8	19.6	11.3	67.9	7.8	14.7	23.0	9.4	27.7	5.8	11.1	10.0	18.0
1	44.2	42.3	51.5	28.0	33.8	38.8	64.8	27.8	53.0	37.6	45.0	29.1	41.2
2 or more	49.0	38.1	37.2	4.1	58.4	46.6	12.2	62.9	19.3	56.6	43.9	60.8	40.8
School transport characteristics													
School travel mode													
Active													
Walking	24.1	39.0	34.2	22.2	71.6	54.8	3.8	40.9	27.1	57.9	50.3	9.8	36.9
Bicycle, rollerblade, skateboard, scooter	7.2	1.0	0.7	10.1	1.8	24.4	1.3	2.9	1.0	0.9	12.2	0.5	4.9
Motorized													
Bus, train, tram, underground or boat	4.5	32.3	38.3	7.5	18.4	13.1	61.8	27.9	12.1	4.8	3.2	34.8	22.2
Car, motorcycle or moped	63.8	26.7	26.5	55.1	7.5	7.5	33.0	23.6	58.9	36.3	33.9	54.3	34.8
Other[f]	0.4	1.0	0.4	5.0	0.8	0.2	0.0	4.7	0.9	0.0	0.4	0.7	1.2
Travel time													
⩽ 15 min	85.2	68.7	74.8	65.6	61.7	79.0	37.2	56.5	84.1	70.7	79.5	70.3	68.8
⩾ 16 min	14.8	31.3	25.2	34.4	38.3	21.0	62.8	43.5	15.9	29.3	20.5	29.7	31.2

Table 2. (Continued)

	Australia (Adelaide)	Brazil (São Paulo)	Canada (Ottawa)	China (Tianjin)	Colombia (Bogota)	Finland (Helsinki, Espoo and Vantaa)	India (Bangalore)	Kenya (Nairobi)	Portugal (Porto)	South Africa (Cape Town)	UK (Bath and North East Somerset)	USA (Baton Rouge)	Total
School-level ICC for school travel mode[g]	0.18	0.25	0.31	0.09	0.56	0.24	0.00	0.38	0.11	0.55	0.10	0.27	NA

Abbreviations: ICC, intra-class correlation coefficient; ISCOLE, International Study of Childhood Obesity, Lifestyle and the Environment, NA, not applicable. [a]World Bank Data at country level: World Development Indicators 2012. The World Bank: Washington, DC; 2012. [b]World Bank Data: Gini index at country level. [c]World Bank Data at country level: motor vehicles (per 1000 people) include cars, buses and freight vehicles but not two-wheelers. [d]World Health Organization data: Global status report on road safety 2013. [e]Mean and s.d. [f]Other includes school van, matatu, bus feeder, riding on the top tube of the bike's frame, pedicab and wheelchair. [g]ICC calculated in an 'empty' model with only school entered as a random effect (Cerin, 2011).

environment was generally rated more poorly in the United States than in other high-income countries.

Multivariable site-specific models are shown in Table 4. In general, gender was not associated with AST, except in Canada, where girls were about half as likely to engage in AST as boys. Motor vehicle ownership was negatively associated with AST in 3 out of 12 sites: China, Portugal and South Africa. Parental education was associated with AST only in the United States where children of less educated parents were more likely to engage in AST. The number of siblings was not associated with AST except in Brazil and South Africa where children who had 1 sibling were less likely to engage in AST than those who had ⩾2 siblings. In both countries, the likelihood of AST did not differ between children who had no siblings and those who had either 1 or ⩾2 siblings. Child-reported school travel time was negatively associated with AST in 8 sites: Brazil, Canada, China, Finland, India, Kenya, South Africa and the United States.

Relationships between the social environment and children's travel mode varied across countries. Parental social support for PA was positively associated with AST only in India. Each unit increase in the collective efficacy subscale was associated with about 20% lower odds of AST in China. In contrast, each unit increase in the crime safety subscale was associated with 65% higher odds of AST, but only in Finland.

With respect to road safety constructs, parental perception that the speed of traffic is usually slow was associated with lower odds of AST among British children (odds ratio (OR) = 0.39). Australian children whose parents perceived that the traffic makes it difficult/unpleasant for walking and that there are crosswalks and signals on busy streets were almost half as likely to engage in AST as children whose parents disagreed with these items. Counter-intuitively, Brazilian children whose parents disagreed that most drivers go faster than the speed limit were about half as likely to engage in AST. In contrast, the opposite relationship was found in Australia and India.

Associations between indicators of neighborhood walkability and AST also varied across sites. Each unit increase in the land use mix–diversity subscale was associated with higher odds of AST in Canada (OR = 1.38), but lower odds in China (OR = 0.76). Children whose parents perceived that there is a transit stop within walking distance were about twice as likely to engage in AST in the United States; however, they were about half as likely to do so in Portugal. The perception that there are many places to go within walking distance was positively associated with AST in Australia and the United Kingdom (OR = 1.77 and 1.81 respectively), whereas the opposite was found in Colombia (OR = 0.61). South African children whose parents perceived that there are not too many dead end streets were more than 3 times as likely to engage in AST. Similarly, Finnish children whose parents reported that there are many routes for getting from place to place were about 3 times as likely to be active travelers. Finally, the presence of sidewalks was associated with about two times higher odds of AST in Portugal.

DISCUSSION

Our primary objectives were to describe school travel behavior in a large heterogeneous sample of children from 12 different country sites and to investigate the individual and environmental factors associated with AST. Across sites, between 0 and 52% of the variance in travel mode was explained by school-level factors. We also noted very large differences both within and between sites in children's travel behavior. For instance, the prevalence of AST was almost 20 times higher in Finland compared to India. Previous reviews have also noted substantial differences between countries in the rates of AST.[2,32,33] However, these reviews were limited by heterogeneity in the measurement of travel behavior. Our findings suggest that differences between countries are not

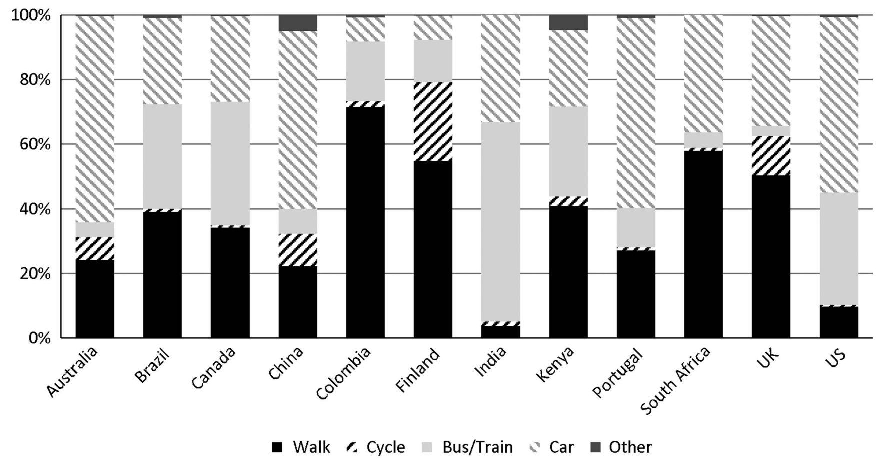

Figure 1. Children's main school travel mode stratified by country-site in the ISCOLE ($n = 6872$). Note that the other modes included active modes: such as running and jogging; motorized modes: such as the school van, matatu, bus feeder, pedicab; and non-active non-motorized modes: such as being a passenger on a bicycle. These travel modes were classified as active or motorized/inactive as appropriate.

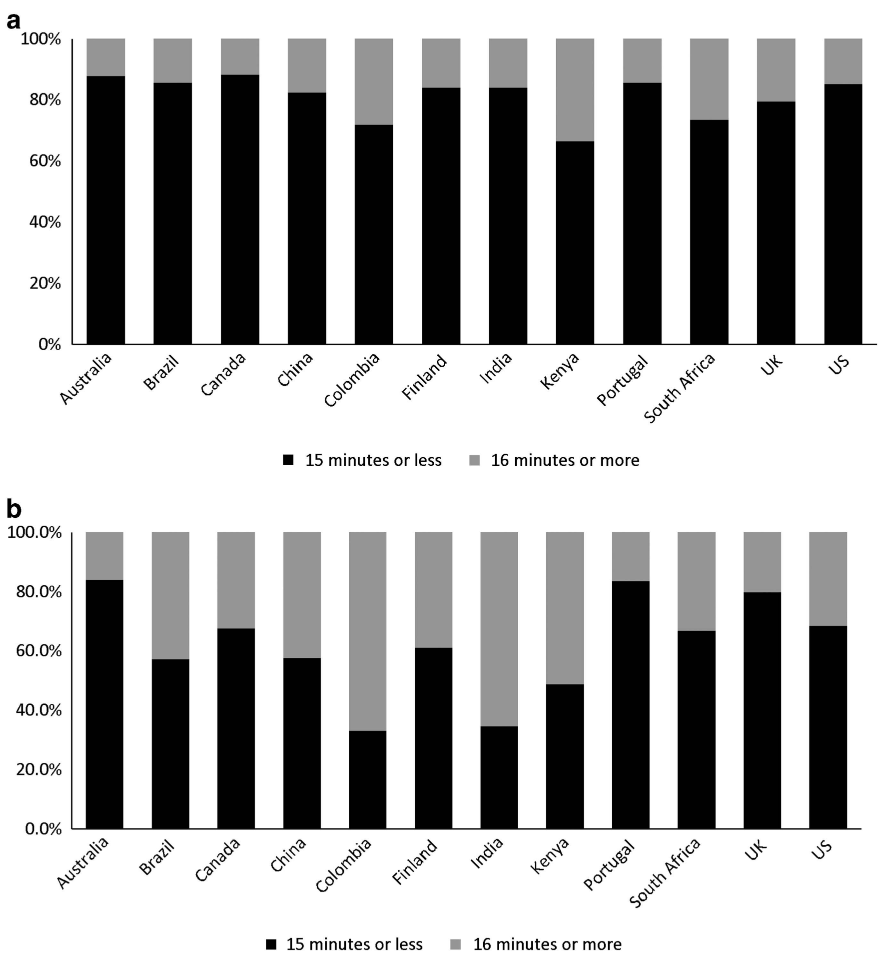

Figure 2. Children's school travel duration stratified by country-site in the ISCOLE ($n = 6872$). Note that the (**a**) shows travel duration for active travelers and the (**b** shows travel duration for motorized travelers.

an artifact of methodological differences in the assessment of travel behavior.

Given these large differences between countries and the consistent associations observed between AST, accelerometry-measured PA[3] and indicators of adiposity[34] in ISCOLE, investigating the correlates of AST in this sample is of particular interest. We found that travel time was the most consistent correlate of AST. Specifically, children reporting trips of 16 min or more were less likely to engage in AST in 8 out of 12 sites. Moreover, in the entire sample, the association between travel time and travel mode was moderated by country-site ($P < 0.001$), suggesting that the 'acceptable' duration of an active trip varies across country sites. While trip duration and distance can both be conceived as indicators of 'generalized travel cost' from a behavioral economic

Table 3. Parent-perceived environmental characteristics stratified by study site in the ISCOLE

	Australia (Adelaide)	*Brazil (São Paulo)*	*Canada (Ottawa)*	*China (Tianjin)*	*Colombia (Bogota)*	*Finland (Helsinki, Espoo and Vantaa)*	*India (Bangalore)*	*Kenya (Nairobi)*	*Portugal (Porto)*	*South Africa (Cape Town)*	*UK (Bath and North East Somerset)*	*US (Baton Rouge)*	*Total*
	n = *512*	n = *498*	n = *559*	n = *544*	n = *911*	n = *496*	n = *600*	n = *552*	n = *672*	n = *437*	n = *469*	n = *622*	n = *6 872*
Social support for PA subscale (range 1–5)	2.8 (0.8)	2.2 (0.9)	2.8 (0.8)	2.5 (1.0)	2.3 (0.8)	2.5 (0.8)	3.0 (0.9)	2.5 (1.0)	2.5 (0.9)	2.7 (1.1)	2.6 (0.8)	2.9 (1.0)	2.6 (0.9)
Collective efficacy subscale (range 2–10)	7.0 (1.3)	6.3 (1.2)	7.7 (1.4)	7.5 (1.2)	6.7 (1.5)	7.4 (1.3)	7.0 (1.3)	6.9 (1.5)	6.9 (1.4)	6.7 (1.7)	7.4 (1.3)	7.3 (1.7)	7.1 (1.5)
Land use mix–diversity subscale (range 1–5)	3.3 (1.0)	2.8 (0.9)	2.8 (1.0)	2.3 (0.8)	1.9 (0.7)	3.0 (1.0)	2.6 (0.8)	2.9 (1.0)	2.8 (1.0)	3.3 (0.9)	2.8 (0.9)	3.3 (1.1)	2.8 (1.0)
Neighborhood recreation facilities subscale (range 1–5)	3.1 (0.9)	3.7 (0.9)	2.5 (0.8)	3.6 (0.9)	3.3 (0.6)	2.5 (0.8)	3.8 (0.8)	4.2 (0.7)	3.9 (0.8)	4.0 (0.8)	3.2 (0.7)	3.8 (1.0)	3.5 (0.9)
Crime safety subscale (range 1–4)	2.6 (0.7)	2.1 (0.6)	3.0 (0.7)	2.2 (0.7)	1.6 (0.7)	3.4 (0.6)	2.5 (0.7)	2.3 (0.8)	2.4 (0.7)	1.9 (0.8)	2.9 (0.7)	2.6 (0.8)	2.4 (0.9)
There are shops, stores, markets or places to buy things within easy walking distance (percentage agree)	75.5	86.4	74.3	92.4	94.1	79.6	93.1	85.2	83.9	83.8	87.9	45.1	82.1
There is a bus, subway or train stop within easy walking distance (percentage agree)	89.8	90.0	96.1	78.8	84.2	98.4	88.7	76.4	89.2	79.8	96.6	43.8	83.8
There are sidewalks on most streets (percentage agree)	86.5	92.9	85.4	88.0	97.3	91.0	73.8	67.1	80,6	83.3	91.3	60.9	83.4
There are not many dead end streets (percentage agree)	79.5	74.1	87.2	86.6	93.2	81.8	71.0	64.0	77,6	73.8	77.3	65.5	78.4
There are many different routes for getting from place to place (percentage agree)	86.1	84.5	90.7	85.6	95.7	88.7	81.7	77.6	85.0	82.7	85.3	71.5	85.1
The speed of traffic is usually slow ($<$ 30 mph; percentage agree)	79.4	69.1	82.4	42.7	57.5	52.3	63.5	45.3	63.5	59.4	52.7	6.4	61.0
There are many interesting things to look at while walking in my neighborhood (percentage agree)	73.3	55.2	73.7	49.9	52.4	76.8	55.8	58.6	54.8	44.3	68.7	53.6	59.3
Streets have good lighting at night (percentage agree)	57.8	74.7	72.9	77.4	77.7	76.6	82.9	46.8	73.2	67.0	83.7	62.8	71.5
There are crosswalks and signals on busy streets (percentage agree)	55.7	68.6	81.6	83.0	47.9	79.3	65.4	32.8	72.4	67.8	76.9	43.7	63.4
There are many places to go within walking distance (% agree)	64.8	68.2	75.9	72.4	53.5	69.1	71.6	60.1	40.1	51.1	69.8	34.3	60.0
Most drivers go faster than the posted speed limits (percentage disagree)	34.2	25.4	28.7	56.3	27.7	33.1	27.6	34.9	34.9	24.4	28.7	25.9	31.9
The traffic makes it difficult or unpleasant to walk (percentage disagree)	67.6	39.4	74.0	46.0	49.7	84.0	30.4	52.5	53.1	39.1	58.6	56.5	54.0

Abbreviation: ISCOLE, International Study of Childhood Obesity, Lifestyle and the Environment. Results for the subscales are reported as mean (s.d.). All items were coded so that higher scores indicate greater walkability/safety.

perspective,[35] trip duration is partly dependent on the chosen travel mode, so our results should be interpreted cautiously. Nevertheless, it is worth noting that previous research indicates that distance depends on many factors including parent/child school choice, parental neighborhood selection, availability of walking/cycling paths that may provide shortcuts, and the policies that govern school choice, bussing eligibility, and where new schools are built.[36,37] Therefore, a social-ecological approach targeting multiple levels of influence will likely be needed to overcome the distance barrier.[36]

Of particular importance, we observed that country-site was an important moderator. Specifically, when pooling the data across the 12 sites, the relationship between seven of the independent variables examined and AST was moderated by study site. Furthermore, each of the 12 site-specific multivariable models included a different combination of correlates. These findings suggest that, to increase the prevalence of AST, context-specific interventions should be preferred over a 'one size fits all' approach.

The heterogeneity in the correlates of AST across countries may be partly attributable to the diversity of the country sites. It has been suggested that the lack of motorized alternatives could explain the relatively high prevalence of AST in low- and middle-income countries.[2,38] Nevertheless, we found a negative relationship between motorized vehicle ownership and AST only in China, Portugal and South Africa. Furthermore, despite a high country-level rate of motorized vehicle ownership, Finland had the largest prevalence of AST. The high prevalence of AST in Finland has been attributed to a combination of factors including favorable social norm,[39] supportive policies[40] and high quality walking and cycling infrastructure.[41] In contrast, a 'culture of convenience', wherein the socially acceptable distance for walking to/from school is thought to be less than 1.6 km may partly explain the low prevalence of AST among Canadian children.[42] Perceived convenience of driving has also been described as a key reason why children are driven to school in other studies.[43–45] Unfavorable social norms and the perception of what constitutes 'good parenting' may create so-called 'social traps' in which driving begets driving.[46] In these social traps, parents who previously did not drive their children to school start to do so because they perceive that, otherwise, others will not view them as 'good parents'.

While we found that the correlates of children's travel behavior varied markedly across sites, it is noteworthy that the International Physical Activity and the Environment study found that the environmental correlates of walking, PA and body mass index among adults were generally consistent across diverse study sites, including some middle income countries.[47–49] The environmental factors that encourage active travel and PA among adults—such as density, land use mix, street connectivity and composite measures of neighborhood walkability[47,49–51]—may not be as relevant, or more variable, for children.

Previous reviews have noted that, apart from a consistent negative association between distance and AST, studies of the built environment constructs associated with children's AST have reported conflicting results.[18–20] Moreover, a recent meta-analysis of studies examining the relationship between objective measures of the built environment and PA revealed a strong moderating effect of age.[52] Although neighborhood walkability was positively associated with 15-year olds' PA, there was a small negative association for 9-year olds and inconsistent results for 12-year olds. A potential explanation for these findings is that high walkability areas may also be characterized by heavy traffic, thereby decreasing parental willingness to allow their child to travel on foot or bike.[53]

It is also worth noting that the ISCOLE questionnaire focused on parents' perceptions of their home neighborhood. Beyond the home neighborhood, the characteristics of the route to/from school and those of the school neighborhood may also influence travel mode choice.[54] Therefore, some of our counter-intuitive findings related to walkability and traffic safety aspects may be owing to the presence of other barriers beyond the home neighborhood. This may be compounded by the variability in individuals' perceptions of their home neighborhood boundaries.[55,56] Another potential explanation is that parents may have interpreted some questions differently in different countries. Furthermore, some counter-intuitive findings could also be explained by reverse causality. Parents of active travelers may be more worried about their child's safety en route to/from school, and chauffeuring children may be viewed as a strategy to mitigate these fears.[46,57] Given that causality cannot be inferred from our cross-sectional study, future prospective studies are needed to test this hypothesis.

Finally, it is worth noting that the effect of parental perceptions on their child's travel behavior may be indirect. Therefore, to inform the development of future AST interventions, greater attention should be paid to the mediators of children's travel behavior. To date, few studies have conducted mediation analyses. Nevertheless, Lu and colleagues[58] found that parental self-efficacy explained the relationship between parent-perceived barriers and parents' intention to encourage their child to engage in AST. These results suggest that increasing parent's self-efficacy may be a promising strategy, especially in an environment that is conducive to AST.

The cross-sectional design which precludes causal inferences is the main limitation of our study. Second, while participating schools were purposefully selected in areas that differed in terms of socioeconomic status and urbanisation, the samples are not nationally-representative. Third, the reliability and validity of the questions used to assess travel mode and trip duration are unknown. While reported school travel mode generally shows high test-retest reliability and convergent validity between children and parents,[22] children's perception of their school travel time may be inaccurate at the individual level.[59] School travel time may also be limited as a proxy for distance because it depends on the chosen travel mode (for example, it should take more time to walk than to drive a given distance). Unfortunately, distance was not measured in ISCOLE, so it was impossible to control for distance in our analyses. Fourth, while the parent questionnaire was developed based on validated surveys, it included only a subset of items from the NEWS-Y survey, and the wording of items differed. To minimize this limitation, we have examined the internal consistency of our subscales overall and within each site, and we have used only those subscales that showed satisfactory consistency. Fifth, included and excluded participants differed in several environmental variables. However, effect sizes were trivial to small, so these differences likely had limited impact on our results. Finally, although the correlates of walking and cycling may differ, we did not analyse these modes separately due to the scarcity of cycling in most sites.

To our knowledge, this is the first investigation of the correlates of AST in such a diverse range of country sites. Previous studies of the correlates of AST had mostly been conducted in high-income countries, with very few studies conducted among African children,[22] or children from developing countries more generally. Of particular interest, we identified that country-site was an important moderator of the relationship of individual and environmental variables with AST. Understanding the moderators of health behavior can help identify what works (or may work) for whom.[60] Finally, the very large sample size and the use of multilevel models are other important strengths of our study.

CONCLUSION

We found large differences in the prevalence and correlates of AST among children from 12 diverse country sites across the world, challenging generally held belief that there is a common (or

Table 4. Correlates of active school transport stratified by study site in the ISCOLE.

	Australia (Adelaide)	*Brazil (São Paulo)*	*Canada (Ottawa)*	*China (Tianjin)*	*Colombia (Bogota)*	*Finland (Helsinki, Espoo and Vantaa)*	*India (Bangalore)*	*Kenya (Nairobi)*	*Portugal (Porto)*	*South Africa (Cape Town)*	*UK (Bath and North East Somerset)*	*US (Baton Rouge)*
	n = *496*	n = *430*	n = *551*	n = *541*	n = *834*	n = *439*	n = *559*	n = *537*	n = *639*	n = *336*	n = *456*	n = *532*
Socio-demographic characteristics												
Gender												
Female (ref: male)	0.72 (0.46–1.13)	1.17 (0.72–1.92)	0.46 (0.29–0.74)**	0.98 (0.66–1.47)	1.00 (0.64–1.57)	1.38 (0.79–2.40)	0.58 (0.16–2.17)	0.68 (0.44–1.06)	0.85 (0.58–1.26)	1.11 (0.56–2.21)	1.18 (0.74–1.89)	1.01 (0.59–1.71)
Parental education												
High school/college (ref: university)	1.05 (0.64–1.70)	0.96 (0.51–1.83)	0.82 (0.47–1.42)	0.84 (0.47–1.48)	1.01 (0.49–2.10)	0.94 (0.52–1.70)	0.66 (0.26–1.71)	1.15 (0.69–1.92)	1.30 (0.73–2.34)	1.41 (0.44–4.48)	1.25 (0.76–2.05)	2.40 (1.08–5.35)
< High school (ref: university)	1.04 (0.49–2.23)	0.94 (0.45–1.97)	1.29 (0.23–7.37)	1.13 (0.57–2.22)	1.05 (0.46–2.38)	1.08 (0.22–5.38)	0.90 (0.20–4.03)	1.87 (0.82–4.26)	1.38 (0.76–2.51)	1.30 (0.35–4.80)	2.85 (0.48–16.78)	3.71 (1.32–10.38)
Motorized vehicles ownership												
1 (ref: none)	—	—	—	0.23 (0.11–0.47)***	—	—	—	—	0.57 (0.31–1.03)	0.27 (0.11–0.62)**	—	—
2 or more (ref: none)	—	—	—	0.18 (0.09–0.36)***	—	—	—	—	0.42 (0.22–0.80)**	0.47 (0.17–1.30)	—	—
Number of siblings												
1 (ref: none)	—	0.53 (0.28–1.01)	—	—	—	—	—	—	—	0.22 (0.05–1.11)	—	—
2 or more (ref: none)	—	1.22 (0.64–2.33)	—	—	—	—	—	—	—	0.50 (0.11–2.36)	—	—
Travel time												
⩾ 16 min (ref: ⩽ 15 min)	0.87 (0.46–1.66)	0.29 (0.16–0.51)***	0.42 (0.21–0.81)**	0.35 (0.22–0.58)***	0.67 (0.42–1.08)	0.31 (0.17–0.59)***	0.09 (0.04–0.22)***	0.46 (0.29–0.73)**	0.79 (0.46–1.37)	0.36 (0.17–0.76)**	1.26 (0.69–2.30)	0.45 (0.21–0.93)*
Environmental characteristics												
Social support for physical activity (each unit increase)	—	—	—	—	—	—	1.55 (1.06–2.25)*	—	—	—	—	—
Collective efficacy (each unit increase)	—	—	—	0.80 (0.68–0.94)**	—	—	—	—	—	—	—	—
Crime safety (each unit increase)	—	—	—	—	—	1.65 (1.02–2.66)*	—	—	—	—	—	—
Land use mix–diversity (each unit increase)	—	—	1.38 (1.06–1.80)*	0.76 (0.59–0.97)*	—	—	—	—	—	—	—	—
There is a bus, subway or train stop within easy walking distance (ref: disagree)	—	—	—	—	—	—	—	—	0.44 (0.22–0.88)*	—	—	2.06 (1.14–3.72)*
There are sidewalks on most streets (ref: disagree)	—	—	—	—	—	—	—	—	2.27 (1.14–4.54)*	—	—	—
There are not many dead end streets (ref: disagree)	—	—	—	—	—	—	—	—	—	3.43 (1.48–7.98)**	—	—
There are many different routes for getting from place to place (ref: disagree)	—	—	—	—	—	3.19 (1.37–7.40)**	—	—	—	—	—	—
The speed of traffic is usually slow (< 30 mph) (ref: disagree)	—	—	—	—	—	—	—	—	—	—	0.39 (0.24–0.63)***	—
Streets have good lighting at night (ref: disagree)	—	—	—	—	—	—	—	—	—	—	—	—
There are crosswalks and signals on busy streets (ref: disagree)	0.58 (0.36–0.91)*	—	—	—	—	—	—	—	—	—	—	—
There are many places to go within walking distance (ref: disagree)	1.77 (1.08–2.91)*	—	—	—	0.61 (0.38–0.98)*	—	—	—	—	—	1.81 (1.07–3.04)*	
Most drivers go faster than the posted speed limits (ref: agree)	2.04 (1.28–3.25)**	0.52 (0.30–0.93)*	—	—	—	—	2.09 (1.04–4.20)*	—	—	—	—	—
The traffic makes it difficult or unpleasant to walk (ref: agree)	0.58 (0.36–0.93)*	—	—	—	—	—	—	—	—	—	—	—

Abbreviation: ISCOLE, International Study of Childhood Obesity, Lifestyle and the Environment. Note: odds ratios of engaging in active school transport were calculated with generalized linear mixed models with participant's school entered as a fixed effect. Except for gender, parental education and travel time which were mandatory variables, only independent variables significantly associated with active school transport ($P < 0.05$) were kept in the site-specific multivariate models. Variables that were not associated with active school transport in any country are not shown. Results are reported as odds ratios (95% confidence intervals). $*P < 0.05$; $**P < 0.01$; $***P < 0.001$.

universal) set of correlates of AST. Interestingly, study site moderated the relationship between 7 of the independent variables considered and children's travel behavior. Therefore, policy-makers, urban/transport planners and public health workers should not assume that built environment interventions that are effective in one setting (or in one population) will necessarily work elsewhere. As such, these stakeholders should consider collaborating with researchers to identify the correlates of AST at the local level before implementing interventions. Future multi-country studies should examine the role of variables such as home-school distance, social norms and perceived convenience as potential correlates of AST. Furthermore, there remains a need for studies to identify relevant mediators that could be targeted in future interventions.

CONFLICT OF INTEREST

MF has received a research grant from Fazer Finland and has received an honorarium for speaking for Merck. AK has been a member of the Advisory Boards of Dupont and McCain Foods. RK has received a research grant from Abbott Nutrition Research and Development. VM is a member of the Scientific Advisory Board of Actigraph and has received an honorarium for speaking for the Coca-Cola Company. TO has received an honorarium for speaking for the Coca-Cola Company. JZ has received a grant from The British Academy/Leverhulme Trust. The remaining authors declare no conflict of interest.

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