Original Article

Active School Transport and Weekday Physical Activity in 9-11 year old Children from 12 Countries

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Abstract

Background: Active school transport (AST) may increase the time that children spend in physical activity (PA). This study examined relationships between AST and weekday moderate-to-vigorous physical activity (MVPA), light physical activity (LPA), sedentary time (SED), and total activity during naturally organized time periods (daily, before school, during school, and after school) in a sample of children from 12 countries.

Methods: The sample included 6 224 children aged 9-11 years. PA and sedentary time were objectively measured using Actigraph accelerometers. AST was self-reported by participants. Multi-level generalized linear and logistic regression statistical models were used to determine associations between PA, SED and AST across and within study sites.

Results: After adjustment for age, highest parental educational attainment, BMI z-score, and accelerometer wear time, children who engaged in AST accumulated significantly more weekday MVPA during all studied time periods and significantly less time in LPA before school compared to children who used motorized transport to school. AST was unrelated to time spent in sedentary behaviors. Across all study sites, AST was associated with 6.0 min (95% CI: 4.7-7.3; $p<0.0001$) more of weekday MVPA; however, there was some evidence that this differed across study sites (p for interaction=0.06). Significant positive associations were identified within 7 of 12 study sites, with differences ranging from 4.6 min (95% CI: 0.3-8.9; $p=0.04$, in Canada) to 10.2 min (95% CI: 5.9-14.4; $p<0.0001$, in Brazil) more of daily MVPA among children who engaged in AST compared to motorized transport.

Conclusions: The present study demonstrated that AST was associated with children spending more time engaged in MVPA throughout the day and less time in LPA before school. AST represents a good behavioral target to increase levels of PA in children.

Keywords: commuting, walking, pediatrics, accelerometer, global

Trial Registration: ClinicalTrials.gov: Identifier NCT01722500.

Introduction

Physical activity (PA) guidelines recommend that children engage in at least 60 min of moderate-to-vigorous physical activity (MVPA) each day to lower their risk of negative health consequences; yet globally, many children do not meet these guidelines.[1-3] The journeys to and from school provide an opportunity to establish habitual PA patterns.[4] Previous research suggests that children who engage in active school transport (AST), such as walking or biking, accumulate more PA and experience better cardiorespiratory, muscular, and metabolic fitness and a lower likelihood of diabetes and obesity than those who travel using motorized transport alternatives including by car or bus.[5-8]

Despite the documented benefits of AST, the prevalence has declined in many countries over recent decades. In the United States (US), the proportion of children who walked or bicycled to school declined from 48% to 13% between 1969 and 2009.[9] Similar declines have been documented in the United Kingdom (UK)[10], Australia[11], Brazil[12], Canada[13], Kenya[14] and Switzerland.[15] The most common parent-reported barriers to AST include distance from home to school, traffic concerns, and crime.[16, 17]

While a positive association between AST and MVPA among children has been shown,[4, 13] the majority of evidence has been limited to developed countries. Additionally, few studies have examined associations between AST and light-intensity physical activity (LPA) or sedentary time (SED). Further, little is known about the contribution of AST to PA (MVPA or other intensities) or sedentary time during different naturally organized time periods throughout the segmented school day. It is important to more fully understand how AST contributes to PA of various intensities and SED time globally in order to plan and implement effective interventions, programs, and policies in a variety of settings.

Given these research gaps, the aims of this study were to examine: (a) relationships between AST and objectively measured weekday MVPA, LPA, total activity, and SED; (b) how these relationships differ across different time periods of the school day; and (c) associations

between children's AST and accumulating an average of at least 60 min per weekday (Monday through Friday) of MVPA in a sample of 9 to 11 year old children from 12 countries ranging in level of socio-economic and human development.

Methods

Study Design and Participants

The International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE) is a cross-sectional, multi-national study conducted in sites in 12 countries including Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, UK, and US. The ISCOLE protocol was approved by the ethics committee at the Pennington Biomedical Research Center and each participating institution. Written informed consent was obtained from parents or legal guardians, and child assent, if required by the site's local ethics committee, was also obtained before children participated in the study. Data were collected from September 2011 through December 2013. Detailed information on the study design and methods can be found elsewhere.[18]

A total of 7 372 children 9-11 years of age from 256 schools participated in ISCOLE. The present analytical sample includes 6 224 children after excluding participants missing AST (n=62), valid accelerometry (n=798), parental education (n=283), and body mass index (BMI) z-score (n=5). Participants who were excluded in this study did not differ from those included with respect to the proportion in AST, but were more likely to be older, male, have a higher body mass index (BMI), and have parents who achieved less than a college education. The number of participants per site with complete data for each of the variables of interest for this study ranged from 400 in South Africa to 856 in Colombia. The primary sampling frame was schools which were stratified by an indicator of socioeconomic status. Classrooms within the recruited schools were the secondary sampling frame chosen to yield a sample of children with a mean age of 10 years.

Measurements

Accelerometry

The full accelerometer protocol has been previously reported.[19] Briefly, time spent in MVPA, LPA, and SED and total activity counts were obtained from 24-hour accelerometry. Children were encouraged to wear an Actigraph GT3X+ accelerometer (ActiGraph LLC, Pensacola, FL, USA) on a belt around the waist at the right mid-axillary line 24 hours per day for at least 7 consecutive days. A valid accelerometer record required ≥ 4 days with ≥ 10 h of waking wear time per day, including at least one weekend day. Sleep and non-wear time were identified using an automated algorithm prior to identification of other activities.[20, 21] A waking non-wear period began with 20 consecutive minutes of zero activity counts.[20] Activity cut points were based on Evenson.[22] Total activity was expressed as the number of activity counts per day. MVPA was defined as all activity greater than or equal to 574 activity counts/15 s, LPA was defined as activity from 26 to 573 counts/15 s, and SED was defined as all activity ≤ 25 counts/15 s[22] not including the sleep period and non-wear time. Minutes spent in MVPA, LPA, and SED and total activity counts were assigned to the before school, during school, and after school time periods using school day schedules provided by each participating school. The before school time period was considered wake time (established using a validated algorithm[20]) until school start time, during school was defined as the time between school start and end time, and the after school period was considered school end time through the child's bed time (also determined by our validated algorithm[20]) determined objectively from accelerometry. Only weekday accelerometer data were used in these analyses to more accurately capture the effect of AST on PA.

In order to determine whether or not children met PA guidelines, the number of valid weekdays contained in the accelerometer file was determined, and the mean number of MVPA minutes per valid weekday that children accumulated was calculated. Children were then

classified as meeting PA guidelines (yes or no) if they obtained a mean of ≥ 60 min of MVPA per weekday over the measurement period.

Active school transport (AST)

AST was self-reported by participants using a diet and lifestyle questionnaire[18] with the question “In the last week you were in school, the main part of your journey to school was by”. Response options included “walking”, “bicycle, roller-blade, skateboard or non-motorized scooter”, “bus, train, tram, underground or boat”, “car, motorcycle or moped”, and “other”. A participant was considered to have engaged in AST if they reported walking, running, bicycle, roller-blades, skateboard, or non-motorized scooter. Motorized transportation response options included bus, train, tram, underground, boat, car, motorcycle, or moped. These options were collapsed into a binomial variable indicating AST or motorized transport to school.

Covariates

Standing height and body weight were measured using standard procedures across study sites.[18] Detailed measurement procedures have been published elsewhere.[18] Body mass index ([weight(kg)/height(m)^2]; BMI) was derived from the average standing height and weight, and BMI z-score was computed using age- and sex-specific reference values from the World Health Organization (WHO).[23] A demographic questionnaire completed by parents captured the participant’s date of birth, sex, and parents' educational attainment. Age was computed from the date of birth and date anthropometric measurements were performed. Highest parental educational attainment was created based on the highest education level completed by either parent (did not complete high school, completed high school or some college, completed bachelor’s degree or postgraduate degree).

Statistical analysis

Means and standard deviations were computed for variables by study site and sex for participants with complete data for accelerometry, AST, and covariates. AST was the independent variable in all analyses. Separate multi-level generalized linear mixed models (SAS

version 9.4, PROC MIXED) were used to examine the associations between mean daily, before school, during school, and after school MVPA, LPA, SED, and AST (0 = no, 1 = yes). All linear models were stratified by sex and adjusted for mean waking accelerometer wear time, highest parental educational attainment, average BMI z-score, and a site by AST interaction. Study site and school nested within study site were treated as fixed effects to account for the clustering of the data (weekday MVPA intra-class correlation; ICC= .14 at site; ICC=0.26 at school nested within site). Results are presented as adjusted means using the LSMEANS option. The PDIFF option was used to obtain the difference in the number of weekday MVPA minutes obtained by children who used AST versus motorized transport alternatives within each site. Multi-level logistic mixed models (PROC GLIMMIX) with the SLICEDIFFS and ODDSRATIO options specified were used to obtain the within-site odds of children meeting PA guidelines (0 = no, 1= yes) for those who engaged in AST compared to those who used motorized transport. Logistic models were adjusted for mean waking accelerometer wear time, highest parental educational attainment, average BMI z-score, and a site by AST interaction. All data management and statistical analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC). The significance level was set at $P < 0.05$.

Results

The descriptive characteristics of the study sample, stratified by study site and sex, are provided in Table 1. The mean ± SD age of the full sample was 10.4 ± 0.6 years and 54.4% of the participants were girls. The prevalence of AST was 43.1% among boys and 41.8% among girls, and this ranged across sites from 7.2% to 76.2% among boys and 3.7% to 81.0% among girls. Approximately 37% of children travelled to school by walking, 5% by bicycle, roller-blade, skateboard, or non-motorized scooter, 22% by bus, train, tram, underground, or boat, 35% by car, motorcycle, or moped, and 1% travelled by some other mode. More detail regarding mode of transportation prevalences by site can be found elsewhere.[24] Across sites, the mean time

spent in daily MVPA ranged from 50.9 ± 17.6 min/day to 85.8 ± 29.2 min/day among boys and 38.9 ± 14.8 min/day to 66.3 ± 21.6 min/day among girls.

The adjusted mean minutes of weekday MVPA, LPA, SED, and total activity counts by mode of transport to school are presented in Table 2. After adjustment for age, highest parental educational attainment, BMI z-score, accelerometer wear time, and an AST by site interaction, AST was associated with obtaining more minutes of MVPA and a higher number of total activity counts for boys at all time periods (daily, before, during, and after school) compared to motorized transport alternatives. Results were similar among girls, but the associations apparent during the school time period were not significant. Girls who engaged in AST accumulated less LPA time daily, and also before, during, and after school compared to those who did not. Among boys, daily and before school LPA was significantly lower among those who reported AST compared to those who did not. There were no significant differences in the amounts of SED time.

The differences in mean minutes of daily MVPA between children who engaged in AST compared to motorized transport to school adjusted for age, highest parental educational attainment, BMI z-score, accelerometer wear time, and an AST by site interaction (p for interaction=0.06) are presented in Figure 1. Across all study sites, AST was associated with 6.0 min (95% CI: 4.7-7.3; p<0.0001) more of daily MVPA. The association was significant within 7 of 12 ISCOLE study sites, including Brazil, Canada, Finland, Kenya, Portugal, South Africa, and the UK. Among those with a significant association, the effect size of AST on daily MVPA ranged from 4.6 min (95% CI: 0.3-8.9; p=0.04) in Canada to 10.2 min (95% CI: 5.9-14.4; p<0.0001) in Brazil.

The site-specific odds ratios for the association of AST and obtaining a weekday average of 60 or more minutes of MVPA adjusted for age, highest parental educational attainment, BMI z-score, accelerometer wear time, and an AST by site interaction are shown in Figure 2. AST was associated with significantly higher odds of obtaining the recommended amount of MVPA

across all sites (OR: 1.8; 95% CI: 1.5-2.1) and within 7 of 12 study sites, including Brazil (OR: 2.3; 95% CI: 1.4-3.8), Canada (OR:1.7 ; 95% CI: 1.0-2.8), Finland (OR: 2.1; 95% CI: 1.2-3.8), Kenya (OR: 1.9; 95% CI: 1.1-3.4), Portugal (OR: 2.5; 95% CI: 1.6-3.8), South Africa (OR: 2.8; 95% CI: 1.4-5.3), and the UK (OR: 2.4; 95% CI: 1.4-3.9).

Discussion

The present study showed that AST was associated with children spending more time engaged in MVPA and less time in LPA throughout the weekday. Overall, children who undertook AST were 1.8 times more likely to meet daily PA guidelines, though this varied across different study sites.

Children who practiced AST recorded almost 10% more daily time in MVPA compared to those who did not. A multicenter study of adolescents from 10 European cities reported similar findings in that time spent walking and biking for travel was positively associated with objectively measured MVPA compared to those who reported less time walking and biking for travel.[25] However, that study did not differentiate active travel to/from school from trips to other locations. Further, a recent review of 49 studies found that 82% of included studies showed a positive association between AST and daily PA levels (e.g., MVPA, energy expenditure expressed as kilocalorie/day, steps, total PA, etc.) as determined by accelerometry, pedometry, or self-report.[8] Additionally, Lee and colleagues[26] showed that children who practiced AST accumulated 6.9 min of MVPA during the trip contributing approximately 11% to daily time in MVPA. This agrees with our findings that children who engaged in AST obtained 6 additional minutes per day in MVPA. One study we identified examined AST and associations with MVPA at various time periods throughout the day among 10 year old children in England and found that objectively measured MVPA was significantly higher before and after school among boys and before school among girls who participated in AST.[27] These results were similar to the present study; however, our findings also suggest significant positive associations between AST and weekday MVPA during school among boys and after school among girls. Further, intervention studies

provide causal evidence that introducing AST into children's daily routine can significantly increase MVPA. For example, in a randomized controlled trial among 149 4th graders, Mendoza and colleagues[28] implemented a 5-week walking school bus intervention in which study staff walked the children to and from school. Children in the intervention group significantly increased their daily MVPA levels from 46.6 min/day to 48.8 min/day while control group children significantly decreased their daily MVPA levels from 46.1 min/day to 41.3 min/day.

In contrast to our main findings, no association between AST and MVPA was identified for 5 ISCOLE study sites including Australia, China, Colombia, India, and the US. This may have been due to the low AST prevalence in India (5.3%) and the US (8.2%) and lack of power to detect a difference. Additionally, the average weekday MVPA time in our sample was high for Australian children irrespective of school transportation mode suggesting that behaviors other than AST may influence their activity levels. Alternatively, both active and motorized travelers in China spent less time than recommended in weekday MVPA (45.9 min/day vs 43.4 min/day) indicating that behavioral interventions in addition to those promoting AST may be needed to increase MVPA. In Colombia, car ownership is low, and the majority of Colombian children in our sample either practices AST (72.6%) or uses a motorized form of public transportation (20.0%). In the present analysis, public transportation ("bus, train, tram, underground or boat") was categorized as motorized, but this method likely includes some active travel, such as walking to bus stops, which may have resulted in an underestimation of weekday MVPA among Colombian children who use motorized transport to school.

Across all 12 study sites, AST was associated with 80% higher odds of children obtaining the recommended 60 min of MVPA on weekdays compared to motorized transport to school. Further, AST was associated with significantly higher odds of children obtaining a weekday average of at least 60 min per day of MVPA in 7 of 12 study sites. This result supports previous studies that have quantified the association between AST and PA guidelines. Although limited to Russian children, Tudor-Locke and colleagues[29] found that omitting activity obtained through

AST decreased the prevalence of meeting PA guidelines by 17-19% for boys and girls. While in the same direction, our finding was greater in magnitude which may be due to the use of different PA guidelines; we used an average of 60 min per day during the school week as our proxy for meeting PA guidelines while the aforementioned study utilized a different guideline of 'at least 150 min per week or 30 min per school day'.[30] Additionally, Tudor-Locke[29] measured children's PA by parent-proxy report rather than objectively as was done in the present study.

In the present study, boys and girls who engaged in AST recorded approximately 7% less time in LPA before school compared to those who used motorized transport to school. No previous studies were found that examined the relationship between LPA time and AST, but our results suggest that children who participate in AST substitute minutes of LPA for MVPA. LPA confers some health benefits to children, especially those overweight or just beginning a PA routine; however, studies suggest greater health benefits are obtained from more intense PA (i.e., MVPA). Carson, et al.[31] found that each additional hour adolescents spent in objectively measured higher intensity LPA (800 counts/min - <4 METs) was associated with significantly lower diastolic blood pressure and higher high-density lipoprotein (HDL) cholesterol while additional time spent in MVPA was associated with greater cardiometabolic benefits, including lower systolic blood pressure and insulin, smaller waist circumference, and higher insulin sensitivity (HOMA-S%). Additionally, Ekelund and colleagues[32] examined associations between various intensities of objectively measured physical activity among children and adolescents from the European Youth Heart Study and found that MVPA was associated with better cardiometabolic risk profiles compared to LPA. Similar results were found in a sample of Spanish adolescents. Objectively measured MVPA was associated with better body composition measures while LPA was not.[33] This suggests that children who engage in AST accumulate additional health benefits by replacing LPA with MVPA.

Insight into the relationship between AST and health in the present sample of children was beyond the scope of this study, but has been reported elsewhere.[34] Briefly, Sarmiento and

298 colleagues reported that ISCOLE children who engaged in AST had lower odds of obesity
299 (OR=0.72; 95% CI: 0.60-0.87) and lower body fat percentage (ß=-0.56 (0.22); p=0.002)
300 compared to those that did not. These findings are in line with previous studies that
301 demonstrated an inverse association between AST and objectively measured overweight and
302 obesity among children.[35-37] In contrast, a recent review[8] concluded that the relationship
303 between AST and body composition is inconsistent. Compared to children who engaged in
304 motorized transport to school, 56% of included studies showed no difference in body
305 composition among active travelers, 36% of studies found more favorable body composition
306 among active travelers, and 8% of studies observed a less favorable body composition among
307 active travelers. [8] Additionally, a systematic review by Lubans and colleagues[38] suggested a
308 positive association between bicycling to school and better cardiorespiratory fitness. Finally, it is
309 well accepted that higher levels of MVPA are associated with decreased risk of obesity and
310 better cardiovascular and metabolic risk profiles.[39-42] Therefore, MVPA may be the mechanism
311 by which AST leads to better health and lower odds of obesity, but intervention studies are
312 needed to elucidate causality in these relationships.
313 Finally, we found no evidence of a relationship between AST and time spent in SED
314 behaviors during any period of the day. A study of 9- and 15-year old children in Europe
315 similarly failed to identify a correlation between walking or biking to school and percent of time
316 spent sedentary.[43] The null findings between AST and SED in the present study support
317 previous findings that correlates of children's MVPA appear distinct from those of SED.[44] This is
318 in line with the growing evidence base that SED and MVPA are independent behaviors.[45-47]
319 Additionally, since children spend such a large amount of time in SED behaviors, it is unlikely
320 that AST alone would be sufficient to significantly reduce SED time. However, Hinckson and
321 colleagues[48] found that among children who engage in AST, those living in a 1-2 km radius from
322 their school accumulated less SED time than those living closer or further from school. This

suggests that future studies should examine the relationship between AST and SED across various home-to-school distances.

Our study has several strengths including the large sample size consisting of children from all major world regions and various levels of development. Additionally, the rigorous standardization of the protocol, measurements, and quality control procedures facilitate comparisons across study sites and increase the integrity of our data. Further, ISCOLE was the first study to employ and analyze a 24-hour waist worn accelerometer protocol to objectively measure various intensities of activity, which led to higher wear time and compliance compared to other studies.[49] Additionally, time-stamped accelerometer data matched to local daily school start and end times enabled the present study to examine the associations between AST and activity levels during natural time periods before school, during school and after school time periods when such behaviors may especially contribute to MVPA, the first to our knowledge to do so in an international sample of children.

Our study also has several limitations. First, the cross-sectional study design impedes causal inference. Next, the large number of participants missing valid accelerometer data may have biased our results. However, the observed differences in physical activity between children who engage in AST and motorized transport alternatives are consistent with previous systematic reviews,[8, 13] so it is unlikely that our results would have been drastically different if all participants had provided valid accelerometry data. Previous studies suggest MVPA from wheeled modes of AST, such as biking, may be underestimated by hip-worn accelerometers. A sensitivity analysis comparing MVPA obtained from wheeled modes (bicycle, roller-blade, skateboard or non-motorized scooter) to all other modes of AST and motorized transport revealed that the number of minutes of weekday MVPA obtained from wheeled modes of AST was significantly lower than that from other modes of AST and did not differ from motorized transport modes (data not shown). This suggests that we may be underestimating the association between weekday MVPA and AST in countries with a higher prevalence of wheeled

AST, such as in Finland where nearly 25% of children in our sample bicycled to school. Additionally, several sites had little variability in the prevalence of AST which may have limited our ability to detect significant within-country differences. Further, ISCOLE assessed method of transportation to school, and children who participate in AST both to and from school may accumulate more MVPA than those only using AST to school.[8] Future work should collect transport mode to and from school to avoid this potential source of bias. Additionally, the literature suggests the distance between a child's home and school may affect both their PA levels and participation in AST.[9, 50-52] This distance was not included in the present analyses as a potential moderator as it was not collected in ISCOLE. The between-country variation in the relationship between AST and weekday MVPA may be partially explained if the average home-to-school distance varied across ISCOLE sites. Finally, AST was captured by children's self-report which may be unreliable.[53, 54] Nevertheless, a recent systematic review indicated that child-reported school travel mode showed substantial test-retest reliability and substantial convergent validity with parent reports.[55]

This study was the first to show associations between AST and weekday time in MVPA, LPA, SED, and total activity counts in an international sample of 9-11 year old children. It provided evidence that AST is associated with higher levels of objectively measured MVPA throughout the weekday. Future research should seek to elucidate factors that explain variability in MVPA and AST across various countries. Additionally, there is a need for additional prospective and experimental studies to examine whether or not switching from motorized transport to AST increases MVPA as the cross-sectional design is the key limitation of our study. Finally, barriers to AST need to be further explored in order to develop effective interventions aimed at increasing AST prevalence among children.

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Conflicts 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. The authors reported no other potential conflicts of interest.

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Figure Legends

Figure 1. The difference in mean school day moderate-to-vigorous physical activity (MVPA) among children who engage in active school transport (AST) compared to motorized transport to school in N=6 224 9-11 year old children. Means are adjusted for sex, BMI z-score, age, highest parental educational attainment, accelerometer waking wear time, site by AST interaction, and school nested within site was treated as a fixed effect in the multilevel analysis. Error bars represent 95% confidence intervals.

Figure 2. Associations between active school transport (AST) and obtaining at least 60 minutes of moderate-to-vigorous physical activity (MVPA) per school day in N=6 224 9-11 year old children from 12 countries. Odds ratios are adjusted for sex, BMI z-score, age, highest parental educational attainment, accelerometer waking wear time, site by AST interaction, and school nested within site was treated as a fixed effect in the multilevel analysis. Error bars represent 95% confidence intervals.

Table 1. Descriptive characteristics of ISCOLE participants stratified by sex and study site (n=6 224).

Country (Site)	n	Active Transport Yes (%)	Mean (SD) Age (y)	BMI (kg/m²)	BMI z-score	MVPA[a] (min/day)	LPA[a] (min/day)	SED[a] (min/day)	Total Activity (counts/day)
Boys									
Australia (Adelaide)	220	33.0	10.8 (0.4)	18.6 (2.9)	0.6 (1.1)	79.9 (24.3)	317.6 (48.6)	465.8 (63.9)	564028.9 (132446.3)
Brazil (São Paulo)	217	39.2	10.5 (0.5)	19.9 (4.8)	1.0 (1.5)	74.1 (28.0)	347.4 (53.9)	495.4 (78.5)	536820.8 (147588.2)
Canada (Ottawa)	213	44.1	10.5 (0.4)	18.5 (3.4)	0.6 (1.2)	72.2 (20.8)	318.7 (43.6)	500.8 (66.7)	513246.8 (105426.6)
China (Tianjin)	258	31.4	9.9 (0.5)	19.8 (4.5)	1.1 (1.6)	50.9 (17.6)	307.5 (56.9)	569.1 (72.1)	401917.5 (98427.1)
Colombia (Bogotá)	422	69.4	10.5 (0.6)	17.8 (2.6)	0.3 (1.1)	79.3 (27.4)	344.4 (51.1)	502.5 (71.1)	549247.5 (138015.7)
Finland (Helsinki, Espoo & Vantaa)	218	76.2	10.5 (0.4)	17.6 (2.5)	0.3 (1.1)	85.8 (29.2)	303.0 (44.1)	528.1 (73.0)	578639.7 (156260.4)
India (Bangalore)	249	7.2	10.4 (0.5)	17.6 (3.3)	0.1 (1.5)	62.0 (20.0)	356.1 (51.5)	497.0 (64.1)	489561.4 (104436.9)
Kenya (Nairobi)	230	48.3	10.2 (0.7)	17.1 (2.8)	0.02 (1.2)	78.9 (31.1)	328.6 (56.6)	507.0 (78.6)	546932.8 (147917.5)
Portugal (Porto)	269	29.7	10.4 (0.2)	19.3 (3.3)	1.0 (1.2)	73.6 (24.6)	310.6 (50.8)	539.2 (69.3)	507698.7 (122343.3)
South Africa (Cape Town)	159	52.2	10.3 (0.7)	17.8 (3.3)	0.3 (1.3)	73.6 (25.9)	320.9 (54.0)	495.6 (72.4)	524922.9 (131996.5)
United Kingdom (Bath & NE Somerset)	185	66.0	10.9 (0.4)	18.1 (2.6)	0.4 (1.0)	76.7 (24.8)	289.7 (46.5)	496.1 (63.0)	526362.0 (131745.9)
United States (Baton Rouge)	195	8.7	10.0 (0.6)	18.5 (3.3)	0.7 (1.3)	54.1 (18.0)	318.0 (54.6)	533.9 (65.4)	439918.9 (107853.4)
All Sites	2835	43.1	10.4 (0.6)	18.4 (3.4)	0.5 (1.3)	72.0 (26.8)	324.0 (54.5)	511.8 (74.7)	515841.0 (137393.5)
Girls									
Australia (Adelaide)	258	27.9	10.7 (0.4)	19.0 (3.5)	0.6 (1.1)	59.9 (19.8)	308.4 (49.1)	489.5 (59.2)	473728.8 (119392.7)
Brazil (São Paulo)	228	41.2	10.4 (0.5)	19.7 (4.3)	0.8 (1.3)	49.6 (19.4)	336.3 (55.8)	519.2 (67.5)	418194.0 (108757.1)
Canada (Ottawa)	304	29.9	10.5 (0.4)	18.2 (3.3)	0.3 (1.2)	55.1 (18.3)	308.1 (47.2)	516.3 (63.5)	439736.4 (100951.3)
China (Tianjin)	238	34.0	9.8 (0.4)	18.0 (3.6)	0.3 (1.3)	41.6 (15.1)	281.9 (57.1)	598.8 (72.2)	345893.1 (89348.4)
Colombia (Bogotá)	434	75.6	10.4 (0.6)	17.4 (2.4)	0.1 (1.0)	62.3 (21.5)	333.7 (53.0)	526.4 (70.0)	470448.4 (111298.7)
Finland (Helsinki, Espoo & Vantaa)	252	81.0	10.5 (0.4)	17.9 (2.7)	0.2 (1.0)	66.3 (21.6)	295.9 (46.7)	541.4 (65.3)	486068.3 (131095.2)
India (Bangalore)	297	3.7	10.4 (0.5)	18.2 (3.3)	0.3 (1.3)	38.9 (14.8)	336.1 (53.5)	556.3 (67.0)	370217.0 (89399.1)
Kenya (Nairobi)	266	41.7	10.2 (0.7)	17.3 (3.3)	-0.02 (1.2)	63.0 (30.8)	329.2 (61.5)	521.1 (72.5)	481052.9 (151122.6)
Portugal (Porto)	349	27.5	10.4 (0.3)	19.4 (3.4)	0.8 (1.1)	50.5 (16.6)	301.3 (52.8)	571.3 (60.1)	399559.8 (89138.0)
South Africa (Cape Town)	241	62.7	10.2 (0.7)	18.3 (3.8)	0.4 (1.3)	57.1 (22.6)	319.2 (56.9)	515.5 (64.5)	457427.3 (123594.2)
United Kingdom (Bath & NE Somerset)	243	63.8	10.9 (0.5)	18.7 (3.2)	0.4 (1.1)	59.2 (18.7)	288.3 (47.6)	506.9 (57.3)	444690.1 (100906.2)
United States (Baton Rouge)	279	7.9	9.8 (0.5)	19.0 (4.0)	0.7 (1.3)	42.8 (15.4)	306.9 (53.8)	550.5 (64.4)	385268.2 (100745.5)
All Sites	3389	41.8	10.4 (0.6)	18.4 (3.5)	0.4 (1.2)	54.1 (21.7)	313.2 (55.8)	535.0 (71.3)	431804.9 (118704.3)

BMI: Body Mass Index; MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; SED: Sedentary Time

[a]Weekday (Monday through Friday) average

Table 2. Adjusted mean[a] minutes of weekday moderate-to-vigorous physical activity (MVPA), light physical activity (LPA), sedentary time (SED), and total activity counts by active transportation status and gender among 6 224 9-11 year old children.

	Boys		Girls	
Active Transportation	Yes	No	Yes	No
MVPA, min/day	77.1 (75.1-79.1)	70.4 (68.8-72.0)***	58.1 (56.7-59.6)	53.2 (52.0-54.3)***
Before School	8.8 (8.3-9.2)	6.1 (5.7-6.4)***	7.1 (6.8-7.4)	5.0 (4.7-5.2)***
During School	32.3 (31.4-33.2)	30.6 (29.9-31.4)*	22.0 (21.3-22.6)	21.3 (20.8-21.8)
After School	36.2 (34.9-37.6)	33.8 (32.7-34.9)*	29.0 (28.0-30.0)	26.8 (26.1-27.6)**
LPA, min/day	320.7 (316.6-324.9)	326.3 (323.0-329.7)*	310.7 (306.6-314.8)	319.0 (316.0-322.0)**
Before School	35.9 (35.1-36.7)	38.5 (37.9-39.2)***	36.1 (35.3-36.8)	38.8 (38.2-39.4)***
During School	138.6 (136.3-140.9)	140.2 (138.4-142.1)	125.4 (123.1-127.6)	128.5 (126.8-130.1)*
After School	147.9 (146.1-149.7)	147.5 (145.6-149.3)	148.9 (146.7-151.2)	151.7 (150.1-153.4)*
SED, min/day	509.8 (504.7-515.0)	510.9 (506.8-515.1)	533.5 (528.7-538.3)	530.2 (526.7-533.7)
Before School	54.7 (53.7-55.7)	54.8 (54.0-55.6)	56.6 (55.7-57.5)	56.0 (55.3-56.6)
During School	223.7 (221.0-226.5)	223.8 (221.6-226.0)	242.1 (239.5-244.6)	239.6 (237.8-241.5)
After School	230.7 (227.7-233.7)	231.9 (229.5-234.3)	235.3 (232.5-238.1)	234.7 (232.6-236.8)
Total Activity, counts/day	536816 (526375-547258)	513420 (504991-521849)**	449700 (441270-458131)	433500 (427275-439725)*
Before School	58551 (56519-60583)	49463 (47815-51110)***	51308 (49748-52868)	44619 (43465-45773)***
During School	226377 (221540-231214)	220347 (216433-224261)*	173113 (169291-176934)	171169 (168340-173997)
After School	253150 (246040-260260)	244356 (238618-250094)*	224823 (218999-230647)	217264 (212953-221576)*

MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; SED: Sedentary Time

[a]Multi-level models with site and school nested within site treated as fixed effects; adjusted for age, BMI z-score, highest parental education level, mean accelerometer wear time, and site by active transportation interaction.

Data shown as adjusted mean (95% confidence interval).

***p<0.0001; **p<0.001; *p<0.05

Figure 1. The difference in mean school day moderate-to-vigorous physical activity (MVPA) among children who engage in active school transport (AST) compared to motorized transport to school in N=6 224 9-11 year old children. Means are adjusted for sex, BMI z-score, age, highest parental educational attainment, accelerometer waking wear time, site by AST interaction, and school nested within site was treated as a fixed effect in the multilevel analysis. Error bars represent 95% confidence intervals.

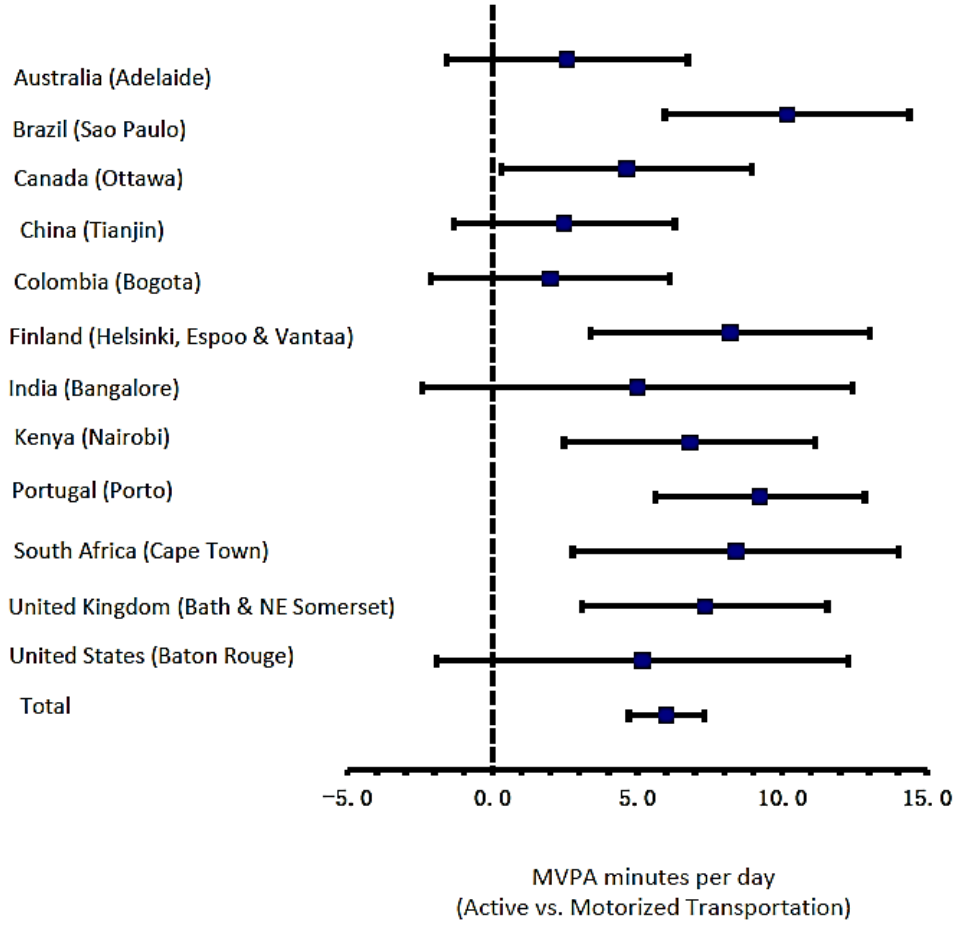

Figure 2. Associations between active school transport (AST) and obtaining at least 60 minutes of moderate-to-vigorous physical activity (MVPA) per school day in N=6 224 9-11 year old children from 12 countries. Odds ratios are adjusted for sex, BMI z-score, age, highest parental educational attainment, accelerometer waking wear time, site by AST interaction, and school nested within site was treated as a fixed effect in the multilevel analysis. Error bars represent 95% confidence intervals.