



Review

Active school transport, physical activity levels and body weight of children and youth: A systematic review

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ABSTRACT

Objectives. Active school transport (AST) may be an important source of children's physical activity (PA). Innovative solutions that increase PA time for children, without putting added pressure on the school curriculum, merit consideration. Before implementing such solutions, it is important to demonstrate that active school transport is associated with health-related outcomes.

Methods. Following a standardized protocol, we conducted a systematic review of published research to address this question and explore whether children who actively commute to school also have a healthier body weight. Online searches of 5 electronic databases were conducted. Potential studies were screened on the basis of objective measures of physical activity.

Results. Thirteen studies were included in this review. Nine studies demonstrated that children who actively commute to school accumulate significantly more PA and two studies reported that they expended significantly more kilocalories per day. Where studies examined body weight ($n=10$), only one reported active commuters having a lower body weight.

Conclusions. These studies demonstrate that active school commuters tend to be more physically active overall than passive commuters. However, evidence for the impact of AST in promoting healthy body weights for children and youth is not compelling.

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Introduction

Importantly, for youth, as time spent on physical activity in school declines (e.g., Faulkner et al., 2007; Dwyer et al., 2006) non-curricular opportunities for increasing physical activity are increasingly drawn

into focus (Jago and Baranowski, 2004). In this regard, active school transport (AST; walking, cycling, and other forms of non-motorized personal mobility) may be an important and consistent utilitarian source of physical activity. Given that physical activity declines through adolescence, and that lifelong physical activity patterns are established in childhood, encouraging active commuting at a young age could also be beneficial, in other ways, over the long-term. As Roberts (1996) suggested, "it may be unrealistic to expect the

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chauffeured children of today to become the ambulant adults of tomorrow". Transportation scholars have acknowledged this path-dependency in travel behaviour, arguing for early childhood intervention as an approach to achieving long term sustainable transport practices (Garrison, 2007; Wellar, 2007). Engaging in AST then, may develop into persistent environmentally sustainable travel practices through time (Evenson et al., 2003; Black et al. 2001), speculatively giving rise to acute and longer term improvements in health status (TRB, 2005; Frumkin et al. 2004), and lead to increased participation in physical activity later in life (Frank et al. 2003).

However, in Canada, over half of children aged 5–17 rely solely on inactive modes of transportation to and from school (Craig et al., 2001). Research consistently demonstrates declining prevalence of AST in the US (McDonald, 2007), Australia (van der Ploeg et al., 2008), and the UK (Black et al., 2001). The Ontario (Canada) Government's Active 2010 strategy paper (Ministry of Health Promotion, 2005) encourages children and youth to walk or cycle to school, as a part of its goal to "enhance opportunities for Ontarians to participate in daily physical activities". The Ontario Professional Planners Institute (OPPI)'s position paper on healthy communities argues that the absence of built environments that facilitate walking to school, and the general decline in the use of active modes (e.g., cycling, walking) partially contributes to obesity in children and youth (OPPI, 2007). The assumption here is that active school transport can be an important source of children's physical activity and promote healthy body weights (Tudor-Locke et al., 2001), and that when framed as a policy outcome, there is potentially some utility in designing urban environments that support the use of active modes. Before implementing strategies to promote AST, that are likely to be complex, contested, politicized and in some measure focused on individuals, households, and the built environment, it is important to demonstrate that AST associates with and influences positive health-related outcomes. This paper focuses on this last issue by examining two research questions: (1) are children who actively commute to school more physically active than children who travel by motorized transport? and (2) do children who actively commute to school (also) have a healthier body weight than passive commuting children?

Method

Following a standardized protocol (see Chalmers and Altman, 1995), we conducted a systematic review of published research to gather evidence concerning the two research questions. Online searches of the following electronic databases were conducted: Sport Discus (1975–6/2008), MEDLINE (1996–6/2008), Web of Science (1945–6/2008), Google Scholar, and Pro Quest Dissertations and Theses – Full Text (1861–2007). Search keywords included: "active", "school*", "transport*", "commuting", "child*", "adolescents", "youth", "non-leisure physical activity", "physical activity", "middle school", "cycling", "walking", "exercise", and "obesity". One hundred and twenty-four articles were identified as potentially relevant. The reference lists of all retrieved articles were inspected to identify additional relevant literature. For the purpose of this review, articles were screened based on the following inclusion criteria: First, the study had to examine active school transportation among children and youth (ages of 5–18). Second, the study had to include an objective measure of physical activity (e.g., pedometers or accelerometers). Third, studies which examined body weights/BMI had to have an objective measure of body weight/BMI. There were no limits on the publication date or research design although the search was limited to published studies in the English language.

Fifteen studies were initially considered for inclusion in this review. One study was excluded as it did not directly address the research questions (Mackett et al., 2005). A second study was excluded (Wilkin et al., 2006) as it included data previously reported elsewhere (Metcalf et al., 2004). Ultimately, thirteen studies were

included and data were extracted in terms of sample and location, age of participants, sampling, physical activity and body weight or composition measures, AST classification, and primary significant differences in physical activity measures (see Table 1). Given the heterogeneity of study design, a narrative review of the findings is presented.

Results

Description of studies

Included studies were primarily European ($n=7$) with three studies in the USA and one each in the Philippines, Australia and New Zealand. Nine studies focused exclusively on elementary school children (age range from 5 to 12 years) and all but two studies (Saksvig et al., 2007; Duncan et al., 2008) included male and female students. Most studies explicitly sampled on the basis of location typically in terms of broad classifications such as urban, suburban or rural (Sirard et al., 2005), socioeconomic status (Cooper et al., 2003, 2005; Sirard et al., 2005; Metcalf et al., 2004) or both (Cooper et al., 2006; Tudor-Locke et al., 2003). All but one study was cross-sectional, so causal relationships between active school transport and health-related outcome measures cannot be inferred. One study was prospective in nature (Rosenberg et al., 2006) although physical activity was only assessed at baseline.

The MTI (model 7164) accelerometer was most commonly used to assess physical activity. Four days of activity monitoring are required to provide a reliable estimate of physical activity (Trost et al., 2000) – in our review, two studies only monitored for one day (Rosenberg et al., 2006; Tudor-Locke et al., 2003). Additionally, there was variation in how researchers calculated and reported physical activity [e.g. mean accelerometer count ($\times 10^5$) reported by Metcalf et al. (2004), accelerometer counts/min accumulated (Cooper et al., 2003), or counts/hour (Rosenberg et al., 2006) or energy expenditure in kcal/day (Tudor-Locke et al., 2003)]. In addition, minutes of Moderate to Vigorous Physical Activity (MVPA), which might be a more appropriate effect measure of active school transport was not provided in some studies (e.g., Ford et al. 2007; Metcalf et al., 2004). Studies objectively assessing weight commonly reported body mass index (BMI) but some studies also collected skinfold measurements (Cooper et al., 2006; Metcalf et al., 2004; Rosenberg et al., 2006). One study assessed body composition using air displacement plethysmography (Ford, Bailey, Coleman, Woolf-May, and Swaine, 2007).

There was often a lack of detail in the included studies concerning how participants were classified as being active or passive school commuters. Generally, studies tended to ask for 'usual mode of travel to/from school'. In some cases, when children/youth returned home from school in a different way than they travelled to school, they were classified as active commuters (e.g., Cooper et al., 2003; Cooper et al., 2006). One study in the Philippines assumed the return trip was the same as the outward trip (Tudor-Locke et al., 2003). Several studies provided cutoff points such as walking/bicycling to school on at least 5 commutes per week (Sirard et al., 2005) or 4–5 days per week of active travel (Rosenberg et al., 2006). One study specified some detail in classifying active school commuters in terms of incorporating both the to and from school journeys, duration (>10 min each trip), frequency (>3 times/week), and history (>15 weeks) (Ford et al., 2007).

Are children and youth who actively commute to school more physically active?

The first objective of this review is to examine the relationship between school travel mode and objectively measured levels of physical activity. Overall, eleven of thirteen studies demonstrated evidence that children and youth who are classified as active school commuters (most commonly walking) are more physically active than

Table 1

Studies included in the systematic review of the relation of active school transport to physical activity and body weight of children and youth

Author (date)	Sample	Age (mean)	Sampling	Physical activity measure	Weight/body composition measures	AST classification	Differences in physical activity
Alexander et al. (2005)	92 adolescents Edinburgh, Scotland	13.8±0.27 years	Convenience sampling of 4 schools	MTI (3–5 days)	Not assessed	Travel to/from school (motorized both ways/walk one way/walk both ways)	AST>PST 25.9 min MVPA daily on weekdays for children walking both ways.
Cooper et al. (2003)	114 children Bristol, England	10.4±0.8 years	Sampled 5 urban schools from different SES areas	MTI (7 days)	Assessed — no difference (data not reported)	Usual travel to/from school (car/cycle/bus/walk)	AST>PST for boys only 20.5 min MVPA daily on weekdays. No difference on weekends.
Cooper et al. (2005)	323 children Odense, Denmark	9.7±0.4 years	Random sampling of 25 schools from different SES areas	MTI (at least 4 days)	Assessed — no difference (data not reported)	Usual travel to/from school (car or motorcycle/bus or train/by bicycle/ on foot)	AST>PST 37.4 min MVPA daily (walking); 10.5 min MVPA daily (cycling). No differences on weekends.
Cooper et al. (2006)	529 children; 390 adolescents Odense, Denmark	Children: 9.7 years±0.5; adolescents: 15.5 years±0.4	Proportional two-stage cluster sample of children from 25 schools stratified by SES and location (urban, suburban, rural)	MTI (at least 4 days). Cycle ergometer test	Assessed — no difference (data not reported)	Usual travel to/from school (car or motorcycle/bus or train/by bicycle/ on foot)	AST>PST for female children who walked only Higher MVPA for walkers and cyclists although not significant. Absolute fitness levels in those who cycled consistently higher than PST or walkers.
Duncan et al. (2008)	1513 girls Auckland, New Zealand	11.58±2.77 years (5–16 years)	Participants randomly selected from 39 schools. Ethnicity and SES examined.	New Lifestyles NL-2000 pedometer (five days)	Not assessed	Usual travel to/from school	AST>PST Girls using AST both ways averaged significantly more weekday steps (1,052) after adjustment for SES, school year, and ethnicity.
Ford et al. (2007)	239 children Southeastern England	8.1±2.0 years	Convenience sampling of 2 schools	MTI (at least 5 days).	Assessed — no difference % body fat: AST=16.4; PST=16.2	Walk to and from school for a period > 10 min, more than 3/week for > 15 weeks	AST>PST No difference between AST (607.2±169.7 activity counts/min) and PST (604.8±169.9 activity counts/min) in daily activity levels.
Loucaides and Jago (2008)	247 children Lemesos, Cyprus	11.1 years	Convenience sampling of 3 urban schools	Yamax Digiwalker (SW-200) pedometer (4 days)	Assessed — differences and data not reported	Usual mode of transport (walk or car)	AST>PST Children who walked to school had significantly higher step counts over the day (14,710) than those using motorized transport (12,795).
Metcalfe et al. (2004)	275 children Plymouth, England	5 years	Convenience sampling of 53 urban schools	MTI (7 days)	Assessed — no difference BMI: AST=16.1; PST=16.2	Usual mode of transport.	AST=PST No difference between AST (4.9±1.41 counts/time period) and PST (4.2±1.19) in total weekly activity.
Michaud-Tomson et al. (2003)	491 children Queensland, Australia	4–7th grade	Convenience sampling of 2 schools	Yamax Digiwalker (SW-200) pedometer (4 days)	Not assessed	Previous day mode of transport to school	AST>PST Boys and girls who walked to school averaged significantly more steps per day (16,045) than those travelling by bus/car (12,579)
Rosenberg et al. (2006)	594 children at baseline Southern California, USA	4–5 th grade	Convenience sampling of 7 suburban schools	Caltrac (1 day)	Assessed — BMI: AST=17.55; PST=17.75. AST over 2 years not associated with BMI change or overweight status.	4–5 days/week active travel (walking, biking/skateboarding).	AST>PST for boys only 0.78 Caltrac counts per hour difference for boys.
Saksvig et al. (2007)	1596 girls Arizona; Maryland, Minnesota, Louisiana, California; South Carolina, USA	12±0.5 years	Random selection of participants from 36 mostly suburban schools	MTI (6 days)	Assessed — no difference (data not reported).	Travel by walking on 1 or more weekdays before/after school. No specific question on transportation.	AST>PST 13.7 more minutes of total physical activity and 4.7 min MVPA daily on weekdays.
Sirard et al. (2005)	219 children South Carolina, USA	10.3 years±0.6	Random sampling of 8 urban and suburban schools	MTI (7 days)	Assessed — no difference BMI: Regular AST=19.5; PST=20.3.	Walk/bicycle on at least 5 commutes/week, 1–4 commutes/week, and motorized transport every commute.	AST>PST Estimated 24 min MVPA daily on weekdays. No difference on weekends.
Tudor-Locke et al. (2003)	1518 adolescents Cebu, Philippines	14–16 years	Community based survey randomly sampling 33 urban or rural communities	Caltrac (1 day)	Assessed — no difference BMI: AST=18.4; PST=18.9.	Usual travel — walk, bicycle, motorized, combination of walk and motorized.	AST>PST 38.7 kcal day ⁻¹ difference between walking and motorized transport modes.

SES: socio-economic status; BE: built environment; AST: active school transport; PST: passive school transport; MVPA: moderate to vigorous minutes of physical activity; BMI: body mass index.

those who take motorized transport with one study showing that cyclists were physically fitter than those who walked or passively commuted (Cooper et al., 2006). Given the different methods of sampling and data collection, and variation in how children are classified as participating in active school transport, it is difficult to explain the two studies reporting no differences although notably both studies were conducted in England. The study with the youngest sample, 5 year old children, did not find any differences in overall physical activity based on usual school travel mode (Metcalf et al., 2004). The second study found no differences in daily activity levels of 5–11 year old children on the basis of travel mode which held when analyses were conducted based on gender and age (Ford et al., 2007).

In terms of physical activity related measures, six of ten accelerometry studies (Cooper et al., 2003, 2005, 2006; Rosenberg et al., 2006; Saksvig et al., 2007; Sirard et al., 2005) demonstrated that children who actively commute to school accumulated a significantly greater volume of PA, as measured in accelerometer counts per minute or hour compared to passive commuters; five studies (Alexander et al., 2005; Cooper et al., 2003, 2005; Saksvig et al., 2007; Sirard et al., 2005) also reported that active commuters accumulated more minutes of moderate or vigorous physical activity (MVPA) compared to passive commuters; and two studies (Saksvig et al., 2007; Tudor-Locke et al., 2003) reported that active commuters expended significantly more kilocalories per day compared to their non-active counterparts. Three studies found active school commuters accumulated a greater number of step counts (Michaud-Tomson et al., 2003; Loucaides and Jago, 2008; Duncan et al., 2008). Duncan et al. (2008) reported significant interactions for ethnicity and school year group. Older girls achieved more steps and Maori and European girls averaged greater steps than girls from the same ethnicity. In contrast, three studies in the United States reported analyses controlling for race or ethnicity and reported no significant differences in the dependent variables (Rosenberg et al., 2006; Saksvig et al., 2007; Sirard et al., 2005).

Reporting minutes of MVPA provide one useful common outcome for comparing results across studies. Four studies demonstrated at least 20 minute difference in daily MVPA between active and passive school commuters. For example, Sirard et al. (2005) found that active commuters recorded 8.5% more minutes in MVPA before school, and 8.5% more minutes after school. This difference in total time spent in MVPA translated to approximately 24 additional minutes of MVPA per day for the regular active commuters. Cooper et al. (2005) reported that boys and girls recorded 34 and 40 more minutes of MVPA per day respectively by walking, and that boys recorded 27.5 more minutes of MVPA by cycling. They noted that the actual journey to school (recorded between 7 am and 8 am) contributed 3.5 min, and that this difference between active and non-active commuters was statistically significant.

Two studies reported modest differences in total MVPA (Cooper et al., 2006; Saksvig et al., 2007). For example, Saksvig et al. (2007) found that on an average weekday, girls who reported travel by walking before and after school had 13.7 more minutes of total PA and 4.7 more minutes of MVPA throughout the day than girls who did not. These girls had significantly higher levels of total PA and MVPA before school, before and after school, and for an entire day, compared to girls who did not. With regard to the actual commute to school, active commuters accumulated 1.4 additional minutes of MVPA before, and 2.1 additional minutes after school compared to non-active commuters.

It may be that children and youth who actively commute to school are more physically active in general. That is, active children tend to walk or cycle to school. However, included studies that examined physical activity patterns on the weekend consistently revealed no significant difference in activity levels between active and non-active school commuters on weekends (e.g., Cooper et al., 2003; 2005; Sirard et al., 2005; Duncan et al., 2008). This suggests a potential mediating

role of AST in increasing physical activity levels in children. In contrast, Michaud-Tomson et al. (2003) reported that children who walked to school were also significantly more likely to play sport.

There was some evidence to suggest that age and gender may also moderate the positive relationship between AST and physical activity levels. In terms of age, there was no relationship between age and PA level for the youngest children (5 year age; Metcalf et al., 2004) and for older adolescents (15.5 years; Cooper et al., 2006). In terms of gender, several studies found that the relationship held only for boys (Cooper et al., 2003; Rosenberg et al., 2006). In contrast, findings reported by Cooper et al. (2006) demonstrated a positive relationship between AST and physical activity for girls only. In other words, there are conflicting findings in the literature regarding the relationship between AST participation, physical activity, gender, and age. Although socioeconomic status and broad built environment characteristics were often considered in participant and school sampling, not all studies stratified their analyses based on these variables. Where reported, socioeconomic status (Cooper et al., 2005; Duncan et al., 2008; Metcalf et al., 2004) or level of urbanization (Sirard et al., 2005) did not alter main findings.

Do children and youth who actively commute to school have lower bodyweight and/or BMI?

The second objective of this review is to examine whether children who commute to school by active modes have healthier body weight and/or lower BMI than their non-active commuting counterparts. Ten of the thirteen studies examined differences in body weight/BMI or body composition among active and passive commuters, and only one study reported a difference on the basis of travel mode. In their prospective study, Rosenberg et al. (2006) reported that although active commuting boys had significantly lower BMI than their passive counterparts, active commuting to school over 2 years was not associated with BMI change or overweight status. The remaining studies did not find any difference in body weight/BMI between active and passive commuters. Indeed, Loucaides and Jago (2008) found significant interactions between weight status and travel mode such that only overweight children who walked to school were more active during the whole day in comparison to overweight children who were driven to school.

Discussion

The data compiled in this review supports the hypothesis that active transportation to school supplements overall physical activity levels among children. There is consistent evidence that children who actively commute to school report significantly higher levels of PA, as measured by accelerometer counts per minute, minutes of activity at all intensities, pedometer steps, and energy expenditure, than those who travel by motorized transport. The cross-sectional nature of existing research prevents detection of a causal relationship between AST and PA. There are also conceptual and empirical difficulties related to the endogeneity of the processes under study. It is difficult to determine, using the cited literature, the extent to which the findings are an artifact of “more active” children choosing active modes, or simply that AST causes children to be more active overall. Some evidence that there are no differences in activity levels on weekends between children who actively or passively commute to school during the week provides tentative evidence for the latter. Isolating the effect of urban design correlates (e.g., children making travel choices within a supportive built environment) on the AST-physical activity relationships described here is also problematic. The causal mechanisms leading to higher levels of physical activity could, for some households, begin to take shape several decisions prior to the school travel mode decision. For example, the well-known self-selection problem, discussed widely in the planning and transportation engineering

literatures, suggests that households favoring the use of active modes will, in the presence of the required capital, select themselves into supportive built environments (TRB 2005; Boarnet and Crane, 2001). Surprisingly little information is provided in the reported studies linking the geographic context of the study sample with the reported results and this remains a future research priority.

Sirard et al. (2005) emphasized the need for more experimental interventions to examine the change in children's physical activity levels which result from incorporating active modes of transportation. Additionally, longitudinal studies are needed to determine the effect of AST on current and future PA levels, other health outcomes, attitudes, beliefs, and enjoyment of overall physical activity. Coupled with the transition to longitudinal analysis, attention should be given to standardizing protocols for the classification of children and youth as "active" or "passive" commuters. Differences across studies in measuring AST frequency complicate comparative analysis. Little attention has been given to the issue of developing a standardized protocol for identifying active versus passive school commuters. It is also difficult to identify within the cited studies, the extent to which AST behaviour persists across schooldays. Measurement issues influence the reporting of active commuting rates which is a key performance indicator for school travel planning. The absence of greater temporal precision (one day, five-days) in measuring the use of active modes also limits current understanding of the contribution of utilitarian AST behaviour to overall levels of physical activity. Moreover, the time-varying quality of AST should be of interest because school and/or city planning interventions could have both desirable and undesirable outcomes across schooldays as household travel demand, for other activities, ebbs and flows throughout the week (see Buliung et al., 2008). Similarly, the results reported by Duncan et al. (2008) highlight that relationships between physical activity levels and transport modes may vary within and across demographic subgroups. AST initiatives may need to be tailored accordingly.

With respect to age, there may be little impact of AST on the activity levels of very young children. Very young children may live closer to their elementary schools, or be only allowed to walk to school when the school is located close to home, or if a parent, guardian or sibling accompanies them to school. In the Metcalf et al. (2004) study, the median time taken to walk to school was 6 min and the median distance was 0.7 km for five year old children. Despite regular active commutes, however, short distances may prevent children from experiencing a significant increase in physical activity derived through active school transport. The literature on childhood autonomy tends to support the hypothesis that adults and older youth will typically enable the mobility of very young children, and that the autonomous mobility of children typically increases with age (Johansson, 2006). Notably, however, progress toward autonomous mobility has been found to evolve unevenly across space (regional, and international variation), and across male and female children and youth (Johansson, 2006; Horelli, 2001; Prezza et al. 2001; Spencer and Woolley, 2000).

Some studies included in this review suggest that the relationship between AST and PA levels may be moderated by gender differences, but the results are far from conclusive (i.e., Cooper et al., 2003, 2005; Cooper et al., 2006; Rosenberg et al., 2006). Further research is required in addressing how the school travel mode choice is experienced by boys and girls, the possibility exists that this process simply varies across the sexes in certain places (e.g., schools, cities, neighbourhoods) and not in others. Researchers have also speculated that differences in overall physical activity levels may be related to the different types of play that boys and girls engage in during the school day, and that participation in organized physical activity is lower for girls than for boys (e.g., Faulkner et al., 2007). There is much research that demonstrates how young people's physical activity, sport and leisure experiences are gendered and that gender differences in physical activity are mediated by ethnicity and socio-economic status (Evans et al., 2004). Few studies explicitly examined the impact of active commuting among children from varying

socioeconomic and ethnic groups, and from different types of suburban, urban or rural settings. In the reported research, participants were often represented as relatively homogenous, and there was little attention paid to the broader social determinants of physical activity that operate in particular environments (see Dovey, 1999) or to the intersections between young people's health concerns and wider social agendas (Davis and Jones, 1996). People are constrained by the kinds of physical activity and leisure spaces they encounter (e.g., Shogan, 2002), and children in particular experience different challenges in their use of and access to physical activity and leisure environments (Wilson et al., 2001). The development of AST research and policy initiatives cannot afford to ignore these salient factors.

There was little evidence to suggest a relationship between active transportation to school and healthier body weight/BMI among children. The studies including measures of body weight/BMI reveal that the difference in body weight/BMI between active and passive commuters was seldom significant and not supported in the long term. For example, Cooper et al. (2003) found that of those who walked to school, 42% had a journey of less than 5 min, while the majority (82%) had a walk of less than 15 min. Reasons for the weak link between ATS and healthy body weight/BMI, therefore, may relate to the distance to school; children who commuted actively were likely to live too close to realize changes in body weight, and children who lived farther than 0.75 km of the school were less likely to walk. This amount of physical activity may not be enough to counteract a chronic positive energy balance (Heelan et al., 2005). In addition to short walking trip durations which may be of low to moderate intensity, current approaches to the classification of respondents to the "active" or "passive" commuter categories could decrease the signal-to-noise ratio in associative empirical studies examining the relationship between AST and bodyweight/BMI. The inclusion of respondents commuting one-day per week using an active mode, in the active commuter category, could give rise to a larger variance for the anthropomorphic variables, than might be case where active commuters include only those individuals whose primary mode (3 or 5 times per week) involves self-locomotion. Alternatively, for children living close to school, AST may be the only travel choice for both healthy and overweight children. In the presence of the results of this systematic review, there is not sufficient evidence to suggest that AST policy and interventions be developed and promoted as a mechanism for achieving healthy body weights for children and youth. It may be that such benefits are not apparent until many years later if active commuting habits are maintained.

Overall, transport-related physical activity is an important focus of research and policy attention because it incorporates health and transport benefits (Badland and Schofield, 2005), while avoiding the direct production of harmful mobile source emissions (e.g., particulates, CO, NO_x, HC). A focus on active school transport is appropriate given that adequate participation in physical activity during childhood and adolescence could be critical to the prevention of chronic disease later in life. This review confirms that PA levels are higher among active commuters although evidence of the impact of AST on body weight is not compelling. These results have implications for policy makers in justifying and funding AST initiatives while research is required to assess how these initiatives promote AST and facilitate increases changes in daily physical activity. Whether such initiatives are cost-effective remains to be seen (Haby et al., 2006).

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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References

- Alexander, L.M., Inchley, J., Todd, J., Currie, D., Cooper, R., Currie, C., 2005. The broader impact of walking to school among adolescents: seven day accelerometry based study. *BMJ* 331, 1061–1082.
- Badland, H.M., Schofield, G.M., 2005. The built environment and transport-related physical activity: what we do and do not know. *JPAH* 2, 435–444.
- Black, C., Collins, A., Snell, M., 2001. Encouraging walking: the case of journey-to-school trips in compact urban areas. *Urban Stud.* 38, 1121–1141.
- Boarnet, M.G., Crane, R., 2001. *Travel by design: the influence of urban form on travel*. Oxford University Press, USA.
- Buliung, R.N., Roorda, M.J., Rummel, T., 2008. Exploring spatial variety in patterns of activity-travel behaviour: initial results from the Toronto Travel-Activity Panel Survey. *Transportation* 36, 697–722.
- Chalmers, I., Altman, D.G. (Eds.), 1995. *Systematic Reviews*. BMJ Publishing Group, London.
- Cooper, A.R., Page, A.S., Foster, L.J., Qahwaji, D., 2003. Commuting to school: are children who walk more physically active? *Am. J. Prev. Med.* 25, 273–276.
- Cooper, A.R., Anderson, L.B., Wedderkopp, N., Page, A.S., Froberg, K., 2005. Physical activity levels of children who walk, cycle, or are driven to school. *Am. J. Prev. Med.* 29, 179–184.
- Cooper, A.R., Wedderkopp, N., Wang, H., Andersen, L.B., Froberg, K., Page, A.S., 2006. Active travel to school and cardiovascular fitness in Danish children and adolescents. *Med. Sci. Sport. Exerc.* 38, 1724–1731.
- Craig, C.L., Cameron, C., Russell, S.J., Beaulieu, A., 2001. *Increasing Physical Activity: Supporting Children's Participation*. Canadian Fitness and Lifestyle Research Institute, Ottawa, Canada.
- Davis, A., Jones, L., 1996. Children in the urban environment: the issue for the new public health agenda. *J. Health Place* 2, 107–113.
- Dovey, K., 1999. *Framing Places: Mediating Power in the Built Form*. Routledge, London.
- Duncan, E.K., Duncan, J.S., Schofield, G., 2008. Pedometer-determined physical activity and active transport in girls. *IJBNPA* 5, 2 (11 January 2008).
- Dwyer, J.J., Allison, K.R., LeMoine, K.N., et al., 2006. A provincial study of opportunities for school-based physical activity in secondary schools. *J. Adolescent Health* 39, 80–86.
- Evans, J., Davies, B., Wright, J., 2004. *Body Knowledge and Control: Studies in the Sociology of Physical Education and Health*. London, Routledge.
- Evenson, K.R., Huston, S.L., McMillen, B.J., Bors, P., Ward, D.S., 2003. Statewide prevalence and correlates of walking and bicycling to school. *Arch. Pediatr. Adolesc. Med.* 157, 887–892.
- Faulkner, G., Adlaf, E., Irving, H., Allison, K., Dwyer, J., Goodman, J., 2007. Participation in high school physical education – Ontario, Canada, 1999–2005. *MMWR* 26, 52–54 (January).
- Ford, P., Bailey, R., Coleman, D., Woolf-May, K., Swaine, I., 2007. Activity levels, dietary energy intake, and body composition in children who walk to school. *Pediatr. Exerc. Sci.* 19, 393–407.
- Frank, L.D., Engelke, P.O., Schmid, T.L., 2003. *Health and Community Design: the Impact of the Built Environment on Physical Activity*. Island Press, Washington DC.
- Frumkin, H., Frank, L., Jackson, R., 2004. *Urban Sprawl and Public Health: Designing, Planning, and Building for Healthy Communities*. Island Press, Washington DC.
- Garrison, W., 2007. Increasing the flexibility of legacy systems. *Proceedings of the 2007 Anderson Lecture, Applied Geography Specialty Group, Annual Meeting of the Association of American Geographers*, San Francisco, CA.
- Haby, M.M., Vos, T., Carter, R., et al., 2006. A new approach to assessing the health benefit from obesity interventions in children and adolescents: the assessing cost-effectiveness in obesity project. *Int. J. Obesity* 30, 1463–1475.
- Heelan, K.A., Donnelly, J.E., Jacobsen, D.J., Mayo, M.S., Washburn, R., Greene, L., 2005. Active commuting to and from school and BMI in elementary school children: preliminary data. *Child Care Health Dev.* 31, 341–349.
- Horelli, L., 2001. A comparison of children's autonomous mobility and environmental participation in northern and southern Europe – the cases of Finland and Italy. *J. Community Appl. Soc.* 11, 451–455.
- Jago, R., Baranowski, T., 2004. Non-curricular approaches for increasing physical activity in youth: a review. *Prev. Med.* 39, 157–163.
- Johansson, M., 2006. Environment and parental factors as determinants of mode for children's leisure travel. *J. Environ. Psychol.* 26, 156–169.
- Loucaides, C.A., Jago, R., 2008. Differences in physical activity by gender, weight status, and travel mode to school in Cypriot children. *Prev. Med.* 47, 107–111.
- Mackett, R.L., Lucas, L., Paskins, J., Turbin, J., 2005. The therapeutic value of children's everyday travel. *Transport Res. A-Pol.* 39, 205–219.
- Metcalfe, B., Voss, L., Jeffery, A., Perkins, J., Wilkin, T., 2004. Physical activity cost of the school run: impact on schoolchildren of being driven to school (Earlybird 22). *BMJ* 329, 832–833.
- McDonald, N., 2007. Active transportation to school: trends among U.S. schoolchildren, 1969–2001. *Am. J. Prev. Med.* 32, 509–516.
- Michaud-Tomson, L., Davidson, M., Cuddihy, T.F., 2003. Walk to school: does it make a difference in children's physical activity levels? *ACHPER Health Life J.* 50, 16–24.
- Ministry of Health Promotion, 2005. *Active 2010: Ontario's Sport and Physical Activity Strategy*. Ministry of Health Promotion, Toronto, Ontario.
- Ontario Professional Planners Institute (OPPI), 2007. *Healthy Communities, Sustainable Communities: the 21st Century Planning Challenge*. OPPI, Toronto, Ontario.
- Prezza, M., Pilloni, S., Morabito, C., Sersante, C., Alparone, F.R., Giuliani, M.V., 2001. The influence of psychosocial and environmental factors on children's independent mobility and relationship to peer frequentation. *J. Community Appl. Soc.* 11, 435–450.
- Roberts, L., 1996. Children and sport: walking to school as future benefits. *BMJ* 312, 1229.
- Rosenberg, D.E., Sallis, J.F., Conway, T.L., Cain, K.L., McKenzie, T.L., 2006. Active transportation to school over 2 years in relation to weight status and physical activity. *Obes* 14, 1771–1776.
- Saksvig, B.L., Catellier, D.J., Pfeiffer, K., et al., 2007. Travel by walking before and after school and physical activity among adolescent girls. *Arch. Pediatr. Adolesc. Med.* 161, 153–158.
- Shogan, D., 2002. Characterizing constraints of leisure: a Foucaultian analysis of leisure constraints. *Leisure Stud.* 21, 27–28.
- Sirard, J.R., Riner Jr, W.F., McIver, K.L., Pate, R.R., 2005. Physical activity and active commuting to elementary school. *Med. Sci. Sport Exerc.* 37, 2062–2069.
- Spencer, C., Woolley, H., 2000. Children and the city: a summary of recent environmental psychology research. *Child Care Hlth. Devel.* 26, 181–198.
- Transportation Research Board, 2005. *Does the Built Environment Influence Physical Activity? Examining the Evidence*. Transportation Research Board, Washington DC.
- Trost, S.G., Pate, R.R., Freedson, P.S., Sallis, J.F., Taylor, W.C., 2000. Using objective physical activity measures with youth: how many days of monitoring are needed? *Med. Sci. Sport Exerc.* 32, 426–431.
- Tudor-Locke, C., Ainsworth, B.E., Popkin, B.M., 2001. Active commuting to school: an overlooked source of children's physical activity? *Sports Med.* 31, 309–313.
- Tudor-Locke, C., Ainsworth, B.E., Adair, L.S., Popkin, B.M., 2003. Objective physical activity of Filipino youth stratified for commuting mode to school. *Med. Sci. Sport Exerc.* 35, 465–471.
- van der Ploeg, H.P., Merom, D., Corpuz, G., Bauman, A.E., 2008. Trends in Australian children traveling to school 1971–2003: burning petrol or carbohydrates? *Prev. Med.* 46, 60–62.
- Wellar, B., 2007. Sustainable transport best practices and geography: making connections. *Text of the Fleming Lecture in Transportation, Transportation Geography Specialty Group, Annual Meeting of the Association of American Geographers*, San Francisco, CA.
- Wilkin, T.J., Mallam, K.M., Metcalf, B.S., Jeffery, A.N., Voss, L.D., 2006. Variation in physical activity lies with the child, not his environment: evidence for an 'activitystat' in young children (EarlyBird 16). *Int. J. Obes.* 30, 1050–1055.
- Wilson, B., White, P., Fisher, K., 2001. Multiple identities in a marginalized culture: female youth in an 'inner-city' recreation/drop-in center. *J. Sport Soc. Issues* 25, 301–323.