



Active transport, independent mobility and territorial range among children residing in disadvantaged areas



Alison Carver*, Jenny Veitch, Shannon Sahlqvist, David Crawford, Clare Hume

Centre for Physical Activity and Nutrition Research, School of Exercise and Nutrition Sciences, Deakin University, 221 Burwood Highway, Burwood, Victoria, Australia

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ABSTRACT

Regular physical activity during childhood and adolescence promotes physical and mental health across the lifespan. Walking and cycling for transport may be important, inexpensive and accessible sources of physical activity among socioeconomically disadvantaged youth. This study aimed to examine active transport and independent mobility (i.e. walking/cycling without adult accompaniment) on journeys to school and other local destinations, and their associations with children's physical activity in disadvantaged urban and rural areas of Victoria, Australia. In addition, associations were examined between children's perceived accessibility of local destinations by walking/cycling and their territorial range (i.e. how far they were allowed to roam without adult accompaniment).

Survey-reported active transport, independent mobility, territorial range, and objectively-measured physical activity were analysed for 271 children (mean age 12.1 (SD 2.2) years). Habitual travel modes (on 3 or more days/week) were examined. Car travel was most prevalent to (43%) and from (33%) school, while 25% walked to school, 31% walked home, and few cycled (6%). Most walking/cycling trips were made independently. Total weekly *duration* rather than frequency of active transport to school was positively associated with physical activity. No associations were found between independent mobility and physical activity. Territorial range was restricted – only a third of children were allowed to roam more than 15 min from home alone, while approximately half were allowed to do so with friends. The number of accessible destination types in the neighbourhood was positively associated with territorial range. This research provides evidence of how active transport contributes to children's physical activity and a preliminary understanding of children's independent mobility on journeys to school and local destinations. Further research is required to explore influences on these behaviours.

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1. Introduction

Regular physical activity during childhood and adolescence is beneficial for physical and mental health across the lifespan (Trost, 2005). However those living in neighbourhoods of low socioeconomic status (SES) (Brodersen et al., 2007; Ziviani et al., 2008) and those experiencing disadvantage at the family level (Woodfield et al., 2002; Lee and Cubbin, 2002) have been shown to participate in lower levels of physical activity compared with high SES children. Additionally, low SES children tend to engage less frequently in structured commercially-available programs, such as organised team sports, and tend to spend more of their leisure time at home compared to high SES children (Ziviani et al., 2008; The Smith Family, 2013). Active transport, such as walking or cycling to school and other destinations, may be a key source of habitual physical activity for all children (Tudor-Locke et al., 2001). Walking and cycling may be particularly important for socioeconomically disadvantaged youth, due to the low cost and accessibility of these activities (Humbert et al., 2006).

Children who engage in active transport alone or with other children rather than with their parents or other adults are considered to be independently mobile. More broadly, children's independent mobility refers to their freedom to move around their neighbourhood without adult accompaniment (Hillman et al., 1990). Children with greater independent mobility tend to spend more time walking, cycling and travelling by scooter, skateboard or rollerblades around their neighbourhood to reach places and have greater 'territorial range' allowing them to visit a broader range of destinations (Mackett et al., 2007). There has been little examination of children's territorial range in relation to the presence of appropriate walkable destinations such as parks or playgrounds within their neighbourhood. However, there is some

* Corresponding author. Tel.: +61 3 9244 6685; fax: +61 3 9244 6017.

E-mail address: alison.carver@deakin.edu.au (A. Carver).

evidence that the types of destination (e.g. friend's house, shops) perceived to be within walking or cycling distance from home are important for promoting adolescents' active transport (Giles-Corti et al., 2009).

A recent systematic review examined studies of children's active transport and/or independent mobility and their associations with physical activity (Schoeppe et al., 2013). In total, 27 out of 34 studies (79%) of active transport to school and physical activity levels reported positive associations between these variables (Schoeppe et al., 2013). Among those 34 studies one reported that for each additional day of active transport to school, there was more than a doubling of the odds of a child aged 8–15 years meeting physical activity recommendations on weekdays (Daly-Smith et al., 2011). However, none of the studies in that review examined whether a dose–response association (i.e. a direct association between a stimulus (dose) and a desired outcome (response)) existed between either the frequency or total duration of active school journeys made each week and children's overall physical activity levels (in this context, for example, the dose may be the number of active trips made per week while the outcome may be the total time spent being physically active). This research gap will be addressed by the current study. In addition, the systematic review described above (Schoeppe et al., 2013) identified only four studies that examined independent mobility and physical activity, but all reported positive associations between these variables (Mackett et al., 2007; Page et al., 2009; Wen et al., 2009; Floyd et al., 2011). The current study will contribute to knowledge on this under-researched topic.

When examining active transport and independent mobility among children who reside in socioeconomically disadvantaged areas, it is important to include those in rural as well as urban areas because residing in a rural area has been shown to be a risk factor for poor health (Australian Institute of Health and Welfare, 2005; U.S. Department of Health and Human Services, 2010). While most data on children's active transport have been gathered in urban rather than rural areas (Hume et al., 2009; Giles-Corti et al., 2011; Hinckson et al., 2011; Carver et al., 2010), one Australian study (Carver et al., 2012) reported higher rates of active transport and independent mobility on the school journey in urban areas compared with rural areas. However, there was no significant difference by location in children's independent mobility on the weekends. The disparities on the school journey were attributable in part to rural children being required to travel greater distances that were less conducive to active transport. In addition, free travel by school bus was provided in rural areas (Carver et al., 2012).

This study explored active transport to school, independent mobility on journeys to school and other local destinations, and their associations with physical activity among children residing in disadvantaged urban and rural areas. In addition, children's perceived accessibility of destinations within walking/cycling distance of home was examined in relation to how far they were allowed to roam without adult accompaniment (i.e. their territorial range).

2. Methods

2.1. Sample

The children in this study were originally recruited via their mothers' participation in a longitudinal study titled 'Resilience for Eating and Activity Despite Inequality (READI)', for which the baseline recruitment methods are described previously (Cleland et al., 2010; Ball et al., 2013). Briefly, women aged 18–45 years residing in 40 urban and 40 rural socioeconomically disadvantaged areas (ranked lowest based on a tertile split) were invited to participate in a postal survey on their dietary behaviours and physical activity. Areas classified as 'urban' in this study were: (a) metropolitan Melbourne; (b) rural cities (defined by the Australian Regional Infrastructure Development Fund Act 1999 (Version no. 003)) and all areas completely within a 10 km radius of the centroid of these cities and (c) areas completely within a 10 km radius of the centroid of other Victorian cities with a population of 20,000 or more. Areas classified as 'rural' were those located outside metropolitan Melbourne and outside a 25 km radius of the rural cities (Ball et al., 2013).

Of these women ($n=11,940$) who were randomly sampled from the electoral roll, 4934 consented to participate (41% response rate). Data collection took place between August 2007 and July 2008. Those with a child aged between 5 and 12 years ($n=1457$) were invited to complete a further questionnaire on their child's diet and physical activity. In total, data were collected for 636 children (44% of eligible children). In August 2010, these women and children (then aged 8–15 years) were re-contacted and invited to participate in a three-year follow-up study, in which the current study examining children's active transport and independent mobility was nested. Parental consent to participate in our study was obtained for 311 children (49% response rate). Ethical approval was obtained from the Deakin University Human Research Ethics Committee, the Catholic Education Office and the Department of Education and Early Childhood Development, Victoria.

2.2. Measures

While at school, children completed a questionnaire (via guided completion either one-on-one or in small groups with a trained research assistant) on their active transport and independent mobility on journeys to school and to other local destinations. The one-week test–retest reliability of selected key items (described below) was established in a separate study of 48 children aged 8–9 years in 2010. Distance from home to school was measured along the most direct route via the road network using a Geographical Information System (GIS), ArcMap 10 (ESRI, California, 2010) with Vicmap Address and Vicmap Transport 2010 databases (State Government of Victoria, 2010).

2.2.1. Active transport on the school journey

Children were asked to report how they usually travelled to and from school in a typical week. For each direction of the journey response options were: (1) 'walk'; (2) 'ride a bike'; (3) 'skateboard/scooter/rollerblade'; (4) 'public transport/school bus (excluding Walking School Bus)'; (5) 'by car (your family only)'; and (6) 'by car pool (with other families)'. It was possible to report multi-modal trips (e.g. trips that combined walking with public transport). In addition the children were asked to report the total number of trips made per week using each mode and the total time per week in minutes spent travelling using each mode. Test–retest reliability of the walking to school measure was moderate to good: frequency of walking to school, ICC=0.90; total weekly duration of walking to school, ICC=0.58. From these responses the number of active trips (i.e. walking, cycling, or by skateboard/scooter/rollerblade; maximum 10 trips) made between home and school each week and the total weekly duration of these active trips was computed. In addition, to examine *habitual* modes of transport, transport mode on three or more days per week was identified as this represents travel mode on most weekdays. Test–retest reliability was high for these measures of habitual modes of transport to and from school ($\kappa=0.77, 0.76$, respectively).

2.2.2. Independent mobility on the school journey

Children who used a particular active mode of transport on at least three days per week reported their level of accompaniment on these journeys to and from school. From their responses a score was derived for independent mobility in each direction of the school journey. Assigned values in parentheses were: (0) 'usually travels with an adult'; (1) 'usually travels with friend/sibling (no adults)'; (2) 'usually travels alone'. Values for journeys in each direction were summed to give a score for independent mobility on these active school journeys (with range of possible values 0–4). Test–retest reliability for this variable was substantial ($\kappa=0.61$).

2.2.3. Independent mobility on journeys to local (non-school) destinations

Children were asked which of the following four types of destinations were located within walking distance of home: friends' houses; sports or activity venues (e.g. walking tracks, skate parks, and tennis courts); parks/playgrounds; and shops. The total number of types of walkable destinations was computed (range of possible values was 0–4). Similarly, the number of types of cycleable destinations was computed.

For each destination type, those children who reported residing within walking distance were asked how often they usually walked to this venue (a) 'by myself'; (b) 'with parent/other adult (can include other children)'; and (c) 'with friends/siblings (no adults)'. Response options were: 'never'; 'rarely'; 'sometimes'; 'often'; and 'very often'. Each child scored one point for each type of destination to which he/she walked 'often' or 'very often' without adult accompaniment. The scores for each of the four types of destinations were summed to give a score for independent mobility when walking to local destinations. Because the number of walkable destinations in each child's neighbourhood varied, this score was then weighted by dividing it by the number of types of walkable destinations, and then multiplying this by 10 to give a value between 0 and 10. Similarly a weighted score was computed for independent mobility when cycling to local destinations. Test–retest reliability for this score was high (ICC=0.83).

2.2.4. Territorial range

Two survey items measured children's territorial range. Children were asked how far from home they were allowed to roam on their own. Response options were (1) 'I am not allowed out alone'; (2) 'within my street'; (3) 'within 2–3 streets away from home'; (4) 'within 15 min' walk from home'; and (5) 'more than 15 min' walk from home'. Similarly children were asked how far from home they were allowed to roam with friends (unaccompanied by an adult). Test–retest reliability for these variables was moderate ($\kappa=0.59$; 0.52 respectively)

2.2.5. Physical activity

Physical activity was objectively measured using a uni-axial accelerometer (Actigraph model 7164, Fort Walton Beach, Florida, USA) worn for an eight day period. Children were instructed to wear the hip-mounted accelerometer during all waking hours except when showering, swimming and engaging in other water-based activities. Data were downloaded according to manufacturer guidelines and processed using a customised Excel macro. Non-wear time was defined as sustained bouts of 20 min of zero counts, and was computed by summing the total duration of these periods of non-wear (Catellier et al., 2005). Data were included in analyses for each child who had recorded activity counts for at least eight hours per day on at least three weekdays. Using age-specific cut-points (Freedson et al., 1997) time spent engaged in moderate-to-vigorous intensity physical activity (MVPA; i.e. at least four METs (Trost et al., 2011)) was determined on weekdays (for analyses of journeys to school and local non-school destinations) and on weekend days (for analyses of journeys to local non-school destinations).

3. Data analyses

Analyses were conducted using SPSS v21 and Stata SE v12 for participants with valid survey and accelerometer data. Descriptive analyses were performed to examine travel modes to and from school (including comparison of modal choice to and from school), frequency and duration of active school journeys, independent mobility on journeys to school and local destinations, the number of destinations within perceived walking and cycling distance of home, and territorial range. Linear regression analyses were performed to examine how the following were associated with MVPA: active transport on the school journey; independent mobility on the school journey and when walking (or cycling) to local destinations. In addition, the number of types of walkable/cycleable destinations in the child's neighbourhood was examined in relation to their territorial range. All regression analyses were adjusted for age and sex of the child, as well as for location (urban/rural). Analyses that included objective physical activity data were adjusted for accelerometer wear-time and days worn, and analyses that focused on the school journey were adjusted for distance between home and school.

4. Results

Survey and accelerometer data were analysed for 271 children. While 311 children had completed the survey, 20 children had chosen not to wear the accelerometer, and a further 20 did not record valid data for at least three weekdays. Among these 271 children, the mean age was 12.1 (SD 2.2) years; almost half (45%) were boys and 69% resided in rural areas. Despite being located in socioeconomically disadvantaged areas, all households except three had access to a car. The median distance travelled to school was 2.19 km (range 0.16–30.79 km) in urban areas and 2.10 km (range 0.03–72.06 km) in rural areas.

4.1. Active transport on the school journey

Just over half of the children (57%) made at least one active school journey per week and those who did so travelled a mean distance of 1.66 (SD 1.41) km between home and school. Those who used active transport made a median number of eight active school journeys per week (range=1–10 active school journeys). The median total weekly duration of the active school journeys was 50 min (range 3–320 min). Around a quarter (26%) of all participants actively travelled on all (ten) school journeys each week. Habitual modes of transport on journeys to and from school (on at least three days per week) are presented in Table 1. Higher proportions of children travelled using motorised rather than active transport modes (e.g. 65% vs. 35% on the journey to school). Car travel was the most prevalent habitual mode of transport on journeys to (43%) and from (33%) school while walking was the most common mode of active transport (25% walked to school, 31% walked home from school) with low proportions cycling (6%) or travelling by skateboard/scooter/rollerblades (4%) in each direction. There was little variation in travel mode on the journey to school compared with the journey home from school. There were few instances of mixed modes of travel for the school journey, with only five children reporting combined walking and car travel and one child reporting combined walking, public transport and car travel on all school journeys. Among those children who engaged in active transport on the school journey, most did so without adult accompaniment. For example 25% of all children walked to school on at least three days per week, and 21% did this independently (Table 1).

The frequency of active transport to and from school was examined in relation to the total time spent each week on these journeys. Fig. 1 shows evidence of an overall positive dose–response association between total weekly frequency and duration of active journeys but there were some anomalies. In particular, the total weekly duration of active school journeys was lower, on average, for those who made all their school journeys using active transport compared with those who made six school journeys in this way (Fig. 1). Children who made ten active school journeys per week spent around 8 min travelling to/from school, while those who made six active journeys per week spent more than twice as long on each journey (around 19 min).

Table 1
Proportion of children who habitually^a used each travel mode to/from school.

Travel mode ^a	To school (%)	From school (%)
Active travel (overall)	35	41
Walk	25	31
Walk independently ^b	21	25
Cycle	6	6
Cycle independently ^b	6	6
Skateboard/scooter/rollerblades	4	4
Skateboard/scooter/rollerblades independently ^b	4	3
Motorised travel (overall)	65	59
Public transport or school bus	22	26
Car	43	33

^a On at least three weekdays.

^b Without adult accompaniment – i.e. alone or with another child.

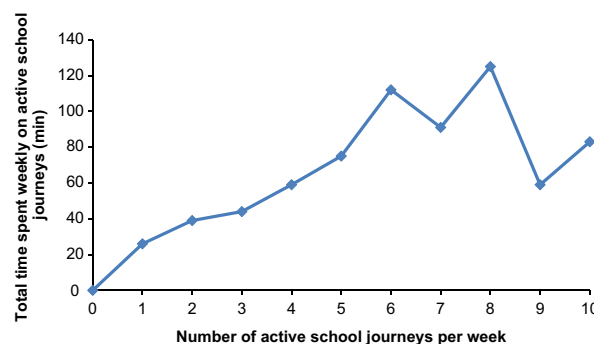


Fig. 1. Mean total weekly duration of active school journeys according to their frequency.

4.2. Associations between active transport on the school journey and physical activity

The dose–response association between the number of active school journeys made in either direction per week and MVPA on weekdays was examined (Fig. 2). Overall, on average, increasing frequency of active school journeys per week was associated with increasing time spent in MVPA, however, there were some anomalies similar to those found in relation to the total weekly duration of active school journeys. For example, those who made all their school journeys (i.e. ten journeys) using active transport spent less time in MVPA than those who made six active journeys each week.

Linear regression analyses revealed that total weekly frequency of active transport on school journeys was not significantly associated with mean time spent in MVPA on weekdays ($B=0.57$; 95% CI 0.03–1.17). The total weekly duration of active school journeys was, however, positively associated ($p < 0.001$) with MVPA on weekdays ($B=0.10$; 95% CI 0.06–0.15). In other words, each additional hour of active transport over the course of the school week was associated with an increase of approximately 6 min of MVPA on weekdays.

4.3. Associations between independent mobility on the school journey and physical activity

Among children who used active transport to or from school on at least three days per week ($n=117$, 43%), the mean score for independent mobility on these journeys was 2 (range 0–4) indicating that the child usually walk/cycled with another child in each direction, or that they walked/cycled alone either to or from school. Among these children, 14% had the minimum score of 0 signifying they were accompanied by an adult on all journeys and 18% had the maximum score of 4, signifying that they usually travelled to and from school alone. This score for independent mobility on the school journey was not significantly associated with MVPA on weekdays ($B = -1.12$, (95% CI -4.83 , 2.60)).

4.4. Associations between independent mobility to local (non-school) destinations and physical activity

Most children reported having at least one type of destination that was within walking (95%) or cycling (97%) distance from their home. Rates of accessibility by walking and cycling and rates of independent mobility to destination types are presented in Table 2. Almost half of all participants reported walking often to a friend's house without adult accompaniment (i.e. independently); lower proportions did so to reach sports/activity venues, parks/playgrounds and shops. Rates of cycling (compared with walking) independently to these destinations were lower (Table 2).

The median scores for independent mobility when walking and cycling to local destinations were 3.33 (range 0–10) and 0 (range 0–10) respectively. These scores were not significantly associated with MVPA on weekdays or on weekend days (Table 3).

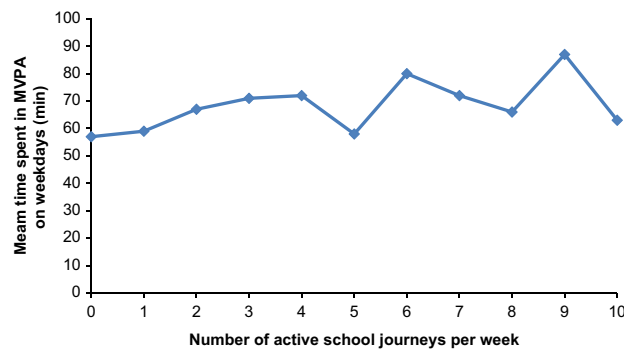


Fig. 2. Mean time spent in MVPA on weekdays according to frequency of active school journeys.

Table 2

Independent mobility to local destinations.

Destination	Within walking distance of home (%)	Within cycling distance of home (%)	Child walks there independently (%)	Child cycles there independently (%)
Friend's house	81	88	47	28
Sports/activity venues	74	78	31	21
Parks/playgrounds	84	88	26	21
Shops	83	89	35	23

Table 3

Associations between independent mobility when walking/cycling to local destinations and moderate-to-vigorous physical activity (MVPA).

	MVPA (min)			
	Weekdays		Weekends	
	Regression coefficient ^a (95% CI)	Standardized Beta	Regression coefficient ^a (95% CI)	Standardized beta
IM_walking_weighted	0.60 (−0.11, 1.31)	0.08	0.27 (−0.80, 1.34)	0.03
IM_cycling_weighted	0.64 (−0.11, 1.40)	0.08	−0.21 (−1.34, 0.92)	−0.02

^a Analyses were adjusted for age and sex of child, accelerometer wear-time and days worn, urban/rural location.

4.5. Territorial range and local destinations

Just over a third (37%) of all children were allowed to roam more than 15 min' walk from home on their own, and half (50%) were allowed to do so with friends (unaccompanied by an adult). Linear regression analyses revealed that the number of types of walkable destinations reported by children was associated with their territorial range when out alone ($B=0.27$; 95% CI 0.17, 0.39) and when accompanied by a friend/sibling ($B=0.27$; 95% CI 0.16, 0.38). Similarly, the number of types of cycleable destinations reported by children was associated with their territorial range when out alone ($B=0.34$; 95% CI 0.22, 0.47) and when accompanied by a friend/sibling ($B=0.32$; 95% CI 0.20, 0.44). In other words, having four destination types within walking distance or three destination types within cycling distance of home was associated with a unit's increase in their territorial range.

5. Discussion

This study is among the first to examine active transport and independent mobility to school and other local destinations and their associations with physical activity, among school-aged children residing in socioeconomically disadvantaged areas. Additionally, because there is a paucity of data that explores children's territorial range in relation to accessible destinations, this paper makes an important contribution to the literature. Findings also provide further rationale for the public health position to promote active transport on the school journey.

In the current study, approximately one third of children walked, cycled or rode scooters/skateboards to and from school on most school days. This rate for active transport is higher than reported in the USA (Evenson et al., 2003), consistent with (Hume et al., 2009), or slightly higher than rates reported by other Australian studies (Merom et al., 2006; Spallek et al., 2006), but lower than those reported in England (Panter et al., 2010) and in New Zealand (Hinckson et al., 2011). However, exact comparisons cannot be made due to methodological differences in measurement of active transport.

Children in the current study who used active modes of transport for the school journey performed more MVPA overall with a dose-response association evident. While this finding concurs with previous studies that demonstrated positive associations between children's active transport to school and their physical activity (Schoeppe et al., 2013; Faulkner et al., 2009), the current study is unique in its presentation of a dose-response association. Furthermore our findings highlight that the total duration of active transport to school rather than the frequency of these trips was more closely associated with physical activity levels. While long distances to school may preclude

active transport (Davison et al., 2008; Panter et al., 2008), the journey needs to be of sufficient distance and duration to contribute significantly to physical activity levels (Van Sluijs et al., 2009). Regardless of adult accompaniment, those who walked or cycled to school on all or most days were living close to their school and the duration of these trips was short (taking around 8 min, on average), thus making only a small contribution to their overall physical activity levels.

Our study included detailed measurement of active transport, in particular, frequency and duration of school journeys. Our measures facilitated the reporting of multi-modal school journeys, and demonstrated that these were rare among children in our study. This was an important finding because use of public transport has been identified as providing opportunities for incidental exercise (CDC, 2010). For example, a recent review (Rissel et al., 2012) reported that increased physical activity accrued by walking to and from transit points has been demonstrated among adults who commute by public transport rather than by car. However, few children in our study reported walking in conjunction with their travel by public transport/school bus. This is consistent with one other study (Merom et al., 2006) which also reported that only a small proportion of children used combined modes of transport. This may be an important intervention point for future studies in settings where public transport is available, as multi-modal trips have the potential to cover greater distance than active transport alone but also provide the health benefits of physical activity. Further research is required, however, to determine how such trips could be best encouraged among children who do not reside within walking distance of school.

One of the unique components of the current study was the focus on independent mobility on the school journey and to other destinations in the neighbourhood. The lack of a significant association between independent mobility on the school journey and MVPA is not surprising considering that we also did not find an association between frequency of active school journeys and MVPA. Independent mobility to non-school destinations in the neighbourhood was also examined with the majority of children reporting they had friend's houses, parks and playgrounds, shops, and sports/activity venues within walking or cycling distance. Approximately half of these children accessed friends' houses independently, with one third of children accessing other destinations independently. Independent mobility to non-school destinations was not significantly associated with physical activity but this may be due to our measure being an indicator of only the degree of independent mobility when travelling to these destinations. A limitation of this study was that the exact number of independent active trips to local destinations was not reported.

Territorial range was restricted among children in this study. One third of children were allowed to roam more than 15 min from home alone, and approximately half of all children were allowed to do so with friends. The number of types of accessible destinations in the neighbourhood was positively associated with children's territorial range. This finding makes an important contribution to the limited existing research on this topic that has tended to focus on sex differences, and on age-related increases in territorial range (Matthews, 1992; Hart, 1979). It is important, however, to interpret these findings with some caution as these data were self-reported by children and their concept of distance and time may not be accurate.

Strengths of this study include the gathering of data from children across a broad age-group (range 8.2–16.2 years). This spans adolescence which is recognised as a time of increased autonomy (Valentine, 1997a) with ongoing re-negotiation of rules and boundaries regarding independent mobility (Valentine, 1997b). Further strengths include the recruitment of children in rural as well as urban areas and the use of guided interviews to collect children's self-reported data. In addition, the focus on children from low SES areas is novel since this population group has been under-researched; however, the generalizability of our findings may be limited to those living in disadvantaged areas. Further limitations include: the relatively small sample size which did not allow the stratification of the sample by age, sex or urban/rural location. Evidence suggest that independent mobility increases with age but is greater overall among boys, compared with girls (Hillman et al., 1990; Carver et al., 2012), and may vary according to urban/rural setting (Carver et al., 2012). Furthermore, the use of hip-worn accelerometers which may under-estimate non-ambulatory activities such as cycling. However, the low rates of cycling among these children lessen the impact of this limitation on the study findings.

6. Conclusions

This research provides evidence of the contribution of active transport to children's overall physical activity. Additionally, this study provides an important preliminary understanding of children's independent mobility on journeys to school and local destinations. However, further research that includes objective measures of distance to local amenities is required to explore factors that influence children's freedom to move around their neighbourhood independently, and in particular how far they are allowed to roam. These factors are likely to be different between older and younger children, as well as those living in urban and rural areas, so further research should focus on examining these behaviours in those population groups. Such research is important for health promotion officers, urban planners and policy makers as it informs the development of programs and plans that encourage active transport behaviours in children. As well as promoting physical activity through active transport such programs will potentially confer further benefits such as reducing carbon emissions and dependency on motorised travel (Bauman et al., 2008) while increasing social interaction on local streets (Mullan, 2003).

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