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Associations between children's active travel and levels of physical activity and sedentary behavior

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ABSTRACT

Objectives: To investigate associations of children's active travel (i.e. walking, cycling) to school and non-school destinations with time spent in sedentary behavior and physical activity at different intensities, and associations stratified by sex.
Methods: Between 2011 and 2012, 375 Australian school children aged 8–13 years (61% female) were recruited into a cross-sectional study. Children's travel modes to school and non-school destinations, and socio-demographic information were assessed through child and parent surveys. Daily time spent in sedentary behavior and physical activity intensities was measured objectively through accelerometer counts from an Actiheart monitor worn on four consecutive days. Associations of active travel with sedentary behavior and physical activity variables were determined using linear mixed models while accounting for clustered sampling and covariates (age, sex, socio-economic factors, Actiheart wear time). Multiple imputation (MissForest method) was used to handle missing at random survey and accelerometer data in 104 (28%) children.
Results: Active travel modes to non-school destinations were positively associated with children's moderate-to-vigorous physical activity ($b=0.18$, $p=0.01$) but not with their sedentary behavior, light or total physical activity. Active travel modes to school were not associated with children's sedentary behavior or physical activity across intensities. No statistically significant differences by sex were detected in the observed associations. However, the positive association between active travel modes to non-school destinations and moderate-to-vigorous physical activity neared statistical significance in boys ($b=0.15$, $p=0.07$) but not in girls.
Conclusions: Active travel was positively associated with children's physical activity but not their sedentary behavior levels. Active travel to non-school destinations may have more potential to increase children's moderate-to-vigorous physical activity levels, than active travel to school.

1. Introduction

In Australia, 60% of children aged 9–13 years do not meet current national physical activity guidelines, which recommend children should accumulate at least 60 min of moderate-to-vigorous physical activity every day (Australian National Children's Nutrition and

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Physical Activity Survey, 2007). Moderate-to-vigorous physical activity is important for children's bone health, motor skills, physical fitness, healthy weight and protection against chronic diseases later in life (Dencker and Andersen, 2008; Hallal et al., 2006; Janz et al., 2010). Light intensity physical activity is also beneficial for children's health; it improves blood pressure and HDL-cholesterol levels which is particularly important in overweight children who are at risk of developing the metabolic syndrome (Ekelund et al., 2012; Cliff et al., 2013).

Besides physical inactivity (i.e. very low levels of physical activity), a high prevalence of sedentary behavior (i.e. sitting or lying down during waking hours) has been observed in Australian children. For example, children aged 9–16 years currently spend around 9–10 h per day in sedentary activities, during school hours, leisure-time and motorized transport (Olds et al., 2010). Prolonged sedentary behavior is an emerging health risk factor in children, which in combination with obesity can lead to metabolic syndrome, type 2 diabetes and other chronic diseases later in life (Stamatakis et al., 2013; Short et al., 2009; Hale, 2004). Recent recommendations suggest increasing outdoor activities and active travel (walking, cycling for transport) are important strategies for reducing daily sedentary time in children (Department of Health, 2014a; Department of Health, 2014b).

Instilling physical activity and limiting sedentary habits at an early age is crucial as these behaviors tend to track from childhood to adolescence and into adulthood (Jones et al., 2013; Biddle et al., 2010; Telama et al., 2005). Active travel is one strategy to achieve this by providing children with habitual physical activity opportunities throughout the day (Loprinzi et al., 2012). In addition, active travel may reduce children's daily sedentary time, by replacing motorized travel and stimulating outdoor activities, which tend to be more active (King et al., 2011). However, in recent decades, children's walking and cycling for transport has dramatically declined in developed countries, such as the United States of America, Canada, England, Denmark, Norway and Finland (Fyhri et al., 2011; McDonald, 2007; Australian National Children's Nutrition and Physical Activity Survey 2007; Buliung et al., 2009). In Australia, trend data show that between 1971 and 2003 children's walking to school decreased from 58% to 35%, whilst the prevalence of being driven to school by car increased from 23% to 67% (Van der Ploeg et al., 2008). The declines in active travel may be a contributor to the low levels of physical activity and the high levels of sedentary behavior currently being observed in children.

Although associations between children's active travel and activity behaviors have been frequently examined (Schoeppe et al., 2012) many issues remain unexplored. Previous studies (Lee et al., 2008; Faulkner et al., 2009; Schoeppe et al., 2012) have mainly focused on associations between school-related active travel modes and physical activity, and mostly show positive associations. However, school travel alone may not fully capture children's active travel behaviors. School is only one of several destinations children travel to, and often, it is too far away from home to be suitable for active travel (McDonald, 2007; Australian National Children's Nutrition and Physical Activity Survey 2007; Mackett, 2012). For example, Timperio et al. (2004) found that 10–12 year olds engaged in between 8–10 walking and cycling trips on average per week; but only three of these trips related to the school journey. Therefore, focusing on active travel to school as well as non-school destinations may be more appropriate when investigating associations between children's active travel and levels of physical activity. Moreover, few studies have examined associations between children's active travel and sedentary behaviors, and in those studies that have, findings remain inconsistent (King et al., 2011; Heelan et al., 2005; Owen et al., 2012; Nilsson et al., 2009; Landsberg et al., 2008). A reason could be that only school-related active travel modes were measured in these studies. Furthermore, examination of differences in associations by sex is important as previous studies have shown that compared with girls, boys tend to have higher levels of active travel, physical activity and sedentary behavior (Davison et al., 2008; Klitsie et al., 2013; Australian National Children's Nutrition and Physical Activity Survey, 2007).

To address these research gaps, this study aimed to investigate associations of children's self-reported active travel to school and non-school destinations with objectively measured sedentary behavior, light, moderate-to-vigorous and total physical activity, including differences in the observed associations by sex.

2. Methods

2.1. Study design

This study used cross-sectional data collected from two Australian projects: Children's Activity, Travel, Connectedness and Health (CATCH) and Independent Mobility, Active Travel and Children's Health (iMATCH). The interrelated CATCH/iMATCH projects were designed to examine the role of policy, social and built environments in influencing children's independent mobility, active travel, and related health outcomes (CATCH/iMATCH, 2015). Ethical approval for the CATCH/iMATCH projects was obtained from Central Queensland University, The University of Melbourne, Curtin University, Griffith University, and State Departments of Education and Training in Queensland (QLD), Victoria (VIC) and Western Australia (WA).

2.2. Participants

A convenience sample with a clustered sampling design was used in the CATCH/iMATCH projects. In total, 375 children aged 8–13 years were recruited from nine public primary schools in Rockhampton (QLD), Brisbane (QLD), Melbourne (VIC) and Perth (WA). The schools in each location represented various levels of neighborhood urbanization (inner suburb, middle suburb, outer suburb and regional city areas) but the student population of all schools had similar socio-economic status (SES) characteristics. The selection of schools was informed by SES information published on Australia's My School website (www.myschool.edu.au); broad SES profiles were determined from various socio-demographic factors such as parents' level of education and occupation. Schools with student populations in the middle SES quartile were eligible to be invited to participate in the study. School principals, teachers, parents and students (Years 3–7) were introduced to the study through information materials and sessions held at the schools. Written consent to study participation was obtained from school principals, parents and children.

2.3. Data collection

Data collection occurred between June 2011 and November 2012 including the Australian winter and summer. With researchers' assistance, students completed a paper-based questionnaire at school, either in class or during lunch recess. Another paper-based survey was administered to parents via mail. Students wore an Actiheart, a combined heart rate and accelerometer monitor (CamNtech Actiheart, Cambridge, UK) for four consecutive days, except when engaging in contact sports and water-based activities (e.g. showering, swimming). The Actiheart monitoring period captured weekdays and weekend days, either consecutively from Thursday until Monday morning, or from Friday until Tuesday morning. The Actiheart monitor was attached directly on the lower left side of the chest using two electrocardiograph (ECG) electrodes (model Red Dot 2238 soft cloth, 3M). One electrode was placed at the base of the child's sternum and the other electrode was put horizontally to the left so the wire of the Actiheart was straight with tension, but comfortable. Initially, the researchers briefed the students on how the Actiheart should be worn. Then the students attached the monitors themselves and the researchers checked the positioning.

2.4. Measures

2.4.1. Socio-demographics

Child sex and age were assessed through the student surveys. Socio-economic covariates (parental education attainment, number of registered motor vehicles in the household) were measured via the parent surveys. Neighborhood urbanization in state capital city locations (Brisbane, Melbourne, Perth) was defined based on neighborhood proximity to the central business district (CBD) with the general post office being a marker of the CBD center. Inner urban, middle suburban, and outer suburban neighborhoods were defined as being located ≤ 5 km, 11–20 km, and ≥ 20 km from the CBD, respectively. A regional city area was defined as a regional town that is not a major state capital city of Australia.

2.4.2. Active travel

Active travel was measured via the student surveys. In the absence of standardized, validated measures of active travel, questions about mode of travel were developed based on child self-report surveys used in similar studies (Hillman et al., 1990; Villanueva et al., 2013). Items were phrased 'How do you usually travel to: (1) school, (2) local shops, (3) local friend's houses, (4) local parks and playgrounds, and (5) organized activities (e.g. at a local sports club, church or recreational center)?' Children selected the response option that best represented their 'usual' travel mode (walk, bicycle, take the scooter, take public transport or be driven). Questions relating to non-school destinations also included the option 'Don't go there'. Two variables were created to assess active travel: 'usual mode of travel to school' and 'usual mode of travel to non-school destinations'. Response options for the 'usual mode of travel to school' variable were categorized as active travel (i.e. walk/bicycle/take non-motorized scooter) and car travel. Using the same classification of travel modes, the response options of the variable 'usual mode of travel to non-school destinations' were initially calculated as a ratio of active travel trips out of all trips a child undertook to non-school destinations. Based on the median distribution this variable was then dichotomized into 'higher levels of active travel' (i.e. 33–100% of all trips occur actively) and 'lower levels of active travel' (i.e. $<33\%$ of all trips occur actively). Children who used public transport during the measurement period ($n=33$) were not considered in the travel measures and excluded from analyses. The rationale for excluding children using public transport was that public transport involves both active and sedentary travel, which may dilute associations of active travel with physical activity and sedentary behavior.

2.4.3. Sedentary behavior and physical activity

Sedentary behavior, and light, moderate-to-vigorous and total physical activity were measured using accelerometer counts generated by the Actiheart monitor. The Actiheart has shown good validity when tested in 13-year old children walking and running on a treadmill in a laboratory. Validity was determined by comparing physical activity energy expenditure measured through the Actiheart with that of other accelerometers (MTI Actigraph, Actical); the Actiheart accelerometer explained 69% ($r^2=0.69$) of the variance in physical activity energy expenditure (Corder et al., 2005). *Data processing:* At the completion of the Actiheart monitoring period, data from the Actiheart monitors were downloaded using the CamNtech Actiheart software. Subsequently, the Actiheart data were transferred into Microsoft Excel and data reduction was conducted to extract daily minutes spent in sedentary behavior, and light, moderate and vigorous physical activity using custom software (National Instruments Labview). The extracted data were imported into SPSS to create variables of average number of minutes per day spent in sedentary behavior, light physical activity, moderate-to-vigorous physical activity (i.e. moderate and vigorous physical activity combined), and total physical activity. *Wear time and non-wear time:* The CamNtech Actiheart software classifies Actiheart recordings as 'OK', 'recovered', 'interpolated', 'lost' or 'not worn'. Only accelerometer counts recorded in the categories 'OK', 'recovered' or 'interpolated' were used for calculating time spent in sedentary behavior and physical activity. 'Recovered' and 'interpolated' relate to the heart rate component of the Actiheart; these classifications mean that the device was unable to detect a heart rate signal for a short period (a few seconds to less than five minutes). In these instances, the heart rate data were calculated based on previous valid heart rate recordings, and then interpolated/imputed. Whilst the device briefly failed to detect a heart rate signal, accelerometer counts were still recorded. Actiheart recordings under the classifications 'recovered', 'interpolated' and 'OK' suggest wear time. Recordings under the classifications 'lost' and 'not worn' indicate non-wear time or that the device did not detect a heart rate signal for longer than five minutes; hence these recordings were excluded from analyses. *Epoch length:* The epoch length represents the amount of time (i.e., seconds) over which movement data (i.e., activity counts) are summed and stored in the accelerometer memory. In this study, the epoch length was aggregated to 60 seconds to overcome differences in epoch length settings across study sites. Sixty second epochs allow for comparison with similar studies (Cooper et al., 2005; Van Sluijs et al., 2009; Cooper et al., 2003). *Cut points*: Child-specific ActiGraph cut points developed by Evenson et al. (2008) were adopted for classifying sedentary behavior, light physical activity, moderate physical activity, and vigorous physical activity (being ≤ 100, 101–2295, 2296–4011 and ≥ 4012 counts per minute, respectively). These thresholds demonstrated acceptable to excellent classification accuracy for sedentary behavior, and light, moderate, and vigorous physical activity with ROC-AUC (area under the receiver operating characteristic curve) curve values ranging between 0.70–0.90 (Evenson et al., 2008; Trost et al., 2011). Additionally, a conversion factor of five (i.e. ActiGraph accelerometer counts = Actiheart accelerometer counts × 5) developed by Ridgway et al.(2011) was used to generate comparable cut points for Actiheart-derived accelerometer data. This resulted in final cut points for sedentary behavior, and light, moderate, and vigorous physical activity of ≤20, 21–459, 460–802 and ≥803 counts per minute, respectively.

2.5. Statistical analyses

Chi-square tests and independent *t*-tests were used to explore differences in socio-demographics, active travel, and time spent in sedentary behavior and physical activity between boys and girls, and children included and excluded from analyses. Linear mixed models were used to investigate associations between children's active travel (predictor variables) and time spent in sedentary behavior, light and moderate-to-vigorous physical activity, and total physical activity (outcome variables). The analyses were adjusted for age, sex, parental education attainment, number of motor vehicles in the household, level of neighborhood urbanization and Actiheart wear time (covariates). Clustering by school was accounted by including a random intercept for the variable ‘school’ in the model. The linear mixed model analyses were repeated with an interaction term by sex in the model to examine differences in the observed associations between boys and girls. Associations are presented using unstandardized beta coefficients, confidence intervals and *p*-values. The significance level was set at 0.05.

Missing data existed in this study across all measured variables. In 104 (28%) of the 375 recruited children, missing data were considered missing at random. The data from these children were imputed and included in analyses. In 117 (31%) children, the missing data were not considered missing at random as children withdrew from the study ($n=13$) or had less than 30 min of accelerometer data on each of the four monitoring days ($n=71$).These children were excluded from analyses. The MissForest method (Stekhoven and Bühlmann, 2012) was used to carry out multiple imputation of randomly missing data. This included five steps: (1) testing the required assumption that data were missing at random, (2) log-transformation of the non-normally distributed variable moderate-to-vigorous physical activity, (3) creating 100 copies of the dataset including observed and imputed values for missing variables with consideration of all variables included in analyses, (4) running analyses in all datasets and (5) calculating averages from each data output. Missing accelerometer data were imputed adopting imputation techniques used in previous studies (Catellier et al., 2005; Lee, 2013). This involved three steps: (1) applying a threshold of at least 480 min per day of accelerometer counts recorded between 6.00 am–11.00 pm to determine a valid day (this threshold was decided upon available accelerometer data), (2) setting data with invalid days as missing and (3) imputing the missing values via 100-fold imputation using information from both observed and imputed data. All analyses were performed in R (version 3.01).

3. Results

For this study, 1534 eligible students were invited across all participating schools. Of these, 375 (24%) students provided written parental consent and child assent to study participation. Overall, 258 (67%) out of 375 recruited children were included in analyses and their descriptive characteristics are presented in Table 1. Children's mean age was 10.63 years (SD: 0.89), 61% were girls, 70% had parents with post-high school education, 76% lived in urban and suburban areas and 68% had two or more motor vehicles in the household. Children's average daily time spent in sedentary behavior was 383 min (SD: 114 min), and average daily time spent in light, moderate-to-vigorous and total physical activity was 371 min (SD: 64 min), 58 min (SD: 37 min) and 428 min (SD: 85 min), respectively. There were no significant differences in socio-demographic factors and active travel between children included and excluded in analyses (data not reported). Moreover, socio-demographics, active travel to school, sedentary behavior, light and total physical activity did not differ significantly by sex (Table 1). However, significantly more boys than girls engaged in active travel to non-school destinations (64% versus 46%, $p=0.01$), and boys accumulated significantly more moderate-to-vigorous physical activity per day than girls (65 mean minutes versus 53 mean minutes, $p=0.01$). Overall, 37% of children usually commuted to school by active modes and 53% traveled to non-school destinations by active modes.

Associations between children's active travel and daily time spent sedentary, and in light, moderate-to-vigorous and total physical activity are presented in Table 2. Children with higher levels of active travel to non-school destinations showed a significant positive association with daily moderate-to-vigorous physical activity ($b=0.18$, $p=0.01$), but no significant associations with sedentary behavior, light and total physical activity. Of note, the beta coefficient of 0.18 is based on a log-transformed moderate-to-vigorous physical activity variable, and as such, does not reflect minutes. For illustration purposes, we re-ran analyses without log-transforming moderate-to-vigorous physical activity resulting in $b=11.88$. This represents a significant gain of nearly 12 min of moderate-to-vigorous physical activity per day when engaged in active travel modes to non-school destinations. In contrast, active travel to school was not significantly associated with daily time spent in sedentary behavior and physical activity across intensities.

No statistically significant sex differences were detected in the associations between active travel and daily time spent sedentary, and in light, moderate-to-vigorous and total physical activity. However, analyses indicated that a positive association between active travel to non-school destinations and moderate-to-vigorous physical activity existed for boys ($b=0.15$, $p=0.07$) but not girls.

4. Discussion

This study investigated associations between children's active travel and time spent sedentary and in light, moderate-to-vigorous, and total physical activity. Compared to car travelers, those who traveled by active modes to non-school destinations accumulated significantly more daily moderate-to-vigorous physical activity. This finding is consistent with the results from a few other studies investigating associations between children's active travel to non-school destinations and physical activity (Smith et al., 2012; Carver et al., 2011; Chillón et al., 2011). For example, Smith et al. (2012) found that active travel to non-school destinations can contribute up to 17 min of moderate-to-vigorous physical activity to a child's day; our study showed that it can yield up to 12 min of moderate-to-vigorous physical activity a day.

Table 1
Descriptive characteristics of children included in analyses.

	All	**Boys**	**Girls**	***p*-value**
N (%)	258	101 (39.1)	157 (60.9)	
Age in years, mean (SD)	10.64 (0.89)	10.74 (0.93)	10.57 (0.85)	0.15
Level of urbanization, *n* (%)				0.27
Inner urban	74 (28.7)	32 (31.7)	42 (26.8)	
Middle suburban	48 (18.6)	22 (21.8)	26 (16.6)	
Outer suburban	73 (28.3)	22 (21.78)	51 (32.5)	
Regional city area	63 (24.4)	25 (24.7)	38 (24.2)	
Parental education[a]**, *n* (%)**				0.35
High school	76 (29.5)	27 (26.7)	50 (31.8)	
Trade/apprenticeship/certificate/diploma	85 (32.9)	38 (37.6)	47 (29.9)	
University degree	96 (37.20)	36 (35.3)	60 (38.2)	
Motor vehicles in household, *n* (%)				0.17
0	3 (1.2)	0 (0)	3 (1.9)	
1	79 (30.6)	38 (37.6)	41 (26.3)	
2	151 (58.5)	52 (51.5)	99 (62.8)	
≥ 3	25 (9.7)	11 (10.9)	14 (8.9)	
Usual mode of travel to school, *n* (%)				0.11
Active travel	95 (36.8)	44 (43.4)	51 (32.5)	
Car travel	163 (63.2)	57 (56.6)	106 (67.5)	
Usual mode of travel to non-school destinations, *n* (%)				0.01
Higher active travel levels	137 (53.1)	64 (63.7)	73 (46.2)	
Lower active travel levels	121 (46.9)	37 (36.3)	85 (53.8)	
Average daily minutes in sedentary behavior Mean (SD)	382.91 (113.84)	382.45 (118.65)	383.33 (111.14)	0.97
Average daily minutes in light PA Mean (SD)	370.56 (64.00)	364.62 (57.01)	374.35 (68.09)	0.21
Average daily minutes in MVPA Mean (SD)	57.53 (36.69)	64.81 (39.09)	52.91 (34.29)	0.01
Median (IQR)[b]	46.36 (36.30)	54.66 (39.14)	43.12 (32.39)	
Average daily minutes in total PA Mean (SD)	428.08 (84.59)	429.32 (79.86)	427.23 (87.69)	0.86

Abbreviations: PA=physical activity, MVPA=moderate-to-vigorous physical activity, SD=standard deviation, IQR=interquartile range.

[a] Highest education attainment was reported by one parent completing a survey.

[b] The distribution of MVPA was positively skewed; hence firstly means and SD, and secondly medians and IQR are presented.

Table 2
Associations between active travel and mean daily minutes spent sedentary, and in light, moderate-to-vigorous and total physical activity.

	Sedentary behavior			**Light PA**			**MVPA**			**Total PA**		
	b	95% CI	*p*-value	*b*	95% CI	*p*-value	*b*	95% CI	*p*-value	*b*	95% CI	*p*-value
Usual travel to school												
Active travel	11.56	−9.55–32.68	0.28	−3.63	−19.97–12.70	0.66	−0.07	−0.22–0.07	0.32	−11.52	−32.45–9.41	0.28
Car travel	–	–	–	–	–	–	–	–	–	–	–	–
Usual travel to non-school destinations												
Higher AT	−12.77	−33.06–7.52	0.22	1.26	−13.99–16.51	0.87	0.18[a]	0.04–0.31	0.01	12.82	−7.21–32.84	0.21
Lower AT	–	–	–	–	–	–	–	–	–	–	–	–

Abbreviations: *b*=unstandardized beta coefficient, 95% CI=95% confidence interval, PA=physical activity, MVPA=moderate-to-vigorous physical activity, AT=active travel. Adjusted for school clustering, age, sex, parental education attainment, number of motor vehicles in the household, level of neighborhood urbanization and Actiheart wear time.

[a] The distribution of MVPA was positively skewed; hence the variable MVPA was log-transformed prior to conducting multiple imputation and linear mixed models. Consequently, this beta coefficient does not present minutes in MVPA.

Contrary to previous studies (Lee et al., 2008; Faulkner et al., 2009; Schoeppe et al., 2012), this study detected no association between children's active travel to school and physical activity engagement. A reason may be that the distances Australian children walk or cycle to school are too short to yield increases in daily physical activity that are detectable using the methods employed in this and many other studies. Unfortunately, the influence of travel distance could not be investigated in this study as an appropriate measure of distance could not be extracted from the CATCH/iMATCH dataset. However, another Australian study (Carver et al., 2013) showed that median distances Australian primary school children traveled by all modes between home and school were 1.32 (0.05–18.21) km in urban areas and 2.65 (0.32–44.29) km in rural areas. As such, for many children the distance to school is likely too far from home to be suitable for walking. Children who walk or cycle to school tend to do so from proximal home locations. For example, Harten and Olds (2004) reported that the median distance Australian 11–12 year-olds travel actively to school was just over 600 m. Travel distances below 800 m can make it difficult to detect associations between active travel and average daily minutes of physical activity when active travel involves solely a short walking or cycling trip to school (Van Sluijs et al., 2009). Instead, multiple active travel trips to various destinations (school, non-school) may be needed to detect associations with physical activity using current methods.

Car travel (a sedentary behavior) was believed to be a major contributor to children's sedentary time. Hence, we hypothesized that children who walk or cycle to school and non-school destinations would spend significantly less time sedentary than those who are being driven to destinations. However, this study showed no association between active travel and daily total time spent sedentary. A possible explanation is that car travel constitutes only a small proportion of children's total sedentary time (Olds et al., 2010). For example, Australian data (Olds et al., 2010) showed that motorized travel constitutes only 9% of children's total sedentary time; most sedentary time is spent in other behaviors, such as screen-time (40%), school hours/studies (25%) and socializing (12%). Hence, replacing car travel with active travel may not substantially reduce children's daily sedentary time.

Analyses by sex showed no significant differences in the associations between active travel and sedentary behavior and physical activity. However, our data indicate that active travel to non-school destinations has a greater impact on moderate-to-vigorous physical activity in boys than girls. This was also found in other studies (Carver et al., 2011; Chillón et al., 2011), and concurs with our descriptive data showing that levels of active travel to non-school destinations and moderate-to-vigorous physical activity were significantly higher in boys than in girls. It may reflect the tendency of less independent active travel in girls in this age group (Brown et al., 2008), and suggests that finding more effective ways of promoting physical activity through active transport is particularly important in girls, especially if they are not attracted to participation in exercise and organized sports.

Strengths of this study include objective measurement of daily sedentary time (not simply screen-time) and physical activity at various intensities, and examination of children's mode of travel to school and non-school destinations. The latter has received little attention in previous research (Schoeppe et al., 2012). Other methodological strengths include the use of multiple imputation techniques to account for randomly missing data, adjustment for a range of potential confounders and examination of differences by sex. Limitations of this study include the cross-sectional study design, reliance on children's self-reports for assessing active travel and the use of a small convenience sample with a low response rate and low adherence to wearing an Actiheart monitor. Although 60 s epoch length has shown to be appropriate for measuring moderate-to-vigorous physical activity (Edwardson and Gorely, 2010), a lower epoch length may have better captured children's spontaneous and intermittent physical activity patterns (Loprinzi and Cardinal, 2011). Moreover, social and built environmental determinants such as perceptions of neighborhood safety, distances to travel destinations, weather, street connectivity, availability of cycling and walking trails were not considered in this study. However, neighborhood urbanization was accounted for in order to capture broad differences in built environments between these areas. In future research, active travel to non-school destinations should receive more attention as this study showed that active travel to non-school destinations is more common in children than active travel to school (53% versus 37%), hence, it may have more potential to increase children's physical activity levels than active school travel. The low response rate and substantial missing data in this study shows the common challenge of recruiting and retaining children in behavioral studies (Schoeppe et al., 2013). More guidance is needed on successful recruitment and retention strategies applied in child populations (Schoeppe et al., 2013).

5. Conclusions

Active travel to non-school destinations was positively associated with children's daily moderate-to-vigorous physical activity. In contrast, active travel to school was not associated with children's physical activity across all intensities. Both active travel to school and non-school destinations were not associated with children's daily sedentary time. These observations suggest that active travel has the potential to increase physical activity levels in children but it is likely insufficient to reduce their sedentary behavior levels.

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