Journal of Transport & Health 12 (2019) 336–348

Contents lists available at ScienceDirect

Journal of Transport & Health

journal homepage: www.elsevier.com/locate/jth

Associations of socio-demographic, perceived environmental, social and psychological factors with active travel in Hong Kong adolescents: The iHealt(H) cross-sectional study

Anthony Barnett[a,*], Cindy H.P. Sit[b], Robin R. Mellecker[c], Ester Cerin[a,d]

[a] Mary MacKillop Institute for Health Research, Australian Catholic University, Level 5, 215 Spring Street, Melbourne, VIC 3000, Australia
[b] Department of Sports Science and Physical Education, The Chinese University of Hong Kong, Hong Kong, China
[c] Faculty of Education, The University of Hong Kong, China
[d] School of Public Health, The University of Hong Kong, Hong Kong, China

ARTICLE INFO

Keywords:
Physical activity
Social support
Socio-ecological model
Environmental psychology
Transportation
Walkability

ABSTRACT

Adolescent active travel (AT) can contribute to health-enhancing physical activity, sense of community, social interactions, spatial and navigational skills and is a sustainable form of transport. Data analysed were from surveys with validated scales, translated and adapted for Chinese speaking Hong Kong adolescents and their parents, and administered to 1299 adolescent/parent dyads. Using hierarchical modelling, this study examined independent associations of socio-demographic, perceived environmental, social and psychological factors (in that order) with adolescent AT to/from school (ATS) and AT to other destinations in Hong Kong. Moderation by gender and age on perceived environmental and social factors and number of household vehicles on proximity to destinations with AT were also estimated. The adolescents participating in ATS (58%), averaged 7.93 trips and 139.79 min per week. Adolescents averaged 7.68 trips/week to destinations other than school. Perceived proximity of school to home and social support for PA from peers were independently associated with higher odds of engaging in ATS. Social support for PA from household adults was associated with lower odds of engaging in ATS, especially in older adolescents. Trip frequency in those who engaged in ATS was positively associated with perceived proximity of school, access to services and parental transport-related PA. Perceived proximity of school was negatively associated with weekly minutes of ATS. Gender modified the association between social support for PA from peers and ATS frequency, and that of perceived proximity to public transport from home with weekly minutes of ATS. Perceived environmental, social and psychological factors were independently associated with AT to destinations other than school. In conclusion, Hong Kong adolescents appear to have high frequencies of ATS and AT to other destinations than reported elsewhere. Social support from peers, parental AT and having schools and other destinations within walking distance from home may independently contribute to adolescents' AT.

* Corresponding author.
E-mail addresses: Anthony.Barnett@acu.edu.au (A. Barnett), sithp@cuhk.edu.hk (C.H.P. Sit), robmel@hku.hk (R.R. Mellecker), Ester.Cerin@acu.edu.au (E. Cerin).

https://doi.org/10.1016/j.jth.2018.08.002
Received 12 April 2018; Received in revised form 29 July 2018; Accepted 1 August 2018
Available online 23 August 2018

1. Introduction

Adolescent engagement in active travel (AT) has been shown to substantially contribute to the accumulation of health-enhancing levels of moderate-to-vigorous physical activity (MVPA) (Larouche et al., 2014; Pizarro et al., 2017; Stewart et al., 2017) and to meeting globally recommended amounts of physical activity (PA) (WHO, 2010). Furthermore, in children, changes in MVPA have been positively associated with changes from passive to active travel to/from school (ATS) (Huang et al., 2017). AT is also a sustainable transport mode with broader health and economic benefits (Cerin et al., 2017a). Unfortunately, adolescent engagement in AT has been decreasing over time in many countries (Dygrýn et al., 2015; McDonald et al., 2011; Pabayo et al., 2011; van der Ploeg et al., 2008; Yang et al., 2017). To reverse this trend, it is important to identify modifiable factors influencing adolescent AT.

Socio-ecological models posit there are a number of levels of influence on AT, encompassing socio-demographic non-modifiable factors (e.g., age and gender) and psychological (e.g., self-efficacy), social (e.g., parental support for AT) and environmental modifiable factors (e.g., walking and cycling infrastructure) (Sallis et al., 2006). Findings to date endorse the use of these models when examining AT in adolescents. For non-modifiable socio-demographic factors, there is evidence supporting a negative association between age (Babey et al., 2009; Pabayo et al., 2011; Yang et al., 2017) and ATS and for boys being more likely to undertake AT than girls (Babey et al., 2009; Bungum et al., 2009; De Meester et al., 2013; Larsen et al., 2009; Nelson et al., 2008; Wang et al., 2017). With reference to psychological attributes, enjoyment of PA has been positively related to higher frequency of AT (Wang et al., 2017). Also, self-efficacy has been positively related to AT, both to/from school and to other destinations (Silva et al., 2014; Verhoeven et al., 2016; Wang et al., 2017). In contrast, one study found a negative association between self-efficacy towards external barriers and non-school walking for transport (De Meester et al., 2013). With regard to social factors, peer support has been positively associated with ATS (Mandic et al., 2015), total AT (Wang et al., 2017) and non-school walking for transport (De Meester et al., 2013), and social support from parents positively related to ATS (Mah et al., 2017; Silva et al., 2014). Lastly, among environmental characteristics, perceived traffic safety and safety from crime have both been positively associated with AT (Carver et al., 2005; Esteban-Cornejo et al., 2016; Hume 2009), as have street connectivity (Bungum et al., 2009; De Meester et al., 2013; Schlossberg et al., 2006) and perceived or objectively-assessed proximity of school from home (Babey et al., 2009; Carlson et al., 2013; Deweese et al., 2013; Kallio et al., 2016; Larsen et al., 2009; Loucaides et al., 2010; Nelson et al., 2008; Mandic et al., 2015; Mah et al., 2017; Schlossberg et al., 2006; Wong et al., 2011).

Most previous studies of potential determinants of adolescent AT have adopted a socio- ecological approach whereby socio-demographic/socio-economic status, psychological, social and environmental variables were considered hierarchically in that order. However, hierarchical modelling from the non-modifiable to the most distal (and modifiable), to the most proximal (and modifiable) may be more appropriate, as it allows detection of more distal influences (environmental factors) that could otherwise be masked by more proximal influences (psychological factors) that may mediate environment-outcome relationships (Singh-Manoux et al., 2002). Few adolescent AT studies to date appear to have used the distal-to-proximal hierarchical modelling approach (De Meester et al., 2013). Additionally, despite being one of the fundamental premises of socio-ecological models of health behaviour and able to provide evidence for multi-level interventions to increase AT in adolescents, few studies have assessed interactive effects of various levels of influence on AT in adolescents (Carlson et al., 2014; Hume et al., 2009; Oyeyemi et al., 2014; Wang et al., 2017). Recently, Wang et al. (2017) found an interaction between self-efficacy and walkability on adolescent AT, highlighting the importance of examining interactive effects.

The vast majority of studies investigating factors associated with AT in adolescents have been undertaken in relatively low-density cities and rural areas in North America, Europe and Australia. High-density cities are common in Asia, the home of most of the world's population, and, as urban populations are forecasted to increase worldwide (United Nations, 2014), likely to reflect the future density of cities across the world. Therefore, understanding factors contributing to adolescent AT in such cities is pertinent and this paper investigates adolescent AT in Hong Kong, a high-density, sub-tropical, East Asian city. Also, only a few studies on adolescents' AT have examined AT to destinations other than school (De Meester et al., 2013; Verhoeven et al., 2016; Wang et al., 2017).

In light of the above, this study employed hierarchical modelling to examine the independent associations of socio-demographic, perceived environmental, social and psychological factors (in this order) with AT to/from school and to other destinations in Hong Kong adolescents. We hypothesized that all four sets of factors would be independently associated with AT in Hong Kong adolescents. A secondary aim of the study was to examine age and gender as moderators of the associations of perceived social and environmental factors with AT, and number of motor vehicles in the household as a moderator of the associations between perceived proximity of school/destinations to home and AT. As parents determine the neighbourhood in which their children live and influence adolescents' AT (Carver et al., 2010; Loucaides et al., 2010; Mah et al., 2017; Silva et al., 2014), unlike most studies in this field, we adjusted for parent-reported neighbourhood selection (Cerin et al., 2007b). We also adjusted for adolescents' social desirability given that it may be associated with the provision of inflated self-reports of AT. In fact, social desirability has been found to be positively associated with adolescents' self-reported self-efficacy for PA and PA (Jago et al., 2007).

2. Material and methods

This article was based on data from the international Healthy environments and active living in teenagers – (Hong Kong) [iHealt (H)] study, a contributor to the International Physical Activity and the Environment Network (IPEN) - Adolescent study looking at associations of the built environment with PA and sedentary behaviour. To enable inter-country comparison of data, where relevant, the iHealt(H) data collection mirrored that of for the IPEN Adolescent project. Ethical approval for the iHealt(H) study was obtained from the Human Research Ethics Committee for Non-Clinical Faculties of The University of Hong Kong. Data were collected in

2013–2015.

Adolescents and one of their parents/primary caregivers were recruited from Tertiary Planning Units (TPUs) (the smallest census units in Hong Kong) stratified by census-based medium household income and transport-related walkability (an index of environmental attributes associated with utilitarian forms of walking, i.e., to destinations, and comprising of the sum of z-scores of residential density, street intersection density and land use mix, see Supplementary file for detail (Owen, et al., 2007)). To maximize the variability in potential social and environmental correlates of the study outcome measures, which included AT, TPUs were stratified into high walkable/high income, high walkable/low income, low walkable/high income and low walkable/low income categories with 'low' and' high' based on the bottom and top four deciles.

Assuming a maximal cluster effect equivalent to an Intraclass Correlation Coefficient of 0.10 (based on data from our studies on adults and adolescents and studies conducted elsewhere), a sample of 1280 participants living in 128 TPUs would allow us to detect a ~ 1–2% change in explained variance (small effect observed in environmental-PA studies) with 80% power under conditions of p-level of 0.05, two-tailed significance tests and > 10 covariates in a regression model. This large sample size was also needed to assess multilevel interactive effects of various factors on the outcomes. Thirty secondary schools each located in one of the 128 selected TPUs were contacted and recruitment was undertaken in the 20 who agreed to participate in the study (school response rate 67%). Participant adolescent – parent/primary caregiver dyad eligibility requirements were having lived in a study TPU for at least the last 6 months and planning to reside there for at least the following 8 months, and for the adolescent to be 11–18 years of age, attending secondary school, and to not have disability/illness precluding participation in moderate-intensity PA. Students in randomly selected classes from each school were screened for eligibility, including obtaining written parental consent and student assent for participation. A total of 2840 dyads were contacted (students were contacted in person by research and school staff; parents/caregivers were contacted in writing by school staff via students). Twenty-six percent of these (n = 738) were not eligible due to residing outside of the selected TPUs, having moved to their residence within the last 6 months or the student having a disability/illness precluding participation in moderate-intensity PA. Only 4% of our sample reported living in the neighbourhood for less than 1 year and only 15 out of 2840 contacted dyads were not eligible to participate in the study because they reported living in the neighbourhood for less than 6 months. Of the remaining 2002 dyads, 1363 participated in the study; 321 from high walkable/high income, 345 from high income/low walkable, 341 from low walkable/high income and 356 from low walkable/low income TPUs. Thus, the effective response rate was 68%, with 21% students and 11% parent/primary caregivers declining to participate. Within a week of receipt of the surveys, research staff screened all survey items for invalid and missing data and contacted the participants to rectify mistakes or fill in missing information. At the end of the study, 64 dyads provided invalid surveys that could not be corrected. Valid surveys, with no missing data, were obtained from 1299 dyads and used in the analysis.

2.1. Measures

Data analysed in this paper were from paper-based surveys completed by adolescents and one of their parents /caregivers without supervision at home and in their own time. Surveys were adapted and translated for Chinese speaking Hong Kong adolescents and parents. The adolescent survey included validated scales translated and adapted for Hong Kong adolescents measuring PA-related psychological, social and environmental correlates, social desirability and AT. The parent survey included validated items and psychometric scales covering household and participating adolescent socio-demographics, parental PA, parental practices and rules related to PA, perceived neighbourhood and household environment, and reasons for living in the neighbourhood. The psychometric characteristics of self-report measures of AT and correlates of AT used in the iHealt(H) study have been reported elsewhere (Cerin et al., 2014, 2017b). Participants' neighbourhoods were defined in parent/caregiver surveys as an area encompassed by a 10–15 min walking distance from home (Cerin et al., 2007b).

2.1.1. Outcomes

Three AT outcome measures were used in this study. First, self-reported weekly frequency of ATS (walking and cycling) during an average school week was determined from adolescent responses on 6-point frequency (0 to 5 days per week) to- and from-school items (ATS total frequency range: 0–10) (Cerin et al., 2014). Second, weekly time spent in ATS was determined as the product of ATS weekly frequency and adolescent-reported walking time between home and school. Last, weekly frequency of AT to/from destinations other than school was computed from the sum of adolescent reported frequency of walking or cycling to/from nine destinations over the past year (Cerin et al., 2014). Adolescents responded to the question "How often do you usually walk or bike to or from the following?" on a 6-point response scale ranging from "never" (coded as 0) to "4 or more times per week" (coded as 5). The destinations included indoor recreation or exercise facilities, food stores or restaurants/cafés, and public transportation stops.

2.1.2. Environmental variables

Parent-reported perceived environmental variables were assessed using the Chinese version of the Neighbourhood Environment Walkability Scale for Youth (NEWS-Y) (Cerin et al., 2007b; Rosenberg et al., 2009). These included perceived proximity of school (excluded from the analysis of AT to other destinations) (1 item subscale), commercial facilities (11 items), the nearest transit stop (1 item), recreational facilities (15 items) and food outlets to home (6 items); neighbourhood street connectivity (3 items), residential density (6 items), traffic safety (6 items), safety from crime (8 items), aesthetics (3 items), access to services (3 items), barriers to walking (2 items), and pedestrian infrastructure in the neighbourhood (3 items). Perceived proximity-of- destinations subscales were rated by time to walk from home to the closest destination using a 5-point scale (1 = 1–5 min, 2 = 6–10 min, 3 = 11–20 min, 4 = 21–30 min, 5 = 31 + min). These items were subsequently reverse-coded to reflect proximity rather than distance. Scores for each

proximity-of-destination subscale were computed by averaging the reverse-coded values across all items included in the subscale. Perceived neighbourhood residential density was assessed by asking how common 6 types of residences, ranging from detached single residences to ≥ 20-storey apartment blocks, were in the neighbourhood using a 6-point scale from "none" to "all". Scores on this NEWS-Y subscale represented the weighted sum of the ratings across the 6 items reflecting perceived density of housing and computed using algorithms developed for the IPEN studies (Cerin et al., 2013a). All other NEWS-Y perceived environmental variables were quantified by computing the average ratings across multiple (relevant) items assessed using a 4-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree).

2.1.3. Social variables

Social variables were adolescent perceived social support for PA from peers, perceived social support for PA from household adults, parental rules about activity and parental transport-related PA. Social support was assessed with 2 items related to peers and 3 to household adults using a 5-point rating scale from "never" (coded as 0) to "very often" (coded as 5) (Cerin et al., 2017b; Norman et al., 2005). Ratings on the items of the two subscales were averaged. For parental rules about activity, the parent/caregiver responded "yes" or "no" to "Do you have the following rule for your child, whether you tell them often or not?" for 18 activity-related rules. Example statements are "do not go to places alone", "do homework before going out" and "check in frequently" (Cerin et al., 2017b). Positive answers on each of the 18 items were summed to create a total score. Parental transport-related PA (min/week) was measured using relevant items from the Chinese version of the International Physical Activity Questionnaire – Long (Macfarlane et al., 2011) asking to report the number of days in a typical week and time in a typical day spent travelling by walking or cycling.

2.1.4. Psychological variables

Three potential psychological correlates were examined in relation to each of the three AT outcomes (Cerin et al., 2017b; Norman et al., 2005). Self-efficacy for PA was assessed by 6 items, each rated on a 5-point scale ranging from "I'm sure I can't" to "I'm sure I can", and ratings on these items were averaged to obtain a total score. Enjoyment of PA was assessed by a 5-point Likert-like scale with responses to the statement "I enjoy doing physical activity" ranging from "strongly disagree" (coded as 1) to "strongly agree" (coded as 5). Adolescents responded to 5 positive and 5 negative statements regarding attitude to PA on a 4-point Likert scale ranging from "strongly disagree" (coded as 1) to "strongly agree" (coded as 4). The items included "I would feel embarrassed if people saw me doing physical activity" and "I would have fun doing physical activity or playing sports with my friends". Scores on negative statements were reverse-coded and then all ratings on the 10 items were averaged to obtain a total score for attitude towards PA.

2.1.5. Socio-demographic and other potential confounders

Potential confounders of associations between perceived psychological, social and environmental variables and AT outcomes included in the analysis were parent-reported adolescent age and gender, PA-related reasons for living in the neighbourhood (accounting for neighbourhood self-selection related to factors that may likely impact on the adolescents' levels of PA) (Cerin et al., 2007a), length of residence at current address, number of children in the household, number of motor vehicles in the household, highest level of education in the household (post-high school and high school or below), monthly household income and adolescent-reported social desirability. Parents rated 18 reasons for choosing their current neighbourhood on a 5-point scale from "not at all important" to "very important" (Supplementary Table 4). Seven of these were possible indicators of parental bias towards self-selecting to live in a neighbourhood likely to encourage adolescent PA. Due to their potential confounding effect, these 7 items were combined to comprise a scale, which was included as a covariate in all models. Social desirability was assessed using the 9-Item Lie Scale in the Children's Manifest Anxiety Scale (Reynolds and Richmond, 1978).

2.2. Data analyses

Descriptive statistics were computed for all variables. To examine associations between explanatory variables (perceived environmental, social and psychological factors) and AT outcomes and interaction effects, we used generalised linear models and zero-inflated negative binomial models with robust standard errors accounting for TPU- and school-level clustering. Generalised linear models with negative binomial variance and logarithmic link functions were used to model weekly frequency of AT to destinations other than school given that this outcome was positively skewed. Apart from being positively skewed, ATS outcomes had also a larger number of zero values (adolescents who reported not walking or cycling to school at least once a week) than expected by a negative binomial distribution. Hence, ATS were modelled using zero-inflated negative binomial models. These models generate two sets of regression estimates. One, the odds ratios of reporting zero frequency/minutes of ATS associated with a one unit increase in the correlates and, two, the proportional difference in non-zero frequency of ATS associated with a one unit increase in the correlates (Cerin et al., 2010). We first ran baseline models containing socio-demographic characteristics (age and gender) and other potential confounders (social desirability, parent self-selection of neighbourhood based on PA, length of residence, number of children in the household, number of motor vehicles in the household, highest level of education (adults) in the household, neighbourhood SES, household income) as the explanatory variables. A second set of models estimated the confounder-adjusted associations of single perceived environmental, social and psychological correlates of AT outcomes. We also estimated the moderating effects of adolescent gender and age on the associations of perceived social and environmental factors with AT as well as the moderating effects of the number of motor vehicles in the household on the relationships between perceived proximity to destinations and AT outcomes. We then undertook hierarchical modelling and specified multiple-factor models of AT. Only single factors found to be associated with specific AT outcomes at a probability level of 0.10 were initially entered into the multiple-factor models. Environmental factors were

first added to the 'baseline' models (with socio-demographic and other potential confounders) and backward stepwise deletion was applied. Only perceived environmental variables significant at a probability level of 0.05 were retained. This process was repeated for perceived social factors, which were added to models including 'baseline' predictors and environmental factors, and then again with psychological factors and, finally, with interaction terms to determine a fully-adjusted model. All perceived environmental, social and psychological correlates were entered in the final regression models as continuous variables for several reasons. All correlates were assessed using validated quantitative psychometric (sub)scales. Most or all perceived environmental (12 of 14 variables), social (4 of 4) and psychological (2 of 3) variables represented either ratio data (min/week of PA) or non-discrete composite scores (scores with decimal points) based on ratings from multiple items. Also, most of the latter type of variables were based on Likert or Likert-like rating scales with response points assumed to be perceived as equidistant by participants (Thurstone, 1929). The only variables that could have been modelled as categorical were perceived proximity to school and proximity to the nearest transit stop from home because they were quantified using a single item ordinal scale. Following recommended practice, preliminary testing for linearity of effects, indicated that these two variables could be treated as continuous predictors (Long and Freese, 2006). Potential curvilinear effects of other correlates were examined using locally-weighted scatterplot smoothing and restricted cubic splines. All analyses were conducted using Stata 15.0 (StataCorp LLC, 2017).

3. Results

The Hong Kong adolescents (n = 1299) who participated in the study were 57% girls with a mean age of 14.74 years (Table 1). Reported weekly frequency of ATS for the sample was 4.59 ± 4.56 trips/week and, for those adolescents who participated in ATS (n = 752; 58% of sample), 7.93 ± 3.07 trips/week. Adolescents who participated in ATS spent 139.79 ± 149.53 minutes/week in ATS, while the overall weekly mean for the whole sample was 80.93 ± 133.06 minutes/week. The average number of weekly trips to destinations other than school was 7.68 ± 5.76. The majority of ATS was walking, with only 9 students reporting riding bicycles to and from school 5 days per week in a normal week and only 42 any cycling to or from school. Sixty-nine percent of adolescents' households had no motorised vehicle. The above characteristics were similar for boys and girls (Supplementary Table 1).

Highest levels of education in the household and number of motor vehicles in the household were positively associated, and social desirability negatively associated, with not engaging in ATS (Supplementary Table 2). In other words, adolescents from households with higher educational attainment and more motor vehicles were less likely to engage in ATS, while adolescents with higher social desirability scores were more likely to report engaging in ATS. In those who participated in ATS, age was positively associated with frequency of ATS and the highest level of education in the household was positively associated with the total weekly minutes of ATS. In contrast, length of residence was negatively associated with the latter ATS outcome. Finally, household income was positively associated, and number of motor vehicles in the household negatively associated, with weekly frequency of non-school AT (Supplementary Table 2).

3.1. Associations of perceived environmental, social and psychological factors with ATS

In the multi-factor models, perceived proximity of school to home was the only environmental factor associated with the odds of not engaging in ATS (Tables 2 and 3), while four other environmental factors were identified as potential correlates of this AT outcome in the single-factor models (Supplementary Table 3). As expected, greater perceived proximity of school was associated with lower odds of not engaging in any ATS (i.e., higher odds of participation in ATS). Social support for PA from household adults and peers were the only other significant correlates of the odds of not engaging in ATS in the multi-factor models (Tables 2 and 3). Higher levels of social support from peers were associated with lower odds of not engaging in ATS, while the opposite was observed for social support for PA from household adults. The effect of social support for PA from household adults on the odds of not engaging in ATS was influenced by the adolescent's age. No significant association was observed in adolescents with an age 1 SD below the sample mean, whereas, for a one unit increase in social support for PA from household adults at mean age and mean age + 1 SD, there was an increase in the odds of not participating in ATS of 33% and 59%, respectively (Tables 2 and 3). No evidence was found of moderating effects of gender and number of motor vehicles in the household on the associations of specific perceived environmental and social factors with the odds of participating in ATS.

Perceived proximity of school to home and access to services were the environmental factors, and parental transport-related PA the social factor, positively associated with ATS frequency in those who undertook ATS (Table 2). Each unit increase in perceived proximity of school to home was associated with an 8% increase in frequency of ATS. In contrast, perceived proximity to school was negatively associated with weekly minutes of ATS in those who undertook ATS (Table 3). Gender but not age or number of motor vehicles in the household moderated a couple of associations with non-zero ATS frequency or weekly minutes. While in girls the association between social support for PA from peers and ATS frequency tended to be positive ($p = 0.066$), in boys it was not significant with a trend towards being negative (Table 2). Perceived proximity of public transport stop from home was positively related to weekly minutes of ATS only in boys (Table 3).

3.2. Associations of perceived environmental, social and psychological factors with AT frequency to other destinations

In the single-factor models, substantially more factors were significantly associated with AT frequency to other destinations than with ATS (Supplementary Table 3). All three psychological factors (self-efficacy for PA, enjoyment of PA and attitude towards PA) were significantly positively associated with AT to other destinations (Table 4), whereas none were associated with either ATS

Table 1
Sample characteristics (N = 1299).

Variables [theoretical range]		
Sociodemographic characteristics and other covariates	*%*	
Adolescent's gender (girls)	57.04	
	Mean (SD)	*Median (IQR)*
Adolescent's age (years)[P]	14.70 (1.57)	
PA-related reasons for living in the neighbourhood[P] (neighbourhood self-selection) [1 – 5]	3.38 (0.74)	
Social desirability[A] [0 – 9]	4.65 (2.15)	
Length of residence at current address[P] (years)	9.68 (6.62)	10 (10.00)
Number of children in the household[P]	1.66 (0.75)	
Number of motorised vehicles in the household[P]	*%*	*n*
0	69	898
1	23	298
2 or more	8	103
Highest level of education in the household		
High school or below	54	703
Post-high school	46	596
Monthly household income (HKD)[P]		
< 15,000	29	380
15,000–29,999	30	390
30,000–59,999	19	248
≥ 60,000	22	281
Perceived environmental correlates[P]	*Mean (SD)*	*Median (IQR)*
Proximity to school [1–5]	2.19 (1.28)	
Proximity of commercial facilities to home [1–5]	3.17 (0.90)	
Proximity of nearest transit stop to home [1–5]	3.91 (1.08)	
Proximity of recreational PA facility to home [1–5]	2.73 (0.72)	
Proximity of food outlets (restaurants/food stores) to home [1 – 5]	3.69 (0.90)	
Proximity to destinations (composite index) [1–5]	3.09 (0.70)	
Barriers to walking in the neighbourhood [1–4]	1.84 (0.70)	
Neighbourhood street connectivity [1–4]	2.93 (0.60)	
Neighbourhood residential density [0–1048]	468.07 (203.30)	
Neighbourhood traffic safety [1–4]	2.83 (0.40)	
Neighbourhood safety from crime [1–4]	2.81 (0.61)	
Neighbourhood aesthetics [1–4]	2.65 (0.60)	
Access to services [1–4]	3.26 (0.67)	
Pedestrian infrastructure in the neighbourhood [1–4]	2.88 (0.61)	
Social correlates		
Social support for PA from peers[A] [0–4]	1.15 (1.04)	1.00 (2.00)
Social support for PA from household adults[A] [0–4]	1.46 (0.94)	
Parental rules about activity[P] [0–18]	9.24 (3.61)	
Parental transport-related PA[P] (min/week)	166.61 (284.60)	60.00 (210.00)
Psychological correlates[A]		
Self-efficacy for PA [1–5]	2.72 (0.97)	
Enjoyment of PA [1–5]	3.73 (1.03)	
Attitude towards PA [1–4]	3.17 (0.41)	
Outcomes: active travel		
Self-reported weekly frequency of ATS [0–10]	4.59 (4.56)	4.00 (10)
Weekly time spent in ATS (min)	80.93 (133.06)	30.00 (105.00)
Weekly frequency of AT to destinations other than school	7.68 (5.76)	6.75 (8.00)
	%	*n*
Adolescent participation in ATS	57.89	752

Notes: AT = active travel; ATS = active travel to/from school; PA = physical activity; SD = standard deviation; IQR = interquartile range; HKD = Hong Kong dollars; [A] = adolescent survey; [P] = parent/caregiver survey

outcomes. AT frequency to other destinations was also significantly positively associated with two social factors (social support for PA from peers and social support from household adults) and seven of the 12 environmental factors (perceived proximity to food outlets, proximity to facilities, proximity to transit stop, proximity to recreational PA destination, access to services, street connectivity and crime safety). The four proximity-to-destination variables were all significantly associated with AT frequency to other destinations (proximity to food outlets ($p < .001$), facilities ($p < .001$), recreational PA destination ($p = .003$) and transit stop ($p = .044$)) and highly correlated with each other (average $r = 0.53$, range 0.39–0.86). Therefore, we created a composite perceived proximity variable (proximity to destinations (composite index)), which was also significantly associated AT frequency to other destinations, and substituted it for the individual proximity variables in the multi-factor models. In the final multi-factor model, perceived proximity of school to home and social support for PA from peers were associated with higher odds of engaging in ATS. In contrast, social support for PA from household adults with lower odds of engaging in ATS, especially in older adolescents. Also, social support for PA from household adults was positively related to this AT outcome before adjustment for psychological factors suggesting that psychological factors may mediate the effect of social support for PA from household adults on AT frequency to other destinations.

Table 2
Associations of perceived environmental, social and psychological factors with frequency of active travel to/from school in Hong Kong adolescents (multiple-factor models).

Factors	Model 1 (main effects)		Model 2 (main effects)		Model 3 (including interactions)	
	Zero vs non-zero frequency OR (95% CI) *p*-value	Non-zero frequency e^b (95% CI) *p*-value	Zero vs non-zero frequency OR (95% CI) *p*-value	Non-zero frequency e^b (95% CI) *p*-value	Zero vs non-zero frequency OR (95% CI) *p*-value	Non-zero frequency e^b (95% CI) *p*-value
Environmental						
Proximity of school to home	**0.482 (0.402, 0.578) < 0.001**	**1.080 (1.055, 1.104) < 0.001**	**0.489 (0.408, 0.586) < 0.001**	**1.081 (1.057, 1.105) < 0.001**	**0.487 (0.407, 0.584) < 0.001**	**1.080 (1.056, 1.105) < 0.001**
Access to services		**1.050 (1.010, 1.093) 0.015**		**1.048 (1.007, 1.091) 0.022**		**1.048 (1.006, 1.091) 0.024**
Social						
Parental transport-related PA (100 min wk^{-1})				**1.011 (1.006, 1.016) < 0.001**		**1.011 (1.005, 1.016) < 0.001**
Social support for PA from peers			**0.813 (0.689, 0.958) 0.014**		**0.805 (0.686, 0.945) 0.008**	
Social support for PA from household adults			**1.301 (1.112, 1.522) 0.001**			
Interactions: Factor * Moderator [subgroup specific associations]						
Social support for PA from peers * gender						
In girls						1.033 (0.998, 1.070) 0.066
In boys						0.976 (0.942, 1.011) 0.171
Social support for PA from household adults * Adolescent age						
Mean – 1 SD (13.13 years)					1.115 (0.901, 1.378) 0.316	
Mean (14.70 years)					**1.333 (1.140, 1.559) < 0.001**	
Mean + 1 SD (16.27 years)					**1.594 (1.312, 1.937) < 0.001**	

Notes. PA = physical activity; OR = odds ratio; e^b = antilogarithm of regression coefficient; CI = confidence interval; SD = standard deviation. In bold = statistically significant associations ($p < .05$); Results are based on zero-inflated negative binomial models with robust standard errors accounting for clustering; All models were adjusted for adolescent gender and age, social desirability, parent-reported neighbourhood self-selection and length of residence, number of children in the household, highest education level in the household, number of motorised vehicles in the household, neighbourhood-level socio-economic status and monthly household income.

This finding supports the value of hierarchical modelling from more distal to more proximal modifiable independent variables. No significant negative associations or interactions of possible correlates of AT frequency and adolescent gender, age or number of motor vehicles in the household were found.

4. Discussion

Perceived environmental and social factors were found to be significant correlates of both ATS and AT to other destinations, while significant correlates of AT to other destinations also included psychological variables. These findings highlight the importance of applying a socio-ecological approach when examining potential correlates of AT in adolescents.

Table 3
Associations of perceived environmental, social and psychological factors with weekly minutes of active travel to/from school in Hong Kong adolescents (multiple-factor models).

Factors	Model 1 (main effects)		Model 2 (main effects)		Model 3 (including interactions)	
	Zero vs non-zero minutes OR (95% CI) *p*-value	Non-zero minutes e^b (95% CI) *p*-value	Zero vs non-zero minutes OR (95% CI) *p*-value	Non-zero minutes e^b (95% CI) *p*-value	Zero vs non-zero minutes OR (95% CI) *p*-value	Non-zero minutes e^b (95% CI) *p*-value
Environmental						
Proximity of school to home	**0.481 (0.401, 0.576) < 0.001**	**0.773 (0.728, 0.822) < 0.001**	**0.487 (0.407, 0.584) < 0.001**	**0.773 (0.728, 0.822) < 0.001**	**0.485 (0.405, 0.582) < 0.001**	**0.771 (0.725, 0.821) < 0.001**
Social						
Social support for PA from peers			**0.812 (0.689, 0.958) 0.013**		**0.804 (0.686, 0.944) 0.008**	
Social support for PA from household adults			**1.301 (1.112, 1.522) 0.001**			
Interactions: Factor * Moderator [subgroup specific associations]						
Proximity of transit stop to home*gender						
In girls						0.951 (0.864, 1.046) 0.298
In boys						**1.116 (1.014, 1.229) 0.025**
Social support for PA from household adults * age						
Mean – 1 SD (13.13 years)					1.115 (0.901, 1.378) 0.316	
Mean (14.70 years)					**1.333 (1.140, 1.559) < 0.001**	
Mean + 1 SD(16.27 years)					**1.595 (1.312, 1.938) < 0.001**	

Notes. PA = physical activity; OR = odds ratio; e^b = antilogarithm of regression coefficient; CI = confidence interval; SD = standard deviation. In bold = statistically significant associations ($p < .05$); Results are based on zero-inflated negative binomial models with robust standard errors accounting for clustering; All models were adjusted for adolescent gender and age, social desirability, parent-reported neighbourhood self-selection and length of residence, number of children in the household, highest education level in the household, number of motorised vehicles in the household, neighbourhood-level socio-economic status and monthly household income.

4.1. ATS

Fifty-eight percent of the adolescent participants reported engaging in ATS. Our use of stratified sampling to maximize the variability in potential environmental and social correlates of the outcome measures involved 50% of the sample being drawn from high SES neighbourhoods where households were more likely to have access to private vehicles. This oversampling probably resulted in our adolescent ATS participation rate being an underestimation of that in Hong Kong overall. However, while lower than observed in a Finnish study where prevalence was 79% in spring and fall and 63% in winter (Kallio et al., 2016), it was at the high end of adolescent participation rates reported elsewhere, with, for example, USA ATS participation rate of 12–14 year-old school children being 11.8% in 2009 (McDonald et al., 2011).

The average amount of ATS of 140 min/week in those who undertook ATS may provide a substantial contribution to achieving positive health outcomes. As intensity of ATS was not assessed in this study, time spent undertaking MVPA, the intensity recommended in PA guidelines (Granger et al., 2017), cannot be determined. However, like other localities (Spiteri et al., 2017), Hong Kong students are known to carry heavy school bags to and from school (Education Bureau, Hong Kong, 2015), which suggests a considerable amount of MVPA may have taken place. In any case, a recent review on PA in adolescents concluded that levels of PA below recommended intensity can improve self-reported health status (Granger et al., 2017). This is supported by a review of systematic reviews, largely on adult populations, concluding that PA below current intensity guidelines has numerous health benefits (Warburton and Bredin, 2017).

Table 4
Associations of perceived environmental, social and psychological factors with active travel frequency to other destinations in Hong Kong adolescents (multiple-factor models).

Factor	Model 1 e^b (95% CI) *p*-value	Model 2 e^b (95% CI) *p*-value	Model 3 e^b (95% CI) *p*-value
Environmental			
Proximity to destinations (composite index)[a]	**1.004** **(1.002, 1.006)** **p < 0.001**	**1.004** **(1.002, 1.006)** **p < 0.001**	**1.004** **(1.002, 1.006)** **p < 0.001**
Social			
Social support for PA from peers		**1.114** **(1.078, 1.151)** **p < 0.001**	**1.084** **(1.049, 1.121)** **p < 0.001**
Social support for PA from household adults		**1.088** **(1.041, 1.138)** **p < 0.001**	
Psychological			
Self-efficacy for PA			**1.160** **(1.091, 1.233)** **p < 0.001**
Enjoyment of PA			**1.082** **(1.028, 1.139)** **0.002**

Notes. PA = physical activity; e^b = antilogarithm of regression coefficient; CI = confidence interval. In bold = statistically significant associations ($p < .05$); [a]This factor is a composite measure of Proximity to food outlets, facilities, transit stop and recreational PA destinations; Results are based on generalised linear models with negative binomial variance and logarithmic link functions with robust standard errors accounting for clustering; All models were adjusted for adolescent gender and age, social desirability, parent-reported neighbourhood self-selection and length of residence, number of children in the household, highest education level in the household, number of motorised vehicles in the household, neighbourhood-level socio-economic status and monthly household income.

4.1.1. Perceived environmental factors

While a number of perceived environmental attributes were related to ATS in the single-factor models, only perceived proximity to school and access to services were present in the final multi-factor models. The other environmental factors did not independently contribute to the explanation of ATS probably due to them being positively correlated (i.e., co-occurring) with proximity to school or access to services. Consistent with earlier research on ATS mentioned above, perceived proximity to school was a very strong positive correlate of both engagement in and amount of ATS. However, in those who participated, proximity was negatively related to weekly minutes of ATS, likely due to the decrease in distance walked with increased proximity. Although having the school closer to home can lead to a lower amount of accumulated ATS by the individual adolescent, it encourages students to participate in ATS, potentially increasing population levels of PA. Also participation in ATS has additional benefits, such as reduction in traffic and associated air and noise pollution. Access to services in the neighbourhood may be an additional incentive to engaging in ATS due to potential of the trip being multi-purpose.

The only observed interaction involving perceived environmental factors was found with respect to weekly minutes of ATS. While there was no significant relationship in girls, perceived proximity of a transit stop to home was positively associated with weekly minutes of ATS in boys. This unexpected finding is difficult to explain since it is plausible to assume that proximity to public transport may act as a disincentive to ATS. It is possible that the observed interaction effect might be due to chance given that all other moderating effects of gender on the associations between environmental factors and ATS were not significant. Alternatively, access to transport stops may be an indicator of neighbourhood walkability that may encourage engagement in ATS even in cases when the school is located further from home. These effects may apply more to boys than girls because the former may have higher levels of independent mobility. Based on parent and adolescent fear and safety concerns in other countries, boys may be allowed by parents to walk further from home than girls and feel safer doing so (Carver et al., 2010; Esteban-Cornejo et al., 2016).

4.1.2. Social factors

After adjustment for proximity to school, children from a household where parents engaged in higher amounts of transport-related PA were more likely to engage in ATS more frequently (Table 2). This may be due to enculturation of a positive attitude to walking for transport, or parental encouragement of ATS independent of the adolescent's attitude. While there is some evidence that parent modelling of PA may influence adolescent PA (Laird et al., 2016; Edwardson and Gorely 2010), only one other study to date appears to have examined associations between parent transport-related PA and adolescent AT. Compared to not undertaking ATS, Carlson et al. (2014), who excluded adolescents living more than 2 miles from their school, found parent transport-related PA was associated with undertaking 5–10, but not 1–4, ATS trips/ week.

It is interesting that while parental transportation-PA behaviour appeared to have a positive effect on adolescents' ATS, social support for PA from household adults was not related to the likelihood of engaging in ATS in those under 14.7 years and negatively related in those over 14.7 years. This was consistent with findings in 12–15 year-old USA adolescents, where social support for PA from household adults was not associated with ATS frequency (Carlson et al. 2014). In data from our sample of adolescents presented

elsewhere, there was a significant positive association between social support for PA from household adults and days/week with ≥ 60 min of PA outside school (Cerin et al., 2013b). The different results for AT and overall PA reflected the nature of items in the measure of social support for PA from household adults used in this study, which focussed on sport/exercise (e.g., "provide transportation to a place where you can do physical activity or play sports) rather than transportation PA. Together, our findings suggest that parents of older adolescents offering high levels of social support for PA may support their children's participation in organised PA at the expense of ATS. Also, older adolescents engaging in other PA outside of school would likely spend time travelling to other destinations to participate, which, may lead to less ATS due to it not being as time convenient as other forms of transport to and from school. In China, children (6–17 years) living in metropolitan areas where less likely to undertake ATS if they accumulated > 40 min of total PA per day (Yang et al., 2017). One of the strengths of AT as a type of PA with potential influence at a population level is the notion of it often being incidental (Cerin et al., 2017a), and less affected by enjoyment of and attitude towards being physically active than are engagement in sporting and recreational activities. For this reason, high levels of parental social support for PA affecting adolescents' attitude towards PA may have limited influence on adolescent ATS.

Having friends with whom there are both positive relationships and engagement with when undertaking PA promotes engagement in PA (Salvy et al., 2012; Fitzgerald et al., 2012). In this study, social support for PA from peers was positively associated with engagement in ATS (Table 2). Similar findings have been reported in 12–16 year-old New Zealand adolescents where low peer support was associated with reduced odds of ATS (Hohepa et al., 2007). In contrast, no relationships between social support for PA from peers and engagement in ATS were found in Portuguese and USA adolescents, while in Australian adolescents the relationship was positive for boys, but not for girls (Carlson et al., 2014). In those participating, we also found increased levels of social support for PA from peers was more likely to be associated with increased frequency of ATS in girls than in boys (Table 2). Similarly, in Australian adolescent girls, but not boys, 'having many friends in the neighbourhood' and 'lots of boys/girls to hang out with' were positively associated with frequency of ATS (Carver et al., 2005).

4.1.3. Psychological factors

No significant associations between psychological factors and ATS were found. This suggests that ATS is potentially influenced by environmental and social factors, with individual predispositions playing a lesser role. This is an important finding for the promotion of PA in adolescents, showing the potential for proximity to school from home to impact across the whole adolescent population, not only those with a predisposition for being active (those who enjoy PA and those who feel they can engage in PA). In China, a substantial increase in distance from home to school occurred concurrently with the prevalence of ATS in 6–17 year olds dropping from 95.8% in 1997 to 69.3% in 2011(Yang et al., 2017). For health benefits associated with adequate PA and to reduce the negative environmental impacts of non-walking modes of transport to school, adolescents should be able to walk to school and urban planning decisions should consider the value of local schools being accessible by walking from home.

4.2. Associations of perceived environmental, social and psychological factors with AT to destinations other than school

Few studies have investigated adolescent AT to destinations other than school (Carver et al., 2005). In one study, young Australian adolescents reported that the mean frequency of walking for transport other than to school was once every 10 days, with similar frequencies for walking for exercise (Carver et al., 2005), while a study on USA adolescents reported mean frequency of AT to various destinations other than school of between "once every other week" and "once a month or less" (Esteban-Cornejo et al., 2016). In contrast, 39.4% and 51.7% of Belgian older adolescents reported at least some walking or cycling to other destinations at least one day per week, with average amounts of 106 and 125 min $week^{-1}$ (Verhoeven et al., 2016). In the current study, adolescents reported a mean weekly frequency of 7.68 AT trips to destinations other than school. Perceived proximity to destinations was a strong predictor of Hong Kong adolescents' AT to destinations other than school. In the single variable models, all four variables comprising the composite perceived proximity to destination index were significantly positively associated with AT to destinations other than school, highlighting the importance of the proximity of a range of destinations on this outcome. The lack of any moderating effects of age, gender and number of vehicles in the household also suggests that access to these destinations appears to be equally relevant to boys and girls, to ages across the adolescent range, and households with or without motor vehicles, that is, to the majority of the Hong Kong adolescent population, with a potentially important effect on total PA. Due to the high density, very high levels of safety from crime (UNODC Statistics, 2017), easy access to destinations/services, difficulty and cost associated with parking and, therefore, inconvenience associated with using motor vehicles, the level of independent mobility in Hong Kong adolescents is likely to be greater than for those in many other cities.

In line with socio-ecological models of PA, perceived environmental factors were not the only significant correlates of AT to other destinations. Both social and psychological factors independently contributed to the explanation of this AT outcome. The positive associations found for social support from peers, and the psychological variables self-efficacy for PA and enjoyment of PA with AT to destinations other than school in Hong Kong adolescents have support in the literature. In Belgian adolescents, social support from friends and self-efficacy were associated with non-school walking for transport (De Meester et al., 2013). Findings that social support from friends is associated with PA directly and also indirectly via mediation by self-efficacy further support the potential importance of these correlates of AT to other destinations (Cheng et al., 2014). Also, US adolescent walking for transport (school plus other) was positively associated with all three correlates, although the strength of associations were lower for self-efficacy for PA and enjoyment of PA than in the current study (Wang et al., 2017). The similarity of associations across three continents, suggests these three variables may be important determinants of AT, independent of place and culture.

While, in the present study, parental social support for PA was negatively related to ATS, it was positively associated with AT to

other destinations. This may be due to AT to other destinations including walking to recreational facilities where adolescents undertake sport and exercise activities. Furthermore, parents that support adolescent engagement in sporting activities may also support their engagement in other types of activities. If these are close to home, adolescents are likely to walk to these destinations.

4.3. Strengths and limitations

This study had a number of strengths: adjustment for an extensive number of confounders including reasons for living in the neighbourhood (neighbourhood self-selection) and social desirability; stratification by walkability and area-level SES to maximise variability in exposures; use of validated and internationally comparable measures; the application of hierarchical distal-to-proximal-factor modelling; the use of parental-reported perceptions of the neighbourhood environment addressing same-source bias present in studies exclusively relying on surveys of environmental exposures and AT outcomes administered to the same participants; the treatment of outcome and exposure measures as 'continuous' where possible, reducing the likelihood of reporting biased findings due to artificial categorisation of exposure and/or outcome variables (Lamb and White, 2015). This study also had limitations. It was cross-sectional in nature and, therefore, cannot imply causality. While randomised controlled trials are not feasible when examining the effect of neighbourhood environmental characteristics on PA outcomes, longitudinal studies may provide more robust causal evidence in this area. All measurements in this study were reported by adolescents or their parents are, therefore, subjective. Future studies would need to examine objectively-assessed neighbourhood characteristics as correlates of ATS and AT to destinations. Frequency, duration and destinations measurements associated with AT in this study are, hence, unlikely to be as accurate as appropriate objective measures. Objective measurement of context specific PA, such as AT, is complex. Measurement of AT to destinations, as examined in this study, would require GPS and GIS data to determine frequency, distance and duration of trips, as well as types of destinations visited. Due to the high density of tall buildings in Hong Kong, GPS is not functional in many areas. Therefore, it was not possible to collect accurate objective data on AT in this study. For comparison with other studies, we have estimated the distance to school based on parent-reported walking duration: 18.5% of parents reported the school being 1–10 min from home (at 4 km/h this corresponds to within ~ 700 m from home); 40% of parents reported the school being up to 20 min walk from home (~ 1400 m from home); 45% of parents reported the school being more than 30 min walk from home > ~ 2 km). Frequency of travel modes to and from school in an average school week was assessed by the options of 0 to 5 days in each direction. This does not capture the possibility of multi-modal transport on a trip in one direction. However, school buses and taxis in Hong Kong typically collect students at their apartment complex, as would family cars. Parent-reported walking time to the nearest public transit stop from home was ~ 6–10 min (corresponding to an average proximity score of 3.91 in Table 1), somewhat higher than the objectively-assessed mean walking time of ~ 4 minutes from trip origin to a mechanised transport and vice versa reported by the Transport Department of the HKSAR (Transport Department, Government of Hong Kong, 2014). This suggests that adolescents travelling to and from school by public transport may, on average, accumulate in the range of 20–28 min of walking per school day. We examined associations between adolescents' neighbourhood environmental characteristics and their AT. The environment around destinations may have also influenced their AT behaviour (Carlson et al., 2014).

5. Conclusions

Our findings supported the importance of a multi-level socio-ecological approach when examining correlates of AT in Hong Kong adolescents. ATS was positively associated with perceived environmental and social factors, but not the examined psychological factors. In contrast, AT to other destinations was also associated with psychological factors. Also, unlike ATS, no moderation by socio-demographic characteristics was observed, supporting a broad population effect of the examined perceived environmental, social and psychological factors on this outcome in Hong Kong adolescents.

Hong Kong adolescents appear to have frequencies of ATS amongst the highest in the world and higher levels of AT to other destinations than reported elsewhere. Proximity to destinations (actual or perceived), school or other, has been consistently, strongly positively associated with adolescent AT. As AT has numerous benefits for adolescents and their community (e.g., health benefits associated with PA, development of spatial and navigational skills and sense of community (Carver et al., 2013), social interactions (Panter et al., 2008), and, not the least, it being a sustainable form of transport), policy makers and urban planners should ensure that adolescents can access schools and other destinations from home on foot. The findings of this study suggest that, to foster ATS, Hong Kong students should be encouraged to attend schools in their local catchment area. Furthermore, based on the observed positive association between parental transportation PA and frequency of ATS, promoting AT in the overall Hong Kong population should positively affect ATS in adolescents. In addition, the finding that access to services (as perceived by parents) can result in higher prevalence of adolescent AT, Hong Kong may provide a template for adolescent activity enhancing development of East Asian cities, which are increasing in density (World Bank, 2015).

Funding

This work was supported by the Health and Medical Research Fund (Food and Health Bureau, Government of the Hong Kong SAR, PR of China) (Grant number 10111501); and the National Heart, Lung and Blood Institute–National Institutes of Health (USA) (Grant number 5R01HL111378 02). EC is supported by an Australian Research Council Future Fellowship (FT3 140100085).

Conlict of interest

The authors report that they have no conflicts of interest.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.jth.2018.08.002.

References

Babey, S.H., Hastert, T.A., Huang, W., Brown, E.R., 2009. Sociodemographic, family, and environmental factors associated with active commuting to school among US adolescents. J. Public Health Policy 30, S203–S220. https://doi.org/10.1057/jphp.2008.61.

Bungum, T.J., Lounsbery, M., Moonie, S., Gast, J., 2009. Prevalence and correlates of walking and biking to school among adolescents. J. Community Health 34, 129–134. https://doi.org/10.1007/s10900-008-9135-3.

Carlson, J.A., Sallis, J.F., Kerr, J., Conway, T.L., Cain, K., Frank, L.D., Saelens, B.E., 2014. Built environment characteristics and parent active transportation are associated with active travel to school in youth age 12-15. Br. J. Sports Med. 48, 1634–1639. https://doi.org/10.1136/bjsports-2013-093101.

Carver, A., Salmon, J., Campbell, K., Baur, L., Garnett, S., Crawford, D., 2005. How do perceptions of local neighborhood relate to adolescents' walking and cycling? Am. J. Health Promot. 20, 139–147.

Carver, A., Timperio, A., Crawford, D., 2013. Parental chauffeurs: what drives their transport choice? J. Transp. Geogr. 26, 72–77. https://doi.org/10.1016/j.jtrangeo.2012.08.017.

Carver, A., Timperio, A., Hesketh, K., Crawford, D., 2010. Are children and adolescents less active if parents restrict their physical activity and active transport due to perceived risk? Soc. Sci. Med. 70, 1799–1805. https://doi.org/10.1016/j.socscimed.2010.02.010.

Cerin, E., Conway, T.L., Cain, K.L., Kerr, J., De Bourdeaudhuij, I., Owen, N., Reis, R.S., Sarmiento, O.L., Hinckson, E.A., Salvo, D., Christiansen, L.B., Macfarlane, D.J., Davey, R., Mitáš, J., Aguinaga-Ontoso, I., Sallis, J.F., 2013a. Sharing good NEWS across the world: developing comparable scores across 12 countries for the Neighborhood Environment Walkability Scale (NEWS). BMC Public Health 13, 309. https://doi.org/10.1186/1471-2458-13-309.

Cerin, E., Leslie, E., du Toit, L., Owen, N., Frank, L.D., 2007a. Destinations that matter: associations with walking for transport. Health Place 13, 713–724. https://doi.org/10.1016/j.healthplace.2006.11.002.

Cerin, E., Leslie, E., Sugiyama, T., Owen, N., 2010. Perceived barriers to leisure-time physical activity in adults: an ecological perspective. J. Phys. Act. Health 7, 451–459.

Cerin, E., Macfarlane, D.J., Ko, H.H., Chan, K.C.A., 2007b. Measuring perceived neighbourhood walkability in Hong Kong. Cities 24, 209–217. https://doi.org/10.1016/j.cities.2006.12.002.

Cerin, E., Nathan, A., van Cauwenberg, J., Barnett, D.W., Barnett, A., Council on Environment and Physical Activity (CEPA) – Older Adults Working Group, 2017a. The neighbourhood physical environment and active travel in older adults: a systematic review and meta-analysis. Int. J. Behav. Nutr. Phys. Act. 14, 15. https://doi.org/10.1186/s12966-017-0471-5.

Cerin, E., Sit, C.H.P., Barnett, A., Huang, W.Y.J., Gao, G.Y., Wong, S.H.S., Sallis, J.F., 2017b. Reliability of self-report measures of correlates of obesity-related behaviours in Hong Kong adolescents for the iHealt(H) and IPEN adolescent studies. Arch. Public Health 75, 38. https://doi.org/10.1186/s13690-017-0209-5.

Cerin, E., Sit, C.H., Huang, Y.J., Barnett, A., Macfarlane, D.J., Wong, S.S., 2014. Repeatability of self-report measures of physical activity, sedentary and travel behaviour in Hong Kong adolescents for the iHealt(H) and IPEN - Adolescent studies. BMC Pediatr. 14, 142. https://doi.org/10.1186/1471-2431-14-142.

Cerin, E., Sit, C.H.P., Wong, S.H.S., Huang, Y.J., Gao, G.Y., Mak, K.H., Lai, P.C., Macfarlane, D.J., Chow, M.C.B., Barnett, A., 2013b. Understanding the relative contribution and interactive effects of psychological, social and environmental correlates of physical activity, sedentary behaviours and dietary behaviours in Hong Kong adolescents. HMRF - Health and Health Services. Project reference No. 10111501. 〈https://rfs1.fhb.gov.hk/app/fundedsearch/projectdetail.xhtml?Id=1118〉 (Accessed 19 January 2018).

Cheng, L.A., Mendonça, G., Farias Júnior, J.C., 2014. Physical activity in adolescents: analysis of the social influence of parents and friends. J. Pediatr. 90, 35–41. https://doi.org/10.1016/j.jped.2013.05.006.

De Meester, F., Van Dyck, D., De Bourdeaudhuij, I., Deforche, B., Cardon, G., 2013. Does the perception of neighborhood built environmental attributes influence active transport in adolescents? Int. J. Behav. Nutr. Phys. Act. 10, 38. https://doi.org/10.1186/1479-5868-10-38.

Deweese, R.S., Yedidia, M.J., Tulloch, D.L., Ohri-Vachaspati, P., 2013. Neighborhood perceptions and active school commuting in low-income cities. Am. J. Prev. Med. 45, 393–400. https://doi.org/10.1016/j.amepre.2013.04.023.

Dygrýn, J., Mitáš, J., Gába, A., Rubín, L., Frömel, K., 2015. Changes in active commuting to school in Czech adolescents in different types of built environment across a 10-year period. Int. J. Environ. Res. Public Health 12, 12988–12998. https://doi.org/10.3390/ijerph121012988.

Education Bureau, Government of the HKSAR, 2015. Education Bureau Circular No. 17/2015, Guidelines on reducing weight of school bags. 〈http://applications.edb.gov.hk/circular/upload/EDBC/EDBC15017E.pdf〉 (Accessed on 17 May 2018).

Edwardson, C.L., Gorely, T., 2010. Parental influences on different types and intensities of physical activity in youth: a systematic review. Psychol. Sport Exerc. 11https://doi.org/10.1016/j.psychsport.2010.05.001. (522e535).

Esteban-Cornejo, I., Carlson, J.A., Conway, T.L., Cain, K.L., Saelens, B.E., Frank, L.D., Glanz, K., Roman, C.G., Sallis, J.F., 2016. Parental and adolescent perceptions of neighborhood safety related to adolescents' physical activity in their neighborhood. Res. Q. Exerc. Sports 87, 191–199. https://doi.org/10.1080/02701367.2016.1153779.

Fitzgerald, A., Fitzgerald, N., Aherne, C., 2012. Do peers matter? A review of peer and/or friends' influence on physical activity among American adolescents. J. Adolesc. 35, 941–958. https://doi.org/10.1016/j.adolescence.2012.01.002.

Granger, E., Di Nardo, F., Harrison, A., Patterson, L., Holme, R., Verma, A., 2017. A systematic review of the relationship of physical activity and health status in adolescents. Eur. J. Public Health 27 (suppl_2), 100–106. https://doi.org/10.1093/eurpub/ckw187.

Hohepa, M., Scragg, R., Schofield, G., Kolt, G.S., Schaaf, D., 2007. Social support for youth physical activity: importance of siblings, parents, friends and school support across a segmented school day. Int. J. Behav. Nutr. Phys. Act. 4, 54. https://doi.org/10.1186/1479-5868-4-54.

Huang, W.Y., Wong, S.H., He, G., 2017. Is a change to active travel to school an important source of physical activity for Chinese children? Pediatr. Exerc. Sci. 29, 161–168. https://doi.org/10.1123/pes.2016-0001.

Hume, C., Timperio, A., Salmon, J., Carver, A., Giles-Corti, B., Crawford, D., 2009. Walking and cycling to school: predictors of increases among children and adolescents. Am. J. Prev. Med. 36, 195–200. https://doi.org/10.1016/j.amepre.2008.10.011.

International Physical Acivity and Environment Network. IPEN Adolescent. 〈http://www.ipenproject.org/IPEN_adolescent.html〉 (Accessed 01 March 2018).

Jago, R., Baranowski, T., Baranowski, J.C., Cullen, K.W., Thompson, D.I., 2007. Social desirability is associated with some physical activity, psychosocial variables and sedentary behavior but not self-reported physical activity among adolescent males. Health Educ. Res. 22, 438–449. https://doi.org/10.1093/her/cyl107.

Kallio, J., Turpeinen, S., Hakonen, H., Tammelin, T., 2016. Active commuting to school in Finland, the potential for physical activity increase in different seasons. Int. J. Circumpolar Health 75, 33319. https://doi.org/10.3402/ijch.v75.33319.

Laird, Y., Fawkner, S., Kelly, P., McNamee, L., Niven, A., 2016. The role of social support on physical activity behaviour in adolescent girls: a systematic review and meta-analysis. Int. J. Behav. Nutr. Phys. Act. 13, 79. https://doi.org/10.1186/s12966-016-0405-7.

Lamb, K.E., White, S.R., 2015. Categorisation of built environment characteristics: the trouble with tertiles. Int. J. Behav. Nutr. Phys. Act. 12, 19. https://doi.org/10.1186/s12966-015-0181-9.

Larouche, R., Saunders, T.J., Faulkner, G., Colley, R., Tremblay, M., 2014. Associations between active school transport and physical activity, body composition, and cardiovascular fitness: a systematic review of 68 studies. J. Phys. Act. Health 11, 206–227. https://doi.org/10.1123/jpah.2011-0345.
Larsen, K., Gilliland, J., Hess, P., Tucker, P., Irwin, J., He, M., 2009. The influence of the physical environment and sociodemographic characteristics on children's mode of travel to and from school. Am. J. Public Health 99, 520–526. https://doi.org/10.2105/AJPH.2008.135319.
Long, J.S., Freese, J., 2006. Regression Models for Categorical Dependent Variables using Stata, 2nd ed. Stata Press, College Station, TX.
Loucaides, C.A., Jago, R., Theophanous, M., 2010. Prevalence and correlates of active traveling to school among adolescents in Cyprus. Cent. Eur. J. Public Health 18, 151–156.
Macfarlane, D., Chan, A., Cerin, E., 2011. Examining the validity and reliability of the Chinese version of the International Physical Activity Questionnaire, long form (IPAQ-LC). Public Health Nutr. 14, 443–450. https://doi.org/10.1017/S1368980010002806.
Mah, S.K., Nettlefold, L., Macdonald, H.M., Winters, M., Race, D., Voss, C., McKay, H.A., 2017. Does parental support influence children's active school travel? Prev. Med. Rep. 6, 346–351. https://doi.org/10.1016/j.pmedr.2017.04.008.
Mandic, S., Leon de la Barra, S., García Bengoechea, E., Stevens, E., Flaherty, C., Moore, A., Middlemiss, M., Williams, J., Skidmore, P., 2015. Personal, social and environmental correlates of active transport to school among adolescents in Otago, New Zealand. J. Sci. Med. Sports 18, 432–437. https://doi.org/10.1016/j.jsams.2014.06.012.
McDonald, N.C., Brown, A.L., Marchetti, L.M., Pedroso, M.S., 2011. U.S. school travel, 2009 an assessment of trends. Am. J. Prev. Med. 41, 146–151. https://doi.org/10.1016/j.amepre.2011.04.006.
Nelson, N.M., Foley, E., O'Gorman, D.J., Moyna, N.M., Woods, C.B., 2008. Active commuting to school: how far is too far? Int. J. Behav. Nutr. Phys. Act. 5, 1. https://doi.org/10.1186/1479-5868-5-1.
Norman, G.J., Sallis, J.F., Gaskins, R., 2005. Comparability and reliability of paper- and computer-based measures of psychosocial constructs for adolescent physical activity and sedentary behaviors. Res. Q. Exerc. Sports 76, 315–323. https://doi.org/10.1080/02701367.2005.10599302.
Owen, N., Cerin, E., Leslie, E., duToit, L., Coffee, N., Frank, L.D., Bauman, A.E., Hugo, G., Saelens, B.E., Sallis, J.F., 2007. Neighborhood walkability and the walking behavior of Australian adults. Am. J. Prev. Med. 33, 387–395. https://doi.org/10.1016/j.amepre.2007.07.025.
Oyeyemi, A.L., Ishaku, C.M., Deforche, B., Oyeyemi, A.Y., De Bourdeaudhuij, I., Van Dyck, D., 2014. Perception of built environmental factors and physical activity among adolescents in Nigeria. Int. J. Behav. Nutr. Phys. Act. 11, 56. https://doi.org/10.1186/1479-5868-11-56.
Pabayo, R., Gauvin, L., Barnett, T.A., 2011. Longitudinal changes in active transportation to school in Canadian youth aged 6 through 16 years. Pediatrics. 128, e404–e413. https://doi.org/10.1542/peds.2010-1612.
Panter, J.R., Jones, A.P., van Sluijs, E.M., 2008. Environmental determinants of active travel in youth: a review and framework for future research. Int. J. Behav. Nutr. Phys. Act. 5, 34. https://doi.org/10.1186/1479-5868-5-34.
Pizarro, A.N., Schipperijn, J., Ribeiro, J.C., Figueiredo, A., Mota, J., Santos, M.P., 2017. Gender differences in the domain-specific contributions to moderate-to-vigorous physical activity, accessed by GPS. J. Phys. Act. Health. 14, 474–478. https://doi.org/10.1123/jpah.2016-0346.
Reynolds, C.R., Richmond, B.O., 1978. What I think and feel: a revised measure of children's manifest anxiety. J. Abnorm. Child Psychol. 6, 271–280.
Rosenberg, D., Ding, D., Sallis, J.F., Kerr, J., Norman, G.J., Durant, N., Harris, S.K., Saelens, B.E., 2009. Neighborhood Environment Walkability Scale for Youth (NEWS-Y): reliability and relationship with physical activity. Prev. Med. 49, 213–218. https://doi.org/10.1016/j.ypmed.2009.07.011.
Sallis, J.F., Cervero, R.B., Ascher, W., Henderson, K.A., Kraft, M.K., Kerr, J., 2006. An ecological approach to creating active living communities. Annu. Rev. Public Health 27, 297–322. https://doi.org/10.1146/annurev.publhealth.27.021405.102100.
Salvy, S.J., de la Haye, K., Bowker, J.C., Hermans, R.C., 2012. Influence of peers and friends on children's and adolescents' eating and activity behaviors. Physiol. Behav. 106, 369–378. https://doi.org/10.1016/j.physbeh.2012.03.022.
Schlossberg, M., Greene, J., Paulsen Phillips, P., Johnson, B., Parker, B., 2006. School trips: effects of urban form and distance on travel mode. J. Am. Plann. Assoc. 72, 337–346. https://doi.org/10.1080/01944360608976755088976755.
Silva, K.S., Pizarro, A.N., Garcia, L.M., Mota, J., Santos, M.P., 2014. Which social support and psychological factors are associated to active commuting to school? Prev. Med. 63, 20–23. https://doi.org/10.1016/j.ypmed.2014.02.019.
Singh-Manoux, A., Clarke, P., Marmot, M., 2002. Multiple measures of socio- economic position and psychosocial health: proximal and distal measures. Int. J. Epidemiol. 31, 1192–1199.
Spiteri, K., Busuttil, M.L., Aquilina, S., Gauci, D., Camilleri, E., Grech, V., 2017. Schoolbags and back pain in children between 8 and 13 years: a national study. Br. J. Pain 11, 81–86. https://doi.org/10.1177/2049463717695144.
StataCorp LLC, 2017. College Station, TX 77845, USA.
Stewart, T., Duncan, S., Schipperijn, J., 2017. Adolescents who engage in active school transport are also more active in other contexts: a space-time investigation. Health Place 43, 25–32. https://doi.org/10.1016/j.healthplace.2016.11.009.
Thurstone, L.L., 1929. Theory of attitude measurement. J. Exp. Psychol. 12, 214–224.
Transport Department, Government of Hong Kong, 2014. Travel Characteristics Survey 2011 Final Report. 〈http://www.td.gov.hk/filemanager/en/content_4652/tcs2011_eng.pdf〉 (Accessed 21 May 2018).
United Nations, Department of Economic and Social Affairs, Population Division, 2014. World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352).
UNODC Statistics, 2017. Updated. 〈https://data.unodc.org/#state:0〉 (Accessed 01 April 2018).
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. https://doi.org/10.1016/j.ypmed.2007.06.002.
Verhoeven, H., Simons, D., Van Dyck, D., Van Cauwenberg, J., Clarys, P., De Bourdeaudhuij, I., de Geus, B., Vandelanotte, C., Deforche, B., 2016. Psychosocial and environmental correlates of walking, cycling, public transport and passive transport to various destinations in Flemish older adolescents. PLoS One 11, e0147128. https://doi.org/10.1371/journal.pone.0147128.
Wang, X., Conway, T.L., Cain, K.L., Frank, L.D., Saelens, B.E., Geremia, C., Kerr, J., Glanz, K., Carlson, J.A., Sallis, J.F., 2017. Interactions of psychosocial factors with built environments in explaining adolescents' active transportation. Prev. Med. 100, 76–83. https://doi.org/10.1016/j.ypmed.2017.04.008.
Warburton, D.E.R., Bredin, S.S.D., 2017. Health benefits of physical activity: a systematic review of current systematic reviews. Curr. Opin. Cardiol. 32, 541–556. https://doi.org/10.1097/HCO.0000000000000437.
Wong, B.Y., Faulkner, G., Buliung, R., Irving, H., 2011. Mode shifting in school travel mode: examining the prevalence and correlates of active school transport in Ontario, Canada. BMC Public Health 11, 618. https://doi.org/10.1186/1471-2458-11-618.
World Bank, 2015. East Asia's Changing Urban Landscape: Measuring a Decade of Spatial Growth. Urban Development Series. World Bank, Washington, DC. https://doi.org/10.1596/978-1-4648-0363-5. (License: Creative Commons Attribution CC BY 3.0 IGO Changing).
World Health Organisation, 2010. Global recommendations on physical activity for health. 〈http://apps.who.int/iris/bitstream/10665/44399/1/9789241599979_eng.pdf〉 (Accessed 31 March 2018).
Yang, Y., Hong, X., Gurney, J.G., Wang, Y., 2017. Active travel to and from school among school age children during 1997–2011 and associated factors in China. J. Phys. Act. Health 17, 1–25. https://doi.org/10.1123/jpah.2016-0590.