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Does activity space size influence physical activity levels of adolescents?—A GPS study of an urban environment

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ABSTRACT

Background. Physical activity (PA) is closely linked with child and youth health, and active travel may be a solution to enhancing PA levels. Activity spaces depict the geographic coverage of one's travel. Little is known about activity spaces and PA in adolescents.

Objective. To explore the relation between adolescent travel (using a spatial measure of activity space size) and daily moderate-to-vigorous PA (MVPA), with a focus on school days.

Methods. We used Global Positioning Systems to manually identify trips and generate activity spaces for each person-day; quantified by area for 39 students (13.8 $\pm$ 0.6 years, 38% female) attending high school in urban Downtown Vancouver, Canada. We assessed the association between activity space area and MVPA using multi-level regression. We calculated total, school-day and trip-based MVPA for each valid person-day (accelerometry; ≥ 600 min wear time).

Results. On school days, students accrued 68.2 min/day (95% CI 60.4–76.0) of MVPA. Daily activity spaces averaged 2.2 km^2 (95% CI 1.3–3.0). There was no association between activity space size and school-day MVPA. Students accrued 21.8 min/day (95% CI 19.2–24.4) of MVPA during school hours, 19.4 min/day (95% CI 15.1–23.7) during travel, and 28.3 min/day (95% CI 22.3–34.3) elsewhere.

Conclusion. School and school travel are important sources of PA in Vancouver adolescents, irrespective of activity space area covered.

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Introduction

Physical activity (PA) is a powerful determinant of health. It is also an effective means to prevent a host of chronic diseases across ages and populations (Warburton et al., 2006). Thus, it is alarming that fewer than 1 in 10 young Canadians meet national PA guidelines (Colley et al., 2011).

Solutions are needed to offset the decline in PA in young people. There is a growing body of evidence that links the built environment to adolescent PA (Ding et al., 2011; Tucker et al., 2009); well-designed neighbourhoods offer adolescents more opportunities to be physically active outdoors or choose active travel modes (e.g. walk, cycle).

Activity spaces are defined as the geographic coverage of an individual's travel by measuring the places people visit and the routes people take to get there (Hirsch et al., 2014), and provide a realistic and accurate definition of the spatial environment that individuals are exposed to and interact with (Zenk et al., 2011). In our study context of downtown Vancouver—a highly walkable setting with good access to public transit—we assume that adolescents' activity spaces are largely reflective of their active travel behaviours, and hypothesize that larger activity spaces are positively associated with PA. We are aware of only one previous study that has directly investigated the association between activity space size and children's PA, and they found no association (Villanueva et al., 2012). Their study defined activity spaces from a mapping exercise, where children self-identified their neighbourhoods (home, destinations) on maps.

Combining accelerometer, global positioning systems (GPS) and geographic information systems (GIS) provides sensitive and accurate measures of context-specific behaviour relative to space and time (Jankowska et al., 2015). The aim of this paper was to employ these state-of-the-art measures to explore the association between the size

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of activity spaces (geographic coverage of daily travel) and moderate-to-vigorous PA (MVPA; min/day) amongst adolescents residing in downtown Vancouver.

Methods

Sample

In Fall 2012, we invited grade 8–10 students who were attending a high school in downtown Vancouver to participate in the *Active Streets, Active People-Junior* study. Of the 49 students who assented and provided parental consent, 39 (13.8 ± 0.6 years, 38% female) had sufficient data to include in the analysis. The Vancouver School Board and the University of British Columbia Behavioural Research Ethics Board approved the study.

Protocol and data processing

Trained research assistants assessed stature (0.1 cm) and body mass (0.1 kg) in schools during physical education classes. Concurrently, students self-reported usual modes of travel to and from school via questionnaire. To better understand our sample in relation to the school's student population, and to illustrate the close proximity between home and school in our sample of urban youth, we used ArcGIS[TM] (v.10.1, ESRI®, Redlands, CA) to calculate the shortest distance along the street network between a student's residential address (parent-reported) and their school, and to determine whether students resided within the defined school catchment area. We fitted students with Global Positioning Systems (GPS; QStarz BT-Q1000XT, QStarz International Co. Ltd., Taipei, Taiwan) and accelerometers (GT3X+; ActiGraph LLC, Pensacola, FL) and instructed them to wear units over the right hip. Data were collected using 1 second epochs for both GPS and accelerometry.

We manually identified GPS trips using the tracking analyst tool in ArcGIS[TM]. We describe these methods in detail elsewhere (Voss et al., 2015). In brief, accelerometry and GPS data were merged for each participant. Then, trained researchers used the tracking analyst tool (ArcGIS) to evaluate second-by-second data and code trips. Trip start, end, and pause times were determined, and trip mode was identified by looking at speed, MVPA intensity, and the actual path the student was taking. Trip-based MVPA was defined as any MVPA accrued while the student was in transit (moving between two discreet locations), regardless of the mode. Trips containing multiple modes (e.g. walk to bus) were coded by mode and were also assigned a main mode (based on the greatest distance travelled) (Voss et al., 2015). We included days for participants with ≥10 h accelerometer wear-time and ≥1 GPS trip for each person-day. From accelerometry, we estimated MVPA (min/day) as total/day, school-day (weekdays between 8:35 and 15:03, based on school schedule) and trip-based (during travel only) for each person-day (ActiLife v.6.5.4; Evenson et al., 2008). We had 74 valid person-days (range 1–4 days/person); most were school days ($n = 54$, 73%). For the remainder of this analysis, we focused on school days only, given the routine nature of school travel and common destinations (home, school).

Activity space generation

Using a previously published python script (Python 2.7.2, Python Software Foundation, www.python.org) (Hirsch et al., 2014) and ArcPy for ArcGIS 10.1 (ESRI, Redlands, CA, USA) we analysed trip-related GPS point data, aggregated by individual to create activity spaces from GPS points for each person-day. In brief, we generated Daily Path Area (DPA) activity spaces by buffering each individual's GPS trips 200-m, dissolving all buffered trips into one polygon, and removing bodies of water. We included GPS points for all trips in a day for each person-day, and used ArcGIS[TM] to quantify activity space area for each person-day (km^2). On a theoretical level, this method may more closely represent the environments these adolescents passed through during the time they wore their GPS units than other types of activity spaces, such as Standard Deviation Ellipses or Minimum Convex Polygons, which may capture large regions not encountered by the wearer of the GPS.

Data analysis

We generated sex-specific descriptives as frequencies or means (SD/95% CI). To account for multiple person-days per adolescent, we used multi-level regression models that evaluated associations between daily activity space area and daily MVPA (total, school-day, and trip-based). We visually inspected the distribution of residuals to confirm the appropriateness of parametric methods. We used Stata (v. 13, StataCorp LP, College Station, TX) to perform our analyses. Results from linear models without clustering produced almost identical estimates (not shown).

Table 1
Characteristics of adolescents and their physical activity.

	All	Boys	Girls	p
n participants	39	24	15	
Sample characteristics				
Age (years)	13.8 (0.6)	13.8 (0.6)	13.7 (0.6)	0.619
BMI percentile[a]	53.4 (33.7)	57.4 (34.8)	46.9 (32.1)	0.345
WHO weight category, n (%)[b]				
Normal	29 (74%)	16 (67%)	13 (87%)	0.164
Overweight (incl. obese)	10 (26%)	8 (33%)	2 (13%)	
Distance to school (km)[c]	2.0 (1.8)	2.3 (2.2)	1.3 (0.7)	**0.046**
Proportion living in school catchment, *n* (%)[d]	36 (92%)	21 (88%)	15 (100%)	0.154
Main mode of travel to and from school, n (%)[e]				
Walk	19 (49%)	11	8	0.600
Transit	14 (36%)	10	4	
Other (incl. car)	6 (15%)	3	3	
School day statistics				
n person-days (participants)	54 (37)	36 (23)	18 (14)	
Activity spaces (km^2)[f]				
Activity space size	2.2 (1.3–3.0)	2.5 (1.2–3.8)	1.5 (0.9–2.2)	0.265
Physical activity (min/day)				
Total MVPA[g]	68.2 (60.4–76.0)	75.9 (65.9–85.9)	53.2 (46.7–59.8)	**0.003**
School-day MVPA[g]	21.8 (19.2–24.4)	23.9 (20.7–27.0)	18.1 (14.6–21.6)	**0.020**
Trip-based MVPA[g]	19.4 (15.1–23.7)	20.8 (14.7–26.9)	17.2 (11.7–22.6)	0.442
Other MVPA[g]	28.3 (22.3–34.3)	33.0 (24.9–41.1)	18.9 (12.8–24.9)	**0.024**

Data are *n*, mean (SD), or mean (95% CI) unless otherwise specified. Significant between-group differences were estimated via Pearson's Chi-Square test for frequency data or independent t-tests for continuous data; significance set at $p < 0.05$ (unadjusted for multiple comparisons), indicated in boldface text. Participants were public high school students from Downtown Vancouver, sampled in October 2012.

[a] BMI—body mass index (kg m^{-2}); percentiles calculated based on age-sex specific WHO 2007 reference charts (De Onis et al., 2007).

[b] World Health Organization age-sex specific BMI weight categorization (De Onis et al., 2007).

[c] Shortest distance between residential address (parent-reported) and school along the street network, calculated using geographic information systems software (ArcGIS v. 10.1; ESRI Inc., CA).

[d] 4.2 km^2 catchment area, furthest distance to school along street network: 3.0 km.

[e] Main mode (≥6 trips/week); based on students' self-report.

[f] Daily Path Area Activity Spaces (Hirsch et al., 2014). Area of 200 m buffer around total daily GPS tracks with water bodies removed, calculated using Python v. 2.7 and geographic information systems software (ArcGIS v. 10.1; ESRI Inc., CA).

[g] Moderate-to-vigorous physical activity (≥2296 CPM) (Evenson et al., 2008).

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