Geospatial Health 8(2), 2014, pp. 569-572

The physical environment and health-enhancing activity during the school commute: global positioning system, geographical information systems and accelerometry

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Abstract. Active school travel is in decline. An understanding of the potential determinants of health-enhancing physical activity during the school commute may help to inform interventions aimed at reversing these trends. The purpose of this study was to identify the physical environmental factors associated with health-enhancing physical activity during the school commute. Data were collected in 2009 on 166 children commuting home from school in Scotland. Data on location and physical activity were measured using global positioning systems (GPS) and accelerometers, and mapped using geographical information systems (GIS). Multi-level logistic regression models accounting for repeated observations within participants were used to test for associations between each land-use category (road/track/path, other man-made, greenspace, other natural) and moderate-to-vigorous physical activity (MVPA). Thirty-nine children provided 2,782 matched data points. Over one third (37.1%) of children's school commute time was spent in MVPA. Children commuted approximately equal amounts of time *via* natural and man-made land-uses (50.2% and 49.8% respectively). Commuting *via* road/track/path was associated with increased likelihood of MVPA (Exp(B)=1.23, P <0.05), but this association was not seen for commuting *via* other man-made land-uses. No association was noted between greenspace use and MVPA, but travelling *via* other natural land-uses was associated with lower odds of MVPA (Exp(B)=0.32, P <0.05). Children spend equal amounts of time commuting to school *via* man-made and natural land-uses, yet man-made transportation route infrastructure appears to provide greater opportunities for achieving health-enhancing physical activity levels.

Keywords: school travel, physical activity, physical environment, children, global positioning systems, geographical information systems, Scotland.

Introduction

Active school travel is declining among children from developed countries (McDonald, 2007; van der Ploeg et al., 2008). Identifying the correlates of health-enhancing physical activity during the school commute may help inform policy in this important area of health promotion. Several personal and environmental correlates that serve to promote or restrict active school travel have been identified. Factors such as belonging to a minority ethnic group (Braza et al., 2004), being of low socio-economic status (Martin et al., 2007), and living in walkable urban areas with high population density (Pabayo and Gauvin, 2008) are positively associated with active commuting. Conversely, factors that are negatively associated include the need to negotiate busy roads (Bringolf-Isler et al., 2008), living far from school (Page et al., 2010), and attending a private/independent school (Merom et al., 2006).

While prior research provides helpful insight into commuting patterns and correlates, the majority of these findings are based on studies that used aggregated self-reported data. The recent availabilty of small and affordable global positioning systems (GPS) and accerelometers has made it possible for researchers to combine these instruments and objectively determine the physical environments where children engage in physical activity (Oreskovic et al., 2012). The present

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study aimed to identify physical environment factors associated with health-enhancing (defined as moderate-to-vigorous intensity) physical activity during the school commute, using objective within-person repeated measurements. The physical environment is of particular interest because it is amenable to change; therefore results from this study may inform urban planning policy, including policy relating to the environmental context of new school builds.

Materials and methods

Sample

Participants were 166 children aged 8-9 years old from five elementary schools in Scotland. Ethical approval was granted from the overseeing university and signed informed consent was obtained from each child and one of their parents or guardian prior to data collection.

Measures

Data were collected as part of a larger school travel intervention study (McMinn et al., 2011). Each participant wore an Actigraph GT1M (Actigraph Inc.; Pensacola, USA) accelerometer on an elastic belt around their waist and carried a Trackstick™ Super (Telespial Systems Inc.; Marina Del Rey, USA) GPS tracking device in their schoolbag during one journey home from school. Accelerometers were initialised to collect data using 5-sec epochs and the GPS trackers were set to full power mode (approximately one recording every 5-sec). Self-reported age and sex were collected. Data were collected during August-September 2009.

Data treatment

Data were downloaded using proprietary software packages for each device (Actilife, version 3.2.2 and Trackstick Manager, version 3.1.0). The PALMS, version 1.4.0 (http://ucsd-palms-project.wikispaces.com) online data processing tool was used (i) to match each pair of corresponding GPS and accelerometer data points based on date/time and (ii) to determine the mode of travel (active travel *vs*. vehicular transport, with vehicular transport classified as speeds >25 km/h), and (iii) calculate the activity intensity for each pair of matched data points with moderate-to-vigorous physical activity (MVPA) classified as activity above a threshold of 2,296 accelerometer counts per min according to age appropriate guidelines (Evenson et al., 2008). Only data points for which both data sources (accelerometer/GPS) were available were retained for analysis. Non-wear was defined as 90-min of consecutive zero counts (Choi et al., 2011).

The land-use category associated with each pair of matched data points was established with a geographical information system (GIS) using ArcGIS, version 10.0 (ESRI; Redlands, USA). Each set of GPS coordinates (latitude/longitude) was overlaid on Scotland's Greenspace and Ordinance Survey GIS layers to determine the following variables:

(i) greenspace;
(ii) road/track/path;
(iii) other natural area (i.e. natural land-use not categorised as greenspace); and
(iv) other man-made area (i.e. man-made land-use not categorised as road/track/path).

Consequently, each pair of matched accelerometer and GPS data points was assigned one of these four land-use categories. These categories were selected using a combination of available GIS data and informed decision based on previous research (Giles-Corti et al., 2011; Wong et al., 2011).

Statistical analyses

Descriptive statistics were calculated for relevant variables. Multi-level logistic regression was used to predict the odds of each land-use category being associated with MVPA, whilst accounting for the nested nature of the data (i.e. observations within participants) and controlling for participant age, sex, and school. SPSS Statistics, version 20 (IBM Corp.; Armonk, USA) and MlwiN, version 2.28 software were used for analyses (Rasbash et al., 2012).

Results

Of the original 166 participants, 102 were lost due to incomplete data resulting from device malfunction/device loss, and 25 were lost due to a combination of non-wear (n = 2,188 data points) and vehicular travel (n = 1,650 data points). Vehicular travel was excluded as the aim of this study was solely to assess active commuting. A further 11 data points were inaccurately classified using GIS and therefore removed. This left a final sample of 39 participants (mean age = 8.5 years, 69% male) with 2,782 matched data points.

More than one third of participants' commuting time was spent in MVPA (37.1%), with commuting activity location split evenly between natural and man-made land-uses (50.2% and 49.8% respectively).

Table 1. Multi-level logistic regression results.

Land-use	N[a]	B[b]	SE[c]	Exp (B)[d]	Lower CI[e]	Upper CI[e]	P-value
Greenspace	1,255	0.04	0.1	1.04	0.86	2.57	>0.05
Other natural	142	-1.16	0.3	0.32	0.19	0.52	<0.05
Road/track/path	974	0.21	0.1	1.23	1.02	1.48	<0.05
Other man-made	411	-0.09	0.1	0.91	0.71	1.18	>0.05

[a]Number of matched data points
[b]Logistic coefficient associated with intercept
[c]Standard error
[d]Odds ratio
[e]95% confidence intervals

Of the total activity time spent within each separate land-use category, the proportion that was MVPA was 36.7%, 17.6%, 41.5% and 35.0% for greenspace, other natural, road/track/path and other man-made, respectively.

Activity in the greenspace and other man-made land-use categories showed no associations with MVPA (Table 1). Activity which occurred on road/track/path was significantly more likely to be MVPA than activity not occurring in this land-use category (Exp(B)=1.23, P <0.05). A negative association was found between activity in the other natural category and MVPA, whereby activity in this land-use category had lower odds of being MVPA (Exp(B)=0.32, P <0.05). Examples of matched GPS and accelerometer travel data plotted onto GIS are displayed in Fig. 1. The marked difference between the two participants is notable. This was not uncommon. The intraclass correlation (ICC) was 0.379, calculated using the methods described by Rasbash et al. (2012), i.e. almost 38% of the variance in activity can be explained by differences between children. Land use had little effect on the ICC.

Fig. 1. Examples of matched GPS and accelerometer data plotted on GIS.

Discussion

Using emerging technologies and analyses, we explored the associations between different land-use categories and MVPA during the school-home commute. Commuting *via* man-made roads, tracks or paths was associated with health-enhancing physical activity. This is unsurprising given that built environments with established infrastructure are likely to be conducive to active travel. We found no association between greenspace and MVPA, a somewhat surprising finding given previous evidence to the contrary (Wheeler et al., 2010; Almanza et al., 2012; Coombes et al., 2013). Greenspace areas are likely to have lower levels of infrastructure and connectivity however, possibly making health-enhancing active travel less viable. Interestingly, we further found that commutes *via* other natural categories (non-greenspace) had a lower likelihood of achieving health-enhancing physical activity levels, though overall activity in this land-use category was rare in our sample. This could be due to the presence of natural obstructions (rock formations, water-bodies) or to the fact that non-established paths may be viewed less favourably by children.

Importantly, we found that a substantial proportion of time (37.1%) during the school-home commute was spent in health-enhancing activity intensities, supporting the continued promotion of active school travel *versus* sedentary modes. Taken together, our findings suggest that built environments with established man-made travel-supporting infrastructures may be optimal for maximizing health-enhancing childhood physical activity during the school commute. Our findings may inform urban planners, designers, city officials and those responsible for zoning spaces in which we live.

Strengths of this study include the use of objective repeated momentary assessments of activity and school commute route, compared to past studies which used self-reported or shortest calculated route. Limitations include a small number of land-use categories in which activity was examined, and limited generalisability of findings due to the small sample. Additionally, we experienced a high level of data loss. Measuring physical activity and travel behaviour using GPS techniques is still in its infancy, and data loss due to device malfunction, loss of signal and poor battery life are well-documented challenges in this area of research (Oliver et al., 2010). As GPS technology improves data loss will likely be minimized.

Conclusion

Man-made infrastructures may have important roles in facilitating active school travel, which in turn provides an important opportunity for children to engage in health-enhancing physical activity.

Acknowledgements

The authors acknowledge Jeff Blossom from the Center for Geographic Analysis, Harvard University, Cambridge, Massachusetts, USA, for assistance in GIS data preparation and processing.

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