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Pedestrian traffic safety and outdoor active play among 10–13 year olds living in a mid-sized city

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ABSTRACT

This cross-sectional study examined the independent and interactive associations between objective and perceived measures of neighborhood pedestrian traffic safety and outdoor active play. A total of 458 children aged 10–13 years from Kingston, Canada were studied in 2015–2016. Outdoor active play was measured over 7 days using data from activity logs, accelerometers, and Global Positioning System loggers. Geographic Information System data were collected within 1 km of participants' homes and used to create traffic volume, traffic calming, traffic speed, and pedestrian infrastructure indexes. Parents' perceptions of these pedestrian safety domains were obtained by questionnaire. Most of the pedestrian safety measures were not significantly associated with outdoor active play, and there were no interactions between the objective and perceived measures ($p > 0.3$). The significant relationships are listed here. Children whose parents perceived moderate or high traffic speeds in their neighborhood had outdoor active play values that were 0.35 (SE = 0.10, $p = 0.021$) and 0.20 (SE = 0.15, $p = 0.048$) SD units higher, respectively, then children whose parents perceived low traffic speed. By comparison to children from neighborhoods in the lowest tertile, children from the highest traffic volume tertile had higher outdoor active play levels (0.26, SE = 0.12, $p = 0.029$), while children from neighborhoods in the moderate traffic calming tertile (−0.28, SE = 0.11, $p = 0.008$) and the moderate pedestrian infrastructure tertile (−0.25, SE = 0.11, $p = 0.023$) had lower outdoor active play levels.

1. Introduction

Active play, particularly when performed outdoors, is a spontaneous, self-motivated, fun, and unstructured form of physical activity that provides children with physical, mental, and social health benefits (Tremblay et al., 2015; Burdette and Whitaker, 2005). In the 2016 Global Matrix on the physical activity of children the overall grade across the 21 countries that provided a grade for active play was a "C", meaning that only about half of the children in these countries met the benchmark for active play (i.e., engaging in unstructured active play for several hours a day) (Tremblay et al., 2016). Therefore, active play is a type of physical activity that needs to be addressed among young people. Understanding the correlates of active play is an important step in developing interventions.

One potential correlate of outdoor active play is the extent to which children are safe and protected from motorized vehicle traffic while playing outdoors or travelling to outdoor play destinations (Carver et al., 2010). Pedestrian safety is a reflection of the speed and volume of motorized vehicle traffic and the availability of pedestrian infrastructure, such as sidewalks and walking paths. Parents who are concerned about the lack of pedestrian safety in their neighborhood are more likely to restrict their children's outdoor active play (Kalish et al., 2010; Weir et al., 2006; Cecil-Karb and Grogan-Kaylor, 2009). However, to our knowledge, no studies have examined the association between objectively measured pedestrian safety features and outdoor active play. This is an important gap that needs to be addressed because parents' perceptions of pedestrian safety are poorly correlated with the actual degree of traffic safety (McGinn et al., 2007; Prins et al., 2009; Brownson et al., 2009). Thus, it is unclear if outdoor active play interventions and policies should be designed to address pedestrian safety itself, or the apparent disconnect between perceptions of pedestrian safety and the real degree of pedestrian safety.

The primary objective of this study was to investigate the independent and interactive associations between perceived and objective measures of pedestrian safety in the home neighborhood and outdoor active play. This study is based on a sample of 10- to 13-year-olds from a mid-sized city.

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2. Methods

2.1. Study design and participants

A total of 458 children aged 10–13 years from Kingston, Ontario, Canada participated in this cross-sectional study between January 2015 and December 2016. Kingston is a city on Canada's southern border with a population of 123,798. To be eligible, children had to live and attend school in Kingston. The only exclusion criteria were a physical disability that would preclude using an accelerometer to assess physical activity. Participants were recruited using social media advertisements, distribution of flyers (at schools, youth groups, etc.), posting of study flyers (at stores, community centers, etc.), and word of mouth. A systematic selection process ensured proportional representation across the seasons, sex, age, and Kingston's 12 electoral districts. Informed consent was provided by participants and a parent/guardian. The study was approved by the General Research Ethics Board at Queen's University.

2.2. Data collection overview

Participation in the study consisted of two visits to our laboratory that were separated by a 7-day physical activity measurement period. During the first visit, participants were given an Actical accelerometer (Philips Respironics, Murrysville, Pennsylvania, USA) and a Garmin Forerunner 220 Global Positioning System (GPS) watch (Garmin Ltd., Schaffhausen, Switzerland), which they wore for the following 7 days. During these 7 days they also completed a log to document their waking and sleep times, times they participated in organized sport and chores/work, and times they removed the accelerometer or GPS watch. In the second laboratory visit participants and a parent each completed an ~20-min long questionnaire on a tablet computer. These questionnaires assessed the demographic characteristics of the child and their family as well as a variety of different child and parent beliefs, perceptions, and barriers to outdoor active play.

2.3. Pedestrian safety in the home neighborhood

Four domains of pedestrian safety were considered: traffic volume, traffic speed, traffic calming, and pedestrian infrastructure. Perceived and objective measures of each domain were obtained. Participants were placed into "low", "moderate", or "high" groups for each domain.

2.3.1. Perceived measures of pedestrian safety

Parental perceptions of traffic safety in their neighborhood were assessed using the following items: 1) "There is heavy traffic on our local streets", 2) "The speed of traffic on our local streets is usually slow (50 km per hour or less)", 3) "There are traffic slowing devices (e.g., speed humps) on our local streets", and 4) "There are sidewalks on most streets in our neighbourhood" (Carver et al., 2008a). For items 1, 3, and 4, responses of "Strongly Disagree" and "Disagree" were merged to create the "low" group, "Neutral" responses created the "moderate" group, and "Agree" and "Strongly Agree" responses were merged to create the "high" group. For item 2, wherein less agreement meant higher traffic speeds, responses were reverse coded.

The test-retest reliability of the perceived traffic safety items was determined in a sample of 50 parents who completed the questionnaire twice separated by 8–10 days. The intraclass correlation between repeated responses indicated strong agreement with values of 0.84 for traffic volume, 0.91 for traffic speed, 0.92 for traffic calming, and 0.70 for pedestrian infrastructure.

2.3.2. Objective measures of pedestrian safety

A 1 km road network buffer surrounding each participant's home defined their home neighborhood for the objective measures of pedestrian safety. The decision around the type and size of buffer was based on previous research in young Canadians (Seliske et al., 2012; Seliske et al., 2013). Pedestrian safety measures were obtained using ArcGIS software version 10.4 (ESRI, Redlands, California, USA) and several geographic information system (GIS) databases developed by the City of Kingston. Note that there is only one expressway in Kingston, and this was excluded from all of the safety measures because pedestrians are not allowed on this road.

The traffic volume index reflected the approximate number of motorized vehicles per day per km of road. It was based on the distances of arterial, collector, and local roads within each buffer and the average number of vehicles that travel on these road types, which based on Kingston's traffic planning studies are 11,054 for arterial roads, 4041 for collector roads, and 400 for local roads. The traffic volume index was calculated as: ((km of arterial roads ∗ 11,054) + (km of collector roads ∗ 4041) + (km of local roads ∗ 400)) / (total road distance in km). Participants were placed into tertiles to define "low", "moderate", and "high" tertiles; the "high" tertile represented the most traffic. Note that these tertiles are relative to other participants in this study.

The traffic speed index was based on the proportion of the total road distance comprised of local roads. This is a proxy measure for traffic speed that reflects that vehicle speeds are typically lower on local roads than they are on collector and arterial roads. The traffic speed index was calculated as: ((distance of local roads in buffer) / (total road distance in buffer) ∗ (−1)). Participants were placed into tertiles to define "low", "moderate", and "high" tertiles; the "high" tertile represented the fastest traffic speeds.

The traffic calming index reflected the number of traffic calming factors per km of road. It was calculated as: (((# 4-way-stop intersection signs) + (# speed hump signs) + (# school zone signs) + (# crosswalk signs) + (# children playing signs) + (# pedestrian walking signs) + (# 40 km/h speed zone signs)) / (total road distance in km). Participants were placed into "low", "moderate", and "high" tertiles; the "high" tertile represented the most traffic calming. Other traffic calming features such as traffic chokers, chicanes, and traffic circles, which are rare in Kingston, were not included because GIS data were not available.

The pedestrian infrastructure variable reflected the total length of sidewalks. Participants were placed into "low", "moderate", and "high" tertiles; the "high" tertile represented the most pedestrian infrastructure. We limited the objective pedestrian infrastructure variable to sidewalks because: 1) it best matched the questionnaire item used to assess parents' perceptions, 2) dedicated walking paths are not commonplace in Kingston, and 3) bicycle lanes in Kingston are primarily located on the shoulder of arterial roads and intended to facilitate active travel in adults over longer distances.

2.4. Outdoor active play

The method for assessing outdoor active play over 7 consecutive days was developed by our laboratory as part of the larger study from which the data for this paper were drawn (Borghese and Janssen, 2018). As explained below, this method uses data from several sources and includes a combination of manual checks and automated steps.

First, times participants recorded in the logs (start and end times for sleep, organized sport, chores/work, and accelerometer non-wear) were checked, and corrected if necessary, by using Actical 3.10 software (Philips Respironics, Murrysville, Pennsylvania, USA) to visually examine the accelerometer data around the recorded times.

Second, Personal Activity and Location Measurement (PALMS) software was used to merge the accelerometer and GPS data based on each 15-second accelerometer epoch. PALMS identified periods of time with missing GPS coordinates, which occurred if the satellite signal was lost (e.g., when a participant entered a large building). When possible, missing coordinates were manually imputed after using Google maps software (Google, Mount View, California, USA) to determine where the participant was immediately before and after the signal was lost.

Third, PALMS detected all vehicle and non-vehicle (e.g., walking, bicycling) trips using a validated algorithm (Carlson et al., 2015), and all 15-second epochs that occurred during trips were flagged. Trip detection was based on distance traveled over time and trip modality was determined by the 90th percentile of travel speed. We manually checked each of the trips identified by PALMS by visually inspecting the GPS recording in Google Maps. During these visual inspections we identified and then deleted a number of false positive trips. An example of a false positive trip is a trip identified by PALMS that, upon visual inspection, was found to occur on school grounds during the recess period.

Fourth, each participant's data was imported into ArcMap version 10.4 software (Esri, Redlands, California, USA). The GPS coordinates for each 15-second epoch were joined to a map layer that contained the footprints for all buildings within Kingston. Each coordinate was identified as being either indoors (in a building) or outdoors.

Fifth, SAS software version 9.4 (SAS Inc., Carry, North Carolina, USA) was used to merge all participants' files together. Then, additional "time" variables were merged into this file including 1) the sleep, organized sport, and chore/work times that were recorded in the logs; 2) the start and end times of the school day and school recess times; and 3) whether each day represented a school day or non-school day.

Sixth, a customized SAS program was used to determine the minutes/day spent in outdoor active play from the merged data. The program started by deleting all 15-second epochs for the days in which there was < 10 h of accelerometer or GPS watch wear time (Colley et al., 2010). It then flagged all 15-second epochs that could not have occurred during outdoor active play because it occurred during one or more of the following conditions: 1) sleeping, 2) indoors, 3) school curriculum time (but not recess time) on a school day, 4) a vehicle trip or non-vehicle trip, 6) participating in an organized sport, or 7) participating in work or chores. All of the 15-second epochs that were not flagged were classified as either occurring during outdoor active play or as sedentary time spent outdoors using a specifically designed algorithm that has a specificity of 85% and sensitivity of 85%. The epochs for outdoor active play were summed to determine the total time for each day, and then a daily average was determined.

2.5. Confounding variables

Confounding variables consisted of age (continuous), sex, race (white vs. non-white), single or dual parent household, number of siblings in the household, annual household income (≤$50,000, $50,001–$100,000, or > $100,000), parental education (high school, 2 year college, university, graduate degree), parents' values on outdoor play (continuous score based on several questionnaire items (Carver et al., 2008a)), average daily temperature and precipitation during the physical activity measurement period, season of participation, and neighborhood built environment features that may influence outdoor play including the Walk Score® (Carr et al., 2011), percentage of land area devoted to green space (Janssen and Rosu, 2015; Laxer and Janssen, 2013), and number of cul-de-sacs (Laxer and Janssen, 2013; Janssen and King, 2015).

2.6. Statistical analysis

Statistical analyses were conducted using SPSS version 24 (International Business Machines Corp, New York, New York, USA). Because some participants had missing values for the family income (11.5%), single or dual parent household (0.7%), or outdoor active play (18.0% missing due to insufficient accelerometer or GPS data) variables, multiple imputation was performed. This simulation based technique handled the missing data in a way that would result in valid statistical inference and allow complete data for all participants to be analyzed (Rubin, 1987). Five iterations of multiple imputation were used. The imputation model contained all exposure, outcomes, and confounders. Estimates from the five imputations were pooled to create the final estimates.

Standard descriptive statistics were used to describe the sample. Associations between perceived and objective measures of pedestrian safety were determined using a Spearman correlation. Because outdoor active play was positively skewed, it was transformed using Templeton's two-step approach to follow a normal distribution (Templeton, 2011), and then converted to a z-score prior to regression analyses. General linear models were used to determine the associations between the pedestrian safety measures and outdoor active play. In a first set of models, the perceived and objective measures were examined in separate models. In a second set of models, the perceived and objective measures were included in the same model. A perceived × objective interaction term was added to a third set of models. A backwards stepwise selection approach was used for all models to remove confounding variables that were not related to the outcome based on a conservative p value of 0.20.

Table 1
Sociodemographic characteristics of participants (Kingston, Canada, 2015–2016).

Characteristic	N	%
Sex		
Male	230	50.2
Female	228	49.8
Age (years)		
10	116	25.3
11	115	25.1
12	118	25.8
13	109	23.8
Race		
White	393	85.8
Non-white	65	14.2
Number of parents in household		
Single parent	66	14.4
Dual parent	339	85.6
Number of siblings in household		
0	50	10.9
1	230	50.2
2	123	26.9
3+	55	12.0
Family income ($ CDN per year)		
≤50,000	84	18.2
50,001–100,000	145	31.6
> 100,000	230	50.2

3. Results

A description of the participants is in Table 1. Approximately half were male and there were equal numbers of 10, 11, 12, and 13 year olds. The majority were white, belonged to a dual parent household, and lived with at least one other sibling. Participants accumulated 38.3 min/day (SD = 27.6) of outdoor active play.

Table 2 shows the distribution of responses to the pedestrian safety questionnaire items. When asked about their local streets, 33% of parents agreed that there was heavy traffic, 60% disagreed that there were traffic slowing devices, 23% disagreed that traffic was usually slow, and 18% disagreed that most streets had sidewalks. Descriptive information on the GIS measures used to create the objective traffic safety measures are in Table 3. The correlations between the perceived and objective measures were: $r = 0.18$ for traffic volume, $r = 0.20$ for traffic speed, $r = 0.43$ for traffic calming, and $r = 0.37$ for pedestrian infrastructure ($p < 0.001$).

Associations between the pedestrian safety measures and outdoor active play are in Table 4. After controlling for confounding variables (Model 1), the perceived measures of traffic volume, traffic calming, and pedestrian infrastructure were not associated with outdoor active play ($p > 0.1$). However, parents' perceptions of traffic speed were

Table 2
Descriptive information on perceived pedestrian safety measures (Kingston, Canada, 2015–2016).

Pedestrian safety questionnaire item and response option	N	%
There is heavy traffic on our local streets		
Disagree or strongly disagree (low traffic volume)	246	53.7
Neutral (moderate traffic volume)	63	13.8
Agree or strongly agree (high traffic volume)	149	32.5
There are traffic slowing devices (e.g., speed humps) on our local streets		
Disagree or strongly disagree (low traffic calming)	275	60.0
Neutral (moderate traffic calming)	28	6.1
Agree or strongly agree (high traffic calming)	155	33.9
The speed of traffic on our local streets is usually slow (50 km per hour or less)		
Disagree or strongly disagree (high traffic speed)	107	23.4
Neutral (moderate traffic speed)	40	8.7
Agree or strongly agree (low traffic speed)	311	67.9
There are sidewalks on most streets in our neighborhood		
Disagree or strongly disagree (low pedestrian infrastructure)	82	17.9
Neutral (moderate pedestrian infrastructure)	10	2.2
Agree or strongly agree (high pedestrian infrastructure)	366	79.9

Table 3
Description of neighborhood GIS measures used to derive the objective pedestrian safety measures (Kingston, Canada, 2015–2016).

GIS measure	Mean (SD)
Traffic volume and traffic speed	
Arterial road distance, km	1.9 (1.6)
Collector road distance, km	1.0 (1.4)
Local road distance, km	8.3 (4.5)
Total road distance, km	11.4 (6.5)
Traffic calming	
School zone signs, n	2.8 (3.4)
Crosswalk signs, n	0.4 (0.9)
Speed hump signs, n	4.6 (5.6)
40 km/h speed zone signs, n	2.6 (4.1)
Playground (children playing) signs, n	3.0 (3.3)
Pedestrian walking signs, n	0.8 (1.3)
4-Way-stop signs, n	2.7 (3.4)
Pedestrian infrastructure	
Sidewalk distance, km	13.3 (12.3)

associated with outdoor active play such that children whose parents perceived moderate or high traffic speed had outdoor active play values that were 0.35 (SE = 0.10, $p = 0.021$) and 0.20 (SE = 0.15, $p = 0.048$) SD units higher, respectively, than children whose parents perceived low traffic speed. The relationship remained significant for the moderate traffic speed group ($p = 0.023$) but not the high traffic speed group ($p = 0.10$) after adjusting for the objective traffic speed measure (Model 2).

The objective measures of traffic volume, traffic calming, and pedestrian infrastructure but not traffic speed were associated with outdoor active play after adjusting for confounding variables (Table 4). By comparison to children in the lowest tertile, children in the highest traffic volume tertile had higher outdoor active play levels (0.26, SE = 0.12, $p = 0.029$) while children in the moderate traffic calming tertile (−0.28, SE = 0.11, $p = 0.008$) and moderate pedestrian infrastructure tertile (−0.25, SE = 0.11, $p = 0.023$) had lower outdoor active play levels. After further adjusting for the perceived measures, the relationships for high traffic volume ($p = 0.025$) and moderate traffic calming ($p = 0.008$) remained significant while the relationship for moderate pedestrian infrastructure ($p = 0.074$) approached significance.

Objective measure × perceived measure interaction terms were added to the models shown in Table 4. None of these interaction terms were significant ($p > 0.3$).

Table 4
Relationship between pedestrian safety measures and outdoor active play z-scores (Kingston, Canada, 2015–2016).

Type of pedestrian safety	Perceived measures		Objective measures	
	Model 1, β (SE)	Model 2, β (SE)	Model 1, β (SE)	Model 2, β (SE)
Traffic volume				
Low	0 (REF)	0 (REF)	0 (REF)	0 (REF)
Moderate	−0.01 (0.14)	0.01 (0.14)	0.06 (0.10)	0.06 (0.10)
High	−0.04 (0.10)	−0.07 (0.10)	0.26 (0.12)*	0.27 (0.12)*
Traffic speed				
Low	0 (REF)	0 (REF)	0 (REF)	0 (REF)
Moderate	0.35 (0.15)*	0.35 (0.15)*	−0.17 (0.11)	−0.15 (0.11)
High	0.20 (0.10)*	0.16 (0.10)	−0.19 (0.12)	−0.15 (0.12)
Traffic calming				
Low	0 (REF)	0 (REF)	0 (REF)	0 (REF)
Moderate	−0.17 (0.18)	−0.18 (0.18)	−0.28 (0.11)*	−0.29 (0.11)*
High	0.02 (0.09)	0.04 (0.10)	−0.06 (0.12)	−0.07 (0.13)
Pedestrian infrastructure				
Low	0 (REF)	0 (REF)	0 (REF)	0 (REF)
Moderate	−0.34 (0.31)	−0.29 (0.31)	−0.25 (0.11)*	−0.21 (0.12)
High	−0.24 (0.16)	−0.19 (0.17)	−0.16 (0.15)	−0.13 (0.15)

β = beta coefficient, SE = standard error.
Model 1: Perceived and objective measures were included in separate regression models. Adjusted for sex, age, season, race, family income, Walk Score, temperature and precipitation during data collection.
Model 2: Perceived and objective measures were included in the same regression models. Adjusted for sex, age, season, race, family income, Walk Score, temperature and precipitation during data collection.
* $p < 0.05$.

4. Discussion

This study examined the association between pedestrian safety and outdoor active play among 10- to 13-year olds from Kingston, Canada. Although some of the pedestrian safety domains were significantly associated with outdoor active play, these associations were not consistent as they were only present for some of the moderate and high risk groups for some of the domains, they did not follow dose-response patterns, they were not consistent with findings of other studies, the strength of the associations were weak, and they were based on cross-sectional data. Thus, it is unlikely that the few significant associations that were observed were causal.

The associations between perceived and objectively measured pedestrian safety and outdoor active play in our study were not as initially expected and are inconsistent with those of similar studies of comparably aged children (Carver et al., 2010; Carver et al., 2008a; Aarts et al., 2012; Faulkner et al., 2015; Veitch et al., 2010; Carver et al., 2008b; Rosenberg et al., 2009). For instance, a study from Toronto, Canada found that parental concerns about fast drivers in their neighborhood were inversely related to the duration that their 10–12 year old children played outdoors on weekdays (Faulkner et al., 2015). Another study from Melbourne, Australia found that the number of traffic lights in the home neighborhood was negatively associated with physical activity among 8–9 year old girls (Carver et al., 2010). It is unlikely that the methodological improvements in our study, which include a more comprehensive assessment of pedestrian safety and a specific measure of outdoor active play that was in large part based on data collected from objective instruments, would explain why we did not find consistent and meaningful associations. If anything, these improvements would have led to stronger associations, had such associations existed. We speculate that the discrepancy in findings reflects that Kingston, the city where our study was conducted, is very different from the cities where previous studies of this topic were conducted. Kingston has a population of 123,798 and a population density of 274 persons per km^2. Previous studies of this topic have been conducted in metropolitan areas such as Toronto (Faulkner et al., 2015), Melbourne (Carver et al., 2010; Carver et al., 2008a; Carver et al., 2008b), San Diego (Rosenberg et al., 2009), Boston (Rosenberg et al., 2009), and Cincinnati (Rosenberg et al., 2009) that have populations ranging from 1 to 6 million and population densities ranging from 400 to 4500 persons per km^2. Traffic patterns and pedestrian safety are likely very different in Kingston in comparison to these considerably larger and more densely populated cities. We speculate that the least pedestrian safe neighborhoods in Kingston would not be as unsafe as the least pedestrian safe neighborhoods in these larger cities. In support of this, > 100,000 vehicles/day pass through Toronto's busiest intersections (Johnston, 2015) while only 23,000 vehicles/day pass through Kingston's busiest intersection (AECOM, 2015).

In our study, the correlation coefficients between the objective and perceived measures of pedestrian traffic safety ranged from 0.18 to 0.43. This indicates that parents' perceptions were mostly determined by factors other than the actual traffic features. The weak to modest associations between the objective and perceived measures could also reflect that many of the parents had little or no experience of being in their neighborhood as a pedestrian. Indeed, there is a greater disconnect between perceived and objective measures in people who are not physically active in their neighborhood (Kirtland et al., 2003).

Our study has several limitations. First, it used a cross-sectional design which means that causal inferences cannot be made. Second, as the study was limited to 10–13 year olds from Kingston, the findings may not be generalizable to children of different ages or to children living in rural or large metropolitan areas. Nonetheless, mid-size cities make up a meaningful proportion of the total population. For instance, approximately 1 in 5 Canadians live in a city with a population between 75,000 and 250,000 people (Canada, 2011). Lastly, some of our objective measures of pedestrian safety were proxy measures. For example, our measurement of traffic speed was based on the proportion of roads in the neighborhood buffers that was made up of local roads and assumed that traffic speeds are slower on local roads. Had we used more direct measures of pedestrian safety the observed relationships may have been stronger.

5. Conclusion

The results of this study suggest that perceived and objective measures of pedestrian safety were not associated with outdoor active play among 10–13 year olds from a mid-sized Canadian city. This suggests that interventions that target perceptions of pedestrian traffic safety or the disconnection between perceived and objective pedestrian traffic safety would likely not lead to a meaningful increase in outdoor active play among preadolescent children in cities such as Kingston. An implication of this finding is that interventions aimed at increasing outdoor active play should target other stronger and more consistent determinants of this behavior. In future analyses of this sample we will explore other parental factors that may relate to children's outdoor active play such as encouragement, facilitation (e.g., allowing independent mobility), and being a physically active role model. The relationship between pedestrian safety and outdoor active play in this mid-sized city was different from that previously observed in large, metropolitan centers (Carver et al., 2010; Carver et al., 2008a; Carver et al., 2009b; Aarts et al., 2012; Faulkner et al., 2015; Veitch et al., 2010; Rosenber et al., 2009). Future studies should investigate whether the relationship between pedestrian safety and physical activity varies according to the municipality size.

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Conflicts of interest

We have no conflicts to declare.

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