



A park typology in the QUALITY cohort: Implications for physical activity and truncal fat among youth at risk of obesity



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ABSTRACT

Background. The operationalization of opportunities for physical activity (PA) in parks has not been studied extensively.

Objectives. To explore associations between park types, PA and adiposity in youth.

Methods. Data were from an ongoing cohort study in children at risk of obesity. Data were collected in 512 participants (2005–2008). Analyses were restricted to 380 participants living within ≥ 1000 m of ≥ 1 park (n parks = 576). Park types were identified using principal component and cluster analyses. Linear and logistic regressions were used to explore associations between park types, and PA and adiposity. The reference category was children living near smaller-sized parks with no team PA features.

Results. Nine park types were identified. Compared to the reference group, children living near esthetically pleasing parks with few team sports installations reported more 15-minute bouts of PA/week (bouts of PA) ($\beta = 5.2$ [90% CI: 2.3; 8.1]) and variety of PA (1.6 [0.1; 3.1]), and had less % truncal fat (-3.4 [-6.4 ; -0.5]). Children living near parks that were low on safety items with cycling infrastructure reported more bouts of PA (2.2 [0; 4.3]) and variety of PA (0; 2.2)]. Children living near parks with a variety of PA installations reported more bouts of PA (2.5 [0.2; 4.7]) and variety of PA (1.4 [0.2; 2.5]). Children living near parks that had team sports and pool features reported more bouts of PA (2.5 [0.4; 4.7]). No significant associations were found for objectively-measured PA.

Conclusion. Parks that emphasize unstructured activities may increase self-reported PA and be associated with less % truncal fat among youth at risk of obesity.

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1. Introduction

Childhood overweight and obesity are recognized public health concerns (Ng et al., 2014). Their associated health risks have been well documented (Hoey, 2014). Increasing levels of physical activity (PA) among children at risk of obesity may be one important factor in obesity prevention and management (Brown et al., 2015). Currently, only 14% of five to 11 year-old, and 5% of 12 to 17-year old Canadians are meeting the Canadian youth guidelines of 60 min daily of moderate to vigorous PA (MVPA) (ParticipACTION, 2015).

Parks are essential aspects of the built environment that can be optimized for health benefits. They provide a widely accessible opportunity for PA, yet little is known about how to operationalize these opportunities or the extent to which they influence PA and adiposity outcomes among youth at risk of obesity. Some park characteristics have been associated with PA among a general youth population including playgrounds (Potwarka et al., 2008; Besenyi et al., 2013; Rung et al., 2011; Cohen et al., 2006), basketball courts (Rung et al., 2011; Cohen et al., 2006; Floyd et al., 2011), trails (Kaczynski et al., 2008; Shores and West, 2008), and walking paths and running tracks among girls (Cohen et al., 2006). One study in children using accelerometers and geographic positioning systems (GPS) found that although park use was low overall, children were more likely to use parks with a high density of green vegetation (Dunton et al., 2014). Although the presence of parks has been correlated with a lower risk of obesity among youth

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(van Hulst et al., 2015; Nesbit et al., 2014), recent literature reviews have found inconsistent findings in the overall relationship between parks, obesity and PA (Casey et al., 2014; Ding and Gebel, 2012). This discrepancy may be because the majority of studies only assess the presence or absence of parks without considering specific park types, features and amenities.

There remains much to learn about how parks differ and which types of parks are most likely to promote PA among youth. An illustration of the installations and amenities that are likely to promote PA and help reduce adiposity among youth may help guide investments in park design. The aims of this study are to 1) distinguish park types in a Canadian city according to their salient features identified in comprehensive in situ audits and 2) explore whether distinct parks types are associated with PA and adiposity outcomes among children living nearby.

2. Methods

2.1. Study design

2.1.1. Participants

Data collected during the baseline assessment of the Quebec Adipose and Lifestyle Investigation in Youth (QUALITY) Cohort Study (Lambert et al., 2011) were used. Youth were considered to be at high risk for obesity because one or both biological parents were obese, a prerequisite to participate in the QUALITY study. A detailed description of the study design and methods is available elsewhere (details can be found in Lambert et al., 2011). Briefly, families were recruited using a school-based recruitment strategy. Among those eligible, 630 families (one child, aged 8–10 years, and both biological parents) completed baseline data collection (September 2005–December 2008), including a clinic visit during which questionnaires were completed and biological and physiological measurements taken. Written informed consent was obtained from the parents, and assent was provided by the children. The Ethics Review Boards of CHU Sainte-Justine and Laval University approved the study. A detailed audit of the parks around the homes ($n = 512$) of the participants located in the Montreal Census Metropolitan Area (MCM) was conducted.

2.1.2. Park identification and audits

Park identification was conducted using a two-stage process. First, land use information from CanMap (Digital Mapping Technologies, Inc., 2007) were integrated in a geographic information system to extract 'parks and open spaces' polygons. The three closest parks within a 500 m walking network buffer around the exact addresses of the participants were identified. Second, additional parks were identified on-site using a 'seek and assess' procedure when observers walked all the street segments in the 500 m buffer zone. If no parks were found within 500 m, the walking buffer was increased to 1000 m, with the closest park being included in the sample. When observers found a park not in the CanMap dataset, they would draw its spatial boundaries on the map provided. A detailed description of the park identification process can be found in Bird et al. (Bird et al., 2015).

All parks were evaluated by two of 9 trained independent observer pairs, using the Parks, Activity and Recreation Among Kids (PARK) Tool, a 92-item direct observation park evaluation tool (Bird et al., 2015). The observers walked through the entire park to make sure they did not miss any sports installations or other park amenities. The PARK tool has demonstrated reliability and was developed specifically for youth PA in parks (Bird et al., 2015). An extensive observer training (detailed in Bird et al., 2015) was conducted to try to achieve high inter-rater reliability. Inter-rater reliability was generally high, with 86% of items across all parks having good to excellent overall agreement ($\geq 75\%$ agreement). Observers assessed a total of 576 unique parks, 345 of which were pre-identified using CanMap and 231 of which were identified on site during mild weather between the hours of 8:00 and 17:00 in 2008 (76%), 2009 (21%), and 2010 (3%), from June to December inclusively.

2.2. Measures

2.2.1. Self-reported physical activity

Child participants responded to a questionnaire on PA administered by a trained interviewer instructed to query participants about the physical activities they did over the past week for at least 15 min outside regular gym class. The response scale was yes or no for each of 28 different activities, for every day of

the week, and included a, "Not in the last week" response option. The 3-day test-retest reliability of the original instrument was 0.74 (Sallis et al., 1993) and, in a different sample of adolescents, this version of the PA recall showed evidence of convergent validity with energy intake (Johnson-Down et al., 1997). Two subsequent recalls were conducted by phone with the participants during different seasons. The three recalls were averaged to create two variables: 1) mean sum of self-reported 15-min bouts of PA over one week (hereinafter referred to as bouts of PA), and 2) mean variety of different self-reported PA (i.e. the average number of different types of physical activities practiced and reported by the child over the three recalls).

2.2.2. Objective physical activity

Objective PA was measured using a calibrated accelerometer (Actigraph, model 7184, Pensacola, Florida, USA) fitted to the child during the clinic visit and instructed to be worn for the following 7 consecutive days. Only data of children with a minimum of 4 days with ≥ 10 h of wear time were retained, based on established guidelines (Colley et al., 2011). The accelerometer data were partitioned into six variables based on established cut-offs of counts-per-minute (Evenson et al., 2008): mean sedentary PA, mean light PA, mean vigorous PA, mean MVPA, and a dichotomized variable of meets the current guidelines of 60 min of daily MVPA or not.

2.2.3. Body composition

Total lean mass, total fat mass and central fat mass were measured in grams during a clinic visit using Dual Energy X-ray Absorptiometry (DXA). We defined child's truncal fat as the percentage of central-to-total body fat. It was calculated as ((central fat mass in grams) / (total fat mass in grams)) * 100.

2.2.4. Anthropometric measurements

Weight, height and waist circumference were measured according to standard protocols (Lambert et al., 2011). BMI was analyzed using two cut-off points: 1) ≥ 85 th percentile for overweight and obese versus not, and 2) ≥ 95 th percentile versus not for obese children versus all others using the CDC reference curves (Centers for Disease Control and Prevention. Recommended BMI-for-age Cutoffs Atlanta, 2014).

2.2.5. Control variables

Child's age was analyzed as a continuous variable. The child's sexual maturity (Tanner stage) was evaluated by a trained nurse using Tanner stages (Marshall and Tanner, 1969; Marshall and Tanner, 1970). Puberty was considered either initiated (Tanner stage > 1) or not (Tanner stage = 1). Household income was self-reported by the participating child's biological parents on a 12-point response scale ranging from $< \$10,000$ to $\geq \$140,000$. Household income was dichotomized as $< \$80,000$ or $\geq \$80,000$.

2.3. Analyses

2.3.1. Park typology

The park typology (PT) was identified using a two-step approach. First, 41 variables from the park audit tool were selected using two criteria: variables with frequencies of $\geq 5\%$, and those that applied to the entire park. A principal component analysis (PCA) was performed using a varimax rotation and principal components extraction. A ten-factor solution was retained based on eigenvalues ≥ 0.95 , for exploratory purposes. The minimum eigenvalue retained was 0.99. Internal consistency of factors was examined. Variables (37/41) were retained if they loaded onto a factor at 0.3 or higher; at this point, 9% of the variance in the variable is explained by the factor, a proportion generally agreed to be the lowest limit for which a component loading should be considered for inclusion (Tabachnick and Fidell, 2007) (see Table 1).

The second step applied a hierarchical cluster analysis using Ward's minimum-variance to the components created in step 1, with the addition of park area (in m^2), in order to identify distinct park types. Hierarchical cluster analysis begins with each multidimensional observation (park) as a single cluster and then repeatedly merges the next two closest until a single cluster encompassing all the data remains (Tan et al., 2005; van Hulst et al., 2012). This method results in a typology wherein substantively comparable parks are grouped together independent of geographical location (van Hulst et al., 2012). We examined results for $N = 6$ to $N = 9$ clusters, attempting to identify substantively distinct park types based on the dendrogram, pseudo F , pseudo R^2 and the cubic clustering criterion plots.

Table 1
Interpretation of the principal components, items, and their loadings.

Component number	Name	Items	Loading		
1	Team sports oriented features	Bleachers	0.82		
		Soccer	0.80		
		Attractive for active play	0.65		
		Baseball	0.53		
		Attractive for youth ^a	0.50		
		Toilets ^a	0.50		
		Basketball ^a	0.40		
2	Pool oriented features	Parking ^a	0.37		
		Chalet/change room	0.73		
		Pool	0.67		
3	Perceived safety	Picnic tables	0.36		
		At least 1 street visible from centre	0.74		
4	Cycling oriented features	At least 1 house visible from centre	0.73		
		Overall safe	0.61		
		Cycle path	0.71		
		Attractive for cycling	0.63		
		Multi-use area	0.50		
		5	Play area features	Bins	0.79
				Benches	0.70
Play area for children 6 years +	0.43				
6	Walking oriented	No dogs sign ^a	0.30		
		Gardens	0.69		
		Walking trail	0.49		
		Overall attractive for walking ^a	0.40		
		Bike locks ^a	0.38		
7	Esthetically pleasing	Pond or fountain	0.72		
		Overall esthetically pleasing	0.57		
		Shady areas	0.49		
8	Incivilities	Vandalism	0.68		
		Graffiti	0.65		
		Litter	0.58		
9	Infrequent park installations	Skateboard park	0.70		
		Water sprinkler ^a	0.50		
		Tennis	0.41		
10	Schoolyard features	Traffic calming measures	0.70		
		School yard ^a	0.59		
		Pedestrian facilitators	0.51		

^a Denotes that the item crossloaded at 0.3 or higher onto more than one component.

2.3.2. Regression models

We performed linear and logistic regression in order to explore associations between the park types and PA and adiposity measures. Confidence intervals are reported at 90% in line with recent recommendations made in the context of critiques of significance testing (Sterne and Smith, 2001), and due to the exploratory nature of the study. The reference category was children living near park type I, i.e., parks that are characterized by being smaller in size, with no team sports features and no play area features for children ages 6 years and over. Each of the other park types was entered into the model as an indicator variable. As the study is exploratory, we chose not to adjust for multiple testing (Bender and Lange, 2001). SAS version 9.4, SAS Institute Inc., Cary, NC, USA, was used for all analyses. Analyses are restricted to participants living in the MCMA with at least one park within 1000 m of their home and with complete data (data were missing for less than 1% of the sample).

3. Results

3.1. Principal components

Principal component analysis was performed on 570 parks. The PCA created ten components (see Table 1) that were easily interpretable based on variable loadings. For example, the three incivilities items from the PARK tool –vandalism, graffiti and litter – loaded highly and uniquely onto one component.

3.2. Cluster analysis

Results are for a 9-cluster solution, representing 39.4% of the total variance in the components. Each park type is summarized according to its dominant characteristics and listed in Table 2.

Table 3 shows a matrix of the principal components and park types, categorizing each principal component as high, low, or non-distinguishing for each park type. For example, park type IV ($n = 122$) is high on team sports related installations, while park type V ($n = 56$), is low on team sports and perceived safety features, and high on cycling infrastructure. Notably, park type V also comprised the second largest parks in the dataset. Because the items designed to assess safety (visibility of surrounding houses from centre of park, visibility of streets from centre of park and lighting throughout the park) are necessarily influenced by the expanse of the park, these parks may not be unsafe, but simply larger than the others.

3.3. Regression analyses

There were 217 (57%), 133 (35%), and 30 (8%) participants with 1, 2, and 3 parks within the maximum 1000 m walking network buffer, respectively, for a total of 570 observations. There were no participants with >3 parks within equidistance from their residence. Table 4 describes individual, familial, and PA characteristics of the 380 participants included in the study, and compares them to the 124 participants excluded because they did not live within 1000 m of a park. Participants who were excluded from this study were slightly younger (p -value = 0.014), had slightly more minutes of moderate PA per day (p -value = 0.043), and a greater proportion were from higher income households (p -value = 0.012).

Table 5 shows the results from the linear regression of the mean sum of bouts of PA, the mean sum of variety of PA and truncal fat. All models were adjusted for household income, sex, age, and puberty initiated. Compared to children living near parks that are small with no team sports features and no play area features for children ages 6 years and over (type I), children living near parks that were very esthetically pleasing with few team sports installations (type VIII) reported 5.2 (90% C.I.: 2.3; 8.1) more bouts of PA, an additional 1.6 (90% C.I.: 0.1; 3.1) different types of PA, and had 3.4% (90% C.I.: –6.4; –0.5) less truncal fat. Children living near parks that were low on safety items and high on cycling infrastructure (type V) reported 2.2 (90% C.I.: 0.0; 4.3) more bouts of PA, and 1.1 (90% C.I.: 0.0; 2.2) greater variety of PA. Children living near parks with a variety of PA installations (type VI) reported 2.5 (90% C.I.: 0.2; 4.7) more bouts of PA, and 1.4 (90% C.I.: 0.2; 2.5) more variety of PA. Finally, children living near parks that had team sports and pool features (type VII) reported 2.5 (90% C.I.: 0.4; 4.7) more bouts of PA.

Table 2
Summary of 9 park types.

Park type	Mean area (m ²)	N	Description
I	18,000	25	No team sports features; no play area
II	9000	180	No team sports features; no walking paths
III	17,000	64	No team sports features; high on incivilities
IV	30,000	122	Many team sports features
V	53,000	56	No team sports features; not safe; cycling infrastructure
VI	43,000	46	Variety of physical activity installations; skate parks; high on incivilities
VII	29,000	58	Many team sports features; pool
VIII	44,000	15	No team sports features; very esthetically pleasing
IX	1,300,000	4	No team sports features; cycling infrastructure; very esthetically pleasing

Table 3
Matrix of components on park type.

Principal component label	Park type								
	I	II	III	IV	V	VI	VII	VIII	IX
1. Team sports features	–	–	–	++	–	+	+	–	–
2. Pool features	○	○	○	○	○	○	++	○	○
3. Perceived safety	○	○	○	○	–	○	○	○	○
4. Cycling infrastructure	○	○	○	○	+	○	○	○	++
5. 6+ play area features	--	○	○	○	○	○	○	○	○
6. Walking features	○	–	○	○	○	○	○	○	○
7. Esthetically pleasing	○	○	○	○	○	○	○	++	+
8. Incivilities	○	○	++	○	○	+	○	○	○
9. Infrequent installations	○	○	○	○	○	++	○	○	○
10. School yard features	○	○	○	○	○	○	○	○	○
Park area	○	○	○	○	○	○	○	○	+++

+ indicates the park type is high on the principal component.

– indicates the park type is low on the principal component.

○ indicates the park type is non-distinguishing on the principal component.

No statistically significant associations were found for the objectively measured PA variables or anthropometric measures (results for these logistic and linear regressions not shown).

4. Discussion

This study developed a park typology, then explored which types were associated with PA and adiposity-related outcomes among a cohort of youth at risk of obesity. It adds to the literature by using directly observed park measures to identify conceptually distinct park types using a cluster analysis. We found that parks types that provided opportunities for active play were associated with greater self-reported bouts of PA, variety of self-reported PA and less truncal fat.

Previous research used categories from administrative park associations (Cohen et al., 2006) or desktop methods (Taylor et al., 2011) to identify park types. In our study, we were able to capture important

Table 4
Comparison of the distribution of individual, familial, and PA characteristics between QUALITY study participants with at least one park and no park at baseline (2005–2008) (n = 570).

	Have no parks (n = 124)	Have at least one park (n = 380)	p-Value
<i>Individual characteristics</i>			
Age, years, mean (SD)	9.4 (0.96)	9.7 (0.89)	0.014
Sex, % (n)	60.5 (75)	52.4 (199)	0.115
Puberty initiated at baseline, % (n)	20.2 (25)	25.1 (95)	0.266
Sum of bouts of weekly PA, mean (SD)	10.7 (4.8)	11.2 (5.4)	0.381
Variety of weekly PA, mean (SD)	5.6 (2.6)	5.8 (2.8)	0.545
Truncal fat, mean %, (SD)	40.9 (5.5)	40.9 (5.4)	0.969
Overweight and obese (BMI percentile ≥85), % (n)	43.6 (54)	41.3 (157)	0.662
Obese (BMI percentile ≥95), % (n)	24.2 (30)	22.1 (84)	0.629
<i>Family characteristics</i>			
Household income, ≥\$80,000, % (n)	65.6 (80)	52.7 (199)	0.012
<i>Accelerometer-measured PA</i>			
Minutes of sedentary activity per day, mean (SD)	359.7 (76.5)	369.1 (71.2)	0.244
Minutes of light PA per day, mean (SD)	409.7 (53.8)	403.0 (56.6)	0.282
Minutes of moderate PA per day, mean (SD)	40.1 (18.5)	36.4 (16.2)	0.043
Minutes of vigorous PA per day, mean (SD)	15.4 (14.4)	13.5 (11.2)	0.172
Minutes of moderate-to-vigorous PA per day, mean (SD)	55.5 (29.6)	49.9 (25.2)	0.055
Meeting PA guidelines, % (N)	33.1 (41)	27.2 (103)	0.202

Bold values indicate significance at $p \leq 0.05$.

user-oriented aspects (e.g. esthetics) of parks because they were audited directly with a tool designed to capture features potentially associated with youth PA (Bird et al., 2015). In addition, cluster analysis allowed the development of a park typology that identified distinguishing clusters of park features, rather than to partition parks into distinct activity areas for further study, as has been done elsewhere (Rung et al., 2011).

Little has been published on the relation between overall park context and PA or adiposity among youth. Among the literature focusing on team sports and park context, our findings run contrary to studies demonstrating an increase in PA in parks where there are competitive sports activities (Cohen et al., 2010) and team sports installations (Rung et al., 2011). However, our findings concord with studies that found an association between non-team sports oriented features of parks such as playgrounds, trails and 'green' parks and PA among a pediatric population (Potwarka et al., 2008; Dunton et al., 2014). This may be because the overall context of where the PA takes place may be just as important as the kinds of opportunities for PA found in parks for a pediatric population at risk of obesity. Weight criticism during PA can be significantly higher for overweight children than normal weight children (Faith et al., 2002), which can negatively impact the PA behaviors and enjoyment of team sports activities of overweight children. Most team sports provide a context in which teasing may be present. It may be that overweight youth are more comfortable being physically active in areas that provide opportunities for active, unstructured play, rather than through organized activities perceived to be more 'sport' than 'play' (Janssen, 2014). Opportunities for a variety of active play in parks may be important *in addition* to a small or negligible presence of team sports oriented activities.

This study did not find any significant associations between park types and directly measured PA. These results are consistent with other studies that report a lower likelihood of finding beneficial associations between the built environment and PA when PA is objectively measured (Oakes et al., 2007; Ferdinand et al., 2012). Several studies have reported a low correlation between self-reported and directly measured PA (Prince et al., 2008), with the present study being no exception (mean bouts of PA correlated with mean counts per minute at $r = 0.24$ and mean variety of PA correlated with mean counts per minute at $r = 0.18$). Self-reported questionnaires tend to overestimate PA, although among children, PA questionnaires administered by an interviewer, as was done here, tend to be more reliable than independent self-report (Sallis and Saelens, 2000). The low correlation may indicate that these variables are measuring different constructs. Self-reported PA is a better measure of the context and type of PA (Sallis and Saelens, 2000), than the intensity and duration of PA captured by accelerometer. It remains important to attempt to capture lifestyle behaviors among youth, for these may initiate long-lasting trends that are favorably influenced by the built environment and that reduce risk of adiposity over time.

The majority of studies assessing the built environment and adiposity use BMI as a measure of adiposity, and we are unaware of any studies assessing the relationship between parks and truncal fat among youth. Surprisingly, our findings were not consistent across anthropometric measures. This study did not find significant associations between BMI and park type. BMI is strongly associated with body fat, however children and adolescents can have a wide range of body fat % for a given BMI value (Pietrobello et al., 1998) and variations in BMI in general pediatric populations are largely attributed to differences in lean body mass (Freedman and Sherry, 2009). Visceral adipose tissue tends to demonstrate a stronger relationship with cardiometabolic risk factors than total body fat or subcutaneous adipose tissue, and DXA measures of visceral adipose tissue were found to correlate highly with the gold standard measure of single slice computed tomography (Bosch et al., 2015). Access to esthetically pleasing parks may be beneficial in reducing potentially dangerous visceral adipose deposits in youth via an increase in PA, however further studies will need to examine these

Table 5

Linear regression examining the relationship between park type and self-reported mean bouts of physical activity, mean variety of physical activities and truncal fat (n = 570).

Children living near	Bouts of physical activity		Variety of physical activities		Truncal fat (%)	
	Beta estimate	90% CI	Beta estimate	90% CI	Beta estimate	90% CI
Park type I	Reference category					
Park type II	1.9	0; 3.8	0.9	−0.1; 1.9	−0.6	−2.6; 1.3
Park type III	1.8	−0.3; 3.9	1.0	−0.1; 2.0	−1.8	−3.9; 1.3
Park type IV	1.9	0; 3.9	0.9	−0.1; 2.0	−1.0	−3.0; 1.0
Park type V	2.2**	0; 4.3	1.1**	0; 2.2	−0.2	−2.4; 2.0
Park type VI	2.5**	0.2; 4.7	1.4**	0.2; 2.5	−0.5	−2.7; 1.8
Park type VII	2.5**	0.4; 4.7	0.9	−0.2; 1.9	−1.7	−3.9; 0.5
Park type VIII	5.2*	2.3; 8.1	1.6**	0.1; 3.1	−3.4**	−6.4; −0.5
Park type IX	1.9	−2.9; 6.7	1.8	−0.7; 4.2	−0.5	−5.4; 4.3

CI: Confidence interval.

Bouts of physical activity refers to the mean sum of 3 recalls of 15-minute bouts of PA over a one week period outside of regular gym class.

Variety of physical activities refers to the average number of different types of PA practiced and reported by the child over the three recalls.

Truncal fat refers to the percentage of central-to-total body fat, calculated as ((central fat mass in grams) / (total fat mass in grams)) * 100.

All models include household income, sex, age and puberty initiated as covariates.

* p < 0.05.

** p < 0.10.

associations more closely to better understand why the relationship holds for some types of adiposity measures and not others. While this study found a statistically significant decrease in truncal fat %, we are unable to assess whether this represents a clinically significant weight loss as there are no established thresholds for what constitutes a clinically significant weight loss in children.

This study has both strengths and limitations. Strengths include: highly reliable and direct measures of park characteristics, adiposity, tanner stage, and accelerometer-measured PA, access to an at-risk population and a sample that is more overweight and obese than the general population. This study is limited by its cross-sectional design and it may be affected by issues of endogeneity. It may be that families who are more active choose to live close to certain types of parks versus others. Also, because we did not use GPS on the youth, our study was unable to specifically locate where the PA was taking place. Nevertheless, the pathways between park type and PA and adiposity outcomes among youth are complex. While we are interested in which types of parks may be associated with PA and adiposity outcomes, we recognize that the presence of certain park types has the potential to influence behavior both inside and outside of parks. We therefore argue that the endogeneity issue is not critical to our findings because it is plausible that some park types increase environmental-level exposure to PA, making it a more normative behavior.

The study population is likely not generalizable to a general pediatric population. Despite this limitation, the study may be generalizable to youth who are overweight or obese, or at risk of being so due to a parental history of obesity. Given that currently 31% of the Canadian school-age population is considered overweight and obese (Statistics Canada, 2014), this study focuses on an important sub-population of youth who represent a significant proportion of the population that may have a disproportionate disease burden.

The park typology may not be generalizable to other geographical locations. In addition, although a typology with nine park types may best reflect the variation in park types that exist in the MCMA, the high number of park types, along with a low number of participants in each park type, may have impacted on the study's power to detect meaningful differences in the outcomes of interest. Also, the park types and control variables explained little in the variation of self-reported PA behaviors and truncal fat. The park types explained only 4% of the variation in the reported bouts of PA, 1.5% of the variation in the mean variety of PA, and 7% of the variation in truncal fat. At the population level, however, this may have a large impact on the future health burden (Rose, 1992). Finally, our interpretation of the study findings are to be considered within the context of their exploratory nature.

This study adds to a growing body of literature describing associations between features of parks and PA and adiposity outcomes in

youth. Such findings may be relevant to obesity prevention strategies related to urban planning designed to motivate at-risk youth to be more physically active. Future studies should attempt to validate the park typology as well as generate hypotheses of park type and PA and adiposity outcomes among youth at risk of obesity using longitudinal data.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

Transparency document

The [Transparency document](#) associated with this article can be found, in online version.

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MB conducted the literature search, data analyses and interpretation, and generation of tables. GDD defined specific aims, guided analyses and interpreted the findings. AVH conducted data collection and data interpretation. M-SC conducted data interpretation. MH conducted data interpretation. TB conceived of the study design, guided analyses and conducted data collection and interpretation. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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