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ORIGINAL ARTICLE

A multilevel examination of factors of the school environment and time spent in moderate to vigorous physical activity among a sample of secondary school students in grades 9–12 in Ontario, Canada

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Abstract
Objective To examine associations between students' time spent in moderate to vigorous physical activity (MVPA) and the school built environment while also considering features of the schools' social environment and student-level characteristics.
Methods Using surveys and GIS measures, multilevel linear regression analysis was applied to examine the environment- and student-level characteristics associated with time spent in MVPA among grade 9–12 students ($n = 22{,}117$) attending 76 secondary schools in Ontario, Canada as part of the SHAPES-Ontario study.
Results Statistically significant between-school random variation in student MVPA was identified [$\sigma^2_{\mu 0} = 9{,}065.22$ (250.64)]; school-level differences accounted for 3.0% of the variability in student MVPA. Students attending a school that offered daily physical education or provided an alternate room for physical activity spent more time in MVPA than students attending a school without these resources. Moreover, as land-use mix diversity and walkability of the school neighbourhood increased, students' time spent in MVPA decreased.
Conclusion Developing a better understanding of the environment- and student-level characteristics associated with students' time spent in MVPA is critical for informing school-based physical activity intervention programmes and policies.

Keywords Physical activity · Built environment · Prevention · Youth · School

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Introduction

A lack of regular physical activity (PA) is associated with an increased risk for 25 chronic illnesses (Booth 2007). Despite these health risks, 7% of youth in Canada accumulate the recommended 60 min of moderate to vigorous PA (MVPA) per day required for optimal health, with almost twice as many 6–10 year olds meeting this criterion as 15–19 year olds (Colley et al. 2011). The decline in MVPA during adolescence is of concern as regular PA in adolescence protects against obesity and reduces risk of several chronic diseases, and improves quality of life during adulthood (Bouchard et al. 1994; Herman et al. 2009). As low levels of MVPA become more normative among adolescents, population-level interventions will be required to shift the risk profile of this population with respect to PA.

The use of ecological frameworks in population-level PA promotion interventions is receiving increased attention (Ontario Ministry of Health Promotion 2007). An ecological perspective addresses multiple influences on individuals' PA behaviour (McLeroy et al. 1988). Several ecological models have been proposed for health generally (Bronfenbrenner 1977; Stokols 1992), and PA, or PA-related health outcomes (e.g. obesity) more specifically (Spence and Lee 2003; Kremers et al. 2006). Each of these models uses different typologies, but all include both the social and built environments and posit multiple levels of environmental influences.

International and national policy documents have identified the school as a key environment for promoting PA among young people (Stewart-Brown 2006; Public Health Agency of Canada 2010). As such, ecological approaches to school-based PA promotion involve moving beyond individual factors that rely on traditional knowledge-based classroom models, to a more holistic approach that reinforces PA at the individual- and environmental-levels (Stewart-Brown 2006). Recently, researchers have applied a multilevel analytic approach to simultaneously examine the effects of individual- and environment-level influences on student PA in school-based studies, and have successfully detected significant between-school variability (Hobin et al. 2010; Veugelers and Fitzgerald 2005; Robertson-Wilson et al. 2007; Haug et al. 2010; Nichol et al. 2009, 2010; Loucaides et al. 2007; Cradock et al. 2009). Despite the growing number of these multilevel studies, it remains unclear as to which school policy and practice-level initiatives are important for explaining school-level variance in student PA. A relatively consistent finding, however, is the cumulative effect of school PA programming and facilities on student PA. For example, results of one Norwegian study examining the PA of students in grades 8–10 and the availability of eight school PA outdoor facilities found that students had more than 2.5 times higher odds of being more active if they attended a school with all eight PA facilities compared to no PA facilities (Haug et al. 2010). A study of Canadian students in grades 9 and 10 also found the cumulative effect of 5 to 6 school PA-related opportunities and facilities to be positively associated with higher levels of PA at school compared to having one or fewer, even after adjusting for potential confounders. These studies, however, examined school PA programming and facilities associated with the variance in PA among students attending middle and secondary schools and do not involve older students in grades 11 and 12. Given the excessively low levels of PA among adolescents aged 15–19 years, focusing on the secondary school environment in school-based examinations of PA would be helpful for informing PA promotion interventions.

As research suggests that students accumulate a substantial portion of their PA in the neighbourhood's surrounding schools (Asanin-Dean and Elliott 2011; Trilk et al. 2011), the built environment features within this area may also help to explain the variability in student PA across schools. Results of three multilevel studies investigating built environment features within the school neighbourhood reveal few associations with student PA (Cradock et al. 2009; Deforche et al. 2010; Nichol et al. 2010) with some exceptions including destinations of interest to youth (e.g. shopping malls, fast-food outlets) (Cradock et al. 2009). The limited associations between the built environment of the school neighbourhood and student PA may be due to methodological limitations inherent in these studies. For example, all three studies used the area surrounding the school as a proxy for the students' residential neighbourhoods and two of the three studies assessed students' PA outside school time (e.g. PA on weekends). It is possible that students do not live within close proximity to the schools they attend, and thus the school neighbourhood characteristics examined in these studies may have been ascribed to students who do not reside within this area. In addition, two of the three studies constructed buffers surrounding schools to capture factors of the built environment believed to associate with student PA (Cradock et al. 2009; Nichol et al. 2010). Since no standard method exists for assessing school neighbourhood environments in PA research, it is unclear what buffer distance around schools would be appropriate for modelling student PA. Nichol et al. (2010) applied a 5-km circular buffer around the school when measuring the availability of PA facilities. Five kilometres may be too large a distance to expect students to travel to access neighbourhood PA resources. Indeed, recent PA research suggests that a buffer of 1 km is considered to be an easy walking distance for adolescents (Colabianchi et al. 2007, Trilk et al. 2011). Learning more about the associations between student PA and features of the built environment within 1 km of schools may provide important insight for school-based PA interventions targeting adolescents.

With the overall goal of creating healthy school environments for PA promotion among adolescents, this research aims to determine whether the built environment on school grounds and within the neighbourhood surrounding secondary schools are associated with students' time spent in PA when also considering school PA programming initiatives and controlling for student-level differences.

Methods

Design

This cross-sectional secondary analysis used self-report data collected from students in grades 9–12 and administrators at 76 secondary schools in Ontario as part of the SHAPES-Ontario study (2005–2006). Objective measures of the built environment surrounding each of the 76 schools were also collected. The University of Waterloo Office of Research Ethics and appropriate School Board Ethics committees approved this study and data collection procedures.

Data sources and procedures

Student-level data

Student-level data were collected using the SHAPES PA survey. The survey asks students about their demographic information and PA-related behaviours. Validity testing has previously demonstrated significant criterion validity based on Spearman correlations for the SHAPES self-reported measures of height ($r = 0.97$, $p < 0.001$), weight ($r = 0.98$, $p < 0.001$), and MVPA ($r = 0.44$, $p < 0.01$) (Wong et al. 2006). Additional details about SHAPES, SHAPES-Ontario, and the survey measures are available in print (Wong et al. 2006; Leatherdale et al. 2009) and online (http://www.shapes.uwaterloo.ca).

Of the 34,578 students invited to participate in the SHAPES-Ontario project, a total of 25,416 students (73.5%) completed the survey. This distribution is consistent with previous SHAPES data collections. Students were further removed from the sample due to missing data (12.6%, $n = 3{,}192$), biologically implausible values (0.01%, $n = 65$), or if they reported not being in grades 9–12 (0.01%, $n = 42$). As such, data from 22,117 students (64.0%) were used in the present study.

Environment-level data

As part of the SHAPES-Ontario project, all 76 school administrators completed and returned the Canadian Lifestyle and Fitness Research Institute's School Capacity Survey. Administrators indicated the availability of 14 PA facilities at the school as well as the geographical location of the school (i.e. urban, suburban, rural). Researchers mailed administrators a standardized package including a consent form and the School Capacity Survey.

Built environment features in the neighbourhood surrounding the 76 schools were assessed using geographic information systems (GIS) data from the Desktop Mapping Technologies Inc. (DMTI) data resource. Built environment features within 1-km circular buffers surrounding each of the 76 schools were identified using data provided by the CanMap RouteLogistics (CMRL) spatial information database as well as the Enhanced Points of Interest (EPOI) data resource from DMTI. Consistent with previous research (Pouliou and Elliott 2010; Leatherdale et al. 2011), the process of identifying and linking the DMTI-EPOI data to the SHAPES-Ontario student and school survey data involved three steps: (1) geocoding the address for each SHAPES-Ontario school; (2) creating 1-km circular buffers; and (3) linking quantified built environment data for each school to the student and school survey data. Arcview 3.3 (ESRI 2002) software was used to geocode the school addresses and to create the 1-km buffers.

School neighbourhood SES information was collected from the 2006 Canadian Census Tract Profiles (Statistics Canada 2006) by entering the postal codes of the schools.

Measures

Outcome measure

The outcome measure was a student's average daily minutes spent performing MVPA. To calculate MVPA, each student's responses to the items "Mark how many minutes of moderate physical activity you did on each of the last 7 days" and "Mark how many minutes of hard physical activity you did on each of the last 7 days" were summed and divided by 7 days.

Student characteristics

Students were asked to report their age, grade, gender, and height and weight. Age- and sex-adjusted body mass index (BMI) cut-points derived from the WHO growth charts were used to classify students' weight status (Onis et al. 2007). Students within the lowest 5 percentiles for BMI adjusted for age and sex were classified as underweight, students within the 6th–84th percentile for BMI adjusted for age and sex were classified as normal weight, students within the 85th–94th percentile for BMI for age and sex were classified as overweight, and students within the highest 5 percentiles for BMI adjusted for age and sex were classified as obese. Dummy variables were created to compare normal weight students (referent) to underweight, overweight, and obese.

To assess students' mode of transportation to school, students responded to the single item: "In the last 7 days, how did you usually get to and from school" with response options of "actively" (e.g. walk, bike), "mixed", or "inactively" (e.g. car, bus; referent).

Finally, enrolment in school physical education (PE) was measured by asking students, "In a typical PE class, how much time are you actually active?" If adolescent student responded "I am not taking a PE class", they were considered as to not being enroled in PE (referent). If a student responded to spending any amount of time being active in PE class, they were considered to be enroled in PE.

School social environment variables

Given international and national health experts recommend school PE be provided daily to students (WHO 2007;

Public Health Agency of Canada 2010), and previous research indicates a positive relationship between secondary school student enrolment in PE and schools offering daily PE (Hobin et al. 2010), administrators were asked to report in a typical week, how many times does a typical junior student and a typical senior student in your school take part in a PE class. The responses for junior and senior were averaged. Schools that reported 5 days of PE classes per week (daily PE) were compared with schools that reported <5 days of PE classes per week (referent).

Previous research suggests offering school intramural and interschool PA programs to positively associate with student PA (Nichol et al. 2009). Generally, intramural activities are competitive and non-competitive activities are open to anyone wishing to participate, and competition occurs within a school. Interschool sports are those that compete with other schools and often require tryouts. Offering intramural PA programs was measured by asking administrators, "Does your school offer intramural programs/club activities that involve PA?" [Yes/No (referent)]. Offering interschool PA programs was measured by asking administrators, "Does your school offer interschool programs that involve PA?" [Yes/No (referent)].

School and neighbourhood built environment variables

For this study, measures of the built environment included 14 indoor and outdoor PA facilities on school grounds. Administrators were asked to report if their school has access to the following PA facilities during school hours. Those who reported having the PA facility on school grounds (Yes, on grounds) were compared to those who reported not having the PA facility on school grounds [Yes, off grounds; No; don't know (referent)]. Since "gymnasium", "room with cardio and weight equipment", and "playing fields" were available at all 76 schools and "playground equipment" was not available at any of the 76 schools, these factors were excluded from the analysis. A school facilities index was also created representing the cumulative number of PA facilities available on school grounds on a continuum of 1–10.

The density of built environment variables located within a 1-km circular buffer of each school including recreation facilities (includes dance studios, fitness/gym facilities, sport and recreation clubs, and golf courses), parks, fast-food outlets, and shopping malls were recorded. Three measures of neighbourhood design features were also considered—land-mix use, residential density, and street connectivity—independently as well as part of a walkability index (Frank et al. 2005). Brief operational definitions of each of the built environment measures are presented in Table 1.

School characteristics

An administrator at each school reported the location of the school. For school location, urban and suburban were compared to rural schools (referent). Based on the date of data collection, schools were classified according to the season in which data were collected. As in other studies (Merriam et al. 1999; Robertson-Wilson et al. 2007), common seasons (winter: December 21–March 20, spring: March 21–June 20, summer: June 21–September 20, fall: September 21–December 20) were used. Data collected from schools in the winter (referent) were compared to data collected from schools in the spring and fall seasons.

Using data from the 2006 Canadian Census Tract Profiles, the area-level SES measure for each school was based on the proportion of households in the census tract living below the Statistics Canada low-income cut-off (LICO) level. The LICO values identify those who are substantially worse off than the average population as it represents the proportion of households in the census tract that attribute 20% more than the average Canadian family to food, shelter, and clothing (Giles 2004). There are different cutoffs according to the number of people in the household and whether the household is located in a rural, suburban, or large urban areas. These values are based on after-tax income. The LICO function at the census tract level was available for postal codes of 74% (N = 56) of all 76 schools. School postal codes that did not have a LICO value at the census tract level were taken at the level of the census agglomeration.

Analysis

Due to the hierarchical nature of these data (students nested within schools), a hierarchical linear regression modeling approach was used to evaluate the degree to which school social and built environment variables associate with students' time spent in MVPA while controlling for student-level variables. Consistent with previous research (Elliott et al. 1993; Loucaides et al. 2007), a three-step modeling procedure was used to examine student MVPA. Step 1 used an empty model to determine the variability in students' time spent in MVPA across schools.

Step 2 included a series of univariate analyses examining if each of the school social environment variables and school and neighbourhood built environment variables were associated with students' time spent in MVPA. School PA facility and walkability index variables were also examined. To be reasonable but yet not too restrictive at the initial screening stage, explanatory variables that were not statistically significant ($p > 0.2$) were removed from the analysis.

Table 1 Operational definitions of built environment variables

Variable name	Operational definition	Scale of measurement	Equation	Data source
Density of PA opportunity structures	Total number of opportunities available in the school's geographic area	1-km circular buffer surrounding school	Number of opportunities/kilometre	Enhanced points of interest file from the Desktop Mapping Technologies Incorporation
Land-use mix diversity	Using the method provided by Frank and Engelke (2001), LUM is a measure of the evenness of distribution of several land-use types (i.e. residential, commercial, industrial, institutional and open space) within the study's geographic area. In general, values of LUM vary on a continuous scale between 0 and 1, with one indicating even distribution of all land-use categories (heterogeneity) and zero implying a single type of land-use (homogeneity). The formula is showed in[a]	1-km circular buffer surrounding school	Equation below[a]	CanMap RouteLogistics (CMRL) spatial information database on land uses
Street connectivity	Total number of street intersections within the school's geographic area	1-km circular buffer surrounding school	Number of intersections/kilometre	CanMap RouteLogistics (CMRL) spatial information database on land uses
Residential density	Total number of private dwellings per square kilometre in the schools given census tract	Census block group	Number of occupied households/kilometre	2006 Canadian census data
Walkability index	Using the method provided by Frank et al. (2005), the walkability index is the sum of z scores for the residential density, street network connectivity, and land-use mix variables. Higher values of the walkability index indicate a more walkable built environment. The formula is showed in[b]	1-km circular buffer surrounding school	Equation below[b]	CanMap RouteLogistics (CMRL) spatial information database on land uses

[a] Land-use mix diversity = (−1) x [(square footage of commercial/total square footage of commercial, residential, and office) ln (square footage of commercial/total square footage of commercial, residential, and office) + (square footage of office/total square footage of commercial, residential, and office) ln (square footage of office/total square footage of commercial, residential, and office) + (square footage of residential/total square footage of commercial, residential, and office) ln (square footage of residential/total square footage of commercial, residential, and office)]/ln ($n3$); where $n3 = 0$ through 3 depending on the number of different land uses present

[b] Walkability index = (6 × z score of land-use mix) + (z score of residential density) + (z score of intersection density)

In step 3, multivariate models were developed following a blockwise modeling approach. Order of entry into the regression model was based on ecological frameworks positing that multilevel factors influence PA behaviour, from the proximal factors (e.g. student characteristics) to the more distal factors (e.g. school and neighbourhood built environment variables). However, only the factors identified as significant in Step 2 and at the $p < 0.2$ level within the block were retained in the multivariate analysis. Therefore, to create a more parsimonious model, factors not significant at the $p < 0.2$ level within the block were backward removed from the model, starting with the least significant factor. If all of the variables within a block proved not to be significant, the entire block was removed from the analysis. Due to the model building process applied, where each model builds on the previous model, the contribution of adding each block of variables to the model fit was tested using the −2 log likelihood procedure. Cross-level interactions between student- and environment-level variables found to be significant in the univariate analyses were also tested while controlling for confounders. Due to their a priori importance, gender, grade, weight status, school location, and season of data collection were forced into every model regardless of their contribution. Analyses were conducted using PROC MIXED in SAS version 9.2 (Cary, NC).

Results

Student characteristics

As shown in Table 2, the sample was 49.4% ($n = 10{,}925$) female and 51.6% ($n = 11{,}192$) male ($\chi^2 = 1.9, p = 0.59$).

Although the majority of males [70.2%, $n = 7{,}862$; mean BMI = 22.0 (SD = ±3.5)] and females [80.6%, $n = 8{,}810$; mean BMI = 21.3 (SD ± 3.4)] were classified as a healthy weight, 28.1% ($n = 3{,}145$) and 18.0% ($n = 1{,}968$) of males and females were classified as overweight and obese, respectively ($\chi^2 = 330.4$, $p < 0.0001$). Most students (57.4%, $n = 12{,}684$) reported using an inactive mode of transportation to school. Only 34.9% ($n = 7{,}685$) of students were enroled in PE and of those enroled in PE more were male than female ($\chi^2 = 98.4$, $p < 0.0001$). Males (mean PA = 166.9 min/day, SD = ±101.4) also reported that more time was spent in MVPA than females (mean PA = 134.8 min/day, SD = ±88.1; $t = 25.1$, $p < 0.0001$).

Environment characteristics

As presented in Table 3, the majority of schools offered intramural (76.3%) and interschool sports (86.8%) to students. Of the ten PA-related facilities on school grounds included in the analyses, the most frequently reported included an alternate room for PA (80.3%), bicycle racks (82.9%), and running/walking tracks (86.8%). The average area-level SES of neighbourhoods where schools were located was 13.0% (SD = ±8.8), slightly above the provincial average SES in Ontario (11.1%) indicating on average schools in this study were located in slightly lower SES neighbourhoods in Ontario.

Student and environment characteristics associated with time spent in physical activity

Significant between-school variation was identified for time spent in MVPA [$\sigma^2_{\mu 0} = 9{,}065.22$ (250.64)]. Using the null models, we found school-level differences accounted for 3.0% of the variability in student MVPA when controlling for individual-level variance.

Building on the results of the univariate analyses (Table 4) and using a blockwise modeling approach, findings from the final model indicate students who were male [$\beta = 28.20$ (1.25), $p < 0.0001$], used an active [$\beta = 14.92$ (1.67), $p < 0.0001$] or mixed [$\beta = 7.49$ (1.56), $p < 0.0001$] mode of transportation, and enroled in PE [$\beta = 39.16$ (1.35), $p < 0.0001$], spent more time in PA than their counterparts (Table 5). Students attending a school that offers daily PE [$\beta = 7.45$ (3.75), $p = 0.0498$] spent more time in MVPA than students attending schools that did not offer daily PE. As well, students attending a school with an alternate room for PA [$\beta = 11.49$(4.23), $p = 0.012$] were also found to spend more time in MVPA than students attending a school without this PA-related facility. Furthermore, results demonstrate that students who were in grades 10 [$\beta = -4.17$ (1.70), $p = 0.013$], 11 [$\beta = -12.38$ (1.77), $p < 0.0001$] and 12 [$\beta = -21.19$ (1.81), $p < 0.0001$] (referent = grade 9), and were obese [$\beta = -7.95$ (2.52), $p = 0.01$; referent = healthy weight

Table 2 Descriptive statistics for student-level factors

Student-level factors	Students $n = 22{,}117$ % (n)	Females $n = 10{,}925$ % (n)	Males $n = 11{,}192$ % (n)	Chi-square/t test Testing sex differences
Grade				
9	27.6 (6,120)	27.4 (2,995)	27.9 (3,125)	$\chi^2 = 1.9$
10	26.6 (5,893)	27.0 (2,946)	26.3 (2,947)	$p = 0.59$
11	23.0 (5,082)	23.1 (2,525)	22.9 (2,557)	
12	22.8 (5,022)	22.5 (2,459)	22.9 (2,563)	
Body mass index (BMI)				
Underweight	1.5 (332)	1.4 (147)	1.7 (185)	$\chi^2 = 330.4$
Overweight	16.6 (3,667)	13.2 (1,445)	19.9 (2,222)	$p < 0.0001$
Obese	6.6 (1,446)	4.8 (523)	8.2 (923)	
Healthy weight	75.4 (16,672)	80.6 (8,810)	70.2 (7,862)	
Mode of transportation to school				
Active	20.3 (4,496)	23.7 (2,651)	16.9 (1,845)	$\chi^2 = 178.6$
Mixed	22.3 (4,937)	20.2 (2,257)	24.5 (2,680)	$p < 0.0001$
Inactive	57.4 (12,684)	58.6 (6,400)	56.1 (6,284)	
Enroled in PE				
Yes	34.9 (7,714)	31.7 (3,459)	38.0 (4,255)	$\chi^2 = 98.4$
No	65.1 (14,403)	68.3 (7,466)	62.0 (6,937)	$p < 0.0001$
Physical activity time[a]				
Average minutes of moderate to vigorous PA per day	151.0 (96.4)	134.8 (88.1)	166.9 (101.4)	$t = 25.1$ $p < 0.0001$

[a] Mean (SD) presented for continuous variable

Table 3 Descriptive statistics for the sample of secondary schools ($N = 76$)

Environment-level factors	% (*n*)/mean (SD; range)
School social environment	
Offer daily PE	
Yes	72.4 (55)
No	27.6 (21)
Offer intramural activities	
Yes	76.3 (58)
No	23.4 (18)
Offer varsity sports	
Yes	86.8 (66)
No	13.2 (10)
School built environment	
Other room for PA	80.3 (61)
Dance studio	36.8 (28)
Swimming pool	6.6 (5)
Baseball diamond	36.8 (28)
Outdoor hoops	51.3 (39)
Tennis court	19.7 (15)
Paved area for games	46.1 (35)
Bicycle racks	82.9 (63)
Skating rink	7.9 (6)
Running/walking track	86.8 (66)
School PA facilities index	5.4 (1.7, 1–10)
Neighbourhood built environment	
Fast-food outlets	2.8 (3.5, 0–15)
Recreation facilities	1.6 (2.5, 0–13)
Shopping malls	0.4 (0.8, 0–4)
Parks	0.6 (1.4, 0–9)
Street connectivity	148.9 (81.3, 0–360.0)
Land-use mix diversity	0.5 (0.2, 0–0.8)
Residential density	808.2 (778.2, 0.9–3,906.0)
Walkability index	0.2 (5.7; −18.8, 12.4)
Potential school-level confounders	
SES	13.0 (8.8; 2.1–47.7)
School location	
Urban	34.2 (26)
Suburban	39.5 (30)
Rural	26.3 (20)
Season of data collection	
Winter	11.8 (9)
Spring	19.7 (15)
Fall	68.4 (52)

status] spent less time in MVPA. Moreover, a negative relationship between land-use mix diversity [$\beta = -20.82$ (10.66), $p = 0.043$] and attending a school in a suburban area [$\beta = -9.63$ (4.22), $p = 0.025$; referent = rural] were also detected. No contextual interactions were identified.

Table 4 Univariate analyses for environment-level factors in relation to students' time spent in PA

Environment-level factors	Estimate (SE)	*p* value
School social environment		
Offer daily PE	**8.88 (4.31)**	**0.0432**
Offer intramurals	−4.46 (4.57)	0.3320
Offer interschool sports	2.83 (6.10)	0.6437
School built environment		
Other room for PA	**8.35 (4.97)**	**0.0973**
Dance studio	−2.25 (4.06)	0.5805
Swimming pool	4.60 (7.93)	0.5638
Baseball diamond	−3.16 (4.08)	0.4407
Outdoor hoops	−2.85 (3.94)	0.4718
Tennis court	−2.69 (4.90)	0.5845
Paved area for games	−1.73 (3.95)	0.6621
Bicycle racks	−2.32 (5.35)	0.6659
Skating rink	4.46 (7.30)	0.5432
Running/walking track	−1.85 (5.93)	0.7560
School PA facilities index	0.51 (1.14)	0.6591
Neighbourhood built environment		
Fast-food outlets	−0.28 (0.57)	0.6176
Recreation facilities	−0.86 (0.78)	0.2741
Shopping malls	2.19 (2.48)	0.2805
Parks	3.55 (4.33)	0.4146
Street connectivity	**−0.04 (0.02)**	**0.1170**
Land-use mix diversity	**−19.20 (11.81)**	**0.1082**
Residential density	−0.01 (0.00)	0.4655
Walkability index	**−1.81 (1.21)**	**0.1394**

Bold values are statistically significant ($p < 0.2$)

Although not shown in Table 5, a separate model including the walkability index, student- and environment-level variables, and potential environment-level confounders was also examined. The association between the walkability index [$\beta = -2.56$ (1.00), $p = 0.013$] and student MVPA remained significant after adjusting for other variables in the final model.

Discussion

The school environment appears to be associated with students' time spent in MVPA. Consistent with previous research also investigating students' time spent in MVPA (Loucaides et al. 2007; Cradock et al. 2007, 2009), we identified significant variation in student MVPA across schools. Although the amount of school-level variability identified was modest in the present study (3.0%), from a population perspective it is meaningful as even small shifts in students' time spent in MVPA at the school-level could

Table 5 Multilevel regression analysis for students' time spent in PA and student- and environment-level factors ($n = 22{,}117$)

Characteristics	Student variables β (SE)	Student and school social environment variables β (SE)	Student, school social environment, and school built environment variables β (SE)	Student, school social environment, and school and neighbourhood built environment variables β (SE)	Student, school social environment, school and neighbourhood built environment variables, controlling for confounders β (SE)
Student-level					
Gender					
Female	REF	REF	REF	REF	REF
Male	28.27 (1.25)[c]	28.28 (1.25)[c]	28.26 (1.25)[c]	28.24 (1.25)[c]	28.20 (1.25)[c]
Grades					
9	REF	REF	REF	REF	REF
10	−4.15 (1.70)[a]	−4.16 (1.70)[a]	−4.17 (1.70)[a]	−4.17 (1.70)[b]	−4.17 (1.70)[b]
11	−12.38 (1.77)[c]	−12.39 (1.77)[c]	−12.40 (1.77)[c]	−12.38 (1.77)[c]	−12.38 (1.77)[c]
12	−21.24 (1.81)[c]	−21.6 (1.81)[c]	−21.26 (1.81)[c]	−21.24 (1.81)[c]	−21.19 (1.81)[c]
Weight status					
Healthy weight	REF	REF	REF	REF	REF
Underweight	−2.66 (5.07)	−2.63 (5.07)	−2.60 (5.07)	−2.59 (5.07)	−2.49 (5.07)
Overweight	−1.73 (1.68)	−1.74 (1.68)	−1.73 (1.68)	−1.73 (1.68)	−1.74 (1.68)
Obese	−7.97 (2.52)[b]	−7.98 (2.52)[b]	−7.99 (2.52)[b]	−7.99 (2.75)[b]	−7.95 (2.52)[b]
Mode of transport to school					
Inactive	REF	REF	REF	REF	REF
Active	14.92 (1.67)[c]	14.86 (1.67)[c]	14.90 (1.67)[c]	14.92 (1.67)[c]	14.92 (1.67)[c]
Mixed	7.42 (1.56)[c]	7.37 (1.56)[c]	7.39 (1.56)[c]	7.45 (1.56)	7.49 (1.56)
Enroled in PE					
No	REF	REF	REF	REF	REF
Yes	39.06 (1.35)	39.05 (1.35)[c]	39.06 (1.35)[c]	39.09 (1.35)[c]	39.16 (1.35)[c]
Environment-level					
Offer daily PE					
No		REF	REF	REF	REF
Yes		7.85 (4.085)	8.00 (3.96)[a]	8.56 (3.88)[a]	7.45 (3.75)[a]
Other room for PA					
No			REF	REF	REF
Yes			8.57 (4.56)	8.87 (4.46)[a]	11.49 (4.23)[b]
Land-use mix diversity				−22.93 (10.59)[a]	−20.82 (10.66)[a]
Street connectivity				Excluded to create more parsimonious model*	Excluded to create more parsimonious model*
Area-level SES					0.40 (0.22)
School location					
Rural					REF
Suburban					−9.63 (4.22)[a]
Urban					−8.42 (5.11)
Seasons					
Winter					REF
Fall					−5.03 (5.13)
Spring					10.59 (5.88)
−2LL	262,526*	262,518*	262,509*	262,498*	262,461*

−2LL: −2 log likelihood

[a] $p < 0.05$, [b] $p < 0.01$, [c] $p < 0.001$ (* indicates significant improvement in model fit at $p < 0.05$)

result in a substantial population-level impact when applied across a large number of schools (Leatherdale and Papadakis 2011).

As anticipated, students reported high levels of MVPA with an overall daily average of 151.0 (SD = ±96.4) min. Using direct measures of MVPA, recent results of the Canadian Health Measures Survey indicate youth aged 6–19 years accumulate ~54 min of MVPA per day (Colley et al. 2011). Over-reporting in self-report measures of MVPA among youth is common (Wong et al. 2006; McMurray et al. 2004); nevertheless, the SHAPES PA survey used in this study has been validated for comparing youth who report more compared to less MVPA (Wong et al. 2006) and therefore is appropriate for the purposes of this study. The MVPA results should not be used, however, to group youth as active or inactive according to PA time standards.

Consistent with previous research, time spent in MVPA was associated with both students being enroled in PE (Veugelers and Fitzgerald 2005; Hobin et al. 2010; Cradock et al. 2007) and schools offering daily PE. This is positive considering that there is an emergence of education policies designed to increase the frequency of PE classes or extend the number of PE credits required for graduation (e.g. the policy recently implemented in Manitoba, Canada) for the purposes of increasing student PA. These findings are also consistent with the advice of stakeholders who have been advocating for schools to provide daily PE classes to students (WHO 2007).

The factors associated with students' time spent in MVPA also included school built environment features. Having an alternate room for PA within schools was found to positively associate with student MVPA. One explanation for the positive association between student MVPA and an alternate room for PA in schools is that secondary school students in Canada spend the majority of time indoors when at school. However, a common complaint from school staff is indoor space for PA in schools in limited (Dwyer et al. 2006; Jenkinson and Benson 2010). Adapting a room within a school to be used for PA may be a promising solution for increasing the amount of indoor space in schools for student PA; however, this approach requires evaluation.

Finally, land-use mix diversity in the final model and the walkability index in the additional model (not shown in Table 5) were found to negatively associate with students' time spent in MVPA. These negative findings are opposite to the results found for adults in international and US studies, showing consistently that adults living in areas with higher land-use mix diversity or in high-walkable neighbourhoods are more physically active (Duncan et al. 2010; Sallis and Owen 2002; De Bourdeaudhuij et al. 2003). According to Van Dyck and colleagues (2009), who also found a negative relationship between PA and walkability among a sample of Belgian adolescents, this suggests that the associations between neighbourhood walkability and PA may be different for adolescents than for adults, which is important for the development of future environmental interventions. However, one potential explanation for the negative associations with land-use mix diversity and walkability specific to this study may be the nature of items used to assess PA on the SHAPES survey. Although the SHAPES PA survey has been validated for measuring overall MVPA, it is possible that students may focus more on PA occurring at school, since the survey is completed at school and does not measure more specific PA behaviours such as walking which would more likely relate to land-use mix diversity and walkability.

Limitations

Some limitations also must be considered. The cross-sectional nature of the data prevents causal inferences to be made. Because no data on ethnicity were available, it was not possible to examine whether student MVPA vary by ethnic groups. Moreover, individual-level measures of SES (e.g. household SES) were not available, and area-level SES measures have been found to be weaker predictors of adolescent MVPA by comparison to individual SES measures (Janssen et al. 2006). Although validity of data based on self-report may be questioned, measures in the PA module have been previously demonstrated to be reliable and valid (Wong et al. 2006), and honest reporting was encouraged by ensuring confidentiality during data collection. Yet, collecting more direct measures of MVPA using pedometers or accelerometers could better profile student PA behaviours and provide more accurate data for testing the associations between students and features of the school built environments. Future studies may also consider incorporating geographic positioning systems (GPS) to provide insight into the appropriate buffer size for investigating features of the school built environment associated with student PA. Finally, additional components of the school environment such as school-community partnerships were not included in the analyses and could provide additional information to inform PA promotion strategies.

Conclusions

After considering the schools' social environment and controlling for student-level differences, results of this study indicate three associations between features of the schools' built environment and students' time spent in MVPA. First, attending a school providing an alternate room for PA was found to promote more time spent in MVPA among students. Moreover, higher walkability and land-use mix diversity in the school neighbourhood were associated with students spending less time in MVPA; however, more research is needed to better understand these negative relationships with adolescent MVPA. To combat the low levels of MVPA among adolescents, these results further strengthen the argument for ecological approaches that consider both individual- and environment-level factors as a means to improve school-based PA promotion interventions in secondary schools.

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