Research Article **IRJPH (2019) 3:31**

International Research Journal of Public Health (ISSN:2573-380X)

Should We Build Our School Here? Children's Level of Fitness, School Site-Typology and the Built Environment

Milena Bernardinello, PhD[1] and Aaron L. Carrel, MD[2]

[1]University of Wisconsin-Madison Department of Planning and Landscape Architecture.
[2]University of Wisconsin School of Medicine and Public Health Department of Pediatrics, Madison

ABSTRACT

Background: No prior studies have assessed the relationship of school-sites with children's fitness, nor evaluated how it is influenced by types of built environments surrounding school-sites. **Purpose:** To create a typology of school-sites and assess their associations, with school-level cardiorespiratory fitness (PACER score), as well as 34 environmental measures, reflecting food retailers and parks. **Methods:** PACER scores (#laps) were obtained on 20,900 children, 5-18 years-old, attending 103 rural and urban public schools in Wisconsin 2009-2010. Scores were aggregated at the school-level (mean 25.2±10.5). School-site typology reflects walkability context and parcel size. Schools were classified as: Neighborhood-School, Neighborhood-Campus, Neighborhood-Suburban, or Campus-School. Geospatial and linear regression were performed , overall and by sex and age strata, using a 1600-meter circular buffer around each school. Associations with school-level-PACER score were assessed for school types; density of unhealthy and healthier food retailers; and types of parks. **Results:** Campus-Schools predict a school average-PACER 7 laps significantly higher than Neighborhood-schools. 'Neighborhood-Campus' showed the lowest PACER for males and 11-13 years-old (10 and 12 laps lower). Negatively correlated with average-PACER were, unhealthy convenience stores for both sex, large parks for females. More fast-casual restaurants predict higher average-PACER. Schools with more students predict higher average-PACER for males and 6-10 years-old. **Conclusion:** Among Wisconsin schools, school-site and its context are associated with children's physical fitness, suggesting that school-siting should include a health benefit analyses in the process. This study demonstrates the utility of school-level PACER scores and suggests further study of the mechanisms by which children's fitness is influenced by food retailers around school zones.

Keywords: School typology, child fitness, PACER, food environment, geospatial analysis.

***Correspondence to Author:**
Milena Bernardinello, PhD
University of Wisconsin-Madison Department of Planning and Landscape Architecture

How to cite this article:
Milena Bernardinello and Aaron L. Carrel. Should We Build Our School Here? Children's Level of Fitness, School Site-Typology and the Built Environment. International Research Journal of Public Health, 2019; 3:31.

eSciPub LLC, Houston, TX USA.
Website: http://escipub.com/

Introduction

Physical fitness is as important as healthy body weight for health and academic performance, with aerobic activities having the largest benefits,[1-2-3] especially when continued outside the school curriculum.[4] School locations, and their surrounding environments, can provide opportunities for aerobic activity. School-siting [Footnote 1] has changed in the last 40 years, transitioning from the construction of walkable neighborhood schools toward campus-style schools on large, isolated sites in unwalkable areas, mainly to provide athletic facilities.[5,6] School-sites and surrounding environments are potentially correlated with levels of fitness, as they are with physical activity,[7] and these correlations likely differ throughout childhood as interactions with the built environment change with age.

Nevertheless, these associations are still understudied.[8] If associations between school-site and aerobic fitness exist and vary across age-groups, this can have important policy implications, for it may require a variety of built environment interventions to be effective across the full age-range. Creating a school-site typology linked to health benefits is an approach, yet to be used, that can help in planning for public schools that are holistically supportive of children's health. Moreover, while the association of school-site surroundings, such as parks and food retailers,[9] with children's BMI has been established,[10-11] their association with fitness is less explored. If an association of specific types of parks and food retailers with children's fitness exists, it could have zoning and ordinance implications for areas surrounding school sites.[12] Lastly, assessing individual-level fitness for school age-children is challenging due to the need to protect confidentiality. Aggregation of data at the school level avoids such difficulties and could lay the ground work for more studies on children's health.

To address these research questions, first, a school-site typology was created based on walkability and site size. Then, PACER scores (a measure of aerobic fitness) of 20,900 children from 103 Wisconsin public schools were aggregated at the school-level. An ecological analysis of school average-PACER scores across school-site typologies was conducted; then school level associations were evaluated separately for sex and three age-groups hypothesized to be differently affected by their built environments [Footnote 2].

Methods

Study Background and Study Area

Evaluating children's fitness at the population-level is more representative and cost-effective if systematically measured in a non-medical setting. Fitnessgram is a reliable test, developed for educators' use in schools.[13-14] In 2009, Wisconsin enacted bill AB620 [Footnote 3] requiring statewide adoption of the Fitnessgram protocol as a result of a three-year grant the Wisconsin Department of Public Instruction (WDPI) and the University of Wisconsin School of Medicine and Public Health (UW-SMPH)– received for the evaluation of pupils' aerobic capacity.[15] Fitnessgram measures fitness level using the Progressive Aerobic Cardiovascular Endurance Run (PACER [Footnote 4]) test.

[1] School-siting is a type of physical planning. It looks at, and sets standards for, the site-selection appropriate for certain 'types' of schools, and the capacity and type of facilities to build on those sites; it regulates usage/activities, in the context of the surrounding land use plan and policies, and education policies (Berke, Godschalk, et al., 2006 - Urban Land Use Planning, Ch. 13, page 412-414).

[2] Ecologic analysis can lead to more accurate conclusions when the purpose of the study is to understand complex phenomena, where the exposure/outcome associations vary between groups of individuals and/or between geographic locations (Szklo, Nieto, 2012, page 14-17). Ecologic studies potentially carry 'aggregation bias' (ecological fallacy); their results reflect aggregated-level association and should not be claimed to represent individual-level association.

[3] More details about AB620 in the endnotes.

[4] The PACER is a multistage progressive 20-meter shuttle run. The PACER is expressed as number of laps completed. Subjects run back and forth along a 20-meter course, and each minute the pace increases by 0.5 km/hour. The test is finished when the subject fails to complete the 20-meter run in the allotted time twice (Carrell 2012).

Public schools throughout Wisconsin were recruited to perform PACER and body mass index (BMI) measurements; 31% of the school districts participated, providing data from one or more schools. De-identified individual-level data for each school were reported to a centralized database as previously reported.[16] A statewide dataset was provided for the present exploratory study. (Figure 1).

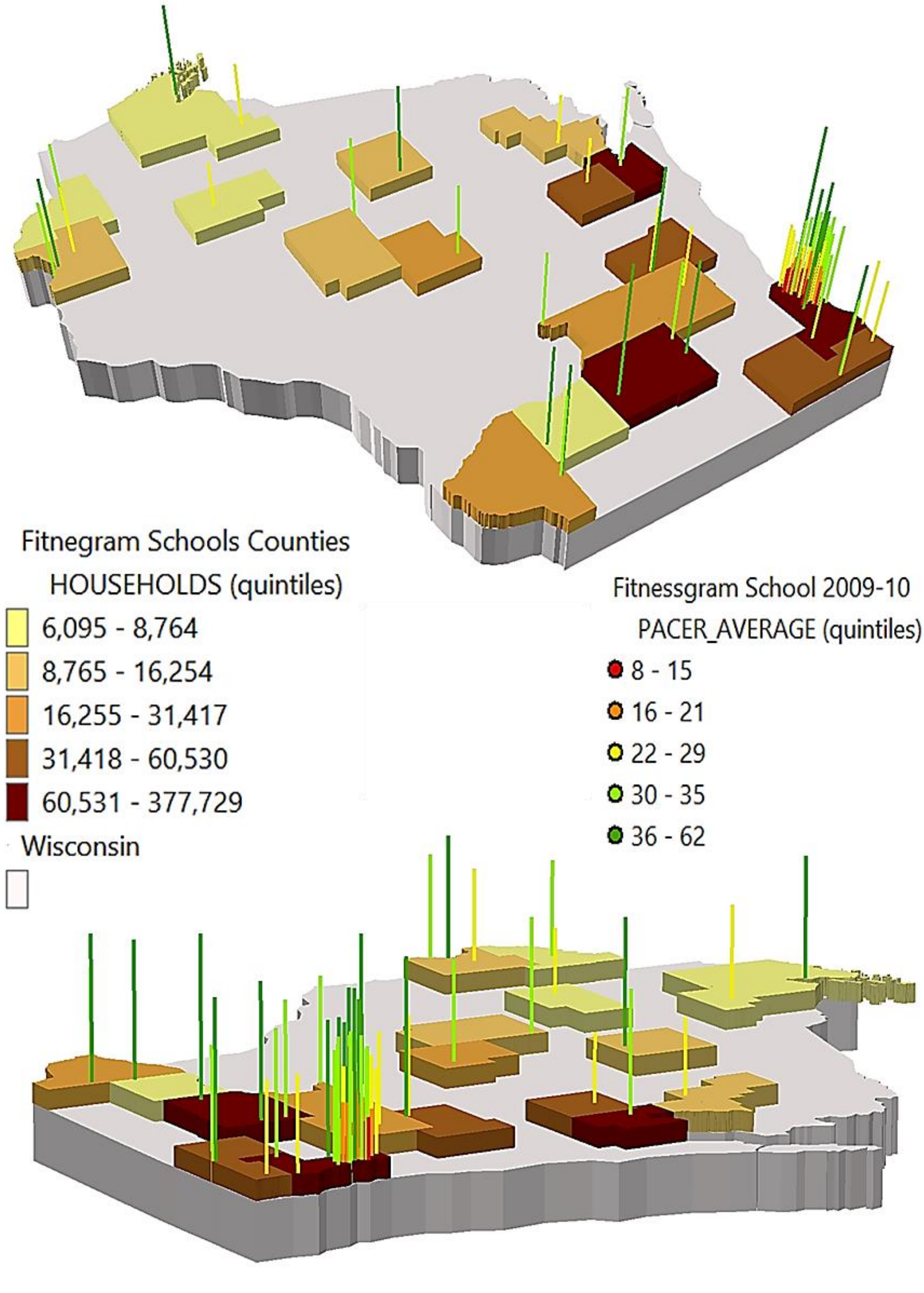


Figure 1 - Study Area - Sample Spatial Distribution across WI counties. Counties are represented by Households count (shaded polygons); PACER score for each school in the sample is represented by a bar (yellow include the mean 25)

Study Population, Study Sample

Our source population was Wisconsin school-aged children attending public schools in the 2009-2010 school-year. Fitnessgram 2009-2010 data, were released for 20,900 children age 5-20 with reported PACER scores attending 103 rural and urban schools in 29 school districts. Pupils' grade and age, school name and school district only were reported. Data were aggregated to make school the unit of analysis.

Data sources

The UW- SMPH- Pediatric Department provided the individual- level Fitnessgram dataset. School characteristics were obtained from: the National Center for Education Statistic (NCES) website [Footnote 5], including geospatial reference; WDPI- Information System for Education-WISEdash [Footnote 6]; U.S. Census SAIPE 2010 [Footnote 7], and ACS 2010. Environment GIS- data were obtained from: ESRI Business Analyst 2012; [17] UW- Madison geography Department GeoData portal [Footnote 8]; UW- Madison State Cartographer's Office [Footnote 9]; Google Maps.

Dependent variable: PACER Score

The health outcome School average-PACER score was modeled as a continuous variable. The PACER score expressed the 'number of 20 m. laps' completed during the aerobic test.

Table 1 – School Grade/age types

tot schools	'hybrid' schools are double counted based on the age group they serve				
103	1	54	64	17	136
	K5	E	MS	HS	
UNIQUE TYPE	1	24	31	14	70
Hybrid TYPE-GRADE/age based		E & M			
		30			30
			M & H		
			3		3
					103
grade	K5	1 - 5 Gr	6 - 8 Gr	9 - 12 Gr.	
kid's age	5-6 y.	6-10 y.	11-13 y	14- 18y.	

School name, status, and total students by grade were verified by WDPI-WISEdash. Exclusion criteria were: records with PACER score zero or missing, and schools with less than 10 records or an unidentifiable location. Valid individual PACER scores were averaged for each of the final 103 schools. To allow a stratified analysis by age and sex difference in PACER score, five secondary levels of aggregation were applied. For each school, two average-PACER by sex, and an average-PACER by school grade/age-groups were created and categorized as: E-elementary (grade 1-5 / 5-10y.); MS-middle school (grade 6-8 / 11-13y.); HS-high school (grade 9-12 / 14-18y.). The three categories were not mutually exclusive.

Schools combining a larger grade-range (e.g. grade 1-6 or 8-12 or other hybrids) and having at least 10 students' PACER records for each grade, were counted twice according to each grade/age-group they served (Table 1). Hybrid schools with less than 10 records per grade/age-

[5] NCES - National Center for Education Statistics https://nces.ed.gov/search/?q=+CCD+public+school+district+data+2010 –
IES – NCES – CCD – Common Core of Data - Public Elementary/Secondary School Universe Survey https://nces.ed.gov/ccd/pubschuniv.asp

[6] WDPI-Information System for Education-WISEdash http://wisedash.dpi.wi.gov/Dashboard/Page/Home/Topic%20Area/

[7] U.S. Census SAIPE 2010 - https://www.census.gov/programs-surveys/saipe/data/datasets.2010.html

[8] UW-Madison GeoData portal - http://maps.sco.wisc.edu/opengeoportal, 2018

[9] UW-Madison State Cartographer's Office - https://www.sco.wisc.edu/data/parcels/

group were assigned to a single category according to their NCES designation. Leading the rationale to categorize PACER records by grade -rather than by age- were: 1) NCES school data categorized by grade; 2) incomplete Fitnessgram age data; 3) larger sample size for each stratum; and 4) a better spatial distribution across the state.

Independent Variables

Fitnessgram individual-level records were matched to NCES school level information using GIS. As a main independent variable, a school-site typology was created with four (4) mutually exclusive types. Fitnessgram schools, matched with NCES school data, were mapped using the NCES geospatial reference and verified in Google maps. All addresses were re-geocoded at the school entrance on the street centerline, to evaluate school surroundings.

School-typologies were empirically created in ArcGIS using two school-site constructs: 1) Location, and 2) Configuration (Table 2); the two constructs were based on how walkable and large each school-site appeared within its context. Expanding from the usual neighborhood vs. campus school types, our school-site typology captured the more articulated historical development pattern visible from the aerial photographs used to verify our sample school-sites. (Figure 2). Schools were initially categorized using an inverse scale from very walkable/small site to not walkable/very large site as, Neighborhood-School (1), Neighborhood-Campus (2), Neighborhood-Suburb (3), Campus-Urban (4), Campus (5). Due to the small sample sizes, the last 2 categories were merged into Campus; the final four types were modelled as categorical variables. (Table 2).

School Surroundings- Parks and Food Retailers

The environments surrounding schools constituted our secondary independent variables, all modelled as continuous. Suggested by previous research,[18,19,20,21,22] 34 environmental measures, organized in two domains, food retailers and parks, were selected in GIS, using a 1600-meter (1mile) Euclidian buffer around each school.

Table 2 - School Typology- Operationalize development patterns. Criteria and Scale

2 Constructs - Final 4 Types

School-site		LOCATION: WALKABLE (primary construct)			
		VERY	GOOD	SOME-HOW	NOT-AT-ALL
CONFIGURATION: PARCEL SIZE (secondary construct)	SMALL	Neighborhood-School (1)		Neighborhood-Suburb (3)	
	LARGER		Neighborhood-Campus (2)		
	VERY LARGE				Campus-School (4)
Typology Place-Based (inverse scale)		1	2	3	4

MAIN CRITERIA: "CAN A KID WALK THERE?"

typology 1 & 2 - school mainly sourrounded by residential area (grid structure)

typology 3 - school sourrounded or at the fringe of a suburban residential area (cul-de-sac)

typology 4 - school at the edge surrounded by farm or industrial area, often separated from the inhabited area by a main thorowghfare.

GOOGLE AERIAL VIEWS used to confirm CATEGORIES LOCATION and CONFIGURATION

Figure 2- School Typology – Capturing development patterns. Examples of the 4 types of school site in context from very walkable/small site (1) to not walkable/very large site (4)

Table 3 - Classification of Unhealthy vs. Healthier Food Retailers by Type of Food Stores and Restaurants present within 1600m circular buffer around sampled schools.

total	Health*ier* (H)	Unhealthy (U)	total
	FS		
70	Supermarkets *	Convenience Stores w or w/o gas station	84
58	Grocery Stores * large	Grocery Stores * small	53
25	Big-Box stores* w/food	Big-Box stores w/snack	30
23	Fresh Food market*	Dollar Store	68
26	Farmers market *	Pharmacy	86
10	Specialty Dairy	Specialty Snack	30
66	Ethnic		
	FS or R		
57	Bakery	Dollar Tree (snack)	22
55	Coffee & Tea Shop	Liquor Store	85
	R		
99	Fast Casual (H)	Fast Casual (U)	41
20	Fast Casual – Deli (H)	Fast Casual – Deli (U)	2
20	Pastry – Snack (H)	Pastry – Snack (U)	47
86	Sit Down (H)	Sit Down (U)	74
		Drink w/Food (Bar/Tavern)	97
		Fast Food *	89
602			**812**

Type of food retailers, extracted based on the North American Industry Classification System (NAICS), were reclassified as food store-FS or restaurants-R according to prior [Footnote 10] research [23,24,25] to reduce misclassification.[26] The 1,491 food retailers available within the buffers were verified on Google-Maps. Building upon the CDC mRFEI [Footnote 11] index [27] we sub-categorized FS and R as Unhealthy-U (812) or Healthier-H (602) for kids, to calculate a child appropriate modified-Retail-Food-Environment-index (K-mRFEI), a single construct used in Food Swamp research.[20,28] Twenty-nine

[10] Appendix available for more detailed food retailers classification – Main research: Morland, 2002 , CDC 2011, and NEMS 2007 – Nutrition Environment Measurements Survey – NEMS-R for restaurant and NEMS-S for Food Stores.

[11] CDC 2011 – mRFEI Modified Retailer Food Environment Index identifies census tracts that either lack access to healthy food retailers or contain very high densities of fast food restaurants and convenience stores relative to the number of healthy food retailers (https://www.cdc.gov/obesity/resources/reports.html)
Food retailer categories : Healthy vs. Less Healthy (table 4 above (*)
Healthy *Food Retailers* : Supermarkets - Large Grocery Stores – Supercenters - Produce Stores
Less Healthy *Food Retailers* : – Convenience Stores – Small Grocery Stores – Fast Food Restaurants

variables (27 types; FS and R totals) were defined to model the food retailers (Table 3).

Parks and open space were compiled from a variety of county-level GIS layers. Completeness was verified in Google map; missing parks were manually digitized. ‘Park’ variables included public parks, open spaces, natural area, public athletic fields and tennis courts, fully or partially within each buffer. The main inclusion criterion was open access for unstructured physical activity. Each of the 1,212 ‘parks’ was categorized by size (scaled 1 to 5), based on the quintile distribution of parks area surrounding our Milwaukee County schools Footnote [12], then summed in 5 variables (Psc1-Psc2-Psc3-Psc4-Psc5) to model ‘number of parks of a certain size’ (Table 4).

Table 4 – Parks within buffers - Scale by size

Parks scale (1600m. Euclidian buffer - 103 schools)		**N**
PARK Total		1,212
PARK Scale 1	<0.5 acres	227
PARK Scale 2	0.5 - 1.5 acres	243
PARK Scale 3	1.5 - 4 acres	234
PARK Scale 4	4 - 12.5 acres	269
PARK Scale 5	> 12.5 acres	239
	Acres	10,029.6

Other Covariates

Four additional covariates were included. The size of the ‘student-body’ and the school-district Gini-coefficient (indexed 0-100), both modelled as continuous. The first was selected because of the trend in school-siting toward hybrid, large capacity, ‘mega-schools’, in unwalkable remote locations, with potential health implications.[11,29] The second, a measure of income inequality Footnote [13], is often a confounding factor for weight status,[30] highly predicting health disparity; it also indicates school economic resources, and it is used in studies on food insecurity and food swamps.[20] The number of kids eligible for free-lunch’ (the very poor), and the ‘number of minority’ kids for each school were modeled.

Statistical Analysis

Both a spatial and a non-spatial statistic were conducted to identify predictors spatially associated with the 2009-2010 school average-PACER Footnote [14]. First, variables’ descriptive statistics were tabulated, and their spatial distribution mapped. (Table 5; Table 6; Figure 3). Then, Spearman correlation and Moran’s I diagnostic tools were evaluated to ensure the associations were not due to the presence of outliers, or to the spatial distribution of some schools. Next, to find key variables, school-

[12] Milwaukee county schools constitute the majority in our sample, it also had the largest park variability, so we thought appropriate to use this distribution as baseline for developing our scale.

[13] The Gini index, or Gini coefficient, is used by researchers to describe the distribution (as opposed to the level) of income in an area. It ranges from 0 to 1 (or 0-100); lower numbers denote less income dispersion, with a score 0 denoting complete income equality (in this case all families in the school district have the same income) and a score of 100 denoting the highest degree of inequality. The Gini index for Wisconsin counties ranges from 0.38 to 0.47 Source: American Community Survey (ACS), 2011-2015 5y. estimates-School District. -Table B19083

[14] Spatial statistics tools are designed specifically for geographic data. Unlike non-spatial statistic, they incorporate space into their mathematics for identify spatial relations. (ESRI, 2016 – An overview of Spatial Statistics toolbox)

PACER, environmental variables, student-body, and school typology were modelled using ArcGIS Exploratory OLS [31] [Footnote 15]. Given the sample size, 6 variables were the maximum criterium used to identify a model with the highest Adj R2 that met most of the parameter for spatial relation. As a proxy for individual-level SES and race/ethnicity of the school student-body, two additional covariates were evaluated for each school. Although highly correlated (VIF>7): the 'number of kids eligible for free-lunch' (the very poor), and the 'number of minority' kids were modeled. None was found significant and were dropped. Tested and dropped were also: counts of all Unhealthy food retailers, all Healthier food retailers, and the K-mRFE Index. Exploratory OLS identified as significant, number of unhealthy convenience stores, healthier fast-casual restaurants, and very large parks (Scale5), which were retained in the final models. Last, models were fitted separately for overall PACER and each sex and age-group stratum. Any variable found to be either predictive or a confounder (p-value <0.05 and 10% change in B- coefficient) in any stratum was retained in the model.[32] School average-PACER final adjusted model was fit on: 'total students'; school typologies as 3 dummy variables relative to Campus-School(D_4); number of unhealthy convenient stores; number of healthier fast casual restaurants; number of Parks Scale5; and Gini coefficient. Missing data were excluded listwise. Five stratified models were fit by sex and grade/age-group school type (El-MS-HS), using the structure below.

$$\textbf{School PACER}_i = \alpha + (\beta_1 * \text{Students}) + (\beta_2 * D_2 \text{ Neighborhood-school}) + (\beta_3 * D_3 \text{ Neighborhood-campus}) + (\beta_4 * D_4 \text{ Neighborhood-suburb}) + (\beta_5 * \text{Convenient Stores-U}) + (\beta_6 * \text{Fast Casual-H}) + (\beta_7 * \text{Parks Sc.5}) + (\beta_8 * \text{GINI}) + \varepsilon$$

relative to D_4Campus-school

As in previous research,[33,11] multivariate regression was used to identify each predictor's change in R2. Predictors were entered blockwise with forced entry; the 'order of entry' [Footnote 16] was designed *a priori* [34] informed by the Social Ecological Model.[35] Coefficients were also estimated via geospatial OLS for exploring the global spatial relationship and coefficients robust standard error. Spatial independence of the residuals was estimated via Global Moran's I. Non-spatial statistics were conducted in SPPS v.22[36]; geospatial statistics in ArcGIS 10.2.[37]

Results: School Typology predicts PACER score

Descriptive Statistics

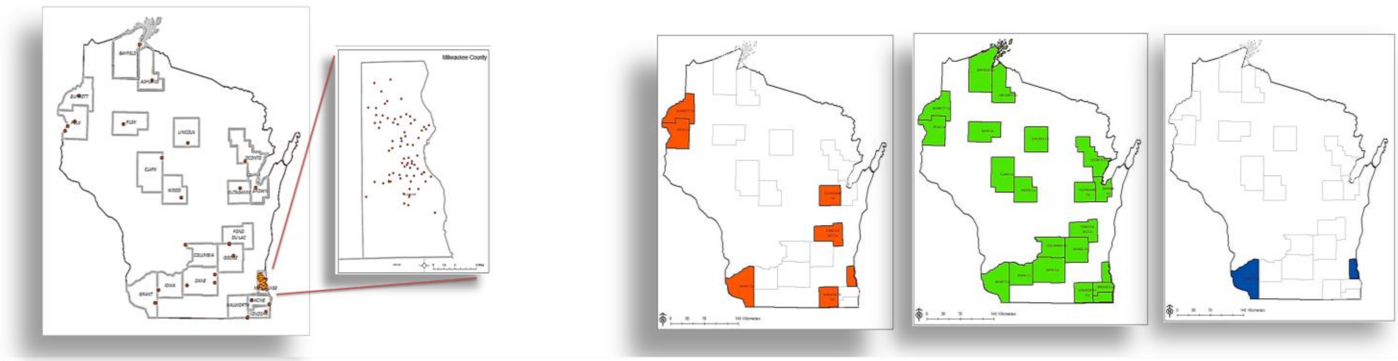
Study Sample

The 103 schools in the sample represented 4.5% of Wisconsin schools in 2009-2010. Thirty (30) schools were spread across 20 of the 78 WI counties, while 73 schools were clustered in

[15] ESRI 2016– Exploratory Regression - The Exploratory OLS 6-steps Diagnostics tool produces an optimal table of all models meeting the value criteria set for: maximum coefficient p-value cutoff (**<0.05**) and 2. Variance Inflation Factor (**VIF<3**), 3. Minimum Acceptable Adj R Squared (**>0.1**), 4. Minimum Acceptable Jarque-Bera p-value (**>0.05**), 5. Spatial Autocorrelation cut-off (**0.05**). The spatial relation for testing regression residuals is conceptualized by default as INVERSE distance (of the 8 nearest neighbor): nearby neighboring features (schools in this study) have larger influences in the computation than feature farther away. (ESRI, 2016- Spatial Statistic)

[16] Social Ecological Model-SEM is used as framework for 'layers of exposure': School characteristics capacity (Individuals) – School-site – School surroundings (Social), District resources (Economy).

Milwaukee Co. The student body (mean age 12±8 years) was 52% male in younger age-groups and 53% female in the high-school age-group. School-level average-PACER scores ranged from 8 to 62 laps (mean 25.2±10.5). It was similar to the *individual-level* reference standard (mean 29.2±18.2) for middle schoolers (mean age 12.1±2.0 years) in the Wisconsin Fitness Database.[16] Average-PACER score was lowest for females and Elementary age-group. The spatial distribution of the 3 types of grade/age-school (E-MS-HS) showed, the 64 middle schools were distributed across all our counties and had the larger share of students-with-PACER in the sample (66%). The 54 elementary schools were distributed across 7 counties (23% of students-with-PACER); the 17 High Schools were in only 2 southern counties (9.5% of the students-with-PACER) (Figure 3). Sixty-percent of schools were classified as Neighborhood-school; 13% as Neighborhood-Campus; 7% as Neighborhood-suburb; 20% as Campus-School (Table 5). School capacity ranged from 102 to 1977 students, with no statistically significant differences across school typologies. Students w/PACER represented on average 35% of the average schools' student-body. Our school-districts (S.D.) had lower income inequality than Wisconsin counties overall (Gini 38 to 47), with Gini-index varying from 33 for Marshall S.D. (10% children in poverty (103)) to 44 for Milwaukee School District (41% children in poverty (46,310).



Students w/PACER					
20,900	10,023	10,598	4,928	13,969	1,973
Schools w/PACER					
TOTAL	**w/PACER F**	**w/PACER M**	**ELEMENTARY**	**MIDDLE SCHOOL**	**HIGH SCHOOL**
103	**102**	**102**	**54**	**64**	**17**

Figure 3 - Schools with Reported PACER by Strata-

Descriptive Statistics and Spatial Distribution of the 3 types of grade/age-school (E-MS-HS)

Unit of analysis: Schools. Students count are reported only for information purpose.

School-site surroundings

More than 85% of schools had at least one convenience store, a tavern, a liquor store, a pharmacy, or a fast-casual restaurant (the only healthier) food retailer within a 1-mile radius. Only three schools had no parks available within the buffer, two of which also had no food retailers. Neighborhood-schools had the highest parks/school ratio (13:1) and food retailers/school ratio (16:1) within their buffer; Campus-Schools had the lowest parks/school ratio (7:1); Neighborhood-Suburb-schools had the lowest ratio of food retailers/school (10:1) (Table 6) (Figure 4).

Table 5 – Descriptive Statistics – Dependent Variables and Covariates

Descriptive Statistics

	unit of analysis School	N	%	Mean	Std. Deviation	Min	Max
	Dependent Variable (s)						
	PACER score (average)	103		**25.17**	10.53	8	62
	PACER Female (average)	102		**20.92**	9.03	8	52
	PACER Male (average)	102		**29.30**	12.85	9	72
	PACER Elementary (average)	54		**18.48**	6.51	8	38
	PACER Middle Sch (average)	64		**27.06**	9.90	7	53
	PACER High Sch (average)	17		**32.65**	10.53	18	62
	Independent Variables						
1	*** StyPLscale4b_NeighbSch (1)**	62	60.2				
2	*** StyPLscale4b_NeighbCampuSch (2)**	13	12.6				
3	*** StyPLscale4b_NeighbSuburbSch (3)**	7	6.8				
4	**(*) StyPLscale4b_CampuSch (4)**	21	20.4				
5	*** Tot Students**	103		**568.18**	341.83	102	1977
6	Tot Students w/PACER	103		**202.91**	236.88	10	1370
7	*** GINI coef100 - School District**	103		**42.36**	3.03	33	44
8	PARK_Total (1600m.buffer)	103		**11.77**	7.26	0	32
9	PARK Scale 1	103		**2.20**	2.54	0	10
10	PARK Scale 2	103		**2.36**	2.39	0	10
11	PARK Scale 3	103		**2.27**	2.12	0	10
12	PARK Scale 4	103		**2.61**	2.07	0	8
13	*** PARK Scale 5**	103		**2.32**	1.59	0	7
14	Total Food Retailers (1600m.buffer)	103		**14.48**	6.13	0	29
15	UNHEALTHY Food Retailers	103		**7.88**	3.11	0	13
16	HEATHIER Food Retailers	103		**5.84**	2.88	0	13
17	KmRFEI [(Un/Un+H)*100]	103		**41.79**	12.69	-4	100
18	*** Convenient Store (w-w/o Gas Stat)_U**	103		**0.82**	0.39	0	1
19	*** FAST CASUAL _R_H**	103		**0.96**	0.19	0	1
20	Big Box_snack only_U	103		**0.29**	0.46	0	1
21	BIG BOX_w/FOOD_H	103		**0.22**	0.42	0	1
22	BAKERY_H	103		**0.55**	0.56	0	2
23	COFFEE or TEA shop_H	103		**0.53**	0.64	0	2
24	Drinking w/Food_U	103		**0.94**	0.24	0	1
25	Dollar Store_U	103		**0.66**	0.48	0	1
26	Dollar Store snack only_U	103		**0.21**	0.41	0	1
27	ETHNIC_food_H	103		**0.64**	0.64	0	2
28	Fast Casual_FS-Deli_U	103		**0.06**	0.24	0	1
29	FAST CASUAL_FS-Deli_H	103		**0.19**	0.40	0	1
30	Fast Casual_R_U	103		**0.40**	0.49	0	1
31	Fast Food_R_U	103		**0.86**	0.34	0	1
32	FRESH FOOD MARKET_H	103		**0.22**	0.42	0	1
33	GROCERY STORE_LARGE_H	103		**0.56**	0.50	0	1
34	Grocery Store_small_U	103		**0.51**	0.50	0	1
35	Liquor Store_U	103		**0.83**	0.38	0	1
36	Pharmacy_U	103		**0.83**	0.37	0	1
37	Pastry_U	103		**0.46**	0.50	0	1
38	PASTRY_H	103		**0.19**	0.44	0	2
39	Sit Down_R_U	103		**0.72**	0.45	0	1
40	SIT DOWN_R_H	103		**0.83**	0.37	0	1
41	SUPERMARKET_H	103		**0.68**	0.47	0	1
42	SPECIALTY_FS-DAIRY_H	103		**0.10**	0.30	0	1
43	Specialty_FS_Snack_U	103		**0.29**	0.46	0	1
44	SPECIALTY_SNACK_H	103		**0.15**	0.35	0	1

Valid N (listwise) 103

* included in the final model / **(*)** referent dummy variable / U - Unhealthy / H - HEALTHIER

Table 6- Frequency of Type of Food Retailers and Parks by School-site ttpolpgy (1600m. Euclidian buffer)

School Typology	FE and BE significant predictors	N	TOT
Neighborhood school (n=62)	FS-U - Convenient Store (w-w/o Gas Stat)	57	997
	R-H - Fast Casual	62	
	Other food retailers	878	
	Parks sc. 1 to sc. 4	660	818
	PARK Scale 5	158	
Neighborhood-Campus school (n=13)	FS-U - Convenient Store (w-w/o Gas Stat)	11	199
	R-H - Fast Casual	13	
	Other food retailers	175	
	Parks sc. 1 to sc. 4	116	150
	PARK Scale 5	34	
Neighborhood-Suburb school (n=7)	FS-U - Convenient Store (w-w/o Gas Stat)	3	70
	R-H - Fast Casual	7	
	Other food retailers	60	
	Parks sc. 1 to sc. 4	75	83
	PARK Scale 5	8	
Campus school (n=21)	FS-U - Convenient Store (w-w/o Gas Stat)	13	225
	R-H - Fast Casual	17	
	Other food retailers	195	
	Parks sc. 1 to sc. 4	122	161
	PARK Scale 5	39	

U - Unhealthy ; H - Healthier ; FS - Food Store ; R - Restaurant

Park Sc.5 - Parks 12.5 acres or larger partially within the buffer

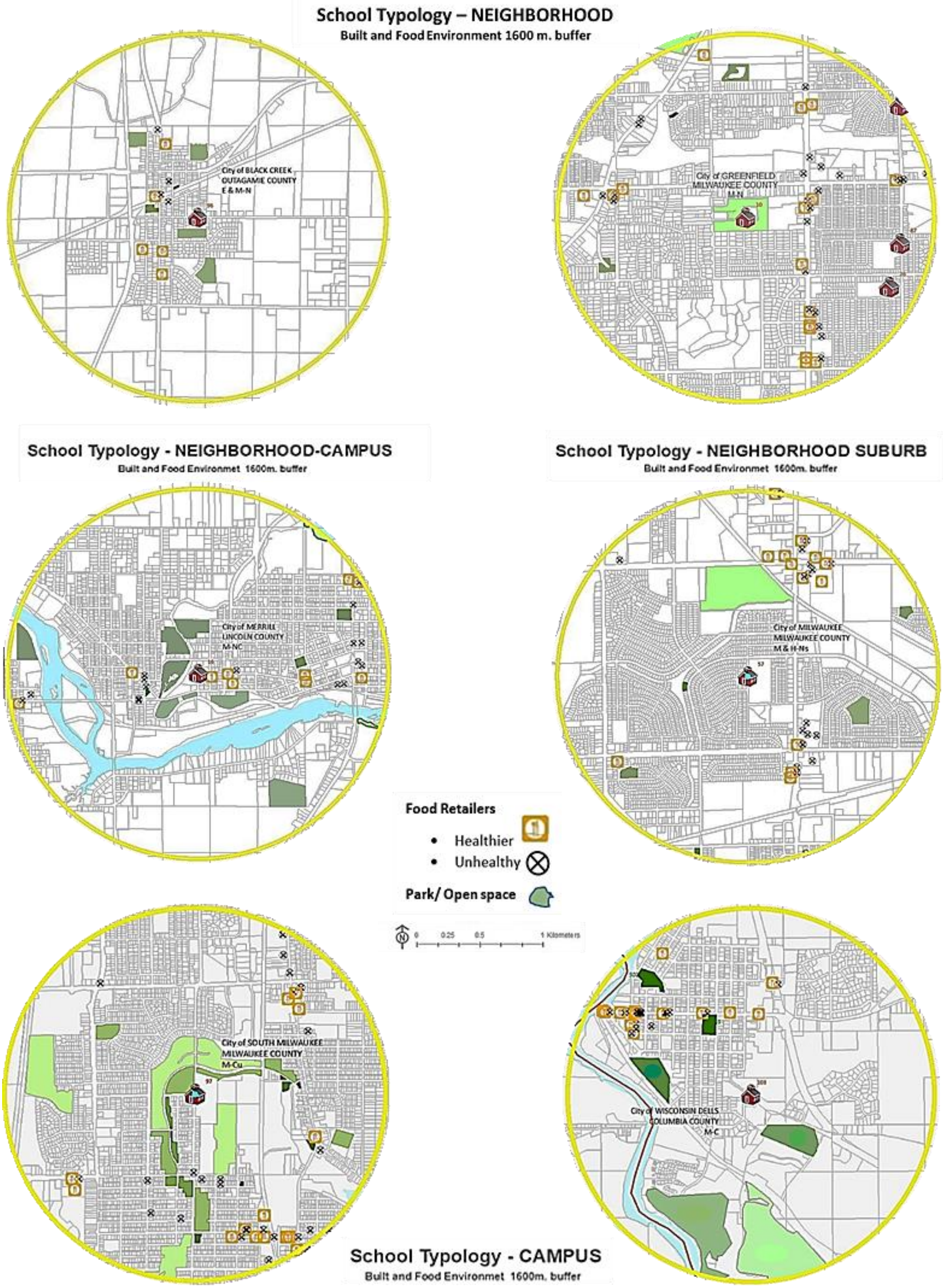


Figure 4 - School Typology – Parks and Food Environment Buffers- Visual Representation of the Modeled BE Variables and Example of Variability Between the 4 Types of School Sites and Within the 2 More Prominent Types of School Site (Neighborhood-School and Campus-School)

Multivariate Regression Modeling of PACER

The predictors in the main model were maintained in the 5 stratified models even when lacking significance since similar coefficients justified the presence of a similar effect. For convenient comparability the six models (overall, 2 sex, and 3 grade/age groups) were juxtaposed (Table 7 and 8).

Among school-typology, average-PACER scores were found statistically significantly different (K-W test), except for high schools (likely due to few observations). In regression, Neighborhood-Suburb typology (3) was not-significant excluding for the PACER-HS model. Neighborhood-Campus typology (2) was significant except for PACER-EL. Neighborhood-School typology (1) was significant except for PACER-EL and PACER-MS.

Moran's I tests confirmed that spatial OLS residuals[38] were randomly distributed for all models but for PACER-HS (clustered $p<0.05$). Additional cluster analysis (Local Moran's I) for PACER-HS showed 2 significant low clusters. Given the lack of residuals independence found for PACER-HS, its results were tabulated for illustrative purpose only.

In the main model for all ages together, relative to Campus-School (4) typology, Neighborhood-School (1) and Neighborhood-Campus (2) typologies, predicted a lower average-PACER score, each significantly explaining the larger variability in average-PACER (10%). Higher number of unhealthy-convenience stores predicted lower average-PACER score and explained 7% of its variability. Associated with higher average-PACER score were larger school student-body and more fast-casual healthier-restaurants (explaining 3.6% variability), even after controlling for the lowering effect of a higher Gini-Index.

In the sex stratified analysis (Table 7), the full models explained 37% variability in males' average-PACER compared to 30% for female. Neighborhood-School (1), Neighborhood-Campus (2) typologies, and more unhealthy-convenient stores predicted a much lower average-PACER score for males than for females. More parks larger than 12.5 acres (scale 5) predicted a lower females' average-PACER and no effect on males' average-PACER, while larger school's students-body predicted higher average-PACER for male only, explaining 8.8% variability. More fast-casual healthier-restaurants showed not-significant for both sex. Higher Gini-index predicted lower average-PACER for male only.

In the grade/age-groups stratified analysis (Table 8) the full models explained 23% variability in average-PACER for 11-13-year age-group compared to 18% for the younger age-group. Due to residuals spatial autocorrelation, results for the oldest age-group (PACER-HS) will not be interpreted. Neighborhood-Campus typology (2) predicted for the 11-13-year age-group a lower average-PACER(MS), and explained most variability (14%). No school typology was significant for 6-10-year age-group. While larger schools predicted a slightly higher average-PACER for younger age-groups and no-effect on the older age-group, higher Gini-index predicted a slightly lower average-PACER for the 11-13-year age-group only. Neither food retailers nor parks Scale5 were significant across the two youngest age-groups.

Discussion

In a statewide study of school-siting in diverse rural and urban built environments, different associations were observed between a novel school typology, and the school-level physical fitness (PACER) by age-group and sex (mean 25.2±10.5). Contrary to our hypothesis, school-level PACER score was higher in the less walkable, isolated, and largest school-site type (Campus-School). Compared to the non-neighborhood schools, we can expect a more walkable and smaller site Neighborhood-school having an average-PACER score 7 laps lower, for all age-groups, all else being equal; we can expect 9 laps lower average-PACER score for a

Table 7 - Association of School-site Typology with average-PACER Overall and by Sex

	PACER					PACER Female					PACER Male				
n= schools	n = 103					n = 102					n = 102				
OLS and Model Fit	B-coeff	Std. Error	β	p-value	R2 change %	B-coeff	Std. Error	β	p-value	R2 change %	B-coeff	Std. Error	β	p-value	R2 change %
Intercept	59.256	15.442				47.34	14.25				71.79	19.23			
Total students (school capacity)	**0.01**	0.00	*0.32*	**.000**	2.8%	0.00	0.00	0.12	.185	0.0%	**0.016**	0.003	0.44	**.000**	**8.8%**
Sch. Typology 1 - Neighborhood (D1)*	**-7.07**	2.63	-0.33	**.009**	**10%**	**-6.43**	2.32	-0.35	**.007**	**12.0%**	**-7.57**	3.14	-0.29	**.018**	**7.8%**
Sch. Typology 2 - Neighborhood-Campus (D2)*	**-8.71**	3.36	-0.28	**.011**	**10.2%**	**-6.39**	2.97	-0.24	**.034**	**8.2%**	**-10.42**	4.01	-0.27	**.011**	**10.2%**
Sch. Typology 3 - Neighborhood-Suburb (D3)*	-5.40	4.05	-0.13	.186	0.1%	-4.71	3.58	-0.13	.192	0.1%	-5.86	4.84	-0.12	.229	0.2%
Convenient Store -U	**-7.74**	2.95	-0.29	**.010**	**7.1%**	**-6.56**	2.61	-0.28	**.014**	**7.1%**	**-8.93**	3.53	-0.27	**.013**	**7.5%**
Fast Casual Restaurant - H	**10.75**	5.33	0.20	**.046**	**3.6%**	8.67	5.35	0.16	.109	2.0%	11.28	7.22	0.15	.122	**2.7%**
Park Scale 5	-0.77	0.57	-0.12	.181	1.7%	**-1.06**	0.51	-0.19	**.040**	**3.8%**	-0.44	0.69	-0.06	.522	0.6%
GINI coefficient (0-100) School District	**-.854**	.382	-.246	**.028**	**3.3%**	-0.56	0.34	-0.19	.103	1.9%	**-1.13**	0.46	-0.26	**.015**	**3.8%**
Model Fit Summary															
Adj R2 FULL model	**33.6%**					**29.6%**					**36.7%**				
F	**7.45**					**6.30**					**8.30**				
p-value	**0.000**					**0.000**					**0.000**				
df	8 , 94					8 , 93					8 , 93				
Durbin Watson	1.86					1.75					2				
SPATIAL OLS Global Moran's *I*	**Random** (p-value 0.87)					**Random** (p-value 0.97)					**Random** (p-value 0.94)				
Local Moran's I	NA					NA					NA				

* relative to Sch. Typology 4 - Campus (D4)
(bold) Significant p-value < 0.05 -

Kruskal-Wallis test	PACER		PACER Female		PACER Male	
	Chi-square[a]	Asympt. Sig.	Chi-square[a]	Asympt. Sig.	Chi-square[a]	Asympt. Sig.
School Typology 4 categories (df=3)	24.26	**0.000**	26.62	**0.000**	21.45	**0.000**

a. Chi-square reported only for School Typology to show difference between strata across full models
Asymptotic sign. Sig. 0.05***bold***

Table 8 - Association of School-site Typology with average-PACER Overall and by Grade/Age

	PACER					PACER ELEMENTARY			PACER Middle School (MS)			PACER High School (HS) **		
n= schools	n = 103					n = 54			n = 64			n = 17		
OLS and Model Fit	B-coeff	Std. Error	β	p-value	R2 change %	B-coeff	Std. Error	R2 change %	B-coeff	Std. Error	R2 change %	B-coeff	Std. Error	R2 change %
Intercept	59.256	15.442				56.07	23.58		71.00	17.78		-671.35	142.30	
Total students (school capacity)	**0.01**	0.00	*0.32*	**.000**	2.8%	**0.015**	0.005	**9.1%**	0.004	0.006	1.1%	**0.008**	0.003	0.3%
Sch. Typology 1 - Neighborhood (D1)*	**-7.07**	2.63	-0.33	**.009**	**10%**	-3.38	3.46	0.0%	-4.94	3.30	**7.1%**	**-11.08**	3.21	2.4%
Sch. Typology 2 - Neighborhood-Campus (D2)*	**-8.71**	3.36	-0.28	**.011**	**10.2%**	-5.76	4.07	**9.1%**	**-12.19**	4.62	**14.1%**	**-14.44**	4.99	2.8%
Sch. Typology 3 - Neighborhood-Suburb (D3)*	-5.40	4.05	-0.13	.186	0.1%	-1.00	8.89	0.0%	-1.42	4.52	0.1%	**-15.00**	5.22	5.9%
Convenient Store -U	**-7.74**	2.95	-0.29	**.010**	**7.1%**	-0.84	4.43	5.4%	-1.89	3.53	1.6%	**-38.44**	4.68	19.5%
Fast Casual Restaurant - H	**10.75**	5.33	0.20	**.046**	**3.6%**	excluded - lack of variability			4.07	6.20	1.7%	**55.02**	6.77	**36.2%**
Park Scale 5	-0.77	0.57	-0.12	.181	1.7%	-0.52	0.57	2.1%	0.35	0.78	0.1%	**-1.50**	0.60	4.5%
GINI coefficient (0-100) School District	**-.854**	.382	-.246	**.028**	**3.3%**	-0.91	0.64	3.1%	**-1.08**	0.46	**6.9%**	**15.68**	3.24	**21.2%**
Model Fit Summary												** causcion small 'n' - results reported for visual porpuose		
Adj R2 FULL model	**33.6%**					**18.1%**			**22.8%**			**85.5%**		
F	**7.45**					**2.67**			**3.32**			**12.84**		
p-value	**0.000**					**0.021**			**0.004**			**0.001**		
df	8 , 94					7 , 46			8 , 55			8 , 8		
Durbin Watson	1.86					1.82			1.65			1.89		
SPATIAL OLS Global Moran's *I*	**Random** (p-value 0.87)					**Random** (p-value 0.28)			**Random** (p-value 0.13)			**Clustered** (p-value 0.04)		
Local Moran's I	NA					3HH 1LL (p-value < 0.05)			NA			2 LL (p-value < 0.05)		

* relative to Sch. Typology 4 - Campus (D4)
(bold) Significant p-value < 0.05 -

Kruskal-Wallis test	PACER		PACER ELEMENTARY		PACER Middle School (MS)		PACER High School (HS)	
	Chi-square[a]	Asympt. Sig.	Chi-square[a]	Asympt. Sig	Chi-square[a]	Asympt. Sig	Chi-square[a]	Asympt. Sig
School Typology 4 categories (df=3)	24.26	**0.000**	8.18	**0.042**	15.64	**0.001**	3.18	0.36

a. Chi-square reported only for School Typology to show difference between strata across full models
Asymptotic sign. Sig. 0.05***bold***

relatively walkable and larger Neighborhood-Campus school. Also, negative - although not significant - was the effect of a mid-size not-so-walkable Neighborhood-suburb school.

Contrary to the research on obesogenic environments,[40] health behavior,[41,19] and school-siting and transportation,[42,43,44] the results of our ecological analysis suggest that unwalkable, isolated, large campus schools are a good option for increasing children's aerobic fitness.

Even school districts with higher income inequality can expect less than 1 laps decrease in school-level PACER for every point increase in the Gini-index; a finding different from prior individual-level studies of students attending lower SES schools.[13] Although in the same direction, different effect sizes of typologies were found for boys and girls, suggesting a smaller benefit for females, as in prior studies,[45,46] with 10 laps higher average-PACER for males in Campus schools than in Neighborhood-Campus school. A 12 laps difference is observed between those two typologies for schools serving the 11-13-year age-group, suggesting different benefits across age-groups, larger for the older group. These results suggest that the trend of moving schools out-of-neighborhoods to allow large sport facilities seems appropriate to increase children' fitness. In contrast , the school-capacity effect, across strata, showed an increase of 1 lap for an additional 100 children, significant only for male, and younger age-groups, which suggests that mega hybrid-school might not benefit all kids and not-consistently across their developmental stages.

As hypothesized, unhealthy convenient stores (CS) within one mile predicted lower average-PACER (8 lower laps of any additional CS), with a larger effect on males; this measure has the strongest evidence in research on BMI, neighborhood obesogenic environments, and individual-level association.[23,18,20,47] As a novelty in food environment research, a new food retailer was found significant; fast-casual restaurants (healthier food retailer) were associated with an increase in average-PACER of 11 laps; the predictor in the main model with the largest coefficient. As in prior studies for BMI [10,11] the school average-PACER for high-schoolers seemed the most affected by the food retailers surrounding the school site, as dietary independence emerges at this age. Unfortunately, our results need to be confirmed using a large sample to be interpreted. These finding showed the benefit of having healthier food retailers around schools, and ideally zero convenience stores, which could improve both sides of the energy balance. Lastly, contrary to our hypothesis and prior neighborhood studies,[21,28] no park or open space, of any size, within a 1-mile buffer from school was associated with children's level of fitness. Only a higher number of parks larger than 12.5 acre showed a negative association with females' average-PACER, perhaps due to personal safety concerns.[46] It is possible that given the car-oriented life style, kids were not given the possibility to use the parks surrounding their school. As shown in neighborhood studies[22] it seems more effective for unstructured playing and fitness having a park around home.

Strengths of the study included: 1) a large sample of children with a broad age range supporting the derived school-level PACER scores; 2) the comparability of the obtained school-level PACER scores with the statewide individual-level standard; 3) diverse school-sites across an extensive geography; 4) the inclusion of spatial analysis into an epidemiological study. To our knowledge, this is the first study to evaluate the associations of school-site attributes with fitness levels, and to have assessed it at the school-level. Remarkably, the study suggests that three school-site typologies are relevant to aerobic fitness across age and sex, and that a certain type of food retailer near schools may positively influence students' fitness levels. The study has also some limitations.

The study was cross-sectional. Although the study included rural areas, most schools were in an urban core, with a different demographic make-up and land development pattern from the rest of the state. Level of urbanicity has a role in school-siting, and in children's interaction with their environment. Across school-typologies, the inconsistent results for high school's average-PACER, deserves a note. Although the model explained 85% of variability , this was likely due to the clustered residuals, the magnitude of those results mirrors prior research on BMI for 9th graders [7] using Fitnessgram data, which suggest further studies are needed on HS with a larger and more spatially distributed sample. Lack of SES or race/ethnic information for the Fitnessgram precluded the evaluation of representativeness of our sample and could have masked well known disparities.[13] Lastly, although individual-level BMI is known for being correlated with PACER, [16] we were unable to evaluate school-level BMI or their combined influence, due to the small sample size.

Conclusion

Creating a school-siting typology linked to health benefits seems a valid new approach for school site planning, worthy of future research toward more systematic measures. The effect of school-site surroundings on children's fitness exists; it was different from "neighborhood effect"; it showed similarities with research on children's BMI. The hypothesis that school locations and the surrounding environments can provide opportunities for continuing aerobic activity outside the school curriculum is still not clear, but as in prior studies, it likely varies by age-groups with a larger effect on older kids. Using data aggregated at the school-level showed results comparable to those obtained with individual-level data, supporting an alternative analytical approach to assess school age-children level of fitness.

Our results confirm that school-siting of the last 40 years has supported the benefits of aerobic activities,[48,49] even in school districts with many disadvantaged students. However, the findings of this study should be read within the concept of fit–fat balance, with physical fitness being as important as body weight for children's health. Increased levels of fitness should have provided health and academic benefits. Prior research on fit-fat balance have shown otherwise. Likewise, research of health behavior and walking to school. Translating these research into policy and practice is key.[50] Zoning and ordinances around schools can easily support a system change. School-site planning, and school boards, in collaboration with pediatricians and local planning, should start evaluating the benefit of both aspects of the fit-fat balance, rather than mere athletic opportunities. Planning for new schools or retrofitting current ones using these lenses could avoid perpetuating those structural, unintended consequences that have contributed to the obesity epidemic.

Endnote

AB620 The Bill 'directs public schools, charter schools, and private schools to ensure that the physical fitness of pupils in grades 3 through 12 is assessed annually and specifies that the assessment must include an evaluation of pupils' aerobic capacity. These schools are not required to assess pupils who have a disability or other condition as specified by DPI administrative rule. The results must be kept confidential, but schools are required to send results to DPI and provide an individual child's results to their parent or guardian.'

However, since Wisconsin is a local control state, DPI does not collect PACER or any other Fitnessgram components. Each school district administers, maintains, and interprets the test (WiDPI-Division of Library and Technology-Data Request. Email correspondence 02/02/2018).

Acknowledgement

The author thanks Professor Aaron Carrel University of Wisconsin School of Medicine and Public Health (UW-SMPH)–Department of Pediatrics for providing the Fitnessgram dataset. Author's gratitude extends to her dissertation committee for the valuable comments and review.

Declaration of Conflicting Interests

The author received no direct funding. The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article

References

1. Eisenmann JC. Aerobic fitness, fatness and the metabolic syndrome in children and adolescents. Acta Paediatrica. 2007 Dec 1;96(12):1723-9.
2. Rauner RR, Walters RW, Avery M, Wanser TJ. Evidence that aerobic fitness is more salient than weight status in predicting standardized math and reading outcomes in fourth-through eighth-grade students. The Journal of Pediatrics. 2013 Aug 1;163(2):344-8.
3. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. International Journal of Behavioral Nutrition And Physical Activity. 2010 Dec 1;7(1):40.
4. Glickman, D, Parker, L, Sim, LJ, Cook, H & Miller, EA, (Eds. 2012) in WiDPI – Active School Core4+. Committee on Accelerating Progress in Obesity Prevention. Food and Nutrition Board, Institute of Medicine. Accelerating progress in obesity prevention: Solving the weight of the nation. 2012. https://dpi.wi.gov/sites/default/files/imce/sspw/pdf/pewhycore4.pdf
5. McDonald NC. School siting: contested visions of the community school. Journal of the American Planning Association. 2010 Mar 22;76(2):184-98.
6. EPA - U.S. Environmental Protection Agency - The Smart School Siting Tool User Guide. 2016 https://www.epa.gov/sites/production/files/2016-01/documents/smart_school_siting_tool_user_guide_120815.pdf
7. Frank L. 'Youth Travel to School: Community Design Relationships with Mode Choice, Vehicle Emissions, and Healthy Body Weight. Prepared for Mr. Tim Torma, United States Environmental Protection Agency. 2008.
8. Vincent JM, Miller R, Dillon L. School Siting and Walkability: Experience and Policy Implications in California. California Journal of Politics and Policy. 2017 Jan 1;9(3):1-26.
9. Austin SB, Melly SJ, Sanchez BN, Patel A, Buka S, Gortmaker SL. Clustering of fast-food restaurants around schools: a novel application of spatial statistics to the study of food environments. American Journal of Public Health. 2005 Sep 1;95(9):1575-81.
10. Howard PH, Fitzpatrick M, Fulfrost B. Proximity of food retailers to schools and rates of overweight ninth grade students: an ecological study in California. BMC Public Health. 2011 Dec 1;11(1):68.
11. Schwartz BS, Stewart WF, Godby S, Pollak J, DeWalle J, Larson S, Mercer DG, Glass TA. Body mass index and the built and social environments in children and adolescents using electronic health records. American Journal of Preventive Medicine. 2011 Oct 1;41(4):e17-28.
12. Berke PR, Godschalk DR, Kaiser EJ, Rodriguez DA. Urban land use planning. 5th Ed. Urbana: University of Illinois Press; 2006 Apr.
13. Bowser, John, Ana P. Martinez-Donate, Aaron Carrel, David B. Allen, and D. Paul Moberg. 2016. Disparities in Fitness and Physical Activity Among Children. WMJ 115(5):245-205.
14. WiDPI - Wisconsin Department of Public Instruction. "Wisconsin Standards for Physical Education"(2010). http://www.dpi.wi.gov/sspw/physicaled.html
15. AB620 State of Wisconsin 2009-2010 Legislature LRBs0146/1 Senate Substitute Amendment 1, to 2009 SENATE BILL 313. October 13, 2009. LBR-3902/1 2009 ASSEMBLY BILL 620. December 17, 2009
16. Carrel AL, Bowser J, White D, Moberg DP, Weaver B, Hisgen J, Eickhoff J, Allen DB. Standardized childhood fitness percentiles derived from school-based testing. The Journal of Pediatrics. 2012 Jul 1;161(1):120-4.
17. ESRI ArcGIS-Business Analyst 2012. Environmental System Research Institute. ESRI-Inc. Redlands, CA, USA
18. Frank L, Glanz K, McCarron M, Sallis J, Sealens B, Chapman J. The spatial distribution of food outlet type and quality around schools in differing built environment and demographic contexts. Berkeley Planning Journal. 2006 Jan 1;19(1).
19. Ding D, Sallis JF, Kerr J, Lee S, Rosenberg DE. Neighborhood environment and physical activity among youth: a review. American Journal Of Preventive Medicine. 2011 Oct 1;41(4):442-55.
20. Cooksey-Stowers K, Schwartz MB, Brownell KD. Food Swamps Predict Obesity Rates Better Than Food Deserts in the United States. International Journal Of Environmental Research And Public Health. 2017 Nov 14;14(11):1366.
21. Wolch J, Jerrett M, Reynolds K, McConnell R, Chang R, Dahmann N, Brady K, Gilliland F, Su JG, Berhane K. Childhood obesity and proximity to urban parks and recreational resources: a longitudinal cohort study. Health & Place. 2011 Jan 1;17(1):207-14.

22. Almanza E, Jerrett M, Dunton G, Seto E, Pentz MA. A study of community design, greenness, and physical activity in children using satellite, GPS and accelerometer data. Health & Place. 2012 Jan 1;18(1):46-54.
23. Morland K, Wing S, Roux AD, Poole C. Neighborhood characteristics associated with the location of food stores and food service places. American Journal of Preventive Medicine. 2002 Jan 1;22(1):23-9.
24. Glanz K, Sallis JF, Saelens BE, Frank LD. Nutrition Environment Measures Survey in stores (NEMS-S): development and evaluation. American Journal of Preventive Medicine. 2007 Apr 1;32(4):282-9.
25. Saelens BE, Glanz K, Sallis JF, Frank LD. Nutrition Environment Measures Study in restaurants (NEMS-R): development and evaluation. American Journal of Preventive Medicine. 2007 Apr 1;32(4):273-81.
26. Han E, Powell LM, Zenk SN, Rimkus L, Ohri-Vachaspati P, Chaloupka FJ. Classification bias in commercial business lists for retail food stores in the US. International Journal of Behavioral Nutrition and Physical Activity. 2012 Dec 1;9(1):46. **mREI** – Modified Retail Food Environment :
27. CDC 2012 - Census Tract Level State Maps of the Modified Retail Food Environment Index (mRFEI) http://www.centertrt.org/content/docs/Training_Resources/Healthy_Food_and_Beverage_Access/census-tract-level-state-maps-mrfei_TAG508.pdf Community Commons – Maps & Data - Modified Retail Food Environment Index (mRFEI) https://www.communitycommons.org/docs/modified-retail-food-environment-index-score-by-tract/
28. Paquet C, Coffee NT, Haren MT, Howard NJ, Adams RJ, Taylor AW, Daniel M. Food environment, walkability, and public open spaces are associated with incident development of cardio-metabolic risk factors in a biomedical cohort. Health & Place. 2014 Jul 1;28:173-6.
29. McDonald N, Steiner R, Lytle B, Tsai J, Cook T. Quantifying the Costs of School Transportation. Gainesville, FL: Southeastern Transportation Research, Innovation, Development and Education Center; 2015 Jul.
30. Fiechtner L, Sharifi M, Sequist T, Block J, Duncan DT, Melly SJ, Rifas-Shiman SL, Taveras EM. Food environments and childhood weight status: effects of neighborhood median income. Childhood Obesity. 2015 Jun 1;11(3):260-8.
31. ESRI--Exploratory Regression - OLS 6-steps Diagnostics tool http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-statistics-toolbox/interpreting-gwrresults.htm
32. Szklo M, Nieto FJ. Epidemiology. Jones & Bartlett Publishers; 2014.
33. Frank LD, Sallis JF, Conway TL, Chapman JE, Saelens BE, Bachman W. Many pathways from land use to health: associations between neighborhood walkability and active transportation, body mass index, and air quality. Journal of the American planning Association. 2006 Mar 31;72(1):75-87.
34. Field A. Discovering statistics using SPSS. Sage publications; 2009 Jan 21.
35. WHO (World Health Organization) (2006-2008-2012). Social Determinants of Health (SDOH). http://www.who.int/social_determinants/en Retrieved September 2015.

SDOH-Social Determinant of Health. Healthy People 2020. Office of Disease Prevention and Health Promotion http://www.healthypeople.gov/2020/topics-objectives/topic/social-determinants-health-retrieved October 2015

36. IBM Corp. 2013 SPSS statistics for windows, version 22.0. Armonk, NY: IBM Corp.
37. ESRI 2016. ArcGIS Desktop: Release 10.3. Redlands, CA: Environmental System Research Institute. ESRI-Inc. Redlands, CA, USA – Spatial Statistic
38. ESRI--Regression Analysis Basics – Help http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-statistics-toolbox/regression-analysis-basics.htm #GUID-6D27B3A1-FFC6-4BF5-893F-F6D60AB2E783
39. ESRI--Interpreting OLS results http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-statistics-toolbox/interpreting-ols-results.htm
40. Active Living Research http://activelivingresearch.org/
41. Ferreira I, Van Der Horst K, Wendel-Vos W, Kremers S, Van Lenthe FJ, Brug J. Environmental correlates of physical activity in youth–a review and update. Obesity reviews. 2007 Mar 1;8(2):129-54.
42. McDonald NC, Brown AL, Marchetti LM, Pedroso MS. US school travel, 2009: an assessment of trends. American journal of preventive medicine. 2011 Aug 1;41(2):146-51.
43. McDonald NC. Children's mode choice for the school trip: the role of distance and school location in walking to school. Transportation. 2008 Jan 1;35(1):23-35.

44. Schlossberg M, Greene J, Phillips PP, Johnson B, Parker B. School trips: effects of urban form and distance on travel mode. Journal of the American Planning Association. 2006 Sep 30;72(3):337-46.
45. Kerr J, Frank L, Sallis JF, Chapman J. Urban form correlates of pedestrian travel in youth: Differences by gender, race-ethnicity and household attributes. Transportation Research Part D: Transport and Environment. 2007 May 1;12(3):177-82.
46. Fahlman MM, Hall HL, Lock R. Ethnic and socioeconomic comparisons of fitness, activity levels, and barriers to exercise in high school females. Journal of School Health. 2006 Jan 1;76(1):12-7.
47. Saelens, Brian E., James F. Sallis, Lawrence D. Frank, Sarah C. Couch, Chuan Zhou, Trina Colburn, Kelli L. Cain, James Chapman, and Karen Glanz. 2012. "Obesogenic neighborhood environments, child and parent obesity: the Neighborhood Impact on Kids study." American journal of preventive medicine 42, no. 5: e57-e64.
48. Weisser AS. “Little Red School House, What Now?” Two Centuries of American Public School Architecture. Journal of Planning History. 2006 Aug;5(3):196-217.
49. McDonald NC, Salvesen DA, Kuhlman HR, Combs TS. The Impact of Changes in State Minimum Acreage Policies on School Siting Practices. Journal of Planning Education and Research. 2014 Jun 1;34(2):169-79.
50. Giles-Corti B, Sallis JF, Sugiyama T, Frank LD, Lowe M, Owen N. Translating active living research into policy and practice: one important pathway to chronic disease prevention. Journal of public health policy. 2015 May 1;36(2):231-43.

- Title: International Research Journal of Public Health
- ISSN: 2573-380X
- DOI: 10.28933/IRJPH
- IF: 1.36 (citefactor)
- Email: IRJPH@escipub.com
- TEL: +1-281-656-1158