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

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**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.

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Introduction

Physical fitness is as important as healthy body weight for health and academic performance, with aerobic activities having the largest benefits.\textsuperscript{1-2-3} Especially when continued outside the school curriculum.\textsuperscript{4} School locations, and their surrounding environments, can provide opportunities for aerobic activity. School-siting 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.\textsuperscript{5,6} School-sites and surrounding environments are potentially correlated with levels of fitness, as they are with physical activity,\textsuperscript{7} and these correlations likely differ throughout childhood as interactions with the built environment change with age.

Nevertheless, these associations are still understudied.\textsuperscript{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,\textsuperscript{9} with children’s BMI has been established,\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{13-14} In 2009, Wisconsin enacted bill AB620 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.\textsuperscript{15} Fitnessgram measures fitness level using the Progressive Aerobic Cardiovascular Endurance Run (PACER)\textsuperscript{4} test.

\textsuperscript{1} School-siting is a type of physical planning. It looks at, and sets standards for, the site-evaluation 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).

\textsuperscript{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).

\textsuperscript{3} More details about AB620 in the endnotes.

\textsuperscript{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 (Carrel 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. 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, including geospatial reference; WDPI- Information System for Education-WISEdash; U.S. Census SAÏPE 2010 and ACS 2010. Environment GIS- data were obtained from: ESRI Business Analyst; UW- Madison geography Department GeoData portal; UW- Madison State Cartographer’s Office; 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 103                  |
| Hybrid Type/Grade/age based      |
| 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: 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-

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5 NCES - National Center for Education Statistics; https://nces.ed.gov/search/?q=ccdpublic+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 SAÏPE 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,25,26,27,28,29,30 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 |
| SMALL       | Neighborhood-School (1) |
| LARGER      | Neighborhood-Campus (2) |
| VERY LARGE  | Neighborhood-Suburb (3) |
|             | Campus-School (4) |

MAIN CRITERIA: "CAN A KID WALK THERE?"
typology 1 & 2 - school mainly surrounded by residential area (grid structure)
typology 3 - school surrounded 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 thoroughfare.

GOOGLE AERIAL VIEWS used to confirm CATEGORIES LOCATION and CONFIGURATION

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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.

|                  | Healthier (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    |

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 research to reduce misclassification. The 1,491 food retailers available within the buffers were verified on Google-Maps. Building upon the CDC mRFEI index, 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. Twenty-nine convenience stores relative to the number of healthy food retailers (https://www.cdc.gov/obesity/resources/reports.html)

Footnote 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

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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          | 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. The second, a measure of income inequality, is often a confounding factor for weight status, highly predicting health disparity; it also indicates school economic resources, and it is used in studies on food insecurity and food swamps. 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. 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-
PACER, environmental variables, student-body, and school typology were modelled using ArcGIS Exploratory OLS. 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. School average-PACER final adjusted model was fit on: ‘total students’; school typologies as 3 dummy variables relative to Campus-School(D4); 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 (EI-MS-HS), using the structure below.

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

relative to D4\text{Campus-school}

As in previous research, multivariate regression was used to identify each predictor’s change in R2. Predictors were entered blockwise with forced entry; the ‘order of entry’ was designed a priori informed by the Social Ecological Model. 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; geospatial statistics in ArcGIS 10.2.

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

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

\[ \text{IRJPH: https://escipub.com/international-research-journal-of-public-health/ } \]
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.\textsuperscript{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 (46310)).

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).

| 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     |
Table 5 – Descriptive Statistics – Dependent Variables and Covariates

| Dependent Variable(s) | unit of analysis | N  | %    | Mean | Std. Deviation | Min | Max |
|-----------------------|-----------------|----|------|------|----------------|-----|-----|
| PACER score (average) | School          | 103|      | 25.17| 10.53          | 8   | 62  |
| PACER Female (average)| School          | 102|      | 20.92| 9.03           | 8   | 52  |
| PACER Male (average)  | School          | 102|      | 29.30| 12.85          | 9   | 72  |
| PACER Elementary (average)| School     | 54 |      | 18.48| 6.51           | 8   | 38  |
| PACER Middle Sch (average)| School     | 64 |      | 27.06| 9.90           | 7   | 53  |
| PACER High Sch (average)| School        | 17 |      | 32.65| 10.53          | 18  | 62  |

Independent Variables

1. *StyLscales4b_NeighSch (1)* | 62 | 60.2 |
2. *StyLscales4b_NeighCampusSch (2)* | 13 | 12.6 |
3. *StyLscales4b_NeighSuburbSch (3)* | 7  | 6.8  |
4. (*) *StyLscales4b_CampusSch (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. *GNI coef100 - School District* | 103 | 42.36 | 3.03 | 35 | 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 | 3.22 | 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/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. SPECIALITY_FS-DAIRY_H | 103 | 0.10 | 0.30 | 0 | 1 |
43. Specialty_FS_Snack_U | 103 | 0.29 | 0.46 | 0 | 1 |
44. SPECIALITY_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 Euclidian buffer (1600m. Euclidian buffer)

| School Typology                | FE and BE significant predictors                  | N   | TOT |
|-------------------------------|-------------------------------------------------|-----|-----|
| Neighborhood school (n=62)     | FS-U - Convenient Store (w/o a 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/o a 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/o a 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/o a 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)

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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 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

| OLS and Model Fit                  | PACER          | PACER Female | PACER Male       |
|-----------------------------------|----------------|--------------|------------------|
|                                   | n= schools     | B-coef       | Std. Error       | β     | p-value | R2 change % | B-coef       | Std. Error       | β     | p-value | R2 change % | B-coef       | Std. Error       | β     | p-value | R2 change % |
| Intercept                         | n = 103        | 59.256       | 15.442           | 0.32  | 0.000   | 2.8%       | 47.34       | 14.25            | 0.12  | 0.185   | 0.00%       | 51.79       | 19.23            | -0.29 | 0.018   | 8.8%       |
| Total students (school capacity)  |                | 0.01         | 0.00             | 0.12  | 0.000   | 0.00%      | 0.004        | 0.000            | 0.44  | 0.000   | 0.000       | 0.016         | 0.003            | 0.44  | 0.000   | 8.8%       |
| Sch. Typology 1 - Neighborhood (D1)* |            | -7.07        | 2.63             | -0.33 | 0.009   | 10%        | -6.43       | 2.32            | -0.35 | 0.007   | 12.0%       | -7.57       | 3.14            | -0.29 | 0.018   | 7.8%       |
| Sch. Typology 2 - Neighborhood-Campus (D2)* |         | -8.71        | 3.36             | -0.28 | 0.011   | 10.2%      | -6.39       | 2.97            | -0.24 | 0.034   | 8.2%        | -10.42      | 4.01            | -0.27 | 0.011   | 10.2%      |
| Sch. Typology 3 - Neighborhood-Suburb (D3)* |         | -5.40        | 4.05             | -0.13 | 0.186   | 0.1%       | -4.71       | 3.58            | -0.13 | 0.192   | 0.1%        | -5.86       | 4.84            | -0.12 | 0.229   | 0.2%       |
| Convenient Store - U              |                | -7.74        | 2.95             | -0.29 | 0.010   | 7.1%       | -6.56       | 2.61            | -0.28 | 0.014   | 7.1%        | -8.93       | 3.53            | -0.27 | 0.013   | 7.5%       |
| Fast Casual Restaurant - H        |                | 10.75        | 5.33             | 0.20  | 0.046   | 3.6%       | 8.67        | 5.35            | 0.16  | 0.109   | 2.0%        | 11.28       | 7.22            | 0.15  | 0.122   | 2.7%       |
| Park Scale 5                      |                | -0.77        | 0.57             | -0.12 | 0.181   | 1.7%       | -1.06       | 0.51            | -0.19 | 0.040   | 3.8%        | -0.44       | 0.69            | -0.06 | 0.522   | 0.6%       |
| GINI coefficient (0-100) School District |         | -0.854       | 0.382            | -0.246 | 0.028   | 3.3%       | -0.56       | 0.34            | -0.19 | 0.103   | 1.9%        | -1.13       | 0.46            | -0.26 | 0.015   | 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  | 2.00  |

SPATIAL OLS

| Global Moran's I | Random (p-value 0.87) | Random (p-value 0.97) | Random (p-value 0.94) |
|------------------|-----------------------|-----------------------|-----------------------|
|                  | NA                    | NA                    | NA                    |

Kruskal-Wallis test

| School Typology 4 categories (df=3) | PACER | PACER Female | PACER Male |
|-------------------------------------|-------|--------------|------------|
| Chi-square*                         | 24.26 | 26.62        | 21.45      |
| Asympt. Sig.                        | 0.000 | 0.000        | 0.000      |

* relative to Sch. Typology 4 - Campus (D4)
(bold) Significant p-value < 0.05 -
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=103   | n=54            | n=64                     | n=17                      |
| **OLS and Model Fit**    |         |                  |                          |                           |
| Intercept                | B-coeff | 59.256          | 56.07                    | 671.35                    |
|                          | Std. error | 15.442          | 23.58                    | 142.30                    |
|                          | p-value  | .000            | 9.1%                     | 0.3%                      |
|                          | R2 change % | 2.8%            | 1.1%                     | 0.3%                      |
| Total students (school capacity) | B-coeff | 0.01            | 0.015                    | 0.008                     |
|                          | Std. error | 0.00            | 0.005                    | 0.003                     |
|                          | p-value  | 0.32            | 9.1%                     | 0.03                      |
|                          | R2 change % | .009            | 1.1%                     | 0.3%                      |
| Sch. Typology 1 - Neighborhood (D1)* | B-coeff | -7.07           | -3.38                    | -11.08                    |
|                          | Std. error | 2.63            | 3.46                     | 3.21                      |
|                          | p-value  | .033            | 0.0%                     | 2.4%                      |
|                          | R2 change % | .009            | 0.0%                     | 2.4%                      |
| Sch. Typology 2 - Neighborhood-Campus (D2)* | B-coeff | -8.71           | -5.76                    | -14.44                    |
|                          | Std. error | 3.36            | 4.07                     | 4.99                      |
|                          | p-value  | .028            | 9.1%                     | 2.8%                      |
|                          | R2 change % | .011            | 1.4%                     | 2.8%                      |
| Sch. Typology 3 - Neighborhood-Suburb (D3)* | B-coeff | -5.40           | -1.00                    | -15.00                    |
|                          | Std. error | 4.05            | 8.89                     | 5.22                      |
|                          | p-value  | -0.13           | 0.0%                     | 5.9%                      |
|                          | R2 change % | .186            | 0.1%                     | 5.9%                      |
| Convenient Store -U      | B-coeff | -7.74           | -0.84                    | -38.44                    |
|                          | Std. error | 2.95            | 4.43                     | 4.68                      |
|                          | p-value  | -0.29           | 5.4%                     | 19.5%                     |
|                          | R2 change % | .010            | 1.6%                     | 19.5%                     |
| Fast Casual Restaurant - H | B-coeff | 10.75           | excluded - lack of variability | 55.02                    |
|                          | Std. error | 5.33            | 4.07                     | 6.77                      |
|                          | p-value  | 0.20            | 1.7%                     | 36.2%                     |
|                          | R2 change % | .046            | 0.1%                     | 36.2%                     |
| Park Scale 5             | B-coeff | 0.07            | -0.52                    | -1.50                     |
|                          | Std. error | 0.57            | 0.57                     | 0.60                      |
|                          | p-value  | -0.12           | 2.1%                     | 4.5%                      |
|                          | R2 change % | 0.181            | 0.1%                     | 4.5%                      |
| GINI coefficient (0-100) | B-coeff | -.854           | -0.91                    | 15.68                     |
| School District          | Std. error | .382            | 0.64                     | 3.24                      |
|                          | p-value  | .246            | 3.1%                     | 21.2%                     |
|                          | R2 change % | .028            | 6.9%                     | 21.2%                     |

**Model Fit Summary**

| Adj R2 FULL model | 33.6% | 18.1% | 22.8% | 85.5% |
|--------------------|-------|-------|-------|-------|
| F                  | 7.46  | 2.67  | 3.32  | 12.84 |
| p-value            | 0.001 | 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 0.08) | Random (p-value 0.08) |
|------------------|-----------------------|-----------------------|-----------------------|
| Local Moran's I  | NA                    | 3H-H 1L (p-value < 0.05) | 2LL (p-value < 0.05) |

**Kruskal-Wallis test**

| School Typology 4 categories (df=3) | Chi-square | Asympt. Sig. |
|-------------------------------------|------------|--------------|
| (bold)                              | 24.26      | 0.000        |

| PACER ELEMENTARY | PACER Middle School (MS) | PACER High School (HS) ** |
|------------------|--------------------------|---------------------------|
| Chi-square | 8.18 | 15.64 | 3.18 |
| Asympt. Sig | 0.042 | 0.001 | 0.36 |

* relative to Sch. Typology 4 - Campus (D4)

(bold) Significant p-value < 0.05

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, health behavior, and school-siting and transportation, 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. 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, 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’s 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. 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 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, 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. 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, 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 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. Lastly, although individual-level BMI is known for being correlated with PACER, 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, 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. 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).

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