The Physical Activity Environment and Academic Achievement in Massachusetts Schoolchildren

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ABSTRACT

BACKGROUND: A supportive school-based physical activity environment (PAE) is integral to children’s physical activity behaviors, but less understood is its association with academic achievement. We aimed to assess the association between PAE and academic performance and whether a stronger relationship exists in lower-income schools (LIS) compared to middle-income schools (MIS).

METHODS: Schoolchildren (grades 3rd to 5th) were recruited from 17 Massachusetts public schools. Schools were classified based on geographic characteristics and free/reduced-price lunch (FRPL) eligibility (LIS = 7, Median FRPL = 86%; MIS = 10, Median FRPL = 20%). PAE was measured using a 10-item survey. Mixed-effects logistic regression models were used to examine associations between PAE and scoring Advanced/Proficient on standardized Math and English Language Arts (ELA) tests.

RESULTS: Demographic characteristics differed between LIS (N = 278, 5% non-Hispanic white) and MIS (N = 297, 73% non-Hispanic white). In LIS, PAE was associated with Math (odds ratio = 5.40, 95% CI = 2.52-11.54 p < .001), but not ELA test scores (p > .05). There was no relationship between PAE and MIS test scores (p > .05). Schooltime moderate-to-vigorous physical activity was not associated with test scores (p > .05).

CONCLUSIONS: A beneficial relationship exists between a high-PAE and test scores among LIS children, suggesting that the PAE may be associated with a more supportive environment and may be more fundamentally important for lower-income students.

Keywords: school; physical activity; physical activity environment; academic achievement.

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Physical activity (PA) in children is integral to obesity prevention and is associated with a multitude of other benefits including cognitive health and academic achievement. Given these benefits, experts recommend that children engage in 30 minutes of schooltime moderate-to-vigorous PA (MVPA) per day. However, less than half of American children are reaching the recommended 60 minutes of daily MVPA and even fewer are meeting the daily 30-minutes schooltime recommendation. Racial/ethnic and socioeconomic status (SES) disparities in PA and childhood obesity rates underscore the need for concerted efforts to target children disproportionately at risk.

In 2012, the Institute of Medicine called for a “whole school” approach to make schooltime PA a public health priority. The amount of time that children spend in school each day makes this a critical environment for promoting PA behaviors through strategies such as provision of high-quality physical education (PE), PA before and after school, and active transport. Supportive school policies and environmental factors are associated with boys and girls being more physically active. A “whole school” approach to address PA may be even more
important for underserved children, who may not have sufficient resources outside of the school environment, such as safe neighborhoods and public recreational opportunities, to support PA behaviors.\textsuperscript{13}

Few states have embraced policies and practices to enhance schooltime PA,\textsuperscript{14} despite the growing body of evidence that school-based PA is positively associated with academic achievement.\textsuperscript{15-19} This is especially problematic in lower-SES schools where the limited adoption of PA-supporting policies, activities, and infrastructure\textsuperscript{20-22} can decrease children’s opportunities to be active.\textsuperscript{22} It is possible that lower-SES schools may actually benefit the most from an environment that promotes PA, both in terms of total PA, and also academic achievement.

Therefore, the overall aims of this study were to assess: (1) whether a supportive physical activity environment (PAE) is associated with greater schooltime MVPA and improved academic performance among schoolchildren, and (2) whether there is evidence of stronger relationships among these variables in students from lower-income schools (LIS) compared to students from higher-income schools.

\section*{METHODS}

\textbf{Study Overview and Participants}

Participants were 3rd-5th grade students from 17 public elementary schools across Massachusetts. Schools were classified based on income using free/reduced-price lunch (FRPL) eligibility (7 LIS [Median = 86%] and 10 middle-income schools [MIS] [Median = 20%]),\textsuperscript{23} and geographic characteristics. The schools included in this analysis were from 2 different studies. MIS were suburban and peri-urban and were recruited to serve as control schools in a pilot study on PA programming across the state. LIS were from an urban school district that serves a predominantly Hispanic population.

Participants were recruited through classroom presentations and school assemblies. Recruitment packets in English and Spanish were sent home with all interested and grade-level eligible children approximately 1 week prior to data collection, including information about the study and parent permission/child assent forms. Data collection occurred during the spring of 2014 and included measurements of height, weight, and 7-day accelerometry. The school PAE was also assessed at this time, and standardized test scores for Math and English Language Arts (ELA) were accessed through school records for the year of data collection (2014).

\textbf{Instrumentation}

\textbf{Sociodemographic data.} Parent and child demographic data were collected from a self-administered, 9-item survey that was included in the recruitment packet and returned to research staff with completed parent permission and child assent forms. Child race/ethnicity was parent-reported based on the categories of the National Institutes of Health\textsuperscript{24} and aggregated into 5 groups: non-Hispanic white, Hispanic, black, Multirace/Other, and not applicable. FPRL eligibility was used as an indicator of SES.

\textbf{Anthropometrics.} Assessments of height and weight were conducted in a semiprivate setting with participants dressed in light clothing and without shoes. Height was measured in triplicate to the nearest 1/8 inch using a portable stadiometer (Model 214; Seca Weighing and Measuring Systems, Hanover, MD). Weight was measured in triplicate to the nearest 0.5 lbs/0.2 kg using a portable digital electronic scale (Model 803; Seca Weighing and Measuring Systems/PS-6600 ST, Befour Inc., Saukville, WI). Body mass index (BMI) was calculated as body weight in kilograms divided by height in meters squared (kg/m$^2$) and converted into a percentile and z-score using the Centers for Disease Control and Prevention age- and sex-specific growth charts.\textsuperscript{25} BMI percentiles were classified as: <5th percentile as underweight; 5th to <85th percentile as normal weight; 85th to <95th percentile as overweight; and ≥95th percentile as obese.

\textbf{Measurement of PA}

\textbf{Instrumentation.} PA was measured by Actigraph GT3X and GT3X+ accelerometers (Actigraph; LLC, Pensacola, FL), validated and calibrated for use with children.\textsuperscript{26}
Scaled test scores were used to determine 4th-grade Massachusetts Comprehensive Assessment System (MCAS) Math and ELA standardized test scores. Massachusetts Comprehensive Assessment System and Secondary Education provided child-level test scores for 2014.

Participants were instructed to wear the accelerometer for 7 consecutive days during all waking hours, except when bathing or swimming. Accelerometers were sent home with children. Accelerometers were worn for 7 days and collected by research staff.

Data preparation. Accelerometers were initialized to sample and store activity counts beginning on the first day the participant was instructed to start wearing the device. Stored activity counts from each device were downloaded for data reduction and analysis. Accelerometer data were processed as counts per 30-second epoch. Nonwear-time was defined as 60 minutes of zero activity counts (ie, 120 consecutive zeroes), allowing for 1 minute of light activity (2 consecutive epochs with 1-99 counts) every hour. Wear-time was estimated by subtracting nonwear-time from the total daily monitoring time. A day was considered “valid” if daily wear-time was ≥10 hours. Participants with less than 3 valid wear days were excluded from the analysis.

Counts were classified into the following PA intensity categories using cut points developed specifically for children by Evenson et al: sedentary (≤50 counts per 30 seconds), light (51-1148 counts per 30 seconds), moderate (1149-2005 counts per 30 seconds), and vigorous (≥2006 counts per 30 seconds). Hour and time of day were inserted on the accelerometer output. For each valid wear day, minutes in each intensity category as well as total counts were averaged for each participant across 3 segments: total daily (average of weekdays and weekends), during school and weekday-out-of-school. In-school hours were calculated for each participant, based on the specific start and end times of the school day for each day the accelerometer was worn. This allowed for adjustment of schooltime hours on days when students were released early.

Weather conditions. Weather data were collected from the National Oceanic and Atmospheric Administration. The high temperature (continuous) and precipitation (binary: yes/no) were recorded for each day the accelerometers were worn by participants from the weather station nearest to each school.

Academic Outcomes
The Massachusetts Department of Elementary and Secondary Education provided child-level 2014 Massachusetts Comprehensive Assessment System (MCAS) Math and ELA standardized test scores. Scaled test scores were used to determine 4 levels of performance: advanced, proficient, needs improvement, and warning. A bivariate variable of advanced/proficient and needs improvement/warning for MCAS scores was generated to assess the association between MCAS performance for students that were in LIS and MIS categorized as having a high-PAE score versus a low-PAE score. The 2014 MCAS scores were used also for the regression models exploring the association between the PAE and academic performance.

School Physical Activity Environment
School PAE was assessed using a 10-item survey about PA-related policies, practices, and infrastructure. The person most knowledgeable about the PAE at each school was asked to complete the survey and was typically the principal, other administrator or PE teacher. Questions were adapted from the School Physical Activity Policy Assessment and preliminary data support the reliability of this tool. Questions were grouped to assess PA supporting policies and practices in 4 areas relevant to the school environment: PE, recess, classroom-based PA, and before- and after-school PA opportunities. Scores on the PA scan were tabulated based on policies and practices identified as being most related to children’s time spent in MVPA during school. For example, a PE question asks about requiring all children to take part in a) at least 150 minutes per week, b) 90-149 minutes per week, c) 60-89 minutes per week, or d) 0-60 minutes per week. Answering “a” would indicate adoption of the strongest PA promoting policy. Total point scores on the scan were median-split out of 24 total points into high- (score ≥16) and low- (score <16) PAE for analyses.

Data Analysis
Descriptive statistics of demographic information including sex, grade, race/ethnicity, weight status, and eligibility for FRPL were used to categorize children and their PA behavior. We used independent samples t-tests to compare schooltime MVPA in LIS and MIS that adopted PA-supportive policies to those that did not.

Mixed-effects logistic regression models were used to examine the associations between: (1) PAE score and students scoring “advanced/proficient” on 2014 MCAS Math, and (2) PAE score and students scoring “advanced/proficient” on 2014 MCAS ELA. School was used as a random effect in these models. Separate models were run with schooltime MVPA and total daily MVPA to determine how much the effect of the PAE on Math and ELA scores is mediated through these PA categories. Accelerometer wear-time, average weekday temperature, precipitation, sex, race, BMI-z score, eligibility for FRPL, grade, and clustering within
schools were used as covariates in these analyses. Means and SDs are presented unless otherwise stated. Statistical significance was set at p < .05. All analyses were performed using Stata/SE 14.0 for Windows (College Station, TX).

RESULTS

Demographic characteristics of participants with valid accelerometer wear-time [(LIS: N = 278; 9.6 ± 0.9 years); (MIS: N = 297; 9.4 ± 0.9 years)] are shown in Table 1. Eighty-one percent of children from LIS were Hispanic and 73% of children from MIS were non-Hispanic white. In LIS, 45% of children were overweight/obese compared to 26% in MIS. The majority of LIS children (94%) and 29% of MIS children were eligible for FRPL.

LIS children engaged in less schooltime MVPA (16.2 ± 10.6 minutes; 11% met schooltime MVPA recommendation) than MIS children (17.7 ± 7.3 minutes, p < .05; 7% met schooltime MVPA recommendation). Fifteen percent of LIS children and 25% of the MIS children met the 60-minutes total daily MVPA recommendation (39.6 ± 20.9 minutes versus 46.3 ± 21.8 minutes, p < .001). Differences in schooltime PA by sex, school grade, race/ethnicity, weight status, and eligibility for FRPL are presented in Table 1.

Forty-one percent of students from LIS and 54% of students from MIS were in high-PAE schools (score ≥16). Adoption of PA-promoting policies varied between LIS and MIS schools (Table 2), but all schools had a licensed/certified PE instructor and provided indoor and outdoor space for PE (100% for both LIS and MIS). A higher percentage of MIS had PA-promoting policies across domains spanning PE, recess, and before and after school PA opportunities. For example, MIS had policies that LIS did not have, including recess supervision featuring encouragement of PA and provision of organized activities (30%) and before and after school PA programs available to children (30%). The association between a high-PAE and schooltime MVPA was observed in MIS (low-PAE = 16.3 ± 6.7 minutes; high-PAE = 18.9 ± 7.6 minutes; p < .01).

With regard to the association between individual PA-promoting policies and PA, schooltime MVPA varied between adopting and nonadopting schools (Table 2), but these associations were generally similar between LIS and MIS schools (data not shown). Notably, having policies in place that required PE teachers to assess fitness levels annually was associated with 2.0 more minutes of schooltime MVPA (p < .01). Recess policies also had a substantial impact on schooltime MVPA. Providing recess to all students for at least 100 minutes/week was associated with approximately 3.4 more minutes of schooltime MVPA (p < .001). While the presence of indoor and outdoor facilities for recess was associated with increased schooltime MVPA in MIS (1.7 minutes, p < .05), this component had a negative association among LIS with adopting schools having lower schooltime MVPA (5.7 minutes, p < .0001; data not presented).

Figure 1 presents the differences in Math and ELA advanced/proficient achievement by high- and low-PAE for LIS and MIS. Among LIS, there was a positive relationship between children who attended a high-PAE school and MCAS advanced/proficiency achievement for both Math and ELA. Fifty-one percent of LIS students in a low-PAE school had advanced/proficient in Math scores compared to 79% of children in a high-PAE school. Similarly, for ELA, 39% of LIS students from a low-PAE school had advanced/proficient scores compared to 56% of students from a high-PAE school. This association between PAE and academic achievement was not apparent in MIS.

Schooltime MVPA (Table 3) and total daily MVPA were not associated with Math or ELA test proficiency (p > .05). Mixed-effects logistic regression models including schooltime MVPA demonstrated that in LIS, high PAE was associated with increased odds of students scoring advanced/proficient on Math (odds ratio [OR] = 5.40, 95% CI = 2.52-11.54, p < .001), whereas the relationship with ELA was not significant (OR = 1.75, 95% CI = 0.91-3.37, p = .09). In MIS, there was no relationship between PAE and odds of achieving advanced/proficient on Math or ELA (p > .05).

DISCUSSION

This study reinforces the beneficial role that the school PAE has in contributing to children’s PA behaviors11,33-36 and academic performance37,38 especially for underserved children. Meeting total daily and school-based PA recommendations continues to be a challenge for school-aged children, regardless of race/ethnicity and SES. In these lower- and middle-income samples, children accrued, on average just over half of the 30-minute schooltime MVPA recommendation (~17 min).

A central finding of our study was that in LIS, a more positive PAE was associated with students’ academic performance on math standardized tests and was marginally associated with ELA standardized tests, an association that did not exist for MIS. The high percentage of Hispanic students in the LIS who may not have been as proficient in English may explain the attenuated association between the PAE and ELA standardized tests. These findings suggest that for lower-income children, an environment conducive to being active may translate into academic success and those additional resources in this domain may not play as critical a role for middle-income children.
Table 1. Descriptive Statistics of Children From Lower-Income (N = 278) and Middle-Income (N = 297) Massachusetts Elementary Schools

<table>
<thead>
<tr>
<th></th>
<th>MIS</th>
<th>LIS</th>
<th>MIS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (%)</td>
<td>N (%)</td>
<td>Schooltime MVPA (Minutes) (Mean ± SD)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MIS</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>108 (38.9)</td>
<td>118 (39.7)</td>
<td>193 ± 11.9</td>
</tr>
<tr>
<td>Female</td>
<td>170 (61.1)</td>
<td>179 (60.3)</td>
<td>143 ± 9.2</td>
</tr>
<tr>
<td>Grade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>113 (40.7)</td>
<td>158 (53.2)</td>
<td>154 ± 8.9</td>
</tr>
<tr>
<td>4th</td>
<td>106 (38.1)</td>
<td>79 (26.6)</td>
<td>160 ± 10.9</td>
</tr>
<tr>
<td>5th</td>
<td>59 (21.2)</td>
<td>60 (20.2)</td>
<td>182 ± 12.7</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic white</td>
<td>13 (4.7)</td>
<td>218 (73.4)</td>
<td>122 ± 9.1</td>
</tr>
<tr>
<td>Hispanic</td>
<td>225 (80.9)</td>
<td>36 (12.1)</td>
<td>165 ± 10.3</td>
</tr>
<tr>
<td>Black</td>
<td>5 (1.8)</td>
<td>16 (5.4)</td>
<td>282 ± 15.0</td>
</tr>
<tr>
<td>Multirace/other†</td>
<td>18 (6.5)</td>
<td>19 (6.4)</td>
<td>126 ± 7.9</td>
</tr>
<tr>
<td>N/A</td>
<td>17 (6.1)</td>
<td>8 (2.7)</td>
<td>159 ± 13.6</td>
</tr>
<tr>
<td>Weight status‡</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underweight</td>
<td>5 (1.8)</td>
<td>9 (3.0)</td>
<td>150 ± 8.4</td>
</tr>
<tr>
<td>Normal weight</td>
<td>148 (53.2)</td>
<td>210 (70.7)</td>
<td>174 ± 11.0</td>
</tr>
<tr>
<td>Overweight</td>
<td>59 (21.2)</td>
<td>42 (14.1)</td>
<td>177 ± 12.0</td>
</tr>
<tr>
<td>Obese</td>
<td>66 (23.7)</td>
<td>36 (12.1)</td>
<td>123 ± 6.8</td>
</tr>
<tr>
<td>Free and reduced-lunch price eligible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>244 (93.9)</td>
<td>81 (28.9)</td>
<td>160 ± 10.4</td>
</tr>
<tr>
<td>No</td>
<td>16 (6.2)</td>
<td>199 (71.1)</td>
<td>169 ± 9.0</td>
</tr>
</tbody>
</table>

LIS, lower-income school; MIS, middle-income school; MVPA, moderate-to-vigorous physical activity; N/A, not applicable.

‡Does not add up to 100% because of missing data.
†Multirace/other comprises of American Indian, Pacific Islander, and Asian.
‡Determined by BMI-z score and percentiles; underweight <5th percentile; normal weight 5th-85th percentile; overweight >85th to 95th percentile; obese >95th percentile.

The literature supports that increased PA can improve children’s self-esteem and attention-to-task, which may further explain this link.

In 2012, the Institute of Medicine recommended that schools adopt a “whole school” approach to PA through strategies ranging from active transport to and from school to active classroom lessons. We examined 4 domains including PE, recess, classroom PA, and PA before/after school. In the current study, LIS were all from the same district whereas middle-income schools were from different school districts. It is important to note that some of these PA-promoting policies may be adopted at either the district or school level. Thus, LIS may or may not be representative of other low-income schools across the state. However, there is evident intra-district variability in the adoption of many policies and practices, which is a strength and demonstrates the important role that the school has in promoting PA.

The overall PAE and adoption of supportive policies varied between LIS and MIS, with 13% more students from MIS in high-PAE schools. This may highlight inherent disparities in terms of the capacity for low-income schools to implement these policies/programs for reasons including budgetary constraints and competing demands for academic enrichment. The need for schools to prioritize resources dedicated to PA persists, despite the growing body of literature suggesting that schooltime PA is not detrimental and may even benefit academic performance.

Schooltime MVPA was higher among students in MIS with a more supportive PAE, which underscores the importance of PA-supporting policies, activities, and infrastructure. Individual policies were similarly associated with schooltime PA for both LIS and MIS students. When assessing the association between individual PA-promoting policies and PA, schooltime MVPA was up to 4 minutes higher in schools that adopted specific PA-supporting policies in the domains of PE, recess, and classroom PA compared to schools that did not. More than half of both LIS and MIS reported that PE teachers assess fitness annually, which was associated with an average of 2.5 more minutes of schooltime MVPA. Implementing fitness testing may be indicative of schools’ dedication to and resources available for supporting student PA.

The PA-promoting policies that neither LIS nor MIS adopted broadly included requiring all students to participate in PE for at least 150 minutes per week, which was associated with 4.7 minutes more schooltime MVPA. Nationally, few states have implemented policies regarding time requirements for PE, potentially due to other academic priorities in the school setting. Additionally, none of the schools provided classroom PA breaks during the day across all or most classrooms. Previous studies suggest the benefits
Table 2. Adoption of PA-Promoting Policies in Lower-Income (N = 7) and Middle-Income (N = 10) Massachusetts Elementary Schools

<table>
<thead>
<tr>
<th>Policy Description</th>
<th>Overall (N = 17)</th>
<th>LIS (N = 7)</th>
<th>MIS (N = 10)</th>
<th>Schooltime MVPA (minutes) Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td></td>
<td></td>
<td></td>
<td>Adopted† Nonadopted</td>
</tr>
<tr>
<td>Requiring all students to participate in PE at least 150 minutes per week</td>
<td>1 (5.9)</td>
<td>0 (0.0)</td>
<td>1 (10.0)</td>
<td>204.9 (9.7) 16.8 (9.0)</td>
</tr>
<tr>
<td>PE taught by licensed/certified teachers during most or all PE lessons</td>
<td>17 (100.0)</td>
<td>7 (100.0)</td>
<td>10 (100.0)</td>
<td>170.0 (9.0) -</td>
</tr>
<tr>
<td>Indoor and outdoor facilities available for PE</td>
<td>17 (100.0)</td>
<td>7 (100.0)</td>
<td>10 (100.0)</td>
<td>170.0 (9.0) -</td>
</tr>
<tr>
<td>PE teachers assess student fitness levels annually</td>
<td>10 (58.8)</td>
<td>4 (57.1)</td>
<td>6 (60.0)</td>
<td>178.8 (8.9) 15.8 (9.0)**</td>
</tr>
<tr>
<td>Recess</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recess is provided to all students for ≥100 minutes/week</td>
<td>8 (47.1)</td>
<td>2 (28.6)</td>
<td>6 (60.0)</td>
<td>191.9 (9.1) 15.7 (8.8)**</td>
</tr>
<tr>
<td>Indoor and outdoor facilities available for recess</td>
<td>7 (41.1)</td>
<td>3 (42.9)</td>
<td>4 (40.0)</td>
<td>161.8 (8.7) 17.8 (9.3)*</td>
</tr>
<tr>
<td>Recess supervision featuring encouragement of PA, provision of organized activities, student to supervisor ratio &lt; 75:1</td>
<td>3 (17.6)</td>
<td>0 (0.0)</td>
<td>3 (30.0)</td>
<td>184.7 (7.7) 16.8 (9.2)</td>
</tr>
<tr>
<td>Classroom PA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most or all classroom teachers provide PA breaks during the school day</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>--</td>
<td>-- 17.0 (9.0)</td>
</tr>
<tr>
<td>Before and After School PA</td>
<td>3 (17.6)</td>
<td>0 (0.0)</td>
<td>3 (30.0)</td>
<td>17.7 (6.8) 16.8 (9.5)</td>
</tr>
</tbody>
</table>

Significantly different at †p < .05, **p < .01, ***p < .001.
LIS, lower-income school; MIS, middle-income school; MVPA, moderate-to-vigorous physical activity; PA, physical activity; PE, physical education.
†School adoption of a physical activity-promoting policy.

of classroom PA breaks on learning outcomes and on-task behavior during instruction time. Though these programs are gaining popularity, there is a lack of rigorous research surrounding their implications for children’s PA.

There were disparities in the adoption of PA-promoting policies between LIS and MIS. While approximately one-third of MIS had recess policies characterized by supervisors who encouraged PA and provided organized activities, none of the LIS had these practices. Likewise, nearly one-third of MIS PAE was characterized by the availability of before and after school PA programs; LIS did not. Given that disparities in PA behaviors exist both in the school and out-of-school settings, there is heightened need to target aspects of the PAE that transcend opportunities during school hours. Providing opportunities for children to adopt these PA behaviors at a young age and particularly in low-SES and diverse racial/ethnic populations is critical given evidence that participation in sports is lower in older low-SES and Hispanic students. Whereas the presence of indoor and outdoor facilities for recess was beneficial to schooltime MVPA in MIS, we observed a negative association between having indoor and outdoor recess facilities and schooltime MVPA in LIS. It is possible that having these facilities available may be insufficient to promote positive PA behaviors and may need to be supplemented by additional policies, such as minute requirements and improved supervision.

Limitations
This study is not without its limitations. The tool used in this study to measure the PAE was administered to the individual at the school most knowledgeable about PA and PE practices, it was based on self-report and may have been susceptible to social desirability bias. Though the tool was comprehensive, it was not exhaustive and therefore may not have captured other aspects of the PAE in areas such as active transport to and from school and the interpersonal environment (ie, teacher social support). This tool however, was reliable and was feasible to administer to school personnel most familiar with the school PAE. The study was conducted in a predominantly low- to middle-income sample of schools in Massachusetts and thus may not be generalizable to schools with different geographic and sociodemographic characteristics. Since LIS were all from one district, the school PAE as well as the academic scores may reflect district as well as school characteristics. Our results are bolstered by a sample size of 17 schools and 575 children. In terms of the outcomes measured in this study, MCAS served as an objective measure of academic success; however, this may not be representative of students’ total promise for academic success in other domains. Finally, this study is cross-sectional, and thus, longitudinal studies are needed to explore the association between the PAE and standardized test performance and potentially other measures of academic success.
Figure 1. Percent Advanced/Proficient on Math and English Language Arts (ELA) Standardized Test Scores by Physical Activity Environment, 2014 in Lower-Income (N = 278) and Middle-Income (N = 297) Schools

Table 3. Associations Between PAE Score, Schooltime MVPA, 2014 Math and ELA Standardized Test Proficiency in Lower-Income (N=278) and Middle-Income (N = 297) Elementary School Children

<table>
<thead>
<tr>
<th></th>
<th>Math Advanced/Proficient OR, 95% CI (p-Value)</th>
<th>ELA Advanced/Proficient OR, 95% CI (p-Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIS model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-PAE*</td>
<td>5.40, 2.52-11.54 (&lt;.001)</td>
<td>1.75, 0.91-3.37 (.09)</td>
</tr>
<tr>
<td>Schooltime MVPA</td>
<td>1.00, 0.97-1.03 (.80)</td>
<td>0.99, 0.96-1.01 (.31)</td>
</tr>
<tr>
<td>MIS model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-PAE*</td>
<td>0.49, 0.19-1.29 (.15)</td>
<td>0.59, 0.26-1.37 (.22)</td>
</tr>
<tr>
<td>Schooltime MVPA</td>
<td>0.96, 0.91-1.01 (.14)</td>
<td>1.04, 0.98-1.09 (.18)</td>
</tr>
</tbody>
</table>

Covariates in analyses include accelerometer wear-time, average weekday temperature, precipitation (%weekdays), sex, race, BMI-z score, eligibility for free/reduced-price lunch, grade, and clustering within schools.

BMI, body mass index; CI, confidence interval; ELA, English/Language Arts; LIS, lower-income school; MIS, middle-income school; MVPA, moderate-to-vigorous physical activity; OR, odds ratio; PAE, physical activity environment.

*PAE—High-PAE: Score ≥ 16.

Conclusions

In this sample of Massachusetts schoolchildren, there is a demonstrated beneficial association between a supportive PAE and low-income but not middle-income children’s academic achievement. This study corroborates previous research highlighting the low levels of schooltime and total daily MVPA as evidenced by the overwhelming majority of children not meeting schooltime or total daily activity recommendations. Adoption of PA-supporting policies varied considerably across schools and appeared to be less widely adopted by LIS, but the findings suggest that all schools can improve in the provision of adequate time for children to be active. Notable opportunities for improvements include structured PA sessions during recess and in the classroom, while continued emphasis on adequate PE and recess time is also necessary. Longitudinal studies examining changes in the PAE and academic success are needed, especially for low-income and racially/ethnically diverse communities.

IMPLICATIONS FOR SCHOOL HEALTH

Addressing the PAE in schools holds promise for influencing positive PA behaviors and may even translate into academic outcomes. We found that individual PA-promoting policies were associated with increased schooltime PA. School administrators, teachers, and health practitioners should consider the following general recommendations:

1. Internally assess the school PAE in terms of PE, recess, the classroom, and before/after school programs to identify areas for incorporation of additional PA time.
2. Engage an array of individuals to improve the school PAE—classroom teachers, PE teachers, administrators, and students.

3. Explore opportunities to shape PE through revisiting the amount of time allocated per week for PE, dedicate a greater percentage of PE time to MVPA, and consider fitness testing.

Our study results also suggest that addressing schools’ PAE may be more essential for lower-income students. However, underserved schools may not have the capacity to make major modifications to PA practices and policies. LIS could consider the following less resource-intensive options:

1. Encourage school-wide social support for PA among students, teachers, and staff.
2. Evaluate existing PA-related policies and practices, such as PE and identifying new strategies for boosting children’s MVPA within these programs.
3. Take smaller steps to shift the PAE and infuse opportunities for students to be active across the school day. Examples include modifying the way assignments are handed in to encourage activity, creating “active” hallways spaces, and incorporating PA-promoting signage.

Humans Subjects Approval Statement
The Tufts University Institutional Review Board approved this study.

REFERENCES

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