

RESEARCH ARTICLE

Association of School-Based Physical Activity Opportunities, Socioeconomic Status, and Third-Grade Reading

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ABSTRACT

BACKGROUND: Socioeconomic status (SES) is the most accurate predictor of academic performance in US schools. Third-grade reading is highly predictive of high school graduation. Chronic physical activity (PA) is shown to improve cognition and academic performance. We hypothesized that school-based PA opportunities (recess and physical education) would moderate the negative association between SES and third-grade reading.

METHODS: Schools serving third-grade students were surveyed (N = 1279) for minutes/week of PA opportunities. Allotted weekly PA time and achievement data from participating schools (N = 784) were recorded and analyzed. To test the moderator hypothesis, moderated multiple regression analysis was conducted.

RESULTS: The interaction of PA opportunities and SES explained a significant increase in variance in third-grade reading ($b = .053$, $p < .001$), thus moderating the relationship between SES and third-grade reading. Further analysis showed that schools offering greater than 225 minutes/week of PA opportunities experienced a greater (+5%) moderating effect.

CONCLUSION: School-based PA opportunities positively moderate the relationship between SES and third-grade reading, and lowest SES schools experience greater moderating effects. Future research should consider PA opportunities as a moderator of the SES-academic achievement relationship, and school policy makers should consider the influence that PA opportunities have on student achievement at varying SES levels.

Keywords: academic performance; student achievement; physical education; school recess.

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Socioeconomic status (SES) is a collective measure of social position and is represented by income, education, and occupation. Research indicates that parents' SES is the most accurate predictor of their children's academic performance in US public schools,¹ and is commonly measured by qualification in the parent income-based National School Lunch

Program.² A well-documented body of evidence shows that SES is a significant factor in determining academic performance, including early reading ability.³ Due to the limited financial resources and available discretionary time of their parents/caregivers, children from lower-SES homes have less access to books and less parental involvement in education. In addition,

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because of the lower education levels of many people in low-income communities, these children experience fewer high-quality language interactions with parents and other adults.⁴ Low-SES children also attend schools with fewer resources, experience lower instructional quality in school, and have lower performing peers.⁴ According to a recent study of SES and student reading trajectories, conditions in the family environment contribute most to disparities in reading ability at the start of kindergarten, but schools have the greatest impact on growth of reading ability from kindergarten to third grade.⁵

The ability to read proficiently by the end of third grade may be the most critical benchmark in students' academic career, as strong evidence points to future success, including high school graduation based on this achievement.^{6,7} Proficiency in third-grade reading, measured by state-administered standardized tests, is important for advancement in school, as research shows that over half of fourth-grade curricula is incomprehensible to students who are not proficient readers by the end of third grade.⁸ There are long-term implications of third-grade reading as well. Longitudinal studies spanning 4 decades⁹⁻¹¹ have shown that third-grade reading ability is a significant predictor of academic performance in high school, graduation rate, and college attendance. Experts suggest that long-term health is dependent upon academic success, as research shows that high school graduates have significantly better health outcomes and significantly longer life spans.¹² Children from low-SES homes who read below grade level (ie, proficiency) in third grade fail to graduate approximately 26% of the time, a rate that is 13 times greater than that of higher-SES peers who are proficient third-grade readers.⁹

A growing body of evidence has shown that time spent engaging in physical activity (PA) is associated with improved cognitive function, including academic performance in children.¹³⁻¹⁶ Several recent studies have demonstrated that chronic participation in PA is associated with improved academic performance, including reading ability, in elementary school students^{13,17-21} In addition, research suggests that children with lower cognitive function benefit more from participation in PA.^{22,23} For example, Moore et al²³ reports that children with and without attention deficit hyperactive disorder (ADHD) improved in tests of reading and arithmetic following a 20-minute bout of moderate-intensity exercise, and those with ADHD experienced an added benefit in neurocognitive function.²³ Furthermore, early examples of neuroimaging research investigating the relationship of aerobic fitness to brain function using "academic tasks" in typical children has yielded support for the positive association of fitness to cognitive processes underlying scholastic performance. Specifically, neuroelectric measures (ie, N400) were examined while

higher- and lower-fit children completed arithmetic verification²⁴ and semantic processing tasks.²⁵ Across studies, higher fitness was related to better task performance as well as the greater allocation of cognitive resources during task performance. As such, these early studies have drawn a link between fitness and brain function during academic operations.

Opportunities for PA in elementary schools come primarily from recess and physical education (PE) class. Due to legislative pressures such as the No Child Left Behind (NCLB) Act and Race to the Top of the Nation to demonstrate student achievement, US schools have concentrated their efforts in the core subjects of reading, writing, and mathematics. A common approach taken by many public schools is to increase instruction time in core subjects, thus decreasing time spent in other traditional elementary school activities such as recess and PE. In the 5 years following the passing of NCLB, elementary schools reduced minutes of recess and PE by an average of 90 minutes per week.²⁶ Currently, public schools in the US average less than recommend amounts of PE minutes per week (85-90 minutes vs 150 minutes, recommended) and less than 30 minutes per day of recess.²⁶ Schools with greater concentrations of low-SES students offer considerably less time for both PE and recess.²⁷

Conversely, increased time spent in PA and thus reduced time in core subjects during the school day does not decrease academic achievement, and may improve it and other academic behaviors such as time on task. Research conducted by Sallis et al²⁸ in which weekly PE in elementary schools was doubled over a 2-year period showed no reduction in overall academic achievement, however, there was a tendency for improvements in tests of reading and language, especially when PE was taught by a specialist teacher versus a generalist (classroom teacher). Similarly, Coe et al¹³ showed that elementary school students who participated in more PA throughout the school day had higher grades and no decreases in any academic measures, in spite of reduced daily time spent in classroom academic subjects.¹³ Furthermore, interventions in which designated academic time was replaced with classroom PA breaks have shown no reduction in academic performance and significant increases in desired academic behaviors such as time "on-task."^{17,29,30}

The relationship between SES and academic achievement among elementary school-age children is well established, and correlations between the 2 have been shown to be as high as $r = .85$.³¹ Third-grade reading scores are significantly lower among low-income students,³² and efforts to reduce the achievement gap, such as NCLB have yielded only modest improvements.³³ In spite of considerable evidence that PA promotes academic performance,¹⁵ US public schools continue to reduce PA opportunities in favor of increased time for core subjects.²⁶ While

the relationship of both SES and PA with academic achievement, each individually, is established;^{31,34,35} no research has specifically considered the role that PA plays within the SES-academic achievement relationship. Therefore, the purpose of this study was to examine the relationship between school-based PA opportunities and third-grade reading ability relative to SES. It was hypothesized that school-based PA opportunities would moderate the negative association between SES and third-grade reading.

METHODS

Participants

Using a stratified random sample approach, we surveyed 1279 elementary (kindergarten through fifth grade) schools in 1 midwest US state. Elementary school data from the State Board of Education website provided detailed descriptions of each school. Public elementary schools that serve third-grade students and participated in the state standardized assessment program made up the entire population ($N = 2166$) from which the sample was drawn. School-level SES data were reported on the State Board of Education database as percent low income (%LI), which is based on parent income level. Students are considered low income if their parents/caregivers' combined household income is low enough to qualify for free or reduced lunch prices as defined by the National School Lunch Program eligibility guidelines.² From the total population, a stratified random sample was selected based on the number of schools in each of 5 SES quintiles, such that quintile 5 included schools with (100% to 80% LI), quintile 4 (79% to 60% LI), quintile 3 (59% to 40% LI), quintile 2 (39% to 20% LI), and quintile 1 (< 20% LI) (Table 1).

The sample size included in the study was determined using Cochran's³⁶ formula $n_0 = \frac{Z^2pq}{e^2}$ for calculating a sample for proportions given an unknown or extremely large population. The confidence interval (margin of error) was set at ($e^2 = .05$), with a confidence level set at 95% ($Z = 1.96$), and estimate of variance of .25 ($[p = .5] \times [q = 1 - p = .5 \times .5 = .25]$). The result of sample size calculations indicated that a minimum of 385 schools was necessary for adequate statistical power. To ensure statistical power for comparisons between quintiles, it was decided that a minimum of 100 schools per quintile would be sufficient, therefore additional schools were recruited.

Procedures

Data regarding school PA opportunities were collected by trained data collectors who contacted school officials (PE teachers, principals, and administrative staff) via e-mail and telephone. While the PA opportunities information is considered public knowledge,

it is typically only available through internal school documents, thus to gain access, it was necessary to directly contact schools for the information. An electronic questionnaire was created to determine the frequency and duration of PE class and recess offered to students in third grade on a weekly basis. In addition, schools were asked if a specialist teacher is responsible for teaching PE (licensed and endorsed in PE) and whether additional PA opportunities are regularly scheduled for third-grade students.

The initial round of the questionnaire was administered electronically through a secure online program (Qualtrics© LLC, Provo, UT, USA) to the entire target population. Schools were sent an e-mail with an embedded link to the online questionnaire. Informed consent to release the information was obtained through the first page of the questionnaire with a mandatory response/consent question. There were 123 completed online questionnaires collected from the 1279 schools (quintile 1 [$N = 24$], quintile 2 [$N = 27$], quintile 3 [$N = 28$], quintile 4 [$N = 19$], quintile 5 [$N = 25$]) to which it was sent (10.3% response rate), which is consistent with online questionnaire response rates.³⁷

To increase response, school officials were contacted by telephone in cases where there was no e-mail response. Phone questionnaires were administered to school principals and administrative staff members who had accurate knowledge of the class schedule of third-grade students (ie, days/times that recess and PE is offered). Informed consent was gained verbally prior to administering the phone questionnaire. In total, 797 schools of the 1279 target schools completed the questionnaire either online or via telephone (62.3% response rate). Complete data were available for 784 schools, as student achievement data was unavailable for 13 schools.

Third-grade reading achievement. The State Board of Education provides a public database³⁸ in which aggregate student achievement data, along with demographics and school funding/expenditures is listed per individual school. Student achievement per individual school is reported as the percentage of students "meeting or exceeding standards."³⁸ To meet or exceed standards in third-grade reading, students must perform at or above grade level in the state-sponsored standardized reading test.³⁸ Third-grade reading achievement is reported in the fall semester, and represents student testing, which occurs in the prior spring. Therefore, achievement data were collected in the 2014 fall semester, and PA data were collected in the previous spring semester to assure the validity of the relationship between the 2 measures.

Physical activity opportunities. Weekly minutes of PA opportunities (PAopp minutes/week) was calculated by the summation of weekly minutes of recess (minutes/week recess) and weekly minutes of

Table 1. Description of Sampling of Total, Target, and Surveyed Population per Socioeconomic Status Strata

Quintile	%Low Income	Total Population (N = 2166)	Target Population (N = 1279)	Surveyed Population (N = 784)	PE Specialist (N = 736)
5	100-80	N= 615, 28.5%	N= 364, 28.5%	N= 221, 28.2%	N= 200, 90.5%
4	79-60	N= 344, 15.9%	N= 203, 15.9%	N= 125, 15.9%	N= 112, 89.6%
3	59-40	N= 461, 21.3%	N= 272, 21.3%	N= 157, 20.0%	N= 146, 93.0%
2	39-20	N= 404, 18.6%	N= 237, 18.5%	N= 151, 19.3%	N= 149, 98.7%
1	< 20	N= 344, 15.9%	N= 203, 15.9%	N= 130, 16.6%	N= 129, 99.2%

Total population represents the number of schools that serve third-grade students. PE specialist represents the number of schools within the surveyed population in which third-grade students are taught by a PE specialist teacher. Percentages represent the percent of each individual subpopulation (*n*) respective to the column population. PE, physical education.

PE class (minutes/week PE). Minutes/week recess was calculated by multiplying the number of recess periods offered each day (recess/day) by the minutes per recess period (minutes/recess) by the days per week school is in session. PE minutes/week was similarly calculated by multiplying the number of PE classes scheduled each week (PE classes/week) by the number of minutes per PE class (minutes/PE class). All schools in the state were required to base the school calendar on a 5 day/week school calendar, 185 calendar days, and a minimum 5 hours of instructional time in the school day, therefore PAopp minutes/week calculations were based on a 5-day week and were considered a standardized comparison measure between schools. The following formula illustrates the derivation of PAopp minutes/week:

$$\text{PAopp} \frac{\text{minutes}}{\text{week}} = 5 \left(\frac{\text{recess}}{\text{day}} \times \frac{\text{minutes}}{\text{recess}} \right) + \left(\frac{\text{PE class}}{\text{week}} \times \frac{\text{minutes}}{\text{PE class}} \right)$$

Data Analysis

Descriptive statistics were calculated for the entire sampled population and individually for each SES quintile in third-grade reading and PAopp minutes/week, along with the variable components comprising PAopp minutes/week: recess/day, minutes/recess, minutes/week recess, PE class/week, minutes/PE class, and minutes/week PE. These statistics were also calculated in reference to schools that reported having a PE specialist on staff and schools that did not have a PE specialist.

Prior to conducting multiple regression and moderation analysis, the following assumptions were addressed to determine the normality and the appropriateness of the approach: Presence of outliers, collinearity of data, independent errors, random normal distribution of errors, homoscedasticity and linearity of data, and nonzero variances. All values were within an acceptable range, and no violation of assumptions occurred; therefore, multiple regression and moderation analysis were considered appropriate methods.

To establish baseline relationships between variables, 1-way analysis of variance (ANOVA) were run on all variables with post hoc analysis of mean differences using Tukey HSD (honest significant difference) procedure. In addition, correlations were calculated between all variables overall and within each SES quintile. Attention was paid to the following variables: %LI, third-grade reading, and PAopp minutes/week. PAopp minutes/week was chosen as the unit of analysis because it is an accurate reflection of each individual school's offering of PA opportunities.

Moderation. A moderated multiple regression analysis was conducted to test the hypothesis that third-grade reading achievement is a function of both %LI and PAopp minutes/week. More specifically, the analysis was used to determine whether increases in PAopp minutes/week moderates the relationship between the school %LI and third-grade reading achievement. Whether the school employed a PE specialist was adjusted in the analysis. The %LI, third-grade reading, and PAopp minutes/week were standardized in the regression analysis. In the first step, 1 variable was modeled as the predictor: %LI (SES). In the second step, both %LI and PAopp minutes/week were included as predictors in a multiple regression. In the final step of the regression analysis, a standardized interaction term as a product of %LI and PAopp minutes/week was created.³⁹

To investigate the moderating effect further, the PA opportunities data were dichotomized into "high" and "low" PA opportunity groups. The cutoff for the high- and low-PA opportunities was set at 225 minutes/week (low PAopp <225 minutes/week; high PAopp ≥225 minutes/week). This cutoff was selected because though it is just below the recommended total of 250 PAopp minutes/week (100 minutes/week recess +150 minutes/week PE) by the Society of Health and Physical Educators,^{40,41} it is greater than national mean for PAopp minutes/week (220 PAopp minutes/week), and it includes schools that provide a combination of daily recess (15-20 minutes/day) and daily PE (25-30 minutes/day).

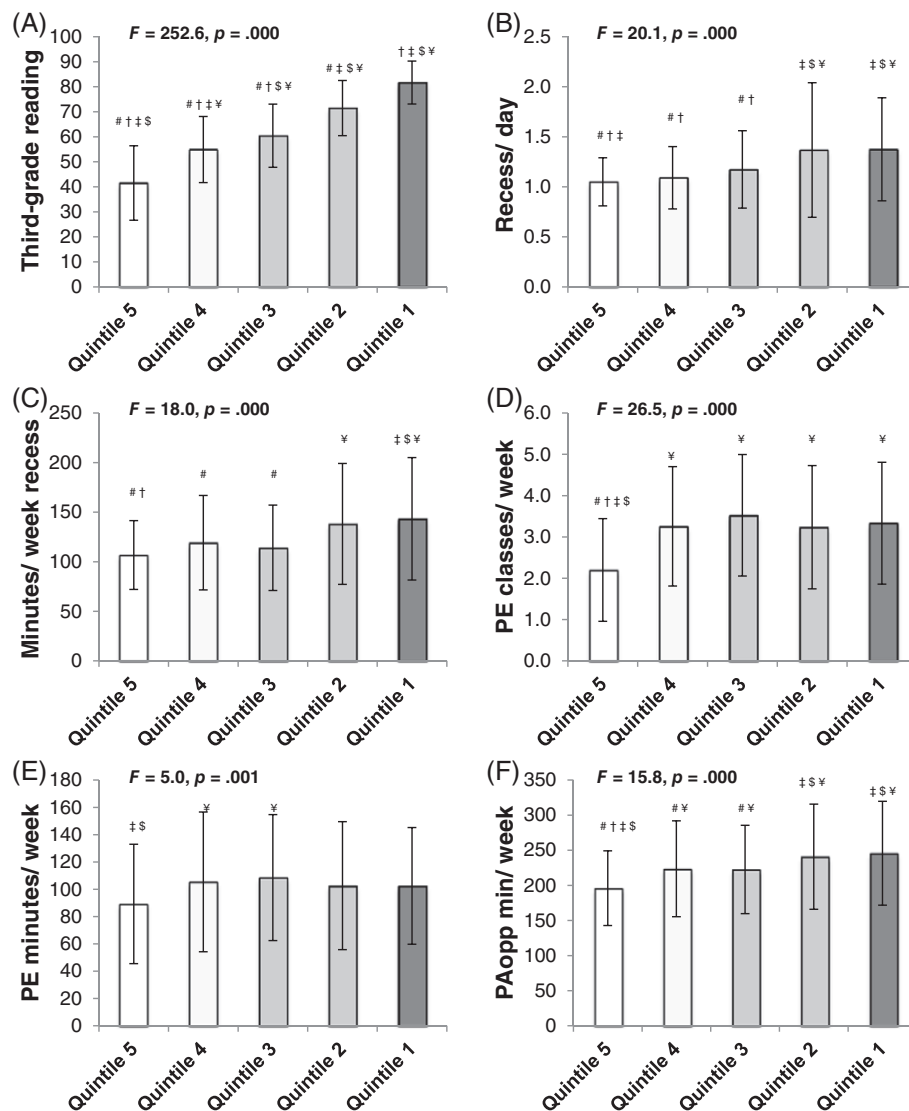
RESULTS

Descriptive statistics regarding PA opportunities and school-level achievement in third-grade reading are represented in Figure 1. Based on 1-way ANOVA, significant differences were observed between SES quintiles for third-grade reading ($p < .01$) and PAopp minutes/week ($p < .01$). Significant differences were also observed for the factors that made up PAopp minutes/week; Recess/day ($p < .01$), minutes/recess, ($p < .05$), minutes/week recess ($p < .01$), PE classes/week ($p < .01$), minutes/PE class ($p < .01$), minutes/week PE ($p < .01$).

Post hoc comparisons (Tukey HSD) showed that third-grade reading in each quintile was statistically different than every other quintile, with values lowest in quintile 5 and progressively increasing in each

quintile (all p -values $< .01$). Significantly higher PAopp minutes/week were observed for quintile 1 compared to all other quintiles ($p < .01$), except quintile 2. Quintile 5 had significantly less PAopp minutes/week than all other quintiles (all p -values $< .01$). Regarding school recess, quintile 1 had significantly more recess/day and minutes/week recess than quintiles 3-5 ($p < .05$), but not quintile 2. Quintile 5 offered significantly less recess/day than all (all p -values $< .01$) but quintile 4 and significantly lower minutes/week recess than quintiles 1 and 2 ($p < .05$). In reference to PE, observations showed schools in quintile 5 scheduled significantly fewer PE classes/week than all other quintiles and have significantly higher minutes/PE class than all of the other quintiles (all p -values $< .05$). Significant differences were observed for PE minutes/week

Figure 1. Mean Values for Third-Grade Reading and Physical Activity Opportunities per SES Quintile



between quintile 5 and quintiles 3 and 4 only (all p-values < .05) (Figure 1).

Statistically significant mean differences were observed in schools having a PE specialist versus those without a PE specialist for: third-grade reading (60.4%, ± .694 vs 49.14%, ± .694 [% ± SE]), PAopp minutes/week (223.1 minutes, ± 2.4 vs 192.1 minutes, ± 10.27 [minutes ± SE]), minutes/PE class (36.4 minutes, ± .424 vs 33.0 minutes, ± 1.6), recess/day (1.19, ± .016 vs 1.06 minutes, ± .04), and minutes/week recess (122.0 minutes, ± 1.72 vs 102.1 minutes, ± 6.67). No differences existed between schools with and without PE teachers on staff for any other variables (p > .05) (Table 2).

Results of correlations within the total sampled population showed a significant negative correlation between %LI and third-grade reading (r = −.758, p = .000) and between %LI and PAopp minutes/week (r = −.257, p = .000). In addition, a significant positive correlation between third-grade reading and PAopp minutes/week (r = .284, p = .000) was observed. Correlation analysis within each SES quintile showed positive correlations between third-grade reading and PAopp minutes/week for all 5 quintiles, with statistical significance in quintile 4 (r = .232, p = .009) and quintile 5 (r = .165, p = .014).

In the first model of regression analysis, %LI accounted for a significant amount of variance in

school third-grade reading scores, $R^2 = .577$, $b = -.730$, $p < .0001$ and partial $\eta^2 = .57$. In the second model, both %LI ($b = -.707$, $p < .001$, partial $\eta^2 = .544$) and PAopp minutes/week ($b = .089$, $p < .001$, partial $\eta^2 = .018$) accounted for a significant amount of variance in third-grade reading scores, $R^2 = .585$, $p < .001$. In the final model of the regression analysis, the standardized interaction term ($b = .052$, $p = .030$, partial $\eta^2 = .005$), when controlled for PE teaching specialist, accounted for a significant proportion of the variance in third-grade reading scores, $\Delta R^2 = .003$, $\Delta F(1, 782) = 177.6$, $p < .001$ (Table 3), indicating that the amount of variance that %LI accounts for in third-grade reading score is moderated by PAopp minutes/week. The results showed that the interaction term of %LI and PAopp minutes/week met the assumptions for a significant moderation in that the coefficient of interaction statistically significantly differed from zero.³⁹

Figure 2 illustrates the moderating effect of PA opportunities on the SES and third-grade reading relationship. Fitted lines for PA opportunities (high vs low) as a result of predicted third-grade reading values in each SES quintile show that reading ability is similar for both high- and low-PA groups in quintile 1, and differed by roughly 5% in quintile 5. The slope of the regression for low-PA opportunities was −10.09 and for high-PA opportunities was −8.89, indicating

Table 2. Comparison of Means of Schools With and Without Physical Education Teacher on Staff

	PE Specialist (N = 736)		No PE Specialist (N = 48)		t	p
	Mean	SD	Mean	SD		
Third-grade reading	60.4	19.0	49.1	16.2	3.446	.001
PA minutes/week	223.1	65.6	192.1	60.7	2.736	.006
Recess/day	1.193	.423	1.057	.236	3.173	.003
Minutes/recess	20.9	6.05	19.2	5.65	1.595	.111
Minutes/week recess	122.0	47.0	102.1	39.5	2.457	.014
PE classes/week	3.01	1.49	2.94	1.63	.274	.784
Minutes/PE class	36.4	11.6	33.0	9.5	2.024	.050
Minutes/week PE	101.1	46.4	90.0	47.0	1.364	.181

PE, physical education.

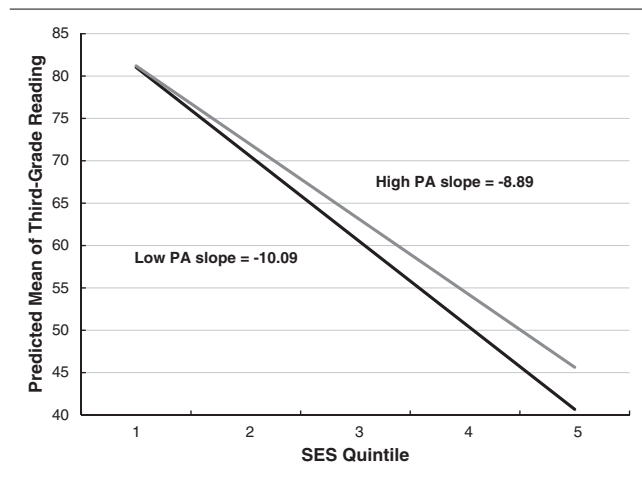
Table 3. Regression Results for the Moderating Effect of Percent of %LI and PA Minutes/Week on School Third-Grade Reading Achievement

	R ²	β	t	p	Partial η ²
Step 1	.577				
% Low income		−.730	−32.20	<.0001	.570
Step 2	.585				
% Low income		−.707	−30.48	<.0001	.544
PAopp minutes/week		.089	3.830	.0001	.018
Step 3	.587				
% Low income		−.704	−30.39	<.0001	.541
PAopp minutes/week		.099	4.18	.026	.021
Interaction		.052	2.23	.030	.005*

%LI, percent low income; PA, physical activity.

*Controlled for PE specialist.

Figure 2. Moderating Effect of PA on the Relationship Between % Low Income and Third-Grade Reading. Third-Grade Reading Values Represent Percentage of Students in Each School Who Meet or Exceed Standards on the State Reading Achievement Test



that third-grade reading decreases at a lower rate with increasing %LI in the presence of higher PA opportunities.

DISCUSSION

Conclusions

The focus of this study was to conduct a school-level analysis examining whether the amount of time schools offer PA opportunities during the school day may affect the association between SES and academic achievement. The results of moderated multiple regression support the hypothesis that school-based PA opportunities moderates the association between SES and third-grade reading. Though statistical significance was demonstrated by p -values $< .01$, it is noted that effect sizes associated with PA opportunities are small; therefore, even relatively large differences in school PA opportunities have a small effect on third-grade reading. However, by examining PA opportunities as a moderator, we contend that despite this small moderating effect, it is important because it demonstrates that PA opportunities can influence a very strong and complex relationship that exists between SES and academic achievement. In other words, the relationship between SES and third-grade reading is altered as PA conditions change. Given the relatively low investment of resources needed to increase PA opportunities in schools, any effect by PA opportunities on academic achievement is worthy of recognition.

Schools that serve higher proportions of low SES students typically underperform on standardized tests compared to schools serving higher SES students.³²

This strong negative association between SES and academic achievement is consistently demonstrated in education research⁵ and data in the current study are consistent with these findings. The current results, however, provide evidence that increased PA opportunities throughout the school day slightly moderates the relationship between SES and academic achievement, such that schools providing greater opportunity for PA experience a smaller decline in third-grade reading scores. This moderating effect is strongest in the schools with highest %LI (ie, lowest SES). The moderating effect diminishes as income levels rise, which may be due to a ceiling effect in both SES and third-grade reading, respectively.

The presence of a stronger moderating effect of PA opportunities in lower-SES schools may indicate that greater school offerings of PA opportunities are more impactful on children from lower-income households. The exact mechanism explaining this phenomenon is beyond the scope of the current school-level study, but may be related to the added neurocognitive benefit lower cognitively functioning children experience when exposed to PA.^{22,23} Schools that offer greater PA opportunities may also be more committed to offering PA opportunities, which may be a greater benefit to lower-SES children compared to their higher-income counterparts, as children in low-income households are typically exposed to fewer factors associated with well-being,⁴ such as opportunities to be physically active. Given the health enhancing effects of PA, and the higher propensity of low-income children to experience both health complications and disparity in academic achievement, it seems that offering more PA opportunities during the school day is a worthwhile endeavor in schools and education and/or health interventions.

Predicted means of third-grade reading based on regression analysis (Figure 2) show schools that provide a minimum of 225 minutes per week of PA (high PA) through recess and PE experience the greatest moderating effect, thereby establishing a PA opportunities threshold. This result has scheduling implications for schools because to reach 225 minutes per week, a reasonable strategy is to offer recess and PE daily (15-20 minutes/day recess and 30 minutes/day PE), as is recommended by public health organizations.^{40,41} In addition to offering support for recess and PE recommendations, the findings provide an estimate of potential benefits associated with meeting the minimum PA opportunities recommendation.

Interestingly, schools with a PE specialist on staff had significantly higher percentage of students meeting or exceeding standards in third-grade reading and higher weekly minutes of PA opportunities. Our use of independent t -test results in this instance provides a general linear model;⁴² therefore, causation cannot be concluded; however, the differences observed

between the 2 conditions (with and without a PE specialist) raise questions as to why the difference exists. Schools with PE specialists also had longer PE classes and provided more weekly minutes of recess. It could be speculated that schools without PE teachers schedule shorter PE classes and less recess to allow for more classroom time, which is consistent with post-NCLB school policies. Research suggests that students in PE classes taught by a specialist experience higher PA levels than those without;⁴³ therefore, instructional quality may also help explain the observed difference in third-grade reading. Furthermore, schools that employ a PE specialist may be more likely to pursue higher quality education in general through stronger commitment to a wider variety of academic topics, as opposed to the narrowing of curricular offerings that is a hallmark of post-NCLB school strategies.²⁶

The results of the present investigation are consistent with national student achievement data in that there was a strong negative correlation observed between %LI and third-grade reading. However, considering the observed moderating effect of PA, it is plausible that increased offerings of recess and PE may accompany a small offset of these negative effects, which could affect the long-term academic trajectory of students. Research shows that gaps in achievement typically grow wider over time,⁴⁴ and the present analysis suggests that schools that provide greater amounts of PA opportunities may experience a smaller degree of this widening. In addition, the moderating effect demonstrated in this study becomes increasingly stronger as SES decreases, thus PA may benefit students in lower-SES schools to a greater extent.

Limitations

While providing a unique perspective on school-based PA, SES, and academic achievement, the current study is not without limitations. The study design does not allow for inference of a causal relationship between PA and academic achievement, though establishing causality was not the purpose. Mechanisms explaining the relationship between SES and child well-being measures, such as academic achievement, are not easily determined with precision, partly because low SES occurs simultaneously with other influencing factors such as minority status, single-parent family, and lower quality school instruction.⁴⁵ By including relatively large numbers of schools and considering the potential interaction effect of PA opportunities on the SES-academic achievement relationship, this study establishes school-level PA opportunities as a moderator, and therefore, worthy of consideration in future studies that examine the dynamics of SES and academic achievement in schools.

It is also noted that the measurement of PA opportunities at the school level does not reflect

student engagement in recess and PE or attendance, thus individual student PA quantities are not certain. Because the data collection procedures did not allow for the quantification of student-level PA resulting from recess and PE, no inference can be made regarding the effect of PA time on individual student achievement. The time that schools made available for PA, however, was measured and is an accurate reflection of the schools' commitment to PA offerings, thus the individual school is the unit of analysis. Recess and PE classes are standard practice in elementary schools and are highly attended by students;⁴⁶ therefore, students in schools with higher scheduled weekly minutes of recess and PE class may also experience greater levels of PA, though this inference is beyond the scope of the study. Future study is needed to confirm whether greater school PA opportunities are associated with greater overall student PA.

IMPLICATIONS FOR SCHOOL HEALTH

Lifelong health quality and life span length are strongly associated with both academic success¹² and PA.⁴⁷ Based on the results of this study, school stakeholders who wish to increase third-grade reading achievement should consider the amounts of weekly PA offered in the form of recess and PE. The results support the notion that additional weekly minutes of PA do not negatively affect academic achievement, despite reduced classroom time. The results also reinforce the recommendation that 20 minutes of daily recess and 30 minutes of daily PE be offered to elementary school students.^{40,41} Schools in the current study that were able to meet this recommendation, showed the strongest moderating effect on the SES-student achievement relationship, particularly in schools with the greatest number of low-income students and schools in which PE is taught by a specialist. As school officials and researchers continue to search for ways to increase overall student achievement, the findings of this study may serve as a notice that recess and PE in sufficient quantity and quality are in accordance with the academic mission of schools, as well as beneficial to overall health. In addition, schools in the most challenging situations, such as lower SES, may benefit more from scheduling and hiring practices that allows for greater amounts of specialist-instructed PE and recess as opposed to reducing PA opportunities during the school day. Future research should reflect the potential relationship PA has with lower-SES schools and design interventions accordingly.

Human Subjects Approval Statement

The University of Illinois Urbana-Champaign Institutional Review Board (Protocol #14745) approved all

research activities. Though all information gathered in this study was publicly available, consent to release information was gained prior to all data collection activities.

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