The Importance of Physical Activity and Physical Education in the Prediction of Academic Achievement

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The purpose of the present investigation was to determine the independent contributions of physical activity not associated with structured physical education and school based physical education participation to academic achievement in children. Prior academic achievement and socioeconomic status were also examined. Elementary school participants were selected from the Early Childhood Longitudinal Study-Kindergarten database. Structural equation models were constructed for both mathematics (boys, n = 3,226; girls, n = 3,256) and reading achievement (boys, n = 3,167; girls, n = 3,226). Physical activity was significantly and positively related to both mathematics and reading achievement in boys and girls. Physical education participation was not significantly related to achievement. Socioeconomic status accounted for approximately 26% of the physical activity. Future longitudinal research is discussed that incorporates more comprehensive physical activity and achievement variables.

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Young children are leading increasingly sedentary lives, with physical activity frequently displaced by television viewing, Internet surfing, and video gaming (Myers, Strikmiller, Webber, & Berenson, 1996). Much concern has surfaced for this lifestyle change as childhood obesity has risen greatly in the last 10 years (World Health Organization, 2000). Within the school context, incorporating physical activity or fitness training is a likely means to improve the physical health status of children (Haskell, 1994) as well as cognitive performance (Sibley & Etnier, 2003) and attention and concentration (Hillman, Castelli, & Buck, 2005; Shephard, 1996; Taras, 2005). Unfortunately, American public school administrators have been decreasing the time allowed for physical education in order to devote more time to the direct instruction of core subject areas (Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Shephard, 1997). In addition, physical education classes are not always centered on physical activity that involves everyone (Block & Burke, 1999). Last, researchers have even suggested that physical education classes do not provide students with an environment to which vigorous prolonged physical activity is possible (Crews, Lochbaum, & Landers, 2004).

Researchers have demonstrated that physical activity is related to improved cognitive performance, and at least two avenues for physical activity in young children (free play and directed play or physical education) appear especially important. The investigation of whether physical education, as it is currently and typically implemented in schools, is as important as vigorous physical activity in the prediction of academic achievement can provide valuable information to school administrators. Hence, the purpose of this study was to evaluate a structural equation model with physical activity and physical education as separate variables to young children's academic achievement while accounting for the effects of socioeconomic status (SES) and prior achievement.

The Relationship between Physical Activity and Academic Achievement

Due to interest in the establishment of a relationship between physical activity and academic achievement, reviews have been conducted to attempt to evaluate the overall effects reported across studies (e.g., Sibley & Etnier, 2003; Taras, 2005). Sibley and Etnier conducted a meta-analysis to examine the effects of physical activity upon several measures of cognitive functioning in school aged youth. Their findings demonstrated an overall significant effect size of .32. The size of the effect was moderated by several variables such as publication status (published greater than unpublished), participant age (middle school largest ES), and cognitive assessment (perceptual skills largest effect size). In a qualitative review, Taras evaluated 14 research articles published since 1984 that addressed the relationship between physical activity and or physical education and student performance. Taras concluded that some evidence exits supporting an association between acute physical activity and improved concen-

tration. Taras' review did not indicate that these improvements would translate into enhanced academic achievement. Taras noted that longitudinal studies with a large sample should be conducted to best understand the role that physical activity plays in students' achievement as the effects may be subtle and may accrue over time. A few recent examples of such studies exist that were not included in the Taras review that are worthy of mention (i.e., Coe et al., 2006; Grissom, 2005)

Coe et al. (2006) employed longitudinal data to study the association between both physical education and activity and the academic achievement of 214 sixth-grade students. Taking advantage of a scheduling system that randomly assigned half of the students to physical education during the first semester and the other half during the second, the authors compared differences in students' achievement based on the timing of physical education enrollment. No significant differences were found. Unfortunately, the students engaged in a minimal amount of activity in that students only average 19 minutes of moderate to vigorous physical activity during a 55 minute physical education class. Therefore, the students' activity level might not have been high enough to elicit any effect on their academic behavior. It is important to note that when students were assigned to a physical education course rather than a classroom period, their achievement did not decline. Coe et al. did find that students who engaged in some vigorous activity, as defined by the Healthy People 2010 guidelines, had significantly higher grades than those students who reported no vigorous activity across the two semesters. The authors found no significant relationship between physical education or physical activity and standardized test scores. Unfortunately, the authors failed to account for differences in socioeconomic backgrounds of the students and cited this omission as an important limitation of the study.

In another longitudinal study with an enormous participant sample, Grissom (2005) utilized a large California database of 884,715 students to evaluate the relationship between physical fitness, a marker of physical activity, and academic achievement over the course of one school year. Grissom also included students' SES and gender. Findings supported the presence of a positive relationship between physical fitness and academic achievement ($r = .19$ for reading and $r = .22$ for mathematics) assessed by the Stanford Achievement Test 9th Edition. Subsequent analyses revealed that this relationship was stronger for girls in comparison to boys and stronger for those from higher socioeconomic backgrounds in comparison to those from lower socioeconomic backgrounds.

The Relationship between Physical Education and Academic Achievement

Assessing the relationship between physical education and academic achievement is a difficult task due to the challenges related to defining and measuring physical education. Coe

et al. avoided the issue of measuring physical education by assigning students to physical education conditions. In defining physical education for their study, they noted that the students achieved levels of moderate to vigorous physical activity for only 19 minutes during the 55 minutes allotted for physical education. Because their participants attended a single school district, this use of physical education time might not be typical. The most recent Shape of the Nation Report (National Association for Sport and Physical Education and American Heart Association, 2006) indicated that 47 states utilize their own standards for physical education. In addition, the report documented that close to 30% of states do not require physical education for elementary and middle school students. Even when physical education is required, an appropriate curriculum implemented by a certified teacher is not guaranteed. Therefore, assessing the association between physical education and academic achievement is quite difficult when the time children spend in physical education as well as the quality of instruction they receive varies across the nation.

Tremarche, Robinson, and Graham (2007) compared the English and Language Arts and Mathematics standardized test scores of fourth grade students from two school districts located in the same state that varied on the amount of physical education provided for students. The authors found that students who received more time in physical education scored significantly higher on the English and Language Arts test; however, no significant difference was found between the two groups' Mathematics test scores. Although Tremarche et al. concluded that schools administrators should increase the amount of physical education required of their students, this conclusion should be tempered due to their failure to control for important variables, such as SES, in their study. Also, the authors failed to address preexisting differences that were reported between schools. For example, one school's population was twice the size of the other and the two student populations varied in ethnicity.

In the aforementioned investigations, physical education was studied as it was taught. The investigation of the quality of physical education is certainly important; however, studying physical education as it is offers some value. The present study evaluated physical education how it currently exists across the nation in an attempt to see how it compared to physical education in importance when predicting academic achievement.

Study Purpose and Hypotheses

The purpose of the present investigation was to determine the independent contributions of physical activity not associated with structured physical education and school based physical education participation to academic achievement in children. The separation of the physical activity from physical education accounts for the possible limitation in assuming that enrollment in a physical education course equates to moderate to vigorous physical activity.

This investigation adds to the extant literature by utilizing a large national longitudinal database that allows for examination of the effects of SES and prior academic achievement both of which are important contributors to standardized test scores. Although Coe et al. and Grissom also analyzed longitudinal data, their data collection spanned only one school year and focused on children in either several schools or in a single state. The data utilized in the present study were collected over the course of the participants' elementary school years. Also by using a national database, we were able to assess the time that children spent in physical education across the nation, which lends to the generalizability of results.

The present study further extends the literature base by including both prior academic achievement and SES in the investigation. Prior academic achievement must be taken into account given the obvious impact on future achievement. SES must be taken into account for several reasons. For example, children growing up in families with low socioeconomic backgrounds are more likely to live in dangerous locations, without the benefit of parks and playgrounds for safe, outdoor play (Evans & Kantrowitz, 2002; Sherman, 1994; Townsend, 1979). Young children of higher SES backgrounds have advanced motor development in comparison to those of lower SES backgrounds because of the advantages afforded by outdoor play and formal involvement in team and individual sports (Frost, Wortham, & Reifel, 2005). Coe et al. failed to include prior academic achievement and SES in their study. Grissom included SES but omitted a measure of prior academic achievement. Also, Grissom only studied the influence of physical fitness on academic achievement and did not assess children's participation in physical education. Therefore, the investigation of the relationship between physical activity and academic achievement as well as physical education and academic achievement is strengthened by our use of a national longitudinal database that includes participant data for the elementary school years, the inclusion of important variables that are known to account for much of the variance in academic achievement, and the inclusion of both physical activity and physical education in the study.

To examine our purpose, a structural equation model positing direct relationships between physical activity and achievement as well as physical education and achievement was tested separately for boys and girls. Separate analyses were conducted for girls and boys because of the interaction by gender found by Grissom (2005). In addition, the model included prior achievement as a predictor of present achievement, with SES as a predictor of prior achievement. SES was measured during kindergarten and first grade due to the powerful effects of parent education, income, and status that occurs early when development is quite rapid and especially dependent upon family variables. Prior achievement was assessed during the students' first grade school year and present achievement was evaluated using both third and fifth grade data. Physical education was measured during the kindergarten, first and third

grade school years, whereas physical activity was assessed during the third grade. Thus, the latent variables represented the constructs at various points in time. Therefore, we hypothesized that even when SES and early achievement are considered, present achievement could still be influenced by the cumulative effects of either or both physical education and physical activity. By evaluating our hypothesis in a structural model, we were able to simultaneously test all of the relationships (Tabachnick & Fidell, 2001), which is an improvement over the regression analyses utilized by prior researchers that only allowed the evaluation of one dependent variable.

Method

Participants

Participants were children selected from the Early Childhood Longitudinal Study-Kindergarten (ECLS-K) database (NCES, 2002). The ECLS-K is a collaborative project involving the U.S. Department of Agriculture, U.S. Department of Health and Human Services, and the U.S. Department of Education. This project has involved ongoing assessment of 22,000 children and families attending more than 1,200 public and private schools. The purpose of this project is to provide data to assist in the investigation of school readiness, elementary school transitions, relationships between the kindergarten experience and subsequent school performance, and growth in cognitive and non-cognitive domains. Data have been collected from parents, teachers, schools, and children themselves. The ECLS-K sample was designed to be nationally representative of kindergartners who began school during the 1998-99 school calendar years.

The most recent publication of ECLS-K data included data collection points at kindergarten (fall and spring semesters), first grade (fall and spring semesters), third grade (spring semester), and fifth grade (spring semester). Because we were interested in fifth grade academic achievement in the context of the students' earlier physical activity, physical education, academic achievement and SES, participants included in the present study were those with data points from kindergarten through their fifth grade school year. This sample was then split by sex. Due to attrition over the five years of the study as well as the presence of missing data, the sample of girls included 3,256 participants for the mathematics achievement analysis and 3,226 for the reading achievement analysis. The sample of boys included 3,226 participants for the mathematics achievement analysis and 3,167 for the reading achievement analysis.

Measures

Socioeconomic Status. The latent construct of socioeconomic status was assessed using a composite variable collected during the fall of the children's kindergarten school year,

again during spring of the kindergarten school year, and again during the spring of the third grade school year. The variable provided a continuous socioeconomic scale based on parent reports of income, education level, and prestige scores for the parents' occupations. Utilizing the same variable assessed across time allowed for a latent variable representing children's socioeconomic status during their early school years rather than at a single point in time.

Physical Activity. The latent construct of physical activity was assessed using three variables that were collected during the participants' third grade school year. The first item asked that parents rate their child's frequency of aerobic activity on a consistent basis in comparison to other children the same age. Parents were provided with the following definition of aerobic activity: *aerobic exercise is exercise that makes the heart work very hard and makes people break out in a sweat* and given the options of "More than other boys/girls," "Less than other boys/girls," "About the same as other boys/girls." Numerical values originally assigned to these responses were recoded so that a higher number (3) indicated more aerobic activity and a lower number (1) indicated less aerobic activity. The second item contributing to the latent construct of physical activity asked parents, "In a typical week, on how many days does your child get exercise that causes rapid breathing, perspiration, and rapid heartbeat for 20 continuous minutes or more?" Responses were coded using a scale of 1 to 7. Finally, parents were asked if their child was engaged in regular exercise through sports teams or leagues. A response of "yes" was coded "1" and a response of "no" was coded "2."

Physical Education. The latent construct of physical education was assessed using one variable collected at three data points; spring of kindergarten, spring of first grade, and spring of third grade. School administrators were asked, "How many times each week do children in your class(es) usually have physical education?" Responses were coded a "1" for never, "2" for less than once a week, "3" for one to two times a week, "4" for three to four times a week, and "5" for daily. By utilizing the same variable across time, we were able to create a latent construct representing the overall time allotted to the participants' physical education during their early school years.

Prior Mathematics Achievement. Prior mathematics achievement was assessed by a single observed variable, participants' standardized mathematics test score collected during the spring of their first grade school year. Results were recorded as T-scores indicating the children's performance relative to their peers on tests of mathematics achievement administered individually at the children's schools.

Prior Reading Achievement. Prior reading achievement was assessed by a single observed variable, participants' standardized reading test score collected during the spring of their first grade school year. Results were recorded as T-scores indicating the children's performance relative to their peers on tests of reading achievement administered individually at the children's schools.

Mathematics Achievement. A latent construct of mathematics achievement was created utilizing the participants' standardized mathematics scores collected during the spring of their third and fifth grade school years. For both tests, results were recorded as T-scores indicating the children's performance relative to their peers on tests of mathematics achievement administered individually at the children's schools.

Reading Achievement. A latent construct of reading achievement was created utilizing the participants' standardized mathematics scores collected during the spring of their third and fifth grade school years. For both tests, results were recorded as T-scores indicating the children's performance relative to their peers on tests of reading achievement administered individually at the children's schools.

Data Analyses

Data screening was conducted for both groups with tests of Mahalanobis distance revealing the presence of nearly 100 multivariate outliers for each group. Because of the large number identified, close examination of each case was not conducted. Instead, the structural models were evaluated first with these cases included and second with them excluded. Skewness and kurtosis remained close to zero for both groups regardless of the inclusion of outliers, which was probably due to the extremely large sample sizes evaluated. The results for all models were also quite similar, with a slight improvement in the strength of the relationship between both physical activity and physical education and academic achievement when outliers were omitted. In addition, the median standardized residual reached zero for girls, which was not achieved with the multivariate outliers included in the analyses. Because of these improvements, we believed the elimination of multivariate outliers was appropriate.

LISREL 8.72 (Joreskog & Sorbom, 1993) was utilized to test the goodness of fit of the hypothesized model across the two samples of children. Since the goal of the study was to evaluate a specific hypothesized model across samples, no modifications to the model were made. The assessment of fit through the evaluation of chi square was not utilized in the current study due to the extensive amount of criticism this method has received; however the statistic was reported. The chi-square value has been criticized for its sensitivity to sample size and lack of robustness to the violation of basic underlying assumptions (Bentler, 1990; Tabachnick & Fidell, 2001). Alternative goodness of fit indices were selected based on the recommendations of Hu and Bentler (1999). In the present study a two-index presentation strategy that involves evaluating both the maximum likelihood (ML) based standardized root mean squared residual (SRMR) and the ML based comparative fit index (CFI) was employed. This combinational rule of CFI $< .95$ and SRMR $> .09$ was utilized in conjunction with a suggestion by Hu and Bentler. The authors recommended that in the case of which a Type I error is being avoided; the CFI and SRMR combination is likely more appropriate.

Results

The Relationship of Physical Activity and Mathematics Achievement

Tables 1 and 2 contain the descriptive and intercorrelations for all variables included or used to construct latent variables in the tested models. The LISREL 8.72 program (Joreskog & Sorbom, 1993) using the SIMPLIS programming language was utilized to evaluate the proposed model's fit across all samples. Maximum likelihood estimation was utilized, and parameter estimation matrices were positive definite, with no parameter estimates outside their permissible range. Goodness of fit indexes revealed an adequate fit to the data for the sample of boys, with CFI = .97 and SRMR = .06 ($\chi^2 = 760.84$ (49), $p < .001$). All paths revealed relationships in the expected direction with the exception of physical education to mathematics achievement. Although all parameter estimates were statistically significant (see Figure 2), this was clearly related to the large sample size as some significant estimates were nearly zero. Not surprisingly, prior mathematics achievement was the strongest predictor of mathematics achievement. Parent reported physical activity of their children did contribute to the prediction of mathematics achievement (parameter estimate -.11) whereas the contribution of school administrator reported physical education involvement of their children was -.04. The amount of variance accounted for in prior mathematics achievement by socioeconomic status was 15% and the amount of variance accounted for in physical activity by socioeconomic status was 27%. In total, 71% of the variance of mathematics achievement was accounted for by the prior mathematics achievement, physical activity, and physical education variables.

The model's fit to the sample of girls was also evaluated. Maximum likelihood estimation was utilized, and parameter estimation matrices were positive definite, with no parameter estimates outside their permissible range. Goodness of fit indexes revealed an adequate fit to the data, with CFI = .97 and SRMR = .06 ($\chi^2 = 705.04$ (49), $p < .001$). All paths revealed relationships in the expected direction with the exception of physical education to mathematics achievement. All parameter estimates were statistically significant with the exception of the path from physical education to mathematics achievement. As expected, prior mathematics achievement was the strongest predictor of mathematics achievement. Physical activity did contribute to the prediction of mathematics achievement (parameter estimate .11). The amount of variance accounted for in prior mathematics achievement by socioeconomic status was 13% and the amount of variance accounted for in physical activity by socioeconomic status was 25%. Overall, 65% of the variance of mathematics achievement was accounted for by the prior mathematics achievement, physical activity, and physical education variables.

Table 1: *Means and Standard Deviations for all Variables by Sex*

	Boys		Girls	
Variable	*M*	*SD*	*M*	*SD*
SES	0.16	0.74	0.18	0.74
Physical activity				
Aerobic Activity	2.13	0.58	2.12	0.58
Exercise (20 min)	4.24	1.99	3.73	1.89
Sports Team/League	1.38	0.49	1.55	0.50
Physical Education				
Kindergarten	3.24	0.97	3.20	0.99
1st Grade	3.33	0.77	3.32	0.75
3rd Grade	3.30	0.75	3.29	0.74
Prior Mathematics Achievement				
1st Grade	52.99	9.04	52.25	0.74
Prior Reading Achievement				
1st Grade	52.10	8.47	53.39	7.83
Mathematics Achievement				
3rd Grade	53.42	9.49	51.44	8.75
5th Grade	53.78	9.27	51.53	8.74
Reading Achievement				
3rd Grade	52.01	9.25	53.37	8.56
5th Grade	52.59	9.24	53.41	8.68

Table 2: *Intercorrelation Matrices for All Variables: Girls on Top of Matrix and Boys on Bottom of Matrix*

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. SES	---	.10**	.03*	-.29**	-.05**	-.02	.00	.35**	.05**	.38**	.40**	.06**	.07**
2. Aerobic Activity	.06**	---	.29**	-.21**	-.03	.03	.01	.09**	-.01	.06**	.06**	.01	.00
3. Exercise (20 min)	.04**	.31**	---	-.10**	.00	.04*	.03	.02	.02	.00	-.01	.01	.01
4. Sports/League	-.31**	-.17**	-.11**	---	.06**	.01	.00	-.21**	-.05**	-.21**	-.21**	-.05**	-.06**
5. PE Kindergarten	-.06**	.01	.06**	.05**	---	.39**	.34**	.00	-.02	.00	-.02	-.03*	.04*
6. PE 1st Grade	-.04*	.04*	.08**	.01	.41**	---	.65**	.03*	-.02	-.02	-.01	-.02	-.03
7. PE 3rd Grade	-.03	.04*	.08**	.01	.34**	.64**	---	.05**	.01	.04*	.04*	-.01	-.01
8. Prior Math 1st Grade	.38**	.04*	.01	-.23**	.01	.05**	.03	---	.04**	.77**	.73**	.03*	.05*
9. Prior Reading 1st Grade	.05**	.01	.02	-.05**	-.06**	-.03	.00	.08**	---	.05**	.03	.73**	.68**
10. Math Achieve 3rd Grade	.42**	.03*	.01	-.23**	-.02	.03	.02	.80**	.08**	---	.87**	.05**	.06**
11. Math Achieve 5th Grade	.42**	.02	-.01	-.21**	-.03	.01	.00	.76**	.07**	.86**	---	.04*	.07**
12. Reading Achieve 3rd Grade	.08**	.00	-.01	-.06**	-.06	-.04*	-.02	.09**	.75**	.10**	.08**	---	.83**
13. Reading Achieve 5th Grade	.08**	.01	-.01	-.05*	-.04*	-.02	-.01	.08**	.69**	.09**	.10**	.84**	---

Note: $*p < .05$; $**p < .01$.

The Relationship of Physical Activity and Reading Achievement

The same model was utilized to evaluate the relationship between physical activity and reading achievement for girls (see Figure 4) and boys (see Figure 5). The model provided a good fit to the sample of girls, with CFI = .97 and SRMR = .06 ($\chi^2 = 699.58$ (49), $p < .001$). Maximum likelihood estimation was utilized, and parameter estimation matrices were positive definite, with no parameter estimates outside their permissible range. All parameter estimates were statistically significant with the exception of the path (parameter estimate -.00) from physical education to reading achievement. As expected, prior reading achievement was the strongest predictor of reading achievement. Parents' reported physical activity of their children did contribute to the prediction of reading achievement (parameter estimate .16). The amount of variance accounted for in prior reading achievement by socioeconomic status was 13% and the amount of variance accounted for in physical activity by socioeconomic status was 27%. Overall, 61% of the variance of reading achievement was accounted for by the prior reading achievement, physical activity, and physical education variables.

Goodness of fit indexes revealed an adequate fit to the data for the sample of boys, with CFI = .97 and SRMR = .06 ($\chi^2 = 775.54$ (49), $p < .001$). All parameter estimates were statistically significant with the exception of the path from physical education to reading achievement (parameter estimate .02). Not surprisingly, prior reading achievement was the strongest predictor of reading achievement. Physical activity did contribute to the prediction of reading achievement (parameter estimate .15). The amount of variance accounted for in prior reading achievement by socioeconomic status was 14% and the amount of variance accounted for in physical activity by socioeconomic status was 27%. Overall, 63% of the variance of reading achievement was accounted for by the prior reading achievement, physical activity, and physical education variables.

Figure 1: Theoretical Model

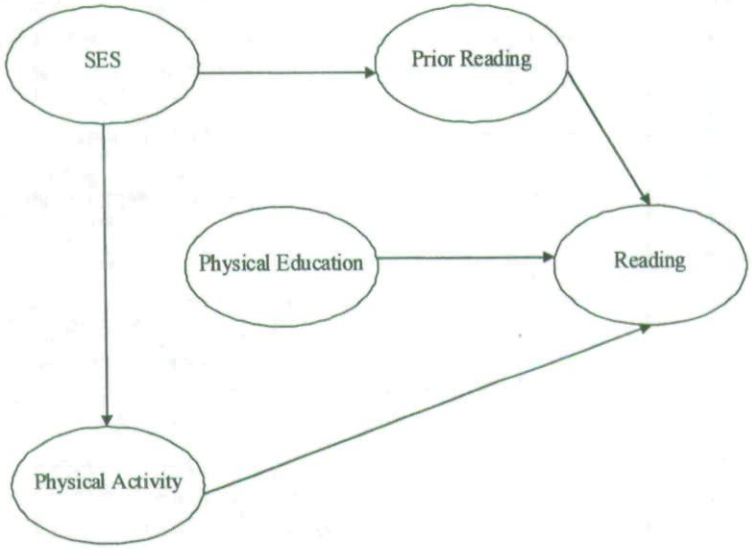


Figure 2: Parameter estimates for boys: Mathematics Achievement

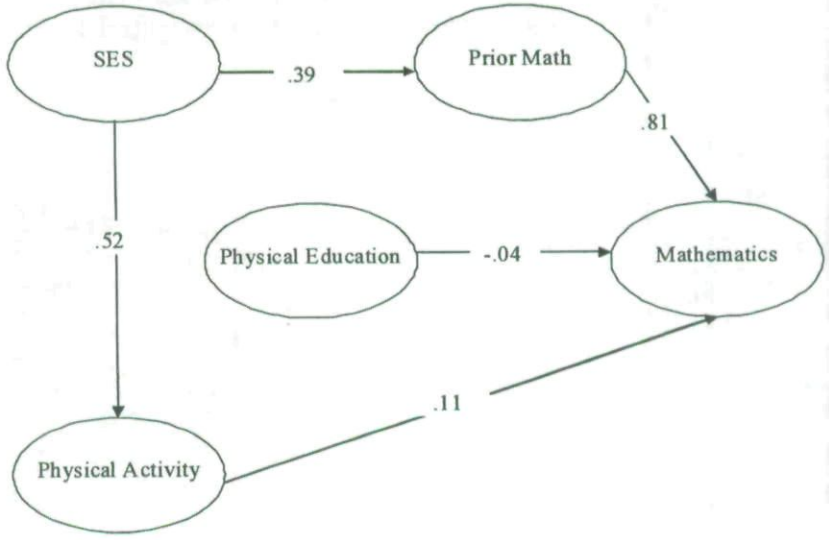


Figure 3: Parameter estimates for girls: Mathematics Achievement

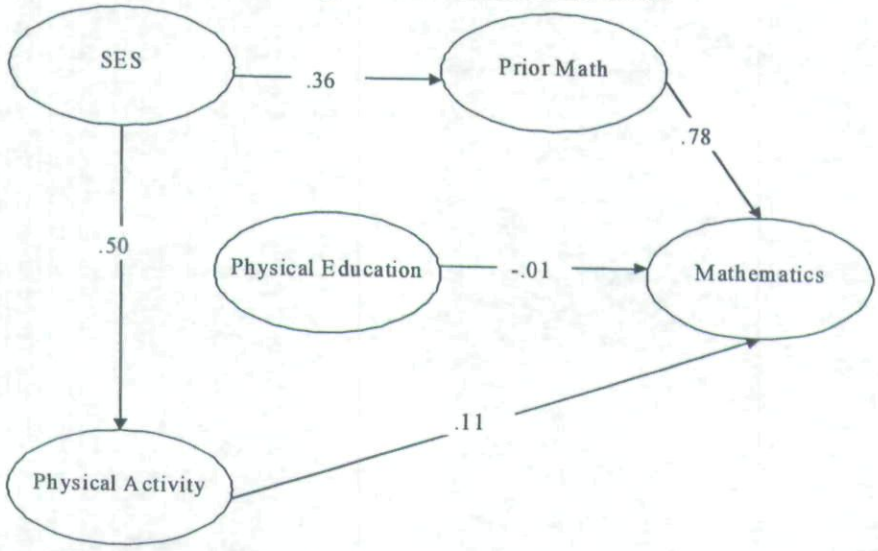


Figure 4: Paramether Estamates for girls: Reading Achievement

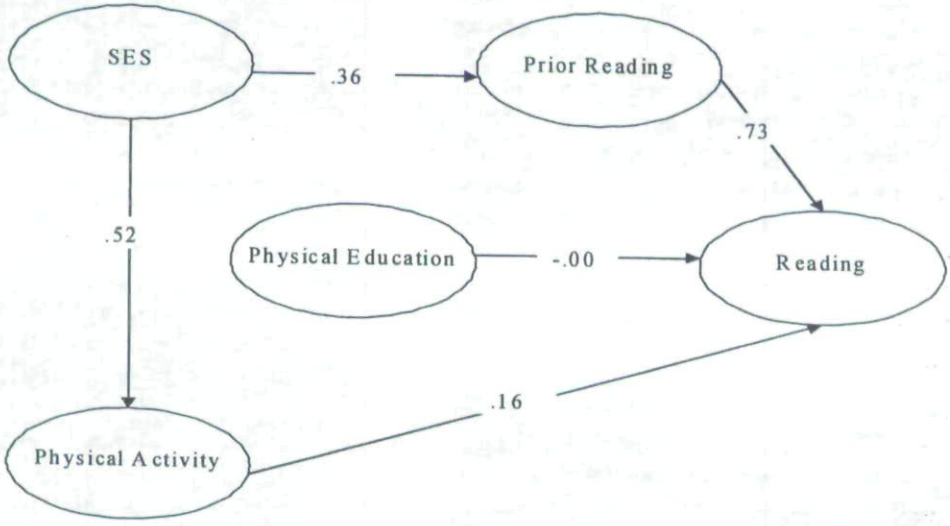
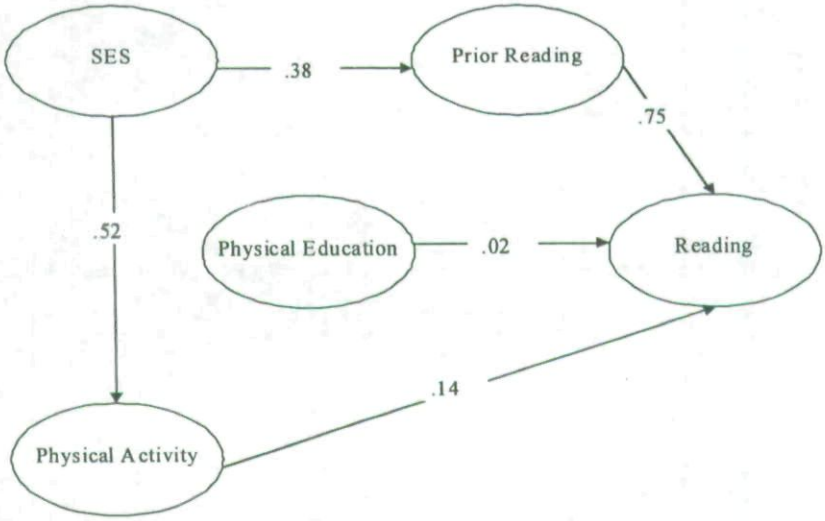


Figure 5: Parameter estimates for boys: Reading Achievement



Discussion

The purpose of the present investigation was to determine the independent contributions of physical activity not associated with structured physical education and school based physical education participation to academic achievement in children. To achieve this purpose, a large sample of boys and girls were selected with appropriate data from the ECLS-K database. Parent reports of their children's involvement in physical activity outside of physical education class as well as school administrator reported physical education of their children in school were our measures of physical activity and physical education. Math and reading achievement in 3rd and 5th grade were our dependent variables with special attention paid to prior math and reading achievement as well as SES. Our predictor variables were aggregates of achievement as well as physical activity and education at several time periods (i.e., kindergarten, 1st, 3rd and 5th grade).

The results of the structural models clearly indicated that parent reported physical activity engagement of their children was more positively influential on math and reading achievement than was physical education participation. Physical activity was comprised of parents'

assessment of their children's involvement in aerobic activity, exercise of at least 20 minutes in duration, and participation in sports not associated with physical education class. Again it is important to remember that the activity variables were aggregates of physical activity and physical education since kindergarten. Our results support several past investigations. For instance many years ago, Shepard, Lavallee, Volle, LaBarre, and Beaucage (1994) conducted the Trois Riveres experience, a large and important investigation. The investigators examined the influence of one hour of required daily physical education upon academic achievement in 546 students over a 6-year period. Experimental subjects began once they entered 1st grade and the experiment was completed once they finished 6th grade. Over this time frame, Shepard and colleagues simply concluded that one hour a day of required physical activity did not have any adverse effects upon achievement. In the present investigation, our results with regard to physical education and academic achievement confirmed the Trois Riveres experience results. Our parameter estimates were not significant and thus, our only conclusion is that physical education within the school day neither improves or detracts from academic achievement specifically math and reading achievement.

Our results also support and extend the more recent results of Coe and colleagues (2006) and Grissom (2005). The Coe et al. findings indicated that while physical education was not related to academic achievement physical activity engagement meeting some or all of the Healthy People 2010 guidelines for vigorous physical activity was significantly related to higher grades over two semesters. Hence, it appears from our data that physical education as it is currently implemented in many schools does not improve or impair academic achievement in pre-pubescent school aged children. It is appears that the key exercise component is that of intensity. Exercise intensity certainly could be incorporated into physical education classes that are offered more frequently. The challenge for physical educators is not only incorporating movement skills and games to promote vigorous physical activity but also to target low SES children. Beyond the Coe et al. findings, the present results also clearly indicated that SES influenced physical activity outside of the school day. SES accounted for 25 to 27% of parent reported physical activity involvement of their children outside of the school day in the four models. In addition, SES also directly influenced prior academic achievement. These relationships clearly indicated that children from higher SES backgrounds have a greater academic achievement advantage over those from lower SES backgrounds.

Grissom also found a statistically significant association between physical activity and academic achievement. Although Grissom accounted for the influence of SES in this relationship, prior academic achievement was not included in the analyses. Grissom commented on the difficulty in raising academic achievement beyond typical expectations even through specific interventions. This difficulty is likely a result of the strong relationships between important

factors, such as cognitive ability, existing knowledge, and teacher quality, and academic achievement. By including prior academic achievement in our structural model, we were able to account for some of these variables. We did not expect to find a strong relationship between physical activity and academic achievement because we understood that prior academic achievement would account for much of the variance. Thus, finding a statistically significant relationship with the influence of prior achievement accounted for extends the research base by lending further credence to the importance of physical activity in academic settings.

Limitations of the Present Investigation

Though our investigation supports findings of past research studies and has demonstrated the importance of including SES, limitations nonetheless exist. First, we would have added estimates of physical activity frequency and intensity to the latent construct of physical education. The observed measures utilized the amount of time that schools devoted to physical education. However, this assessment in no way considers the intensity or frequency of each child's participation in physical education. It is highly unlikely that physical education classes provided the minimal requirements for vigorous physical activity as numerous studies have demonstrated that physical education classes fail in this regard as several investigations have demonstrated that elementary students in physical education classes spend less than 37% of time in moderate to vigorous physical activity (e.g., Friedman et al., 2003). One investigation reported that in a 30 minute physical education class only 3.7 minutes were at a moderate to vigorous intensity (Stewart & Destache, 1992). In addition concerning exercise frequency, students receiving special education services including speech therapy and counseling are often taken from physical education class. Thus, not having accurate measurements of physical activity participation and actual intensity was a limitation.

Despite the concern over the measurement of physical education, the results lend insight into how physical education is valued in the public schools. On average, the children in the present study received physical education only 1-2 times a week. Even if the students benefited from ideal instruction provided by certified teachers that led to vigorous, sustained aerobic activity, the amount of time they would have spent engaged in physical activity would not likely reach the threshold required to enjoy the positive health benefits. The Dietary Guidelines for Americans (U.S. Department of Health and Human Services, 2005) recommends that children participate in 60 minutes of moderate intensity physical activity most days of the week. Given children spend much of their day in the public school setting where they receive physical education only 1-2 times weekly, their opportunity for physical activity and meeting healthy guidelines is limited. This is troubling not only for the implications related to children's health but also because physical activity seems to be positively associated with academic

achievement. The present findings do not indicate that physical education is ineffective at influencing academic achievement. Rather, the findings suggest that physical education should include physical activity and be offered regularly throughout the week.

Similar to our concern about the physical education latent construct, the physical activity latent construct was limited. The scaling of items utilized to assess physical activity limited the variability of responses. For example, the involvement in team sport item response was simply dichotomous (played or did not play). Greater explanation of the children's actual involvement, such as type of sport, amount of time spent physically engaged, and frequency of practice and competition would have provided more information concerning physical activity. This possible restriction in variability could have influenced the size of the association between physical activity and achievement, making it more difficult to estimate the influence present.

Last, utilizing only standardized achievement scores to represent achievement may be viewed as a limitation. Students' achievement can be represented by more than a single score or in the case of the present investigation two scores, math and reading. Standardized tests do not account for other variables such as effort and student capabilities given assistance as test administrators are not typically allowed to provide prompts or cues and test takers are not given the opportunity to provide explanations for their responses. Student grades, another operation definition of academic achievement, reflect opportunities for corrected assignments, conceptual understanding, and collaboration. Unfortunately, this information was not provided by the ECLS-K database and therefore could not be included in our analyses.

Educational Implications and Future Research

Despite the aforementioned limitations, the ECLS-K database provided the opportunity to evaluate the relationship between physical activity and achievement from a longitudinal perspective utilizing a large population of students and accounting for SES, gender, and prior achievement. The results do suggest that the influence of physical activity on achievement may build over time. The findings also indicate that a link does exist between physical activity and achievement. Even though this relationship is small, the recommendation that students engage in physical activity and that physical education should include physical activity opportunities daily appears warranted. The well-established positive association between physical activity and overall health makes it easy to make such a recommendation. In addition, recent research has demonstrated that physical fitness, a result of consistent and vigorous physical activity engagement, was related to enhanced neuronal indicates of cognitive functioning in children (mean age = 9.6 years) compared to unfit children as well as unfit college aged participants (Hillman et al., 2005).

In their investigation, SES was controlled and no significant differences in intelligence existed between the two groups of children. The overall finding was that high fitness level in children was positively related to improved attention, working memory, and response speed to a stimulus discrimination task. Hence, it appears that physical education with the aim of improving physical fitness in children will add in improved academic performance. Research examining whether neurological indices of improved cognitive functioning improve over time as fitness changes would be a very informative line of future research. Understanding the underlying mechanisms responsible for improved cognitive functioning is important, but gaining examining these changes with respect to children of a variety of SES backgrounds as they progress through school with similar physical activity would be very valuable. Until more research is generated, educators should recognize that activity-based physical education is not negatively associated with achievement, but provides a great potential avenue for improving cognitive functioning indices that should translate into improved academic performance.

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