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The Role of School Physical Activity Programs in Child Body Mass Trajectory

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Abstract

Background—Physical activity at school can support obesity prevention among youth. This paper assesses the role of existing school physical activity programs for a national cohort from 1st grade to 5th grade.

Methods—We analyzed a cohort from the Early Childhood Longitudinal Survey – Kindergarten Cohort which included 8,246 children in 970 schools across the country. Growth curve models estimate the effect of physical education (PE) and recess on individual child body mass trajectories controlling for child and school characteristics. Hierarchical models allow for unobserved school and child effects.

Results—Among 1st graders, 7.0% met the National Association of Sport and Physical Education (NASPE) recommended time for PE and 70.7% met the recommended time for recess in the previous week. Boys experienced a greater increase in body mass than girls. Meeting the NASPE recommended time for recess was associated with a 0.74 unit decrease in BMI (body mass index) percentile for children overall. Meeting the NASPE recommendation for physical education was associated with 1.56 unit decrease in BMI percentile among boys but not girls.

Conclusions—We find evidence that meeting the national recommendations for PE and recess is effective in mitigating body mass increase among children.

BACKGROUND

Lack of physical activity is a risk factor for childhood obesity which affects almost one out of five children ages 6-11 in the United States.[1-2] According to a national-level study using accelerometer data, 42% of children met minimum recommended activity levels.[3] Those at greater risk for being inactive include girls, racial/ethnic minorities, and residing in neighborhoods with few public recreational facilities.[4-6]

National recommendations highlight school physical activity programs as an intervention opportunity to mitigate obesity development among children. The National Association for Sport and Physical Education (NASPE) and the Institute of Medicine recommend 150 minutes of physical education (PE) instruction time per week for elementary schoolchildren. 2, 7 One of the Healthy People 2010 objectives is for all schools to require students to attend PE classes everyday.8 In addition, the NASPE recommends 20 minutes of recess per day and the Centers for Disease Control and Prevention (CDC) supports time reserved for unstructured play during school hours.9, 10 Children who attend schools that meet these recommendations can achieve the recommended 60 minutes of physical activity daily more easily.11

This study investigates the role of PE and recess time in body mass development for a national sample of children progressing from 1st to 5th grades between 2000 and 2004 in the Early Childhood Longitudinal Study - Kindergarten Cohort (ECLS-K). We use growth curve models to estimate the likely impact of an additional hour per week of PE and recess as well as an expansion of existing programs to meet national recommendations.

Our study considers the effectiveness of PE programs as they are currently implemented. This is a different approach than most studies that have evaluated interventions to improve the quality of programs, such as Sports, Play and Active Recreation for Kids (SPARK) and Child and Adolescent Trial for Cardiovascular Health (CATCH).[12]

METHODS

Data

The Early Childhood Longitudinal Study - Kindergarten Cohort (ECLS-K) was conducted by the National Center for Educational Statistics to support investigations into how a wide range of family, school, neighborhood and individual factors are associated with child cognitive and social development.[13] It follows a nationally-representative cohort of kindergarteners in the 1998-1999 school year through elementary school. The base year cohort, selected based on a multistage probability design covering the United States including Alaska and Hawaii. The primary sampling units were counties or groups of counties, the second-stage units were schools, and the 3rd-stage units were children within schools. Children from racial/ethnic minority groups or attending private schools were over-sampled.

For each child, the ECLS-K conducted a direct assessment, a telephone computer-assisted interview of the child's parent or guardian and self-administered interviews of the child's teacher and school administrator. The ECLS-K followed-up with the children, parents or guardians, teachers and school administrators in each round of data collection. Data collected in the spring of 2000 (1st grade), 2002 (3rd grade) and 2004 (5th grade) were used for the analysis.

Measures

The main dependent variable for the analysis was body mass index (BMI) percentile. The main explanatory variables for the analysis were the weekly number of hours spent in PE class and recess in the past week and the number of school days for which PE and recess were held. Indicator variables noting if children engaged in the NASPE-recommended levels of PE and recess (150 minutes and 100 minutes per week respectively) as well as daily PE and recess were also tested as explanatory variables. Child demographics and school characteristics were included in regression models to control for confounding effects. These variables are described in more detail below.

BMI Percentile—BMI was calculated from measured height and weight from the direct child assessment and the age- and sex-specific height, weight and BMI percentile for each child was calculated using the SAS program (SAS Institute, Inc., Cary, North Carolina) developed by the Centers for Disease Control and Prevention (CDC) based on the updated 2000 Growth Charts.[14-15] Height and weight were measured by ECLS-K trained assessors using a Shorr Board (Shorr Productions, Olney, MD) and a digital bathroom scale (Seca Model 840, Hanover, MD). Two measurements of each were taken and the average was recorded as the composite weight or height. Those with a BMI percentile of 95 or higher were classified as obese.15

Exposure to Physical Education (PE) and Recess—In each wave of the data, the child's teacher was asked about the frequency of PE class and recess for the relevant child in the past week and the average length for each episode. Response options for PE class frequency include “never”, “less than once a week”, “1-2 times per week”, “3-4 times per week” and “daily”. Conditional on PE class being offered, the response options for class length included “1-15 minutes”, “16-30 minutes”, “31-60 minutes”, and “more than 60 minutes”. Regarding recess, the child's teacher was asked how many days the child had recess and class length response options included “1-15 minutes”, “16-30 minutes”, “31-45 minutes”, and “more than 45 minutes”. We constructed time exposure variables by multiplying the frequency per week (assumed to be the midpoint for each response option and 5 for the “daily” option) by the number of minutes per session (assumed to be the mid-point for each response option).

Other Explanatory Variables—Our models controlled for child and family sociodemographics, child risk behaviors and school characteristics. Child and family sociodemographics included age, gender, race/ethnicity, single-parent household, mother's education level (less than high school degree, high school graduate, some college, college degree or more) and household poverty status (below or above the federal poverty threshold). Child health behaviors included parent-reported hours of television watched in the previous week and participation in sports outside of school which include group sports, individual sports, recreational sports, dance, martial arts, playground activities and calisthenics. School characteristics included management type (private or public), total school enrollment (low enrollment is 0-499 students and high enrollment is 500 or more students), degree of urbanization (rural, suburban or urban), Census region and the percentage of minority students enrolled (0-25%, 25-50%, 50-75% or 75% or more) which were reported by the school administrator.

Data Cleaning—Our analysis is limited to children with measures of BMI percentile in all waves, at least one measure of PE and recess and who did not switch schools during the time period. Those who switched schools were more likely to be male, overweight, Black, Hispanic or from a low-income household ($P<0.05$). Additional data cleaning to remove biologically implausible values resulted in an analytic sample of 8,246 children in 970 schools (see the Appendix for details on the construction of the analytic sample). The average number of children per school was 8 with a maximum of 28. Children from 40 states across the country were represented in the sample.[1]

Analysis

We used growth curve models (a method for longitudinal modeling within the broader class of hierarchical or multi-level models) to identify the effect of PE instruction time and recess time on child BMI trajectory.[16-18] Variation in the dependent variable of our analysis was decomposed into variation at the child-level and the school-level. The serial correlation of measurements within children and the clustering of children in schools were reflected in the intra-class correlation estimates from the empty model. Growth curve models have been applied in several analyses of health trajectories,[19-22] but not in this context before.

BMI percentile rather than BMI was chosen as the dependent variable because BMI percentile measures from multiple time points are directly comparable. An increase in the BMI percentile can be interpreted as excess weight while in increase in BMI may only reflect the natural growth curve of the child.[32] The time and frequency of PE class and

[1]States not represented in the sample are Idaho, District of Columbia, Nevada, Arkansas, Montana, Nebraska, New Hampshire, Vermont, South Carolina and West Virginia.

recess, the explanatory variables of interest, were introduced as fixed effects into the model. PE and recess time was tested in a separate model from the number of days PE and recess were held at school. Interaction terms between PE and recess time with age were tested to determine if school programs attenuated the BMI percentile trajectory. Same-level interactions, for example between PE and recess time with school enrollment, and cross-level interactions, such as between PE and recess time with child race/ethnicity, were tested.

Residual unexplained variation was captured in the random intercept term of the models. A random slope on age at the child-level allowed for child-specific patterns in BMI percentile trajectory. We also considered random slopes on PE and recess time and frequency at the school-level that relaxed the assumption that programs were similarly effective across schools. The effect of PE and recess on BMI percentile trajectory may be heterogeneous due to variation in teacher quality, program content or facility provision.

Physical activity can prevent excess BMI gain, but this not a concern for children who are not overweight. For children who are not overweight, we could even expect the opposite to occur if physical activity increases lean body mass. After testing the impact of PE and recess on BMI percentile for the full sample, we also test the impact for subgroups of children at the upper end of the distribution. More specifically, the groups considered were children whose BMI percentile in 1st grade was 90 or higher, 60 or higher or 30 or higher. If PE and recess were not found to be significant for the full sample, we conducted stratified analyses by gender.

Continuous fixed effect variables were centered separately for boys and girls to ease interpretation of coefficients in all models. This was done by subtracting the grand mean from each of the variables.[16] Hierarchical linear models were conducted in Stata 9.0 (StataCorp. 2005. *Stata Statistical Software: Release 9*. College Station, TX: StataCorp LP) using the “xtmixed” package. Longitudinal sampling weights were applied for descriptive statistics. Maximization was conducted via the Newton-Raphson method and models were fitted using maximum likelihood. Error terms were assumed to have a Gaussian distribution. Final models were selected based on the deviance test.

RESULTS

Table 1 provides descriptive statistics of the children and schools represented in the base year of the analysis. The sample included children from low-income households and racial/ethnic minorities as well as schools that were private or in rural locations. Table 2 indicates that the increase in obesity prevalence that occurred during the time period is concentrated between 1st and 3rd grades. The prevalence of obesity grew from 13.3% in 1st grade to 20.2% in 5th grade while average BMI percentile increased from 60.8 in 1st grade to 65.7 in 5th grade.

PE time increased slightly while recess time dropped substantially on average. The average 1st grader received 64.6 minutes of PE and 111.8 minutes of recess in the past week. 71.4% of children met the NASPE recommendation for recess (100 minutes per week) while only 6.6% met the recommendation for PE (150 minutes per week) in 1st grade. This changed to 54.2% and 12.4% respectively by 5th grade. For children who did not meet recommended levels in 1st grade, the average shortfall was 94.1 minutes of PE and 16.0 minutes of recess.

Trends in health behaviors that could potentially be confounding factors in body mass trajectory are also shown in Table 2. Parents reported that children watched about two hours of television per day. Participation in sports outside of school increased from 72.0% in 3rd grade to 76.3% in 5th grade.

A random slope on age improved the fit of the growth curve models, but random slopes on PE time, recess time, PE frequency and recess frequency at the school level did not. The intra-class correlation for BMI percentile measurements within children from the empty model for PE and recess time was 0.81, suggesting that measurements in later years were highly correlated with measurements in prior years. The corresponding intra-class correlation for children within schools was smaller but still substantial at 0.04. Similar intra-class correlation estimates were obtained from the model where days of PE and recess per week were the explanatory variables.

Table 3 presents the fixed effect estimates for the impact of PE and recess time on BMI percentile trajectory. The impact of an additional hour of PE and recess as well as meeting the NASPE recommended levels of recess and PE are shown. Results are presented for the full sample as well as for the models stratified by gender. Interactions between PE and recess with gender and age were not statistically significant and not included in final models.

Most coefficients presented in Table 3 are negative, but few are statistically significant. For children whose BMI percentile was 30 or less in 1st grade, most estimates were also negative (not shown). We find that an additional hour of recess for the full sample is associated with a 0.30 unit decrease in BMI percentile while meeting the NASPE recommended time for recess is associated with a 0.74 unit decrease ($P<0.05$). The magnitude of the recess time coefficient for children whose BMI exceeded the 30th percentile was greater than for children whose BMI exceeded the 90th percentile in 1st grade. An additional hour of recess was not significant in the stratified models although it approached statistical significance for boys ($P=0.10$). In contrast to recess, an additional hour of PE was not found to be a significant predictor of BMI percentile. Meeting the NASPE recommended level of PE however was associated with a decrease of 1.56 BMI percentile units among boys but not girls ($P<0.05$). The magnitude of the coefficient for PE was higher for children whose BMI exceeded the 30th percentile than for children whose BMI percentile exceeded the 90th percentile in 1st grade. The magnitude of the coefficients for PE were substantially higher for boys than girls overall, but a similar pattern for recess was not evident.

Similar models where the number of days that PE and recess offered at school served as the explanatory variables were tested. No significant findings were obtained for the full sample overall. Among boys, an additional day of PE at school led to a 0.39 unit decrease while daily PE was associated with a 1.63 unit decrease. These findings parallel those found for an additional hour of PE.

Figure 1 plots the predicted BMI percentiles based on the NASPE-recommended PE and recess time model which is presented in Table 3. Boys and girls who do not meet NASPE recommended levels have a higher predicted BMI percentile than those who do; however the difference is only statistically significant for boys.

DISCUSSION

Meeting the recommended levels of PE and recess at school can be effective in obesity prevention for elementary school children. However, only 6.6% of 1st grade children met the NASPE recommended level of PE with an average shortfall of 94.1 minutes in the 2003-2004 school year. 71.4% of 1st graders met the NASPE recommended level for recess with an average shortfall of 16.0 minutes. 10.2% of 1st graders attended PE on all school days as recommended by Healthy People 2010.

Obesity prevalence grew over the time period with the greatest increase occurring between 1st and 3rd grades. Our growth curve modeling analysis found that meeting the NASPE recommendation for recess time was associated with a decrease of 0.74 BMI percentile units

while meeting the NASPE recommendation for PE time was associated with a decline of 1.56 BMI percentile units for boys. These decreases are substantial in consideration that the average increase in BMI percentile over the time period is 3.6 units overall and 4.7 for boys alone. That the impact of meeting the recommendations is substantially larger than an additional hour suggests that there may be a threshold effect such that health benefits do not accrue linearly from physical activity.

We do not find supporting evidence for our hypothesis that PE and recess would be more effective for children with higher body mass in 1st grade. Our results instead suggest that the effectiveness was strongest for children with a body mass in the middle of the BMI percentile distribution in 1st grade. PE and recess were also not found to attenuate body mass trajectory.

This analysis builds on an earlier study that found that an increase in PE between kindergarten and 1st grade had a protective effect for girls at risk for overweight but not for other children.[23] We do not find that this effect continues between 1st and 5th grade. We also explore gender differences in activity levels during school programs. [24, 25] However, our results are not consistent with a prior study finding that boys and girls were similarly active in PE class.[25] Our findings contribute to the literature suggesting that opportunities for physical activity at school can be effective in stemming the development of obesity in children.[23, 26-28] In addition, they provide evidence of the effectiveness of the current national recommendations regarding school physical activity programs.

Among many limitations of this study, three are particularly important: 1. The response options for school PE and recess time were categorical, which reduced important variation in the explanatory variable; 2. Limited variation in PE time and BMI percentile change may have reduced the statistical power of the analysis particularly for girls who experienced a smaller change in BMI percentile over time 3) School physical activity programs may provide health benefits other than obesity prevention that are not considered here.[29,30]

A main finding of our analysis is that meeting the recommended levels of recess is associated with a lower BMI percentile for children between 1st and 5th grade while PE is effective only for boys. Given the current low rates of meeting national recommendations particularly for PE, it is important to evaluate existing policies and consider how resources should be allocated to achieve better child health outcomes. Schools can counter this effect to some extent by providing PE and recess programs for children, which tends to become more important over time as activity levels generally decline with age.[31,32]

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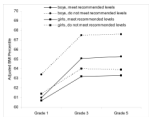

Figure 1.
Predicted BMI Percentile Trajectory by Gender and Meeting the NASPE Recommended Levels for PE or Recess [a]

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Table 1

Descriptive Characteristics of Children and Schools in 1st Grade[a]

Children (n=8,246)			Schools (n=970)		
	n	%		n	%
Gender			Region[b]		
Girls	4,106	49.6	Northeast	170	17.5
Boys	4,131	50.4	Midwest	251	25.9
Race/ethnicity			South	313	32.3
White	5,026	61.2	West	236	24.3
Black	869	13.1	Urbanization[c]		
Hispanic	1378	18.7	Urban	401	41.3
Other[d]	973	7.0	Suburban	344	35.5
Mother's education			Rural	220	22.7
< High school	754	10.5	Unknown	5	0.5
High school diploma	2,422	29.8	Management type		
Some college	2,460	29.9	Private	198	20.4
College degree or more	2,400	27.4	Public	772	79.6
Unknown	210	2.4	Enrollment[f]		
Poverty threshold[e]			High	466	48.0
Above	7,255	87.6	Low	496	51.1
Below	884	11.3	Unknown	8	0.7
Unknown	107	1.1			

[a] Percentages are weighted.

[b] Census 2000 designations of geographic regions in the United States.

[c] Rural refers to small towns, suburban refers to large and mid-size suburbs and large towns and urban refers to large and mid-size cities.

[d] Includes Native Hawaiians, Pacific Islanders, American Indians, Alaskan Natives and multi-race non-Hispanics.

[e] Household poverty status measure constructed by ECLS-K is based on parent report of household annual pre-tax income.

[f] High enrollment schools are those with at least 500 students.

Table 2

Trends for Body Mass, Physical Education, Recess and Health Behaviors Between 1st and 5th Grades (n=8,246)[a]

	1st Grade		3rd Grade		5th Grade	
	% or Mean	(SD)	% or Mean	(SD)	% or Mean	(SD)
Body mass						
BMI percentile[b]	60.8	(28.3)	65.2	(28.5)	65.7	(29.7)
Obese[c], %	13.3		18.2		20.2	
Physical education (PE) time						
Minutes per week	64.6	(43.9)	68.0	(46.6)	78.7	(50.8)
Recommended level[d], %	6.6		8.4		12.4	
Average shortfall (min)[f]	94.1		93.4		87.9	
Days per week	2.2	(1.3)	2.1	(1.3)	2.2	(1.3)
Provided daily, %	10.2		9.1		11.1	
Recess time						
Minutes per week	112.8	(61.0)	106.1	(60.4)	88.3	(55.7)
Recommended level[e], %	71.4		68.3		54.2	
Average shortfall (min)[f]	16.0		17.4		26.7	
Days per week	4.6	(1.2)	4.5	(1.4)	4.3	(1.5)
Provided daily, %	77.8		69.3		71.8	
Child health behaviors						
TV hours per week	13.6	(8.5)	13.2	(8.8)	14.7	(8.6)
Outside school sports[g], %	--	--	72.0		76.3	

[a] All estimates are weighted. Differences across all three waves for all variables in the table were found to be significant at $p<0.001$ by the ANOVA test.

[b] Age- and sex-specific BMI percentiles are obtained from the CDC Growth Charts using measured weight and height.

[c] A child is obese if the BMI exceeds the 95th age- and sex-specific BMI percentile.

[d] The National Association of Sport and Physical Education (NASPE) recommends 150 minutes per week of PE.

[e] The National Association of Sport and Physical Education (NASPE) recommends 100 minutes per week of recess.

[f] Among those who do not meet the recommended level.

[g] Includes group sports, individual sports, recreational sports, dance, martial arts, playground activities and calisthenics.

Table 3

Growth Curve Model Results for the Impact of PE/Recess Time on BMI Percentile[a,b]

	Boys			Girls			Overall		
	n	**Coeff**	**(SE)**	**n**	**Coeff**	**(SE)**		**Coeff**	**(SE)**
Hours per week									
Overall									
PE	4,137	-0.51	0.31	4,109	0.04	0.31	8,246	-0.22	0.22
Recess		-0.35	0.21		-0.23	0.21		-0.30	0.14*
≥90th percentile									
PE	875	-0.07	0.15	804	-0.08	0.15	1,679	--	--
Recess		-0.03	0.10		-0.16	0.11		--	--
≥60th percentile									
PE	2,407	-0.39	0.27	2,232	-0.22	0.27	4,639	-0.30	0.19
Recess		0.13	0.19		-0.23	0.19		-0.05	0.13
≥30th percentile									
PE	3,413	--	--	3,323	0.14	0.3	6,736	-0.27	0.21
Recess		--	--		-0.34	0.2		-0.36	0.14*
Recommended time[c]									
Overall									
PE	4,137	-1.56	0.75*	4,109	0.05	0.74	8,246	-0.74	0.53
Recess		-0.81	0.44		-0.69	0.41		-0.74	0.30*
≥90th percentile									
PE	875	-0.30	0.41	804	-0.22	0.43	1,679	-0.23	0.29
Recess		-0.34	0.21		-0.39	0.21		-0.38	0.15*
≥60th percentile									
PE	2,407	-1.07	0.69	2,232	-0.50	0.69	4,639	-0.83	0.49
Recess		-0.18	0.38		-0.60	0.38		-0.38	0.27
≥30th percentile									
PE	3,413	-1.45	0.72*	3,323	-0.12	0.74	6,736	-0.79	0.52

	Boys			Girls			Overall	
	n	Coeff	(SE)	n	Coeff	(SE)	Coeff	(SE)
Recess		-0.83	0.41*		-0.85	0.41*	-0.84	0.29**

*** p<0.0001.

[a]Model includes random intercepts and the child and school level. Child-level fixed effects include age, mother's education, race, hours of televisions watched and single parent household. School-level fixed effects include urbanization, percent minority, region and management type. Random slope on age.

[b]Results for the full sample are presented as well as for The National Association of Sport and Physical Education (NASPE) recommends 150 minutes per week of PE and 100 minutes per week of recess.

[c]The National Association of Sport and Physical Education (NASPE) recommends 150 minutes per week of PE and 100 minutes per week of recess.

*p<0.05

**p<0.001