The Effects of Physical Education on Child Body Weight and Academic Achievement: New Evidence from the ECLS-K:2011

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Abstract:

This study provides updated evidence on the impact of physical education (PE) on child body weight and student achievement using data from the Early Child Longitudinal Survey Kindergarten Class of 2010-2011 (ECLS-K: 2011). We address endogeneity concerns using state PE laws to instrument for teacher-reported weekly PE time. We also exploit the panel design of the data and estimate individual fixed effects models. We find that while students in the latter ECLS-K: 2011 cohort were exposed to increased accountability pressures by No Child Left Behind, average weekly PE time has increased from that reported in studies using the original ECLS-K cohort. Results suggest PE has essentially no impact on child body weight or achievement of children in kindergarten through third grade. We find one notable exception to these results. Our evidence suggests PE actually increases the likelihood girls are overweight or obese in kindergarten.

1. Introduction

According to a recent Shape of the Nation Report (2016) report, nearly 32 percent of children are overweight or obese and most do not get enough exercise or physical education (PE) time in school. Concern over reductions in school time allocated to PE increased sharply following the passage of the No Child Left Behind Act of 2002 (NCLB). Critics pointed to the growing accountability pressures faced by schools to meet reading and math requirements, arguing increased time on these core subjects would come at the expense of child health and fitness. Research suggests that many schools did, in fact, respond to NCLB by reducing time spent in PE. A report by the Center on Education Policy found that nine percent of U.S. school districts decreased PE time an average of 40 minutes per week between the passage of NCLB and 2007 (McMurrer, 2007). Similarly, a recent USA Today article states that 44 percent of school administrators reported significantly decreasing time allocated for PE and recess following NCLB (Hellmich. 2013). While it has been more than a decade since NCLB became law, concern over insufficient PE time persists in many school systems across the country. Reduced class size mandates coupled with inadequate funding in the state of North Carolina have recently threatened the viability of PE programs in Wake County (Hui, 2017; Blythe, 2018). Similar cuts are being considered in Virginia, Oregon and California (Long, 2017). And, the Institute of Medicine reports that only about 50% of the nation's elementary school children receive their recommended "60 minutes of vigorous or moderate-intensity physical activity at school (Educating the Study Body 2013, p. 1)."

Growing concern over reductions in time devoted to PE is predicated on the assumption that PE programs provide children with vigorous physical activity that is imperative to their health and well-being. The CDC cites numerous positive benefits of physical activity for children and adolescents, including improved cardiorespiratory fitness, improved mental health and

weight control, among others (CDC 2018)[1]. The CDC also cites positive impacts of physical activity on student learning. The reduction in PE time in public schools could therefore also have negative consequences for student achievement. The Institute of Medicine (2013) cites an increasing body of literature finding a positive relationship between moderate to vigorous physical activity and child brain functioning. The report suggests physical activity has a positive impact on child attention spans and improves their cognitive processing speeds (Educating the Student Body 2013). Mahar (2011) reports short physical activity breaks can increase attention-to-task in elementary school children. Providing more minutes of physical activity may therefore increase the productivity of subsequent minutes spent on academics and result in improved achievement. Even if it does not have large effects on physical activity, the break created by PE time may itself help children focus and improve their achievement. Dills et al. (2011) highlights research that suggests young children learn better with short breaks and behave better following recess time (Jarrett, 2002; Pellegrini & Bjorkland, 1997; Jarrett et al., 1998). Proponents of free-play, recess and physical education often point to the case of Finland, whose students consistently rank among the top academic performers in the world. Students in Finland do not begin formal education until the age of seven and once children are in school, the nation mandates schools provide hourly 15-minute recesses (Doyle, 2016).

Despite the many potential benefits of PE, there are a number of reasons why PE may not have these intended positive effects. As discussed by Cawley et al. (2013), in many PE programs children do not actually spend a lot of time in high levels of physical activity. A 2007 policy brief reported California elementary students only spend about four minutes of every 30 minutes engaged in vigorous activity (Failing Fitness, 2007). In a review of the scientific literature, Pate

[1] https://www.cdc.gov/healthyschools/physicalactivity/facts.htm (Accessed February 5, 2018).

et al. (2011) report only between 9 and 42 percent of PE time is spent in moderate or vigorous activities. The theoretical effect of PE time on achievement is also unclear. While physical activity induced by PE may improve cognitive functioning and boost attention in children, if there is little active time during PE, this positive benefit is unlikely. It is also possible that the break for PE may disrupt learning, making it more difficult for students to achieve.

While the importance of PE is widely debated and its theoretical effects are unclear, there is little recent empirical evidence on the effects of PE on child health or achievement. Early evidence provided by Datar and Sturm (2004) suggests additional PE decreases BMI for overweight and obese girls as they move from kindergarten to first grade, but the study finds no impact on the body weight of boys. After their review of the scientific literature, Pate et al. (2011) conclude that the effects of PE on child health and fitness is not yet well understood and recommend further investigation. Prior research generally suggests the impact of PE on achievement suggests the effect is positive or at least does no harm to student achievement. Rasberry et al. (2011) find over half of scientific associations between PE time and academic performance to be positive, whereas as only 1.5% of reported associations are negative.

The best evidence to date comes from Cawley, Frisvold and Meyerhoefer (2013) and Dills et al. (2011). Cawley et al. (2013) estimate plausible causal effects of PE time on child obesity using state PE laws to instrument for actual PE time. Their findings suggest PE lowers BMI and reduces the likelihood of obesity for 5th graders, with a more pronounced effect estimated for boys. Their evidence also suggests increased PE time does not crowd out time in academic subjects and has no discernible impact on student achievement. These results are consistent with those reported by Dills et al. (2011) which finds no statistical impact of additional time on PE and recess on achievement using a variety of econometric methods. While

these studies are well executed, they both rely on data from the ECLS-K, a survey of a cohort of kindergarteners beginning their schooling in 1998. NCLB was not signed into law until January 2002; therefore, the original cohort of the ECLS-K was not exposed to the legislation until the spring of their third grade year. In a recent study of Arkansas schools, Anderson et al. (2017) find evidence that NCLB had a small impact on the prevalence of child overweight and suggest reductions in physical activity as one potential mechanism for this finding. NCLB had clear implications for the distribution of academic coursework and time in school-based physical activity. In light of this, it is important to revisit earlier findings and investigate the extent to which time in PE was impacted by the increased accountability pressures and whether such changes have subsequently affected student health and achievement outcomes.

In this paper, we provide the first post-NCLB era estimates of PE effects on child body weight and achievement using data from the Early Child Longitudinal Survey Kindergarten Class of 2010-2011 (ECLS-K: 2011). The ECLS-K:2011 survey provides data on a cohort of kindergarteners beginning their schooling about a decade after the students in the original ECLS-K cohort used in the earlier studies. By the time students in this latter cohort entered kindergarten NCLB had been in place for eight years and the effects of NCLB should have been fully implemented and realized. As a baseline, we first estimate OLS models including in the models a rich set of observable control variables. We estimate the OLS models with and without state fixed effects. To control for endogeneity concerns, we then follow the instrumenting strategy used by both Cawley et al. (2013) and Dills et al. (2011). We instrument weekly PE time using state PE regulation data from the Classification of Laws Associated with School Students (CLASS)[2] compiled by the National Institute for Health. This allows us to identify the impacts of

[2] https://class.cancer.gov/about.aspx (Accessed February 5, 2018).

PE separate from other school attributes that might influence a student's actual time spent in PE. Finally, we exploit the longitudinal nature of the ECLS-K: 2011 and estimate a panel model, using individual fixed effects to control for potential within-student unobserved heterogeneity.

While students in the latter ECLS-K:2011 cohort were exposed to increased accountability pressures by NCLB, we find average PE time is higher than that reported by either Dills et al. (2011) or Cawley (2013) using the original ECLS-K cohort. Despite the difference in PE time across the two cohorts, our results suggest weekly PE time has little effect on the average child's body weight over the span of kindergarten to third grade. These BMI and obesity results are consistent with Cawley et al. (2013)'s results for kindergarteners through third graders, but differ somewhat from what they find in their fifth grade sample. However, when examining whether there are differential effects by gender, we find evidence to suggest PE increases the likelihood girls are overweight or obese in kindergarten. This somewhat puzzling finding may be a result of PE being a substitute for other forms of physical activity for girls (Cawley et al., 2013). Our findings on achievement outcomes are consistent with those reported by both Dills et al. (2011) and Cawley at al. (2013). Across all models and for both genders, we find there is no economically meaningful impact of PE on either student reading or math achievement gains as measured by scores on standardized cognitive exams administered by the ECLS-K: 2011. These results confirm those found in previous studies, suggesting increased PE time does not come at the expense of diminished academic performance.

Our PE estimates for body weight and achievement models are robust to the inclusion of both weekly recess time and parent reported daily exercise. In contrast to PE time, we find average weekly recess time has decreased somewhat for kindergarteners across the two ECLS-K cohorts, but is similar for latter grades. Similar to Dills et al. (2011), we find recess has

essentially no impact on either body weight or achievement outcomes. Parent-reported daily exercise is associated with a reduced BMI, and lower likelihood a child is obese or overweight. Few of the estimates on daily exercise are statistically significant in the achievement models.

The remainder of the paper is organized as follows. We present our empirical approach in section 2. Section 3 describes our data and discusses the summary statistics. Our results are presented in Section 4. Section 5 concludes.

2. Empirical Approach

To estimate the impact of PE on body weight and achievement, we regress the outcome of interest on weekly PE time, controlling for a number of individual and school level characteristics:

$$y_{ij} = \beta_0 + \beta_1 PE_{ij} + X_{ij}\beta_2 + \varepsilon_{ij} \quad (1)$$

where y_{ij} represents a body weight or achievement outcome for student i in school j. We examine three measures of body weight: BMI, obese, and overweight. We examine two measures of achievement: reading and math test scores. Achievement outcomes reflect changes in test scores to control for academic performance at kindergarten entry. The primary coefficient of interest is β_1, which represents the effect of an additional minute of weekly PE. In subsequent analyses, we examine the effects of two additional measures physical activity: weekly recess time and the number of days/week the student engages in 20 or more minutes of exercise. In addition to our primary independent variables, we control for a wide range of characteristics that are included in the vector X_{ij}. These include standard demographic controls (student age, race, gender), family background (socioeconomic status, mother's education, a dummy variable to

denote mother's education is missing, whether the student's parents live in the home, and how many siblings are in the home) and school characteristics (for class size, school enrollment, teacher tenure, school urbanicity, and the percent minority). We include the number of days between the administrations of the two tests used to construct each achievement measure. We also state controls (real per-capita income, percent of the state population with a bachelor's degree or higher, total state revenues per student, real total state expenditures per student, average student-to-teacher ratio, the percent of the state adult population that is overweight and the percent of the state's child population that is overweight). We estimate baseline OLS models with the above vector of control variables and a second OLS specification where we add a vector of state fixed effects to capture all permanent differences across states.

If PE time was randomly assigned, β_1 would provide an unbiased estimate of its impact. However, PE time is not randomly assigned. High performing schools with more resources may both provide more PE time and have healthier and higher achieving students. Alternatively, low performing schools may decrease PE time in order to improve child achievement. Unless all such differences among schools are included in the vector of observed controls, X_{ij}, OLS estimates of the impact of PE and recess on achievement will be biased. In addition to including in their models a rich set of controls in the vector, X_{ij}, both Dills et al. (2011) and Cawley et al. (2013) address these econometric challenges using an instrumental variables model. We follow a similar strategy and instrument weekly PE with state PE regulations. As long as the state regulations are sufficient predictors of a school's PE time but do not directly impact an individual student's body weight or achievement, they will serve as valid instruments and the resulting estimates may then be interpreted as plausible causal effects. We estimate four separate grade-level cross sectional regressions of equation (1) for each outcome and estimation approach.

Unlike the ECLS-K cohort which did not survey students in the second grade, the updated ECLS-K: 2011 survey includes a second grade survey year, creating a continuous four-year panel. This allows us to also estimate a panel regression model, combining data from the four consecutive survey years. The resulting estimating equation is as follows:

$$y_{ijt} = \alpha_0 + \alpha_1 PE + X_{ijt}\alpha_2 + \phi_i + \varepsilon_{ij} \qquad (2)$$

In this specification, y_{ijt} represents the outcome for student i in school j at time t. Weekly PE time and the control variables now reflect time-specific values, where time represents one of four school years in the sample. In addition to these controls, we include a set of grade fixed effects[3]. Like estimations of equation (1) above, we estimate equation (2) using both OLS and instrumental variables. Here the coefficient of interest, α_1, represents the average impact of PE on body weight or achievement over the span of kindergarten to third grade. Finally, the panel nature of the data also permits us to add individual-level fixed effects to the specification. The inclusion of individual fixed effects controls for all permanent individual unobserved heterogeneity, providing an additional method of controlling for the potential of omitted variable bias.

3. Data

Our primary source of data come from the Early Childhood Longitudinal Survey of Kindergarteners 2011 (ECLS-K: 2011). The ECLS-K: 2011 is the second longitudinal survey following a cohort of kindergartners as they progress through elementary school. The survey comes from the National Center for Education Statistics (NCES)[4] and includes a representative

[3] Because time in this model is perfectly correlated with grade level, the inclusion of grade fixed effects also captures time effects.
[4] The NCES is held within the Institute of Education Sciences in the U.S. Department of Education.

sample of 18,174 students who entered kindergarten in the fall of the 2010. The survey conducted follow up interviews in the spring of kindergarten (2011), the fall and spring of first grade (2011-2012), fall and spring of second grade (2012-2013) and the spring of third grade (2014). Information about the students, their families, their teachers and their schools was collected. The cohort of students in the ECLS-K: 2011 comes a little more than decade after the original cohort of students followed in the ECLS-K survey used by Dills et al. (2011) and Cawley et al. (2013) which allows researchers to make comparisons across the two groups. We limit our sample to those students who attended public school during each year of observation. We also eliminate students who are missing key data included in our analysis.

Our primary independent variable of interest is weekly PE time. We construct this measure using teacher responses to questions on the number of days and time per day students spend in various activities. Days spent in PE is derived from a question asking, "how often does the typical child in your class or classes usually work on lessons or projects in the following general topic areas, whether as a whole class, in small groups, or in individualized arrangements- physical education?" Answers are coded by the ECLS-K: 2011 into the following categories: never, less than once a week, 1 day/week, 2 days/week, 3 days/week, 4 days/week, and 5 days/week. Daily time in PE comes from a survey question that asks the teacher "on the days children work in these areas, how much time does the typical child in your class or classes usually work on lessons or projects in the following general subject areas- physical education?" Responses are coded as: never, less than ½ hour a day, ½ to less than 1 hour, 1 to 1.5 hours, 1.5-2 hours, 2-2.5 hours, 2.5 to 3 hours, 3 or more hours.

Both Dills et al. (2011) and Cawley et al. (2013) construct weekly PE time by multiplying days per week by daily PE time. Unfortunately, both days-per-week and time-per-

day are coded differently in the ECLS-K: 2011 than they are in the original ECLS-K survey. The days per week variable is coded less precisely in the original ECLS-K, with the survey grouping 1-2 days and 3-4 days into single categories, whereas the ECLS-K: 2011 distinguishes between one and two and three and four days. Both previous studies use the midpoint of these day ranges to construct their days-per-week measure. The ECLS-K also divides PE time into finer categories within the first hour and top-codes the final category at 60+ minutes. Time categories in the original ECLS-K are as follows: does not participate, 1-15 min, 16-30 min, 31-60 and 60+ minutes. Dills et al. (2011) uses the midpoints of the minute categories and codes the 60+ category as 75 minutes[5]. Cawley et al. (2013) uses the maximum of each daily time range and top-codes the 60+ category at 90 minutes[6]. ECLS-K weekly PE time averages reported by Cawley et al. (2013) therefore exceed those reported by Dills et al. (2011).

To construct our preferred measure of weekly PE time with ECLS-K:2011, we use the mid-point of the daily time intervals multiplied by days per week[7]. Because PE time is top-coded at 60 or more minutes in the ECLS-K and the more recent ECLS-K: 2011 survey includes several categories above 60 minutes (going up to 180 minutes), it is possible that weekly PE time may appear to be greater in the latter survey even if it has actually decreased over the time frame between the two ECLS-K surveys. To adjust for this difference, we top-code daily PE time at 75 minutes. We also create two additional measures of weekly PE time that are based off of the ranges used by Dills et al. (2011) and Cawley et al. (2013). Following Dills et al. (2011), we collapse days per week from seven categories into five, with 1-2 days being assigned a value of

[5] Dills et al. (2011) categorizes days as 0, 0.5, 1.5, 3.5 and 5 days. PE minute categories are as follows: 0, 8, 23, 45.5, and 75.
[6] Cawley et al. (2013) categorizes days as 0, 0.5, 1.5, 3.5 and 5 days. PE minute categories are as follows: 0, 15, 30, 60 and 90.
[7] Specifically, we use the following categories for minutes: 0 minutes, 15 minutes, 45 minutes, and 75 minutes. Top-coding affects about two and a half percent of the sample. Top coding at 75 minutes is consistent with Dills et al. (2011).

1.5 and 3-4 days being assigned a value of 3.5. For the comparative Cawley et al. (2013) measure, we follow the same guideline as the Dills et al. measure for days per week, but rather than using the midpoint for daily minutes, we use the maximum minutes per day of each range and top-code at 90 minutes rather than 75.

Table 1 shows descriptive statistics for weekly PE time for our analysis sample (Panel A) and for the full sample (Panel B). For comparison purposes, we also include the comparable statistics from the earlier ECLS-K cohort. Looking first at our analysis sample in Panel A, mean weekly PE time of our preferred PE measure falls from about 110 minutes in kindergarten to around 80 minutes by the time that the children reach third grade. In addition to this measure of weekly PE time that is based on the categories in the ECLS-K: 2011, we include our two adjusted measures based on the categories used by Dills et al. (2011) and Cawley et al. (2013). When adjusted, mean PE time is higher than our preferred measure. Regardless of measure, our mean weekly PE time constructed using the ECLS-K: 2011 exceeds mean PE times reported by both Dills et al. (2011) and Cawley et al. (2013). Whereas Dills et al. (2011) reports weekly PE time in kindergarten around 68 minutes and Cawley et al. (2013) reports mean time of about 76 minutes per week in kindergarten, our sample average weekly PE time is roughly 110 minutes per week. We see a similar pattern in the latter grades. These descriptive statistics suggest that despite increased pressures imposed by the NCLB regulations, average weekly PE time actually increased from 1998 to 2010. Another interesting result coming out of the comparison is that weekly PE time decreases across grades in the latter cohort, but increases somewhat in the original ECLS-K. This change in trends suggests that over the last decade schools have increased PE more in earlier grades. Perhaps this reflects differential pressures by NCLB. With most states

beginning testing around the third grade, we might expect the response to NCLB to be more pronounced in latter grades.

While the different scales for PE time creates measurement error that makes it difficult to draw any definitive conclusions regarding differences across the two cohorts, one potential explanation is that decisions regarding sample inclusion in the studies affected the sample means. To investigate this possibility, we use the public use version of the ECLS-K to construct weekly PE time of the full sample. This allows us to collapse the 0-15 and 15-30 daily time categories in the ECLS-K into a single category that is better aligned with the latter ECLS-K:2011 survey. The descriptive statistics of the different PE measures across both of the full ECLS-K and ECLS-K: 2011 samples are shown in Panel B. Overall, the analysis samples have somewhat higher mean PE time than the full samples. For instance, our preferred measure shows mean weekly PE time of around 98 minutes for kindergartners across the full sample; our analysis samples has an average that is about 12 minutes higher. The difference is less pronounced in upper grades. However, the general cross-cohort trends persist. Weekly PE time is higher in each measure of the ECSL-K:2011 sample than its comparable ECLS-K counterpart. We still see PE time fall from kindergarten to third grade in the latter cohort while increasing in the earlier. The fact that PE time appears to have increased across the two ECLS-K cohorts contradicts evidence regarding the effects of NCLB. However, over the last decade many states have increased the stringency of their PE regulations. Tighter regulations may have made it more difficult to cut back on PE despite a school's desire to do so. Schools may have instead opted to reduce time in other areas such as recess, music or art in response to the NCLB regulations. Evidence provided by Bassok, Latham and Rorem (2016) suggests that this may be the case. Comparisons across the

two ECLS-K cohorts in their study show that post-NCLB, schools cut back on time spent in art, music and science for kindergartners[8].

In addition to our primary variable of interest, weekly PE time, we also examine the effects of two other measures of physical activity: weekly recess time and number of days per week engaged in vigorous activity for more than 20 minutes. Similar to PE time, weekly recess time is coded by multiplying days per week by time per day. The days per week variables comes from responses to a question asking "how many days a week do children have recess?" which is coded from zero to five. Daily recess time is constructed from a question asking, "In a typical day, how much time do children in your class or classes spend in the following activity- free play outdoors (including recess)." When constructing weekly recess time we therefore assume that free outdoor play, including recess, is equivalent to daily recess time. Daily recess time is decomposed into five categories: no time, 1-15 minutes, 16-30 minutes, 31-45 minutes, and longer than 45 minutes. These categories are equivalent to those in the ECLS-K survey used to construct the recess measure by Dills et al. (2011). We apply the same methodology as Dills et al. (2011) and use the midpoint of these time ranges to construct our weekly recess time variable[9]. We also examine the effect of non-school exercise. We use a parent reported measure of the number of days per week their child spends engaged in physical activity of more than 20 minutes.

Table 2 shows the means of these variables by grade for the ECLS-K: 2011 cohort. For comparison purposes, we show Dills at al. (2011) summary statistics of weekly recess. We also construct a measure of days in exercise from the ECLS-K cohort of students. In contrast to PE

[8] The authors did not find similar reductions in either PE or recess time. However, the measures for PE and recess are simple zero-one indicators noting daily recess or PE time, which does not account for the time in these activities.
[9] Specifically, daily recess time is coded as 0, 7.5 minutes, 23 minutes, 38 minutes and 53 minutes.

time, weekly recess time in our analysis sample has decreased slightly across the two cohorts relative to Dills et al (2011). Whereas average weekly recess was around 133 minutes/week for kindergartners in the ECLS:K, mean weekly recess time in our analysis sample is slightly lower in the latter ECLS-K: 2011 cohort at around 120 minutes per week. A similar trend is seen for first and third grade across the two cohorts. In each case, whereas weekly PE time has increased relative to that reported in the earlier ECLS-K cohort, mean recess time has fallen. However, when we look at the full samples, we see this difference only remains with the kindergartner sample. Recess time remains constant for both first-graders and third graders across the two cohorts. The difference in cross-cohort trends between PE and recess time may reflect differences in regulatory environments surrounding these activities. While both PE and recess provide students with additional time in physical activity, more states impose regulations on required PE time than on required time for recess. This evidence supports our hypothesis above suggesting that following NCLB, schools likely faced more flexibility with recess time (and potentially other specials) and responded to increased pressures by reducing recess time rather than PE time. Turning to out of school parent reported exercise, on average, students engage in 20 minutes or more of daily exercise about 4.5 days per week. This statistic stays fairly consistent across grade spans.

Our first outcome of interest is a child's body weight. We use three measures of body weight: BMI, obese and overweight. The ECLS-K: 2011 provides BMI data for children at each age grade level. To construct dummy variables to indicate whether a child is obese or overweight, we merge the ECLS-K:2011 data with data from the CDC, which provides gender-age specific percentiles of child BMI based on the 2000 CDC Growth Charts[10]. We classify

[10] https://www.cdc.gov/growthcharts/percentile_data_files.htm (Accessed February 6, 2018).

students as overweight if their BMI is greater than or equal to the 85th percentile of the gender-age BMI distribution and as obese if their BMI is greater than or equal to the 95th percentile of their gender-age BMI distribution. Table 3 shows descriptive statistics of the body weight outcomes by grade for our analysis sample. Mean BMI increases from 16.677 in kindergarten to around 18.5 in third grade. The percentage of the sample considered obese increases from 14 percent in kindergarten to 19 percent by third grade. Similarly, the percent overweight increases from 30.7 percent to 34.6 percent. For reference, we also include the reported body weight summary statistics from Cawley et al. (2013). Comparisons of the two cohorts show that the prevalence of obese and overweight kindergartners and first-graders has increased over the decade between the two ECLS-K cohorts. However, the percentage of both obese and overweight third-graders is remarkably similar across the two cohorts. This finding suggests the growth in the child obesity epidemic may be more pronounced at younger ages.

Our second outcome of interest is a student's academic achievement. We measure achievement using standardized test scores in both reading and math. Both cognitive tests are administered by the ECLS-K: 2011. We use the IRT-scaled scores, which are calculated using IRT procedures. IRT methods estimate a child's achievement based on their pattern of correct and incorrect responses and the characteristics of the questions (e.g. difficultly level). This procedure is advantageous relative to raw number scoring because it is able to adjust for the possibility that a low achieving student happens to guess a difficult question correctly. It is also able to adjust for omitted answers, treating them differently than responses that are answered incorrectly (ECLS-K:2011 User's Manual). The IRT scaled scores allow for longitudinal comparisons, as a student's scores are expected to increase over time[11]. To control for initial

[11]However, while the procedure used to assess students in the ECLS-K:2011 is similar to that used in the original ECLS-K cohort, the scales are different. This makes cross-cohort academic performance comparisons impossible.

achievement levels, our specifications use the change in achievement from one time period to the next as the dependent variable. The change in test scores are calculated across four time periods: spring kindergarten – fall kindergarten, spring first grade – spring kindergarten, spring second grade – spring first grade, and spring third grade – spring second grade. Table 4 shows mean test scores for the spring of each grade level and the mean change in scores. As expected, the average mean scaled scores increase over the grade span and achievement growth is positive for all grades in both reading and math. For both reading and math, the largest mean growth in test scores is seen between first grade and kindergarten.

We also include controls for a large number of individual, classroom, and school characteristics that are available in the ECLS-K: 2011 data. Student level variables include student age, race, gender, socioeconomic status, mother's education, a dummy variable to denote mother's education is missing, whether the student's parents live in the home, and how many siblings are in the home. We also include the number of days between the administrations of the two tests used to construct each achievement measure. Additionally, we include school variables that control for class size, school enrollment, teacher tenure, school urbanicity, and the percent minority.

As discussed above, time spent in PE is not random. We therefore instrument individual PE and time using state-level data on regulations governing time spent in PE. Data on physical education regulations comes from the Classification of Laws Associated with School Students (CLASS). The CLASS data is publically available on the National Cancer Institute website and covers the time period 2003 until 2015[12]. We use the "Physical Education-Related State Policy

The NCES suggests this comparison may be possible in the future; they indicate are working on creating an adjusted measure that is directly comparable.

[12] https://class.cancer.gov/download.aspx (accessed February 16, 2017).

Classification System" data available. The data include a wide range of policy variables regarding both physical education and recess. Regulations in CLASS are coded by attorneys and are based off careful review and interpretation of state legal statutes rather than surveys. We focus on elementary school regulations beginning in 2010, which is the fall the students in the ECLS-K entered kindergarten.

Of primary interest for our study are regulations concerning the state time requirements for PE. These requirements are coded by the CLASS data as no requirement (0), state only recommends a PE requirement or has a physical activity requirement that includes PE as an option (1), state requires public schools provide PE but either does not specify a time requirement or requires fewer than 60 minutes per week (2), state requires 60-90 minutes of PE (3), state requires 90-150 minutes of PE (4) and state requires at least 150 minutes of PE (5). We create dummy variables for each of these categories. Table 5 summarizes the CLASS data by year. While most states require elementary students take PE, almost 70 percent do not mandate a weekly time requirement or require fewer than 60 minutes per week. Only five states mandate students take the nationally recommended 150 minutes of weekly PE. The approximately 20 percent remaining states require schools to provide between 60 and 150 minutes of weekly PE. As is evident in the table, the state PE time requirement regulations do not vary greatly from 2010 to 2013. Because there is little variation beyond the 60-minute time requirement, we group states into one of two groups: (1) requires more than 60 minutes of weekly PE and (2) does not require more than 60 minutes of weekly PE. Table 6 shows mean weekly PE time by these categories. With this classification, the proportion of students in our analysis sample who live in states that require more than 60 minutes of PE per week ranges from about 44 to 51 percent. Among those students who live in a state with the more stringent regulation, we observe higher

mean weekly PE time compared to their counterparts who live in a less regulated state. This descriptive evidence suggests that state regulations do have an effect on a school's PE decisions.

In subsequent estimations, when we are interested in the effects of weekly recess time, we instrument recess with state regulations on recess which are also taken from the CLASS data. States are coded as not having a requirement or recommendation (0), having a recommendation (1), requiring recess for less than 20 minutes per day or requiring recess without a specific time requirement (2), requiring recess for 20-30 minutes per day (3) and requiring at least 30 minutes of recess per day (4). During our time period of analysis, no state is coded as requiring 30 minutes per day and very few are coded as having a requirement at all. We therefore create a dummy variables indicating simply whether the state recommends or requires recess. As shown in Table 5, only four states have a regulation that requires schools to have daily recess.

While state-mandated regulations provide a natural experiment that can make for useful instruments, there is still the possibility of policy endogeneity when using policies as instruments. For example, high-income states might both be more likely to mandate physical education and to have higher achieving students or states with a high proportion of overweight children may increase their state mandated PE time to boost child health. To address these concerns, we follow Cawley et al. (2013) and include state level controls for income, health, and education. More specifically, we include real per-capita income, percent of the state population with a bachelor's degree or higher, total state revenues per student, real total state expenditures per student, average student-to-teacher ratio, the percent of the state adult population that is overweight and the percent of the state's child population that is overweight. We obtain data for per capita income and percent of the state population with a bachelor's degree from the U.S. Census Bureau. State revenue, expenditure and student-to-teacher ratios are taken from the U.S.

Department of Education.[13] Child overweight rates come from the Data Resource Center for Child and Adolescent Health[14] and adult overweight rates comes from the Nutrition, Physical Activity and Obesity Data, Trends and Maps web site[15].

4. Results

4.1 PE and Child Body Weight

Tables 7 through 9 show results of PE on child body weight. Table 7 presents the results based on the full sample. Then, we divide the sample by gender. Table 8 shows the results for male students; results for females are given in Table 9. In the first column of each table, we report estimates from models that exploit the longitudinal design of the data using a panel regression model. Estimates from the four separate grade specific cross-sectional regressions are presented in columns two through five. We report OLS (with and without state fixed effects) and IV estimates for every specification. We also report estimates from specifications that include individual FE estimates for the panel models.

The estimates of PE time on body weight outcomes (Table 7) of the overall sample suggest that PE has little effect on child body weight. Only a handful of the estimates from panel models are statistically different from zero. Those that are statistically significant are very small in magnitude. For example, the point estimate on PE in the BMI panel regression with individual fixed effects is -0.000480. This estimate implies it would take more than 1,000 minutes of

[13] National Center for Education Statistics, Common Core of Data (CCD), "National Public Education Financial Survey (State Fiscal)", 2010-11.
[14] Data Resource Center for Child and Adolescent Health, a project of the Child and Adolescent Health Measurement Initiative (CAHMI). State Obesity Profiles, 2011.
[15] U.S. Department of Health and Human Services, Centers for Disease Control and Prevention (CDC), National Center for Chronic Disease Prevention and Health Promotion, Division of Nutrition, Physical Activity and Obesity, Atlanta, GA, 2015. Available at http://www.cdc.gov/nccdphp/DNPAO/index.html.

additional PE per week to reduce BMI by even 0.5 points. Similarly, the effect of PE on the probability a student is obese is 0.000060. This estimate is statistically different from zero, but is economically negligible and suggests PE has essentially no influence on the likelihood a child is obese. A similar pattern emerges from the grade-specific results shown in columns 2 through 5. Few estimates are statistically different from zero and those that are significant are not economically meaningful.

The largest point estimate is from IV estimates of PE on the likelihood a child is overweight in kindergarten. This estimate, 0.00167, suggests an additional 60 minutes of weekly PE time would increase the likelihood a child is overweight by about 10 percentage points. The corresponding point estimate on the first-grade sample is also statistically significant at the 10 percent level. This estimate implies an additional 60 minutes of weekly PE would increase the likelihood a child is overweight by about 4.5 percentage points. A finding of a positive relationship between increased PE time and bodyweight, albeit small, is somewhat puzzling. Cawley et al. (2013) found evidence that PE reduces BMI and lowers the likelihood a child is obese, however, this effect was found only for 5th graders in the ECLS-K sample. Cawley et al. largely attribute this finding to the strength of their instrument, which was only found to be a statistically significant predictor of weekly PE time for the 5th graders. They suggest this result was likely driven by a large-scale policy change that boosted state PE requirements in Alabama and Texas between the time the students were in third grade in 2002 and fifth grade in 2004. The authors also argue that because the 5th grade sample was the only one exposed to NCLB, the PE regulations were more binding for schools during that year, making the instrument stronger for the fifth grade students. Our findings could similarly be the consequence of a poor instrument. The first-stage results (shown in panel D) suggest this is not the likely explanation. Compared to

Cawley et al. (2013), our instrument performs much better across all grade levels. The first-stage results show that the state PE regulation is a statistically significant predictor of weekly PE time. In the kindergarten regression, the first-stage estimate on the regulation suggests students living in states that require 60 or more minutes of weekly PE time engage in about 25 additional minutes of PE relative to student who live in a state that does not have this requirement. The first-stage F-statistic of 14.222 is small compared to the F-statistics in the other grade specific samples, but is still above 10, the commonly accepted minimum threshold for instrument power (Stock et al., 2002). In each subsequent specification, the instrument is a statistically significant predictor of weekly PE time and the first stage F-statistic is also well above 10.

Even with a well-performing instrument, our results suggest weekly PE time does not affect child body weight or may even have a very small positive impact. A finding of a near zero effect across all estimation methods is consistent with results found by Cawley et al. (2013) for kindergartners through third grade. Our results suggest a finding of no effect in grades K through three in Cawley et al. (2013) is perhaps not only a function of weak instrument power as the authors infer. The results may suggest instead that PE does not affect child body weight until the students are older. A full comparison of results across grade levels is needed to assess whether PE does, in fact, start to affect body weight as children age. Unfortunately, this is not yet possible due to data availability[16]. An additional explanation for these results is that increased PE time in school is offset by decreased physical activity out of school. Cawley et al.'s (2013) results suggests that for at least a subset of students this may be true; they find PE is a complement for other forms of physical activity for boys, but is a substitute for girls. In this case, even if students are active in PE and PE has positive benefits on student health, these benefits

[16] Data for the 4th grade sample is expected to be released in late February, 2018. Data for the 5th grade sample should be released in late fall 2018.

may be negated by reduced physical activity elsewhere. And, if little PE time is spent in vigorous activity as some research suggests, it is even possible that increased PE time (at the expense of other physical activity) could even have a negative impact on student body weight.

Cawley et al. (2013) finds PE is primarily beneficial for boys in the 5th grade and that the relationship between time in PE and time spent on other forms of physical activity varies by gender. Datar and Sturm (2004) also find evidence to suggest the effect of PE differs by gender. They examine the effect of changes in PE time between kindergarten and first grade on BMI of students using the ECLS-K. Their results imply additional PE time reduces BMI in overweight and obese girls, but has no discernible impact on girls of healthy weights or for boys. In light of these findings, which suggest the effects of PE on body weight vary by gender, we next turn to gender-specific estimations.

Looking at Tables 8 and 9, a few patterns emerge. First, for males, there are very few statistically significant point estimates. Similar to the overall results, the only estimates that statistically different from zero are in the individual fixed effects models. These estimates imply increased PE time decreased BMI and the likelihood a male student is obese, however, the estimates are small in magnitude. The point estimate on obese suggests an additional 60 minutes of weekly PE would only decrease the probability a male student is obese by about 0.42 percentage points. Similarly, the point estimate on BMI is -0.000531; this estimate is a little larger than that in the overall sample (-0.000480), but still implies it would take more than 1,000 minutes of additional PE per week to reduce BMI by even 0.5 points. Taken as a whole, the evidence in Table 8 suggests weekly PE time has essentially no effect on the body weight outcomes of boys.

Looking next at the results for female students in Table 9, we see a similar estimate on the overall panel model. Nearly all estimates are near zero in magnitude and few are statistically significant. However, we do see some evidence of a small positive effect of weekly PE time on female body weight for kindergartners. Several point estimates are statistically different from zero. In particular, all of the point estimates in the obesity regressions are statistically significant at the five percent level. The OLS estimates both suggest an additional minute per week in PE increase the likelihood a female kindergartner is obese by 0.091 percentage points. This estimate is small; it implies it would take almost 60 additional minutes of weekly PE to increase the probability a female is obese by a full percentage point. The IV point estimate is larger in magnitude, however. The point estimate is 0.001785 suggests an additional 60 minutes of weekly PE would increase the likelihood a female student is obese by almost 11 percentage points. The point estimate on overweight for female kindergarteners is even larger. The estimate of 0.003267 implies 60 additional minutes of weekly PE would increase the probability a female kindergartener is overweight by almost 20 percentage points. The IV estimates on first grade female students are also statistically significant, though the point estimates drop in magnitude. The estimates suggest an additional 60 minutes of PE would increase the likelihood a female first-grade is obese by about 5.5 percentage points and the likelihood she is overweight by about 7 percentage points. Many of the point estimates for the second and third grade samples turn and sign and almost none remain statistically significant, suggesting the effect of PE may fall as girls get older.

The gender-specific results suggest the small positive effects of PE on the likelihood a student is overweight found with the full sample in Table 7 are largely driven by the female students in the sample. This finding is consistent with Cawley et al.'s (2013) conclusion that PE

time is a substitute for other forms of physical activity for girls but is a complement for boys. In this case, these results are suggestive of the idea that any potential benefits of time in PE for girls are more than compensated by a subsequent decrease in physical activity time elsewhere. These results differ from Datar and Sturm (2004) findings which suggest PE time decreases BMI for overweight and obese girls in the original ECLS-K cohort.

4.2 Weekly PE and Academic Achievement

Tables 10 through 12 show results of PE on academic achievement. Like the body weight results, we first present results of the overall sample (Table 10) and then show results by gender with results for male students in Table 11 and for female students in Table 12. The tables are organized similar to Tables 7 – 10. We present panel regression estimates in column 1; columns 2 through 5 shown estimates from the four separate grade specific cross-sectional regressions. We report OLS (with and without state fixed effects) and IV estimates for every specification and individual FE estimates for the panel models.

Beginning with the panel analyses, the base OLS estimates suggest a small negative impact of PE on reading achievement. However, the estimated impact is quite small (-0.00171), suggesting it would take more than 500 minutes of additional PE weekly to decrease achievement by a single point. Estimates in models with state fixed effects and individual fixed effects are no longer statistically significant, but both are similar in magnitude to the OLS estimates. These similarities suggest controlling for permanent state and individual differences across the four years does not affect the OLS estimates of PE on reading achievement growth. The corresponding IV estimate is larger in magnitude and is statistically significant, but still

implies a relatively modest impact on achievement. The point estimate of -0.016398 suggest an additional 60 minutes of weekly PE would reduce reading achievement by about one point.

Turning next to the within-grade estimates (shown in columns 2 – 5), the baseline OLS estimate on the kindergarten sample suggests PE has a small statistically significant impact on reading. Like the panel estimate, however, the economic magnitude is negligible. This estimate suggests it would take more than 200 minutes of additional PE per week to reduce the average child's reading test score by one point. In the second model that includes state fixed effects, the magnitude of the coefficients on PE is even smaller in magnitude and is no longer statistically different from zero. Similarly, the estimate from the instrumental variables model suggests no statistically significant impacts on reading scores. Results in the other grade specific regressions are similar. The only statistically significant point estimate is the IV estimate in the second grade sample; the estimate implies an additional 60 minutes of weekly PE is associated with about a one point drop in reading score. This finding also suggests the statistically significant IV result in the panel model is driven by the second graders in the sample. Given the standard deviation of reading achievement growth between second and first grade shown in Table 4, this estimate suggests it would take more than 470 minutes of PE to reduce a student's reading score by a full standard deviation.

The math results (panel B) tell a similar story. The only statistically significant point estimate in the panel model is the IV estimate. It is similar in magnitude to the point estimate on reading in the IV models; this estimate suggests an additional 60 minutes of weekly PE would reduce math gains by about 0.7 points. Similar to the panel results, the results on the change in achievement between first and kindergarten (column 3), second and first grade (column 4), and third and second grade (column 5) largely suggest PE has no economically meaningful impact on

either reading or math achievement in any grade. The only statistically significant estimates are on the OLS estimates for first graders. While these point estimates are statistically significant, they are not economically meaningful. The estimates suggest it would take more than 250 minutes of weekly PE to reduce math achievement by even one point.

Similar to the evidence on body weight, the prior literature suggests the effects of PE on achievement may also vary by gender. For instance, Carlson et al. (2008) find a positive relationship between increased PE time and test scores for girls, but no detectable effect for boys. We therefore estimate each model separately by gender. These results (shown in Tables 11 and 12), suggest that the effect of PE on achievement does not vary greatly across genders. We see a handful of statistically significant effects in the OLS models in the kindergarten and first-grade samples, but with both genders, these largely disappear in IV models. However, we do see evidence of a small statistically significant negative impact of PE on reading achievement for both genders in the second grade. The corresponding panel IV estimate, which is largely driven by the second grade sample, is also statistically significant. The IV estimates suggest an additional minute of weekly PE is associated with a drop in reading gains by about 0.021 to 0.023 for second grade males and females, respectively. The panel IV estimates are similar; -0.0018 for males and -0.0145 for females. These estimates suggest the effect of PE is very small. For both genders, these estimates suggest it would take a very large increase in weekly PE time to have a meaningful effect on reading achievement. For example, in order to decrease reading gains by a full standard deviation, these estimates imply it would take more than 400 minutes of weekly PE.

4.3 Other Measures of Physical Activity

The results presented above suggest weekly PE has little effect on body weight or achievement outcomes. As discussed above, one explanation for these results is that little time in PE actually involves the type of vigorous activity needed to affect these outcomes. In this section, we explore whether other forms of physical activity impact child body weight and achievement; we include both weekly recess time and the number of days per week a child engages in more than 20 minutes of exercise as additional regressors. This change in model specification both allows us to condition weekly PE time on additional sources of physical activity and to also directly explore whether these other sources of physical activity affect body weight and achievement. We present results for each outcome and estimation method for the panel model, which pools the kindergarten through third grade samples. These results are shown in Table 13. Similar to our main results, the point estimates on PE in these models suggest PE has essentially no impact on body weight or achievement outcomes. A handful of estimates are statistically different from zero, but are not economically meaningful.

Turning to the other measures of physical activity, similar to PE, we find recess time neither helps nor hinders student body weight or achievement. Across all model specifications, not one point estimate on recess time is statistically different from zero at conventional levels and the magnitude of the coefficients is very small. These results are consistent with those reported by Dills et al. (2011), which also examines the effects of recess on achievement finding no effect on the earlier ECLS-K cohort. The point estimates on the days per week engaged in 20 minutes of vigorous exercise is negative and statistically significant in almost all models for each body weight outcome; in each case it suggests daily exercise has a small effect on body weight. The point estimates on BMI range from -0.01898 in the individual fixed effect model to -0.07915

in the IV model. These estimates suggest an additional day per week engaging in exercising of more than 20 minutes reduces BMI by between 0.02 and 0.08. When we look closer at the top of the weight distribution, we see an additional day spent exercising also reduces the likelihood a child is obese and overweight by a small amount. The IV point estimate suggests an additional day reduces the likelihood a student is obese by about one percentage point; the point estimate on overweight is similar.

[INSERT: RESULTS BY GRADE LEVEL; RESULTS BY GENDER]

5. Conclusion

In this paper, we provide the first post-NCLB estimates of the impact of PE on child body weight and achievement. Despite increased accountability pressures imposed by the legislation, we find little evidence that PE time was reduced in response to the law; we actually find a small increase in mean weekly PE time across the two ECLS-K cohorts. We also find evidence to suggest schools may have reduced recess time for kindergartners. The reduction in recess time is consistent with the assertion that state regulations on PE are more strict than on recess.

Consistent with earlier findings using the original ECLS-K cohort, our results suggests weekly PE time has little effect on the average child's body weight over the span from kindergarten to third grade. These findings suggest PE programs may not be providing the type of vigorous physical activity that is needed to have a meaningful impact on student body weight outcomes. When we separate the sample by gender, we find evidence to suggest increased PE time might actually even increase the likelihood girls are overweight or obese in kindergarten. This result is consistent with Cawley et al.'s (2013) finding that PE time is a substitute for girls. In this case, the lack of vigorous activity in PE is particularly worrisome. If young girls (or their

parents) are reducing out of school physical activity in response to increased PE time in school and there is little physical activity time in PE at school, providing additional PE time would have the opposite effect for which it is intended. Our achievement results suggest PE does not have a meaningful impact. This results suggests PE does little to boost cognitive functioning, but it also suggests that PE does not negatively affect student achievement. This finding is reassuring for schools concerned that PE time takes time away from core subjects and therefore comes at the expense of student learning.

This study opens up several unanswered questions that are deserving of further attention. First, our results imply more attention should be paid to how time is spent in PE class. We are unfortunately unable to observe how much physical activity occurs within a given PE class in our data. Research that is able to address how physical activity in PE relates to these outcomes would be helpful. Second, prior research, and to some extent our results, suggest that effects of PE on child outcomes differ as children progress through elementary school. The positive relationship between PE and the likelihood of obesity and overweight outcomes for girls in our analysis is primarily concentrated in the kindergarten sample, whereas the statistically significant effects on achievement effects are found in older age groups. Cawley et al. (2013)'s effects are also concentrated on 5th graders. This study would benefit from the inclusion of the two upper elementary grades in order to test whether PE becomes more important in the higher grades. Unfortunately, data for the 4th and 5th grade ECLS-K: 2011 samples are not currently available. Finally, our study examines only the effect of total time spent in PE per week on these outcomes. It does not address whether the timing of PE matters. Theory suggests the timing of breaks for PE may be particularly important for achievement outcomes. In related work, we find evidence to suggest the timing of PE does matter. In a study of middle-school students in a large urban

school district, we find PE has a negative effect on student learning when the break occurs in the morning but boosts achievement when it comes later in the day (Bednar and Rouse, 2018).

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Table 1. Weekly PE Minutes by Grade

	Kindergarten	First	Second	Third
A. Analysis Samples				
ECLS-K: 2011				
Preferred Measure[a]	109.8	102.6	96.4	83.3
	(81.8)	(74.5)	(72.0)	(66.4)
Adjusted to Cawley[b]	147.6	136.2	178.1	128.4
	(100.9)	(92.7)	(124.4)	(88.5)
Adjusted to Dills[c]	110.3	102.5	97.5	96.7
	(82.1)	(74.6)	(72.6)	(70.9)
Number of Observations	6400	7690	6810	6410
ECLS-K				
Cawley et al. (2013)	76.3	86.7	N/A	90.4
	(64.4)	(60.0)	N/A	(61.9)
Dills et al. (2011)	68.1	66.7	N/A	68.8
	(48.8)	(43.4)	N/A	(45.0)
B. Full Samples				
ECLS-K: 2011				
Preferred Measure[a]	97.8	100.0	95.4	82.3
	(80.1)	(72.1)	(70.5)	(65.6)
Adjusted to Cawley[b]	133.0	132.3	174.7	126.8
	(98.6)	(89.7)	(121.2)	(86.2)
Adjusted to Dills[c]	98.3	99.4	96.0	95.5
	(79.9)	(72.3)	(70.8)	(69.0)
Number of Observations	15950	13200	12210	11710
ECLS-K				
Preferred Measure	51.7	55.9	N/A	59.9
	(45.3)	(42.9)		(45.1)
Comparable to Cawley et al. (2013)	82.2	87.3	N/A	91.0
	(61.9)	(57.4)		(59.5)
Comparable to Dills et al. (2011)	61.8	66.2	N/A	69.1
	(47.8)	(44.0)		(45.4)
Number of Observations	16840	13890		11030

Notes:

a. Calculated using mid-points of days per week and daily PE time ranges. Daily PE time is top-coded at 75 minutes.

b. Calculated using mid-point of the days per week ranges used in the original ECLS-K cohort and maximum daily PE time of the range. Daily PE time is top-coded at 90 minutes.

c. Calculated using mid-point of the days per week ranges used in the original ECLS-K cohort and mid-point of daily PE time range in ECLS-K:2011. Daily PE time is top-coded at 75 minutes.

d. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.

Table 2. Other Measures of Physical Activity by Grade

	Kindergarten	First	Second	Third
A. Weekly Recess (minutes)[a]				
ECLS-K: 2011				
Analysis Sample	120.0	113.7	107.0	107.8
	(64.7)	(61.9)	(61.3)	(61.0)
Number of Observations	6,360	7,600	6,750	6,320
Full Sample	107.1	115.7	109.3	108.9
	(71.0)	(63.7)	(62.8)	(62.5)
Number of Observations	16,030	13,320	12,400	11,810
ECLS-K				
Dills et al. (2011)	133.4	122.6	N/A	119.1
	(57.1)	(63.3)	N/A	(58.5)
Full Sample	131.11	112.35		108.29
	(56.5)	(66.3)		(64.8)
B. Days per Week Child Exercises More than 20 Minutes				
ECLS-K: 2011				
Analysis Sample	4.665	4.597	4.617	4.399
	(2.363)	(2.258)	(2.177)	(2.165)
Number of Observations	6,100	7,320	6,550	6,090
Full Sample	4.623	4.599	4.594	4.377
	(2.364)	(2.252)	(2.195)	(2.199)
Number of Observations	12,890	12,280	11,530	10,470

Notes:

a. Calculated using mid-points of daily recess time ranges.

b. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.

Table 3. Mean Body Weight Outcomes by Grade

	Kindergarten	First	Second	Third
A. ECLS-K: 2011				
BMI	16.677	17.105	17.768	18.593
	(9.600)	(3.021)	(3.520)	(3.991)
Obese	0.140	0.156	0.175	0.190
	(0.347)	(0.363)	(0.380)	(0.393)
Overweight	0.307	0.308	0.314	0.346
	(0.461)	(0.462)	(0.464)	(0.476)
Number of Observations	6400	7690	6810	6410
B. ECLS-K (Cawley et al. 2013)				
Obese	0.118	0.137	N/A	0.189
	(0.323)	(0.343)		(0.392)
Overweight	0.261	0.275	N/A	0.347
	(0.439)	(0.446)		(0.476)

Notes:

a. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.

Table 4. Mean Achievement Outcomes by Grade

	Kindergarten	First	Second	Third
Reading Achievement	60.838	83.553	95.659	111.011
	(13.487)	(15.692)	(12.434)	(12.364)
Math Achievement	44.753	66.240	80.648	98.922
	(12.192)	(15.439)	(14.029)	(14.128)
Reading Growth	14.769	23.183	11.681	13.908
	(7.992)	(9.516)	(7.933)	(6.552)
Math Growth	13.901	21.981	14.037	16.717
	(7.172)	(8.642)	(7.994)	(6.737)
Number of observations	6390	7680	6800	6390

a. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.

Table 5. CLASS PE Regulation Data by Year

	2010	2012	2013
States without a mandate	1	1	1
States with a mandate with less than 60 min per week or no time requirement	35	34	35
States with a mandate of 60-90 min per week	3	3	3
States with a mandate of 90-150 min per week	7	7	7
States with mandate of 150 min per week	5	6	5
State requires recess	4	4	4
Total	51	51	51

Source: https://class.cancer.gov/download.aspx

Table 6. Weekly PE Time by State PE Regulation and Grade

	Kindergarten	First	Second	Third
State Requires 60+ Minutes				
Mean Weekly PE time	127.104	119.311	110.638	95.620
	(72.299)	(82.190)	(79.076)	(73.144)
Number of observations	2840	3540	3490	3170
% of Analysis sample	44.3%	46.0%	51.2%	49.5%
State Does not Require 60+ Minutes				
Mean Weekly PE time	95.940	88.318	81.369	71.209
	(89.355)	(63.937)	(60.075)	(56.562)
Number of observations	3570	4150	3320	3230
% of Analysis sample	55.7%	54.0%	48.8%	50.5%

Notes:

a. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.

Table 7. Effects of Weekly PE Time on Child Body Weight

	Overall	Kindergarten	First	Second	Third
	(1)	(2)	(3)	(4)	(5)
A. BMI					
OLS	0.000052	0.000943 **	0.000283	-0.000482	-0.000322
	(0.0003)	(0.0004)	(0.0005)	(0.0007)	(0.0008)
OLS with State FE	0.000038	0.000881 **	0.000051	-0.000430	-0.000013
	(0.0003)	(0.0004)	(0.0005)	(0.0007)	(0.0009)
Instrumental Variables	0.002111	0.002926	0.003874	0.002300	0.005642
	(0.0028)	(0.0034)	(0.0027)	(0.0030)	(0.0045)
Individual FE	-0.000480 ***				
	(0.0002)				
B. Obese					
OLS	0.000011	0.000091	0.000003	-0.000017	-0.000003
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
OLS with State FE	0.000017	0.000099 *	-0.000010	-0.000020	0.000024
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Instrumental Variables	0.000363	0.000557	0.000479	0.000376	0.000549
	(0.0003)	(0.0005)	(0.0003)	(0.0003)	(0.0004)
Individual FE	-0.000060 **				
	(0.0000)				
C. Overweight					
OLS	-0.000008	0.000119	0.000017	-0.000077	-0.000045
	(0.0003)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
OLS with State FE	-0.000010	0.000084	0.000009	-0.000061	-0.000043
	(0.0003)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Instrumental Variables	0.000558	0.001672 **	0.000753 *	0.000036	0.000699
	(0.0028)	(0.0007)	(0.0004)	(0.0004)	(0.0005)
Individual FE	-0.000011				
	0.0000				
D. IV first stage					
State requires 60+ minutes of weekly PE	29.509 ***	24.897 ***	33.747 ***	32.906 ***	28.212 ***
	(3.618)	(6.627)	(5.104)	(4.594)	(4.300)
F-statistic	66.009	14.222	43.375	51.525	40.885
Number of Observations	27730	6400	7690	6810	6410

Notes:

a. Standard errors (clustered at school level) in parentheses. ***, ** and * denote statistical significance at the 1, 5, and 10 percent level, respectively.

b. All estimations include controls for student age, race, gender, socioeconomic status, mother's education, mother's education missing, parents live in the home, number of siblings in home, class size, school enrollment, teacher tenure, school urbanicity, percent minority, number of days between the administrations of the two tests used to construct each achievement measure, real per-capita income, percent of the state population with a bachelor's degree or higher, total state revenues per student, real total state expenditures per student, average student-to-teacher ratio, the percent of the state adult population that is overweight and the percent of the state's child population that is overweight. Panel estimates also include grade level fixed effects.

c. Instruments include two dummy variables indicating whether a state requires 60+ minutes of weekly PE.

d. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.

Table 8. Effects of Weekly PE Time on Child Body Weight: Males

	Overall	Kindergarten	First	Second	Third
	(1)	(2)	(3)	(4)	(5)
A. BMI					
OLS	-0.000052	0.000528	-0.000583	0.000665	-0.000158
	(0.0005)	(0.0005)	(0.0007)	(0.0009)	(0.0011)
OLS with State FE	-0.000079	0.000561	-0.000825	0.000725	0.000057
	(0.0005)	(0.0006)	(0.0007)	(0.0009)	(0.0012)
Instrumental Variables	0.002866	-0.001057	0.001644	0.005934	0.005286
	(0.0039)	(0.0048)	(0.0039)	(0.0042)	(0.0057)
Individual FE	-0.000531 **				
	(0.0002)				
B. Obese					
OLS	-0.000031	-0.000012	-0.000124	0.000041	0.000055
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
OLS with State FE	-0.000012	0.000007	-0.000129	0.000056	0.000126
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Instrumental Variables	0.000183	-0.000560	-0.000066	0.000414	0.000309
	(0.0004)	(0.0007)	(0.0005)	(0.0005)	(0.0006)
Individual FE	-0.000073 **				
	(0.0000)				
C. Overweight					
OLS	-0.000030	0.000029	-0.000102	0.000044	0.000018
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
OLS with State FE	-0.000022	0.000020	-0.000098	0.000059	0.000008
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Instrumental Variables	0.000339	0.000219	0.000298	0.000407	0.000508
	(0.0005)	(0.0009)	(0.0006)	(0.0006)	(0.0007)
Individual FE	-0.000031				
	(0.0000)				
D. IV first stage					
State requires 60+ minutes of weekly PE	28.744 ***	25.234 ***	33.230 ***	31.377 ***	28.905 ***
	(3.788)	7.135	5.377	4.898	4.428
F-Statistic	56.996	12.454	37.715	41.382	41.320
Number of Observations	14220	3300	3890	3480	3290

Notes:

a. Standard errors (clustered at school level) in parentheses. ***, ** and * denote statistical significance at the 1, 5, and 10 percent level, respectively.

b. All estimations include controls for student age, race, gender, socioeconomic status, mother's education, mother's education missing, parents live in the home, number of siblings in home, class size, school enrollment, teacher tenure, school urbanicity, percent minority, number of days between the administrations of the two tests used to construct each achievement measure, real per-capita income, percent of the state population with a bachelor's degree or higher, total state revenues per student, real total state expenditures per student, average student-to-teacher ratio, the percent of the state adult population that is overweight and the percent of the state's child population that is overweight. Panel estimates also include grade level fixed effects.

c. Instruments include two dummy variables indicating whether a state requires 60+ minutes of weekly PE.

d. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.

Table 9. Effects of Weekly PE Time on Child Body Weight: Females

	Overall	Kindergarten	First	Second	Third
	(1)	(2)	(3)	(4)	(5)
A. BMI					
OLS	0.000137	0.001373 **	0.001035	-0.001605 *	-0.000368
	(0.0005)	(0.0006)	(0.0007)	(0.0009)	(0.0011)
OLS with State FE	0.000171	0.001256 **	0.000803	-0.001383	0.000024
	(0.0005)	(0.0006)	(0.0007)	(0.0010)	(0.0012)
Instrumental Variables	0.001386	0.006848	0.005563	-0.001181	0.006114
	(0.0039)	(0.0049)	(0.0038)	(0.0041)	(0.0065)
Individual FE	-0.000435 *				
	(0.0002)				
B. Obese					
OLS	0.000051	0.000194 **	0.000110	-0.000078	-0.000050
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
OLS with State FE	0.000045	0.000191 **	0.000089	-0.000083	-0.000068
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Instrumental Variables	0.000525	0.001785 **	0.000947 **	0.000300	0.000779
	(0.0004)	(0.0008)	(0.0005)	(0.0005)	(0.0006)
Individual FE	-0.000046				
	(0.0000)				
C. Overweight					
OLS	0.000008	0.000217 **	0.000110	-0.000194 *	-0.000107
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
OLS with State FE	-0.000001	0.000166	0.000086	-0.000160	-0.000102
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Instrumental Variables	0.000746	0.003267 ***	0.001134 *	-0.000348	0.000913
	(0.0005)	(0.0011)	(0.0006)	(0.0005)	(0.0008)
Individual FE	0.000011				
	(0.0000)				
D. IV first stage					
State requires 60+ minutes of weekly PE	29.967 ***	24.510 ***	33.964 ***	34.326 ***	27.233 ***
	(3.812)	(7.0057)	(5.440)	(4.976)	(4.915)
F-Statistic	61.483	12.483	38.920	47.737	28.489
Number of Observations	13510	3100	3790	3330	3110

Notes:

a. Standard errors (clustered at school level) in parentheses. ***, ** and * denote statistical significance at the 1, 5, and 10 percent level, respectively.

b. All estimations include controls for student age, race, gender, socioeconomic status, mother's education, mother's education missing, parents live in the home, number of siblings in home, class size, school enrollment, teacher tenure, school urbanicity, percent minority, number of days between the administrations of the two tests used to construct each achievement measure, real per-capita income, percent of the state population with a bachelor's degree or higher, total state revenues per student, real total state expenditures per student, average student-to-teacher ratio, the percent of the state adult population that is overweight and the percent of the state's child population that is overweight. Panel estimates also include grade level fixed effects.

c. Instruments include two dummy variables indicating whether a state requires 60+ minutes of weekly PE.

d. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.

Table 10. Effects of Weekly PE Time on Child Achievement

	Overall	Kindergarten	First	Second	Third
	(1)	(2)	(3)	(4)	(5)
A. Reading Growth					
OLS	-0.001705 *	-0.0046 **	-0.0022	0.0012	0.0003
	(0.0009)	(0.0018)	(0.0019)	(0.0016)	(0.0013)
OLS with State FE	-0.000977	-0.0024	-0.0026	0.0016	0.0008
	(0.0009)	(0.0019)	(0.0018)	(0.0016)	(0.0014)
Instrumental Variables	-0.016398 ***	-0.0065	-0.0067	-0.0220 ***	-0.0081
	(0.0058)	(0.0153)	(0.0118)	(0.0084)	(0.0072)
Individual FE	-0.001708				
	(0.0013)				
B. Math Growth					
OLS	-0.001187	-0.0011	-0.0055 ***	-0.0006	0.0003
	(0.0008)	(0.0015)	(0.0016)	(0.0016)	(0.0013)
OLS with State FE	-0.000655	-0.0006	-0.0040 **	-0.0007	0.0008
	(0.0008)	(0.0015)	(0.0016)	(0.0016)	(0.0014)
Instrumental Variables	-0.011529 **	-0.0038	-0.0050	-0.0126	-0.0081
	(0.0055)	(0.0129)	(0.0097)	(0.0087)	(0.0072)
Individual FE	-0.001278				
	(0.0012)				
C. IV first stage					
Reading:					
State requires 60+ minutes of weekly PE	29.509 ***	24.730 ***	33.809 ***	32.901 ***	28.219 ***
	(3.618)	(6.632)	(5.107)	(4.597)	(4.308)
F-Statistic	66.575	13.902	43.828	51.228	42.911
Math:					
State requires 60+ minutes of weekly PE	29.509 ***	24.758 ***	33.803 ***	32.943 ***	28.219 ***
	(3.618)	(6.648)	(5.116)	(4.597)	(4.308)
F-Statistic	66.656	13.868	43.652	51.346	42.911
Number of Observations: Reading	27590	6360	7700	6840	6460
Number of Observations: Math	27550	6340	7680	6830	6460

Notes:

a. Standard errors (clustered at school level) in parentheses. ***, ** and * denote statistical significance at the 1, 5, and 10 percent level, respectively.

b. All estimations include controls for student age, race, gender, socioeconomic status, mother's education, mother's education missing, parents live in the home, number of siblings in home, class size, school enrollment, teacher tenure, school urbanicity, percent minority, number of days between the administrations of the two tests used to construct each achievement measure, real per-capita income, percent of the state population with a bachelor's degree or higher, total state revenues per student, real total state expenditures per student, average student-to-teacher ratio, the percent of the state adult population that is overweight and the percent of the state's child population that is overweight. Panel estimates also include grade level fixed effects.

c. Instruments include two dummy variables indicating whether a state requires 60+ minutes of weekly PE.

d. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.

Table 11. Effects of Weekly PE Time on Child Achievement: Males

	Overall	Kindergarten	First	Second	Third
	(1)	(2)	(3)	(4)	(5)
A. Reading Growth					
OLS	-0.0013 ***	-0.0057 ***	-0.0016	0.0017	0.0004
	(0.0005)	(0.0020)	(0.0024)	(0.0022)	(0.0020)
OLS with State FE	-0.0007	-0.0034 *	-0.0026	0.0017	0.0020
	(0.0005)	(0.0020)	(0.0024)	(0.0022)	(0.0021)
Instrumental Variables	-0.0181 ***	0.0022	0.0024	-0.0207 *	-0.0184 *
	(0.0039)	(0.0180)	(0.0154)	(0.0120)	(0.0100)
Individual FE	-0.0018 ***				
	(0.0002)				
B. Math Growth					
OLS	-0.0010	-0.0019	-0.0081 ***	0.0033	0.0004
	(0.0010)	(0.0017)	(0.0021)	(0.0022)	(0.0020)
OLS with State FE	-0.0003	-0.0010	-0.0064 ***	0.0033	0.0020
	(0.0011)	(0.0018)	(0.0023)	(0.0022)	(0.0021)
Instrumental Variables	-0.0121 *	-0.0060	-0.0169	-0.0091	-0.0184 *
	(0.0068)	(0.0153)	(0.0130)	(0.0119)	(0.0100)
Individual FE	-0.0017				
	(0.0016)				
C. IV first stage					
Reading:					
State requires 60+ minutes of weekly PE	28.744 ***	25.066 ***	33.278 ***	31.352 ***	28.926 ***
	(3.788)	(7.139)	(5.385)	(4.905)	(4.445)
F-Statistic	57.523	12.327	38.187	40.856	42.344
Math:					
State requires 60+ minutes of weekly PE	28.744 ***	24.975 ***	33.264 ***	31.394 ***	28.926 ***
	(3.788)	(7.156)	(5.403)	(4.906)	(4.445)
F-Statistic	57.665	12.181	37.901	40.955	42.344
Number of Observations: Reading	14130	3280	3900	3490	3310
Number of Observations: Math	14100	3260	3880	3490	3310

Notes:

a. Standard errors (clustered at school level) in parentheses. ***, ** and * denote statistical significance at the 1, 5, and 10 percent level, respectively.

b. All estimations include controls for student age, race, gender, socioeconomic status, mother's education, mother's education missing, parents live in the home, number of siblings in home, class size, school enrollment, teacher tenure, school urbanicity, percent minority, number of days between the administrations of the two tests used to construct each achievement measure, real per-capita income, percent of the state population with a bachelor's degree or higher, total state revenues per student, real total state expenditures per student, average student-to-teacher ratio, the percent of the state adult population that is overweight and the percent of the state's child population that is overweight. Panel estimates also include grade level fixed effects.

c. Instruments include two dummy variables indicating whether a state requires 60+ minutes of weekly PE.

d. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.

Table 12. Effects of Weekly PE Time on Child Achievement: Females

	Overall	Kindergarten	First	Second	Third
	(1)	(2)	(3)	(4)	(5)
A. Reading Growth					
OLS	-0.0020 *	-0.0036	-0.0028	0.0008	0.0001
	(0.0012)	(0.0025)	(0.0023)	(0.0021)	(0.0019)
OLS with State FE	-0.0012	-0.0016	-0.0026	0.0016	-0.0002
	(0.0012)	(0.0026)	(0.0024)	(0.0022)	(0.0020)
Instrumental Variables	-0.0145 **	-0.0174	-0.0166	-0.0235 **	0.0044
	(0.0070)	(0.0196)	(0.0136)	(0.0102)	(0.0101)
Individual FE	-0.0017				
	(0.0018)				
B. Math Growth					
OLS	-0.0012	-0.0002	-0.0028	-0.0048 **	0.0001
	(0.0010)	(0.0021)	(0.0019)	(0.0022)	(0.0019)
OLS with State FE	-0.0008	-0.0001	-0.0016	-0.0051 **	-0.0002
	(0.0011)	(0.0021)	(0.0020)	(0.0023)	(0.0020)
Instrumental Variables	-0.0109	-0.0007	0.0075	-0.0155	0.0044
	(0.0068)	(0.0160)	(0.0112)	(0.0104)	(0.0101)
Individual FE	-0.0008				
	(0.0015)				
C. IV first stage					
Reading:					
State requires 60+ minutes of weekly PE	29.967 ***	24.268 ***	33.989 ***	34.321 ***	27.241 ***
	(3.812)	(7.005)	(5.440)	(4.976)	(4.914)
F-Statistic	61.953	12.002	39.035	47.577	30.737
Math:					
State requires 60+ minutes of weekly PE	29.967 ***	24.467 ***	33.979 ***	34.360 ***	27.241 ***
	(3.812)	(7.026)	(5.441)	(4.975)	(4.914)
F-Statistic	62.055	12.127	38.996	47.706	30.737
Number of Observations: Reading	13460	3080	3800	3340	3150
Number of Observations: Math	13450	3080	3800	3340	3150

Notes:

a. Standard errors (clustered at school level) in parentheses. ***, ** and * denote statistical significance at the 1, 5, and 10 percent level, respectively.

b. All estimations include controls for student age, race, gender, socioeconomic status, mother's education, mother's education missing, parents live in the home, number of siblings in home, class size, school enrollment, teacher tenure, school urbanicity, percent minority, number of days between the administrations of the two tests used to construct each achievement measure, real per-capita income, percent of the state population with a bachelor's degree or higher, total state revenues per student, real total state expenditures per student, average student-to-teacher ratio, the percent of the state adult population that is overweight and the percent of the state's child population that is overweight. Panel estimates also include grade level fixed effects.

c. Instruments include two dummy variables indicating whether a state requires 60+ minutes of weekly PE.

d. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.

Table 13. Effects of Weekly PE, Recess, and Exercise Time on Child Body Weight and Achievement

	Body Weight			Achievement	
	BMI	Obese	Overweight	Reading	Math
	(1)	(2)	(3)	(4)	(5)
A. OLS					
PE	0.00005	0.00001	0.00000	-0.00177 *	-0.00136 *
	(0.00034)	(0.00004)	(0.00005)	(0.00093)	(0.00079)
Recess	-0.00026	0.00000	-0.00002	0.00041	0.00035
	(0.00046)	(0.00005)	(0.00006)	(0.00113)	(0.00108)
20 minutes of exercise	-0.05804 ***	-0.00737 ***	-0.00738 ***	0.02586	0.02501
	(0.01167)	(0.00129)	(0.00160)	(0.02185)	(0.02093)
B. OLS with State FE					
PE	0.00003	0.00002	0.00000	-0.00102	-0.00085
	(0.00033)	(0.00004)	(0.00005)	(0.00097)	(0.00083)
Recess	-0.00016	0.00003	0.00001	-0.00034	-0.00018
	(0.00044)	(0.00005)	(0.00006)	(0.00122)	(0.00121)
20 minutes of exercise	-0.05843 ***	-0.00740 ***	-0.00747 ***	0.02390	0.02323
	(0.01167)	(0.00130)	(0.00160)	(0.02186)	(0.02104)
C. Instrumental Variables [a]					
PE	0.00828	0.00157	0.00179	-0.01008	-0.02324 *
	(0.00749)	(0.00098)	(0.00114)	(0.01337)	(0.01410)
Recess	0.01426	0.00274	0.00290	0.01723	-0.02547
	(0.01342)	(0.00170)	(0.00204)	(0.02288)	(0.02449)
20 minutes of exercise	-0.07915 ***	-0.00986 ***	-0.01020 ***	0.03192	0.06150 **
	(0.01620)	(0.00196)	(0.00235)	(0.02954)	(0.03038)
D. Individual FE					
PE	-0.00053 ***	-0.00007 ***	-0.00001	-0.00122	-0.00155
	(0.00017)	(0.00002)	(0.00003)	(0.00141)	(0.00123)
Recess	-0.00043	0.00005	-0.00002	-0.00212	0.00034
	(0.00022)	(0.00003)	(0.00004)	(0.00179)	(0.00182)
20 minutes of exercise	-0.01898 ***	-0.00109	-0.00075	-0.02048	-0.01743
	(0.00562)	(0.00085)	(0.00102)	(0.03869)	(0.03820)
Number of Observations[b]	26190	26190	26190	26060	26030

a. Standard errors (clustered at school level) in parentheses. ***, ** and * denote statistical significance at the 1, 5, and 10 percent level, respectively.

b. All estimations include controls for student age, race, gender, socioeconomic status, mother's education, mother's education missing, parents live in the home, number of siblings in home, class size, school enrollment, teacher tenure, school urbanicity, percent minority, number of days between the administrations of the two tests used to construct each achievement measure, real per-capita income, percent of the state population with a bachelor's degree or higher, total state revenues per student, real total state expenditures per student, average student-to-teacher ratio, the percent of the state adult population that is overweight and the percent of the state's child population that is overweight. Panel estimates also include grade level fixed effects.

c. Instruments include two dummy variables indicating whether a state requires 60+ minutes of weekly PE and/or weekly recess.

d. Observations rounded to the nearest 10 following ECLS-K:2011 restricted data guidelines.