PHYSICAL ACTIVITY PARTICIPATION IN KINDERGARTEN AND CHILDREN'S COGNITIVE AND ACADEMIC ABILITY

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ABSTRACT

CHRISTOPHER J. WRETMAN: Physical Activity Participation in Kindergarten and Children's Cognitive and Academic Ability
(Under the direction of Dr. Michael C. Lambert)

Promoting physical activity (PA) among children is a key research area of interest. Recently, there has been a desire to expand research linking PA and positive child development to two specific areas. First, there is a need to translate the longstanding and evidence-based findings for PA among adolescents to younger populations of children including those in the kindergarten years (ages 4 to 6). Second, there is a need to apply a social justice perspective to the PA disparities found among underserved children to develop nuanced evidence regarding how PA behaviors and outcomes may vary across sub-groups of children. This dissertation aligns itself with these recent PA research efforts. Specifically, it seeks to further evidence regarding how PA participation manifests among children in the kindergarten years, with particular foci on (a) its potential to increase cognitive and academic outcomes and (b) its varying effects for different children. As such, this dissertation exists at the intersection of social work, public health, and education. The first analysis is an examination of PA behaviors across 10 different sub-types with a secondary focus on what demographic characteristics may be associated with participation in each form. The second analysis is an examination of whether schools' provision of PA in the form of physical education and recess is associated with students' cognitive and academic ability. Finally, the third analysis is a meditational examination of whether parent's enrollment of their children in organized PA is associated with cognitive and academic ability.

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INTRODUCTION

PHYSICAL ACTIVITY PARTICIPATION IN KINDERGARTEN AND CHILDREN'S COGNITIVE AND ACADEMIC ABILITY

Physical Activity and Early Child Development

Physical activity (PA) is increasingly viewed as a core component of early child development. Placed within an ecological context, PA can be conceptualized as both ameliorating deleterious outcomes (e.g., obesity) that can threaten young children's short- and long-term well-being, and as promoting advantageous outcomes (e.g., health) that can strengthen pathways to success. As such, promoting PA among all children, including those at very young ages, is now a key public health concern that has unanimous support from researchers, policymakers, community leaders, parents, and other stakeholders (U.S. Department of Health and Human Services [USDHHS], 2008).

Typically, PA is defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen, Powell, & Christenson, 1985, p. 126). A more recent definition from the U.S. Department of Health and Human Services (USDHHS) takes an even broader approach, defining PA as simply "movement that enhances health" (2008, p. 2). Within the range of PA, it is often necessary to distinguish among varying manifestations with a particularly important characteristic being intensity of effort (WHO, 2010). A commonly used relative intensity scale for PA expenditure categorizes PA in terms of each individual's level of comfort and/or capacity (USDHHS, 2008). In this conceptualization, *moderate physical activity* (MPA) comprises a level that is a 5 or 6 on a relative scale of 0–10 where 0 equals sitting and 10 equals the highest possible level of effort (USDHHS, 2008; WHO, 2010). Children doing MPA should experience an elevated heart rate and breathing that is harder than normal. Common examples of MPA for children include brisk walking, hiking, skateboarding, bicycle riding, team sports, and others (USDHHS, 2008). *Vigorous physical activity* (VPA) equates to a 7 or 8 on relative scale of 0–10 (WHO, 2010). Children engaging in VPA should experience a much more elevated heart rate and noticeably heavier breathing. Examples include running, martial arts, team sports, skiing, and dancing. PA that encompasses moderate and vigorous levels is collectively referred to as *moderate-to-vigorous physical activity* (MVPA) and is, in fact, the de facto baseline level used to measure and compare children's PA in many research studies, measurements, and guidelines.

The promulgation PA research has, in turn, engendered the development of evidence-based policy statements designed to guide intervention research to increase young children's PA levels. Overall, the bulk of evidence suggests that PA at the level of MVPA and above is likely to be particularly beneficial for children's developmental outcomes and should be promoted "whenever possible" (USDHHS, 2008, p. 19). Experts in the United States and globally have recently developed several distinct but mostly congruent standards for kindergarten children's PA. These guidelines typically comprise two distinct mandates. First, children in the kindergarten years should engage in approximately 180 minutes/day of total PA through the age of 6. Total PA includes all ranges from light PA (e.g., slow walking) to VPA. Second, beginning at around ages 5 (standards vary) young children should also accumulate 60 minutes/day specifically devoted to MVPA (USDHHS, 2008; Institute of Medicine, 2011; Pate et al., 2015; Tremblay, Boudreau-Larivière, & Cimon-Lambert, 2012).

Hand-in-hand with research efforts to increase PA are efforts that seek to understand the multifaceted ways in which PA can promote development. Overall, extant evidence has found that the benefits of accumulating regular PA such as that recommended above can be substantial. Research using rigorous experimental designs has consistently found that increases in PA are positively associated with increases to a variety of short- and long-term outcomes across the spectrum of ecological factors (Penedo & Dahn, 2005; Warburton, Nicol, & Bredin, 2006). These factors include neuroelectric activity and executive functioning (e.g., Chang, Tsai, Chen, & Hung, 2013; Hillman, Erickson, & Kramer, 2008), academic achievement (e.g., Rasberry et al., 2011), psychological functioning, well-being, and self-worth (e.g., Biddle & Asare, 2011; Janssen & LeBlanc, 2010; Strong et al., 2005), social skills and social bonds (e.g., Dworkin, Larson, & Hansen, 2003; Melnyk et al., 2013), and others.

These beneficial outcomes have been primarily demonstrated for adolescents, but recent efforts have begun to extend the evidence base to younger children, particularly those in kindergarten (Carson et al., 2015; Lee, Burgeson, Fulton, & Spain, 2007; Tucker, 2008). There is an active area of research inquiry that seeks to develop evidence to promote cognitive and academic outcomes among young children in the kindergarten years. Current efforts have focused on identifying key predictor variables, causal mechanisms, and discrepancies of PA by sub-groups of children (e.g., McClelland et al., 2007; Welsh, Nix, Blair, Bierman, & Nelson, 2010). The promotion of PA in kindergarten is, in particular, a vital research concern due to the establishment of resources and processes at this developmental stage (Goldfield et al., 2012).

Physical Activity Research Frameworks

To date, approaches to young children's PA promotion have relied upon a general ecological framework to guide research. Broadly, PA can be modeled within a biodevelopmental framework acting as a system that promotes behavior, ability, and health (see Figure 1; Guralnick, 2011; Shonkoff, 2010). Children's PA exists simultaneously as a resource, an environment, and a relationship that, when present and promoting, can lead to positive proximal and distal outcomes related to a host of developmental outcomes via gene-environment interactions. Conversely, the absence of PA resources, supporting environments, and the relationships established therein can result in neglect and deficiency that serves as a barrier to children's well-being.

This systems perspective provides a useful starting point for why research should care about PA in early childhood. Namely, evidence shows that (a) early intervention is key to establishing positive long-term well-being (Guralnick, 2011; Shonkoff, 2010), and (b) early PA attainment can be an effective and efficient promoter of behaviors and outcomes (Pate et al., 2006). Additionally, conceptualizing PA as a development enhancing system has important practical implications. Relatively speaking, PA has an ease of use and participation in, is inexpensive in many manifestations, and requires few resources or can leverage existing ones. Moreover, and perhaps more importantly, PA is a known and universal entity that already exists within families and schools as a de facto intervention. In comparison with other, competing strategies to implement systems to promote early childhood development, PA can clearly be seen as having great utility and appeal for researchers and stakeholders alike.

What may be missing from this general systems perspective that links PA and well-being is specific theories to guide selection of research questions, variables, and analyses. In fact, beyond rooting PA within a general ecological systems framework, a great deal of PA research to date has been removed from more specific theories of change (Buchan, Ollis, Thomas, & Baker, 2012; Kohl et al., 2012). Although research has begun to develop evidence regarding broad levels of prevalence, correlates, outcomes, and other key facets of knowledge, the overall evidence base is still lacking in key information regarding specific contexts, distinctions, and implications that are vital to understanding behaviors and, in turn, guiding intervention and policy development.

Physical Activity and Social Justice

One specific focus in recent years has been that of approaching children's PA from a social justice perspective in order to inform research and intervention. Some researchers have begun to voice strong criticisms with the state of child PA promotion research and efforts with particular concerns being raised regarding how PA research to date may have overlooked the behaviors and outcomes for underserved children (Kumanyika, Whitt-Glover, & Haire-Joshu, 2014). This inattention is particularly striking given the strong evidence suggesting that significant PA disparities exist among children, with historically underserved and/or marginalized children being more likely to attain lower levels of PA compared with their privileged counterparts. Both female and racial/ethnic minority children have been consistently found to have lower PA prevalence rates compared with males and non-Whites. These disparities suggest systemic issues that prevent PA attainment for sub-groups of children. Overall, based on population estimates it can be estimated that millions of female and racial/ethnic minority children currently do not achieve sufficient levels PA, placing them at risk for serious short- and long-term health problems (U.S. Bureau of the Census, 2013).

Seen in this light, current PA research on children may lack attentiveness to the nuances experienced by underserved children and, in and of itself, constitutes an area of marginalization that may perpetuate disparities. Much of children's PA research and intervention activity, including that directed at very young children, has been characterized by (a) samples that are overwhelmingly White, or (b) analyses that have not tested differential treatment effects for sub-groups of children. In all, too little intervention research has specifically targeted PA among underserved children and, as a result, researchers lack a clear understanding of the PA patterns, behaviors, attitudes, and outcomes for these populations (Yancey, Ory, & Davis, 2006). Recent research has begun to address this knowledge gap by focusing on PA promotion among the underserved such as female, African American, and Hispanic/Latino children (e.g., Holub et al., 2014; Pate et al., 2005; Whitt-Glover & Kumanyika, 2009; Yancey et al., 2006).

It is important to place underserved children's PA behaviors, and the disparities found therein, within historical contexts (Kumanyika et al., 2014). Viewed in the context of the historical legacies of oppression, racial and ethnic minority children's PA in particular can be considered an issue of social justice. Beginning over three decades ago, health outcomes among minority populations became politicized under the umbrella of an *environmental justice* explanatory model (Brulle & Pellow, 2006; Taylor, Floyd, Whitt-Glover, & Brooks, 2007; Taylor, Poston, Jones, & Kraft, 2006). The environmental justice movement has been concerned with the "fair treatment and meaningful involvement" of all stakeholders in the "development, implementation, and enforcement" of laws and policies regarding key health outcomes (Taylor et al., 2006, p. S31). This approach holds that institutional injustice and inequality undergird the totality of health experiences and outcomes for underserved populations in the United States. Those advocating for health justice came to conceptualize key behaviors and outcomes such as those related to PA as being important components of historically underserved children's continued marginalized place in American society (Taylor et al., 2007; Taylor et al., 2006). Alleviation of health disparities through targeted research agendas and resultant macro-level policy initiatives, then, has come to signify a key step towards ameliorating injustices (Brulle & Pellow, 2006; Taylor et al., 2006).

Physical Activity Research Agenda

An overarching issue with the state of young children's PA research is the relative dearth of evidence accumulated to date. Although many PA interventions have produced statistically significant PA increases at posttest, few have been able to produce lasting changes in PA behaviors at follow-up or beyond (Dobbins et al., 2013). Also, many extant studies have featured small samples of questionable representativeness and/or featured other major limitations related to the application and interpretation of their statistical methods (Dobbins et al., 2013). Perhaps due to these issues, it appears that efforts to increase awareness of the substantial benefits of PA has not yet translated into measurable changes in children's behaviors (Pate et al., 2011). Recent surveillance data suggest that activity levels of most American children fall short of federal PA standards and that these shortcomings are regardless of age, biological sex, race/ethnicity, or other individual characteristic.

The following body of research is guided by two broad goals. First, the research seeks to add to the substantive body of evidence regarding kindergartener's PA behaviors and outcomes. There is a noted dearth of research regarding PA for this population. Adding evidence from a large, nationally representative sample and appropriate statistical analyses represents an important contribution to this area. Second, by bring a critical perspective grounded in social justice the evidence can be seen in an important light that brings added meaning to the development of early childhood PA interventions for underserved children in particular. This is particularly important for future work that is targeted at underserved children who are less likely to attain recommended PA and also have lower levels of well-being.

There are three overarching research questions that will be examined herein:

- What are the current rates of kindergarteners' PA participation in the United States?
- How does kindergarteners' PA participation influence their cognitive and academic ability?
- How do kindergarteners' PA behaviors and outcomes vary across sub-groups of children?

These three questions will be addressed over the course of three distinct yet interrelated papers. The first paper, entitled *Physical Activity Participation In Kindergarten: Results From The Early Childhood Longitudinal Study, Kindergarten Class Of 2010-11*, is comprised of a descriptive analysis of PA behaviors across PA sub-type and groups of children. The second paper, entitled *An Exploratory Multi-Level Examination Of The Influence Of School-Based Physical Education And Recess On Kindergarteners' Cognitive And Academic Ability*, is comprised of a multilevel analysis of whether school-based provision of PA is associated with increases to cognitive and academic ability. The third paper, entitled *Kindergarteners' Organized Athletics Participation And Reading And Mathematics Ability: A Structural Equation Modeling Analysis*, is comprised of a meditational analysis of whether organized athletics participation is associated with increases to cognitive and academic ability.

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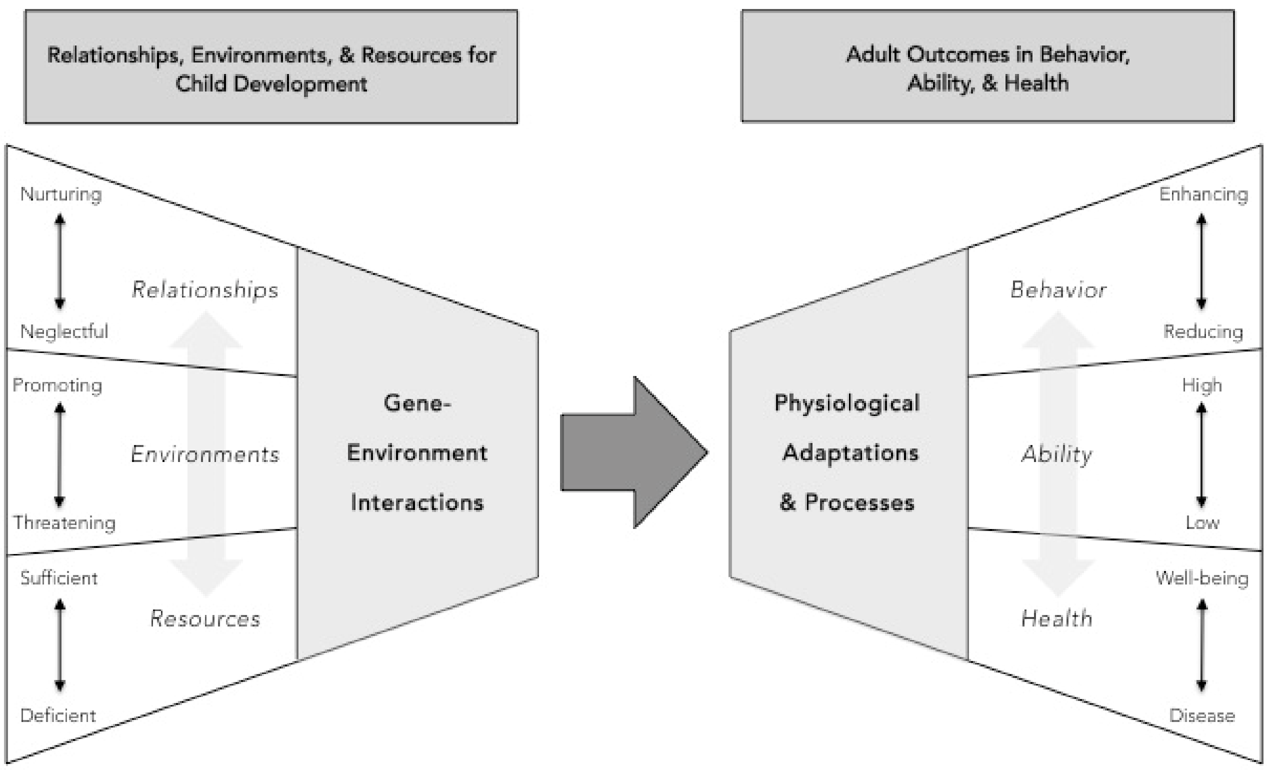
Figure 1
A Biodevelopmental Systems Framework for Understanding Child Health and Well-being



Note: Adapted from Guralnick (2011) and Shonkoff (2010).

PAPER I

PHYSICAL ACTIVITY PARTICIPATION IN KINDERGARTEN: RESULTS FROM THE EARLY CHILDHOOD LONGITUDINAL STUDY, KINDERGARTEN CLASS OF 2010-11

Physical Activity in Kindergarten

Increases in physical activity (PA) are positively associated with subsequent increases to short- and long-term outcomes related to lifelong health and well-being (Penedo & Dahn, 2005; Warburton, Nicol, & Bredin, 2006; World Health Organization [WHO], 2010). PA has consistently been found to provide positive benefits to adults and adolescents, but recent research is extending these findings to very young children (Carson et al., 2015; Lee et al., 2007; Tucker, 2008). PA participation in the early ages can ameliorate proximal outcomes related to cholesterol, blood pressure, body weight, and others that are, in turn, linked to distal health issues such as obesity and heart disease (e.g., Janz et al., 2001; LeBlanc et al., 2012; Sääkslahti et al., 2004; Timmons et al., 2012). Research has more recently begun to demonstrate that PA is also linked to positive changes to additional outcomes including mental health (e.g., Ekeland, Heian, Hagen, & Coren, 2005; Kristjánsson et al., 2010; Timmons et al., 2012; Tomporowski et al., 2011), cognitive functioning and academic achievement (e.g., Davis et al., 2011; Hillman et al., 2011; Rasberry et al., 2011; Timmons et al., 2012), and prosocial behaviors (e.g., Feldman & Matjasko, 2005). Overall, the promulgation of PA research for young children is an important step towards developing intervention endeavors to promote children's health and well-being.

As such, increasing children's PA is a key public health effort (WHO, 2010), with much recent focus being on the early years comprising the transition from preschool and into kindergarten (broadly ages 5 through 7). This developmental stage is thought to be critically important for PA behaviors for two reasons (Goldfield et al., 2012). First, although kindergarteners on average achieve more PA than their older counterparts in middle childhood and beyond (Goldfield et al., 2012; Sigmund et al., 2007), there is evidence that these years are when some children begin to demonstrate significant decreases in PA that may persist into later life (Colley et al., 2013; Taylor et al., 2009). Second, lifelong health-related behaviors are thought to take root at this age, making early intervention important for establishing positive and long-lasting PA behaviors (Goldfield et al., 2012; Malina, 1996; Telama et al., 2005).

A basic concern for kindergarten PA intervention research is establishing the nature of PA behaviors in terms of (a) prevalence across PA type and (b) prevalence across children. This is a crucial first step towards subsequent intervention development efforts. Close examination of existing research points to two core issues regarding kindergarteners' PA behaviors that are in need of further research. First, it has been consistently found that many children, including kindergarteners, do not achieve the levels of PA sufficient to confer health and developmental benefits. More evidence is needed regarding children's attainment of PA levels to determine the scope of such deficits, particularly from large and nationally representative samples. Second, evidence has also found that PA levels vary widely across demographically-based sub-groups of kindergarteners, leading to troubling disparities with some children engaging in seemingly no substantive PA on a regular basis.

Kindergarteners' Overall PA

Heretofore, much attention has focused on assessing PA levels as a function of accumulated daily minutes of PA, preferably measured via objective means such as accelerometers. This is the strategy embraced by experts in the United States and elsewhere who have recently developed a series of standards for young children's PA rates. Briefly, these expert guidelines comprise two distinct mandates. First, children should engage in approximately 180 minutes/day of total PA accumulation through the age of 6. Total PA includes all ranges from light intensity (e.g., walking) to vigorous intensity (e.g., running). Second, beginning around ages 5 children should accumulate 60 minutes/day specifically devoted to moderate-to-vigorous PA (MVPA; e.g., brisk walking and above), which has been found to be particularly beneficial for health (U. S. Department of Health & Human Services, 2008; Institute of Medicine, 2011; National Association for Sport and Physical Education, 2009; Pate et al., 2015; Tremblay et al., 2012).

Estimates have consistently found that a significant number, if not a majority, of kindergarteners fail to meet these guidelines (Beets et al., 2011; Bornstein et al., 2011; Hnatiuk et al., 2014; Okely et al., 2009; Oliver et al., 2007; Tucker, 2008). Estimates for the proportion of kindergarteners meeting the 180 minutes/day of PA standard vary greatly, but findings generally indicate that many young children are not currently meeting this level. A recent cross-sectional study of Australian children (N = 1,004; Mean age = 4.5) is particularly dire, with findings showing a mean accelerometer-based total PA accumulation of just 127 minutes/day, resulting in only 5.1% of participants meeting the 180-minute PA guideline (Hinkley, Salmon, Okely, Crawford, & Hesketh, 2012). A recent cross-sectional analysis of children aged 3- to 5-year olds (N = 623) in South Carolina was more positive, finding in two independent samples that 41.6% and 50.2% of children met the 180 minutes/day standard (Pate et al., 2015). Even more promising, however, is a cross-sectional analysis of young Canadian children (N = 459) that found 83.8% of participants achieved 180 minutes/day of total PA through age 4 (Colley et al., 2013). Regarding the more stringent MVPA recommendation, evidence suggests that most children are attaining even less PA (Beets et al., 2011; Bornstein et al., 2011). For example, a recent meta-analysis of accelerometer-based MVPA studies comprising 29 articles and 6,309 young children calculated a mean MVPA level of 42.8 minutes/day—considerably short of the 60 minutes/day standard (Bornstein et al., 2011).

Variations in Kindergarteners' PA

A second major characteristic of kindergarteners' PA are oft-noted variations found across sub-populations of children. What explains such variations is of key concern for PA researchers seeking to develop interventions, especially those targeted at underserved groups of children who are known to be at risk of PA disparities. Among the many social-environmental factors that affect variation in PA participation, two groups in particular have been studied to date and will be further explored in this study: (a) child-level demographic characteristics and (b) home-level demographic characteristics.

Child-level influences on PA. Of the range of child-level demographic variables, biological sex has been consistently found to be associated with some of the largest variations in PA levels, with all but a handful of studies indicating that kindergarten boys are markedly (≤ 20%) more active than girls (e.g., Hinkley, Salmon, Okely, Crawford, & Hesketh, 2012; Pfeiffer et al., 2009; Tucker, 2008). The recent MVPA meta-analysis by Bornstein and colleagues comprising 6,309 children aged 3–5 years also found striking disparities across biological sex, with the authors' calculations of mean MVPA levels indicating that boys accumulated 9.0 minutes (+ 19.8%) more MVPA per day than girls (2011). These differences result in sharply diverging outcomes for children in terms of meeting the PA standards as evidenced by a recent cross-sectional analysis where boys were 59.7% and 25.5% more likely to achieve to the total PA guidelines compared with girls in two samples (Pate et al., 2015). Age is another variable consistently associated with large variances in PA. For example, some research suggests that each one-year increase in a child's age is likely associated with 10% or more decrease in their PA levels (Hinkley, Salmon, Okely, Hesketh, & Crawford, 2012; Zecevic et al., 2010).

Evidence on other child-level demographic variables is mixed. The influence of race and/or ethnicity is particularly marked by contradictory findings, with a few studies finding African-American children to be particularly active (e.g., Pate et al., 2004; Pfeiffer et al., 2009), but most others finding no real racial/ethnic differences (e.g, Baranowski et al. 1993; Finn et al., 2002; Hinkley et al., 2008; Pate et al., 2015). Some research has found that additional child characteristics such as weight (Trost et al., 2003), engagement in non-PA social and extracurricular activities (Hinkley et al., 2012), and others are significantly associated with PA, while other studies have found either no statistically significant or practically significant associations (Hinkley et al., 2008). It should be noted that many PA studies of kindergarteners have not examined the potential influences of individual demographics on PA outcomes. Overall, beyond biological sex and age, there remains a gap in the literature regarding how children's demographic characteristics may be association with differences in PA behaviors. This is particularly troubling from a social justice perspective that is purposive in identifying potential disparities found among marginalized children. More research is needed to determine if any important associations may exist that could inform future intervention efforts and policy decisions.

Home-level influences on PA. Likely due to their young age and concomitant dependence on parents, kindergarteners' PA participation behaviors have been consistently found to be closely influenced by family- and home-level demographic characteristics (e.g., Irwin et al., 2005; Loprinzi & Trost, 2010). In fact, a recent 9-year longitudinal examination of parents (N = 70) and their young children (Baseline mean age = 5.3 years) that tracked PA behaviors concluded that parents' PA behaviors exerted a stronger influence on their children's PA at the youngest ages (Alderman et al., 2010). This corroborated other research finding that parental factors likely have a particularly strong influence on kindergarten-aged children's PA (e.g., Pugliese & Tinsley, 2007). Although parent variables related to health and PA (e.g., parents' PA levels, support for PA, PA attitudes) have been frequently studied, there have been relatively few inquiries investigating the potentially significant associations of core parent- and home-level demographic characteristics on individual kindergartener's PA. Overall, evidence has occasionally pointed to home characteristics such as parent age (Zecevic et al., 2010), parent employment status (Hinkley et al., 2012), and number of siblings in the home (Hinkley et al., 2012), as being significantly associated with differences in kindergarteners' PA behaviors. Other studies have found that certain home demographics were not associated with PA outcome differences (e.g., Finn et al., 2002; Oliver et al., 2010; Pate et al., 2015). Several of these studies' findings are limited due to relatively small samples that were likely not generalizable or even statistically powered sufficiently to detect significant differences. More research is needed in this area to determine which of the many possible home-level variables may be related to PA outcomes.

Current Study

It is clear that kindergarten-aged children are likely not sufficiently active, and that large differences may exist across sub-groups of children based on either their individual or home characteristics. Although extant research represents an invaluable starting point for determining PA behaviors among young children, existing studies also have important limitations. Most prominently, due to both (a) the relatively small samples found throughout the studies and (b) the variety of locations, the children studied to date are not likely very representative of a national population of young children in the United States and, thus, the results found to date may not be generalizable. A need exists for additional PA studies examining large, nationally representative samples of children at the important ages of kindergarten. Additionally, there have also been scant attempts to clarify the multidimensional nature of the influences shaping young children's PA behaviors (Hinkley et al., 2008). Although many analyses to date have used descriptive statistics to explicate differences in PA levels by child- and home-level variables, too few studies have used sophisticated inferential approaches to determine whether such variables are statistically significantly associated with differential PA behaviors.

To date, too few studies have (a) examined PA participation among kindergarteners specifically or (b) attempted to distinguish between PA sub-types. The specific analytic focus of this study is to address these gaps via two interrelated statistical analyses. First, the study will examine kindergarteners' overall mean PA participation rates for both general PA measures (e.g., daily PA participation) and specific PA types (e.g., team sports, dance, martial arts) using appropriate univariate and bivariate descriptive statistics. Second, the study will examine key demographic characteristics of kindergarteners and their home environments that may be statistically significantly associated with variations in PA participation using appropriate multiple regression statistics.

Findings from this study have the ability to inform future PA research endeavors, interventions, best practice strategies, and macro-level policy initiatives. Overall, the study features three explicit research questions (RQs):

- RQ1: Do kindergarteners' PA participation rates vary across sub-types of PA?

- RQ2: Do kindergarteners' PA participation rates vary across child-level demographic characteristics?
- RQ3: Do kindergarteners' PA participation rates vary across home-level demographic characteristics?

Methods

Sample

The data set used in this study was the Early Childhood Longitudinal Study, Kindergarten Class of 2010-11 study (ECLS-K:2011). The ECLS-K:2011 is an ongoing cohort study begun in 2010 and sponsored by the National Center for Education Statistics (NCES) within the Institute of Education Sciences of the U.S. Department of Education (Tourangeau et al., 2015). The study is also co-sponsored by multiple additional agencies including the U.S. Department of Agriculture and the USDHHS, and is also endorsed by many non-governmental professional educational organizations. The sampling strategy for the ECLS-K:2011 is a multi-stage design involving three specific stages (Tourangeau et al., 2015). First, the United States was divided into 90 geographically based primarily sampling units (PSUs; $N = 23$) comprising single or contiguous groups of counties. Second, public and private schools ($N = 1{,}308$) with kindergarten programs were selected within each PSU Both PSUs and schools were selected with a probability proportional to population size with a correction included to oversample Asian American, Native Hawaiian, and Pacific Islander children. Third, children enrolled in the selected kindergarten programs were sampled. As a result of this sampling strategy, participants in the current ECLS-K:2011 dataset comprise a nationally representative sample of 18,714 public and private school students who entered kindergarten beginning in the 2010-11 school year (Tourangeau et al., 2015). The number of children in each PSU ranged from $n = 14$ to $n =$

6,100. The diversity of children and families included in the ECLS-K:2011 makes it highly representative and, thus, highly generalizable to the national population of children in kindergarten.

Measures

This analysis used the publically-available version of the ECLS-K:2011, which shields potentially identifying information (e.g., zip codes, school locations) available in the full version for use by NCES staff. The first author was responsible for all data management activities. The final data file contained one record for each of the 18,174 participating children. Each record contained data from the respondents associated with the child (e.g., the child herself/himself, parents, teachers, school administrators), weights and imputation flags, and other variables (Tourangeau et al., 2015). The file included cases with (a) child assessment data and (b) parent interview data collected in two rounds of data collection (fall 2010, spring 2011).

Dependent variables. PA participation was measured in the Spring of 2011 with 10 single item variables measuring general PA participation, participation in specific PA types, and levels of PA participation (see Table 1.1). For general PA participation, two binary variables were coded from one core item asking parents whether their children "get exercise that causes rapid breathing, perspiration, and a rapid heartbeat for 20 continuous minutes or more": (a) Daily PA participation and (b) Weekly PA participation (1 = "Yes," 0 = "No"). The specifiers regarding breathing and heart rate mean this item is a proxy measure of MVPA (USDHHS, 2008). Eight binary variables were also used to examine specific PA participation types: (c) Organized Athletics, (d) Group Sports, (e) Individual Sports, (f) Dance, (g) Recreational Activities, (h) Martial Arts, (i) Playground Activities, and (j), Calisthenics (1 = "Yes," 0 = "No"). These 10 PA items are imprecise with regard to setting or context, meaning that parent-reported participation could have occurred at home, school, or any other location, and were of undetermined duration, intensity, and level.

Independent variables. Extant research and theory strongly suggests that kindergarteners' PA behaviors can vary depending on core demographic characteristics related to both child- and home-level factors (e.g., Finn et al., 2002; Hinkley et al., 2012). Preliminary checks on the range of potential covariates in the ECLS-K:2011 identified thirteen demographic characteristics over two domains that were likely associated with the 10 PA variables (see Table 1.2). All variables were assessed in the fall of 2010 by parents. Within the child domain, six variables were examined: (a) Age in years (4.4–8.3), (b) Male biological sex (1 = "Yes," 0 = "No"), (c) Race/Ethnicity (i.e., non-Hispanic White, non-Hispanic African American, Hispanic/Latino, Asian American; 1 = "Yes," 0 = "No"), (d), Disability diagnosis (1 = "Yes," 0 = "No"), (e) objectively measured Body Mass Index level (7.6–49.1), and (f), parent-reported child Health Status (1 = "Fair/Poor," 4 = "Excellent"). Within the home domain, seven variables were analyzed: (a) being primarily an English Speaking household (1 = "Yes," 0 = "No"), (b) a multidimensional composite Socioeconomic Status variable comprising expert recommended items including parents' education, parents' occupational prestige, and household income (.67–5.6; Shavers, 2007; Tourangeau et al., 2015), (c) federal Poverty level status (1 = "At or above," 0 = "Below"), (d) household Food Insecurity (1 = "Yes," 0 = "No"), (e) presence of Two Parents in the home (1 = "Yes," 0 = "No"), (f) primary Reporting Parent Age (19–77), and (g), Household Number of individuals (2–15).

Data Analysis

Diagnostic checks. Diagnostic checks were conducted for (a) clustering and (b) missingness on the study variables. To model expected clustering by schools, the intraclass correlation coefficient (ICC) was computed for each PA variable as a the ratio of between-cluster variance to total variance where the error term is assumed to have logistic distribution with mean of 0 and a variance of $\pi^2/3$. Using Stata's "xtlogit" command to perform the random effects logistic models, the ICC values were found to be relatively small-to-moderate ($\rho = .056$ to .211) for the 10 PA variables, indicating that some percentage of the variance of PA participation in the sample was due to school-level characteristics (Raudenbush & Bryk, 2002). Prior to the subsequent analyses, the variance inflation factor (VIF) values for the covariates were computed by performing individual survey-weighted regressions ($N = 13$) with each covariate as the dependent variable and the remaining covariates as independent variables and then manually calculating the VIF as a function of the tolerance using the formula $1/(1-R^2)$. Results found that the specified covariates did not exhibit problematic levels of collinearity (VIF ≤ 2.03).

A large proportion (29.4%) of the children were missing values for all 10 PA participation variables. Diagnostic checks using Little's test on the PA dependent variables rejected the null hypothesis of MCAR ($p < .05$), suggesting that proceeding without accounting for missingness would result in biased estimates and that a more rigorous strategy was necessary (Rose & Fraser, 2008). Based on this finding, it was decided that the best possible results would be derived only after multiple imputation (MI) of missing data on the PA variables. Stata's set of MI commands including "mi set," "mi register," "mi impute," and "mi estimate" were used to carry out the recommended MI steps involving (a) creation of multiply imputed data, (b) data analysis of the imputed data across m ($N = 10$) iterations, and (c) pooling of the results across all iterations for a final estimate (Rose & Fraser, 2008; Rubin, 1987). In the process, various auxiliary variables were tested and found to be statistically significantly ($p < .05$) associated with missingness, including child demographic characteristics (e.g., race/ethnicity, BMI level), parent demographic characteristics (e.g., race/ethnicity, age), and home characteristics (e.g., socioeconomic status, number of people in the home). The use of MI to account for missingness is both recommended by ECLS-K:2011 developers (Tourangeau et al., 2015) and analysis teams (e.g., Gibbs & Forste, 2013).

Analytic plan. All analyses were conducted in Stata 12.1 for Macintosh (StataCorp). Broadly, the analytic plan for this cross-sectional analysis followed two main stages. First, to answer RQ1, univariate and bivariate statistics were examined to discern mean estimates of PA participation across the 10 PA variables by race/ethnicity and biological sex. Second, to answer RQ2 and RQ3, logistic regression analyses including all 13 demographic independent variables were examined to ascertain the associations of the child- and home-level characteristics' with children's PA participation. The basic logistic regression model for these analyses can be expressed as

$$\ln(P/(1-P)) = X\beta$$

where ln is the logit link function, P is the probability of Y = 1 for PA participation, β is the vector of estimated regression coefficients, and X is the matrix of the 13 independent variables comprising the 13 covariates. Under this framework, if the demographic covariates were found to be (a) non-zero and (b) statistically significant ($p < .05$, two-tailed) predictors of PA participation across the 10 models, this would indicate that intra-individual differences (e.g., variations in age, socioeconomic status) were statistically associated with differences in PA participation.

In addition to MI procedures, all analyses corrected for the complex sample design effects inherent to survey data such as the ECLS-K:2011 (Tourangeau et al., 2015). The cluster-randomized design used in the ECLS-K:2011 has a higher probability of Type II error than a subject-randomized design, meaning parameter estimates may be less precise without weighting. To correct for the design of the data, child-level weights were used to compute correct standard errors. The use of such weights is also necessary to produce estimates that can be generalized to the population of kindergarteners in the United States (Tourangeau et al., 2015). Stata's set of "svy" commands were used to employ the Taylor series method to adjust standard errors. If necessary, statistical significance was corrected using the Benjamini-Hochberg false discovery rate adjustment to avoid Type I error (Benjamini & Hochberg, 1995).

Results

Descriptive Characteristics

The total sample (N = 18,714) was 51.2% male. The mean age was 6.1 years old. The age range was 4.4 to 8.3 but 98.2% of the children were 5- or 6-year-olds. The racial/ethnic composition of the children was diverse: 46.8% White (n = 8,489), 13.2% African American (n = 2,397), 25.3% Hispanic/Latino (n = 4,585), 8.5% Asian American (n = 1,546), 4.5% Multiracial (n = 822), and 1.6% Native Hawaiian, Pacific Islander, American Indian, Alaska Native (Native; n = 285). Almost one-fifth of children (n = 2,566, 19.7%) had a parent-reported professional diagnosis of at least one physical or mental disability. The mean BMI was 16.6 with a range of 7.6 to 49.1. The majority of the sample (80.6%) reported that English was the language most commonly used at home. A full one-quarter (25.5%) of children were living at or below the federal poverty line and almost the same number (22.9%) reported some level of household food insecurity. The majority (71.1%) of children lived in two parent households. Parents' mean age was 34.5 with a range of 19.0 to 77.0.

Univariate and Bivariate Analyses

The number of complete cases for the non-imputed PA variables ranged from 12,888 (70.9%; Daily PA, Weekly PA) to 13,365 (73.5%; Organized Athletics), and were generally (a) negatively skewed (60.0% < 0.0; Range: −4.70 to 3.14) and (b) platykurtic (60.0% < 3.0; Range: 1.00 to 23.06). Given that almost one-third (29.4%) of the sample was not surveyed on any of the 10 PA dependent variables, the ability to impute missing values was limited. The number of imputed cases ranged from $m = 2$ (Organized Athletics, Martial Arts) to $m = 435$ (Calisthenics). The final analytic samples after MI procedures comprised 71.8% to 74.4% of the total sample: Daily PA: $n = 13{,}072$; Weekly PA: $n = 13{,}072$; Organized Athletics: $n = 13{,}367$; Group Sports: $n = 13{,}077$; Individual Sports: $n = 13{,}073$; Dance: $n = 13{,}488$; Recreational Activities: $n = 13{,}488$; Martial Arts: $n = 13{,}073$; Playground Activities: $n = 13{,}490$; Calisthenics: $n = 13{,}490$).

Table 1.3 presents the sampling weight and MI adjusted mean estimates of kindergarteners' PA participation. Results found that PA participation rates varied depending on the nature of the PA form, children's race/ethnicity, and biological sex. Less than half (M_{Total} = 38.63%) of the total sample was found to participate in ≥ 20 minutes of PA each day. White males had the highest daily PA participation rate (M = 45.34%; ΔM_{Total} = +17.40%) and Asian American females had the lowest (M = 24.31%; ΔM_{Total} = −37.07%). Weekly PA participation was much higher (M_{Total} = 90.12%) with white males having the highest rates (M = 95.57%; ΔM_{Total} = +6.05%) and Asian American females the lowest rates (M = 77.15%; ΔM_{Total} = −14.39%). Participation across the eight PA types varied widely from a low of 7.82% for Martial Arts to a high of 95.99% for Playground Activities. The greatest variation in mean estimates was found within Martial Arts where Asian American males demonstrated very high rates (ΔM_{Total} = +170.93%) while White females had very low rates (ΔM_{Total} = −43.12%). The smallest variation in mean estimates was within Playground Activities, ranging from the slightly increased participation of White females (ΔM_{Total} = +2.78%) to the slightly decreased rates for Hispanic/Latino females (ΔM_{Total} = −5.30%). Only 72 children (0.40%) were reported to have not participated in any of the PA forms.

White kindergarteners consistently had the highest PA participation rates, having mean estimates (not pictured) greater than the total mean within 9 out of 10 variables, with a ΔM_{Total} range of −6.69% (Dance) to +25.18% (Organized Athletics). African Americans were the second most active, with a ΔM_{Total} range of −23.74% (Organized Athletics) to +25.07% (Dance). Hispanic/Latino children had lower PA rates than the total mean in all 10 variables, with a ΔM_{Total} range of −36.44% (Organized Athletics) to −2.91% (Individual Sports). Asian American children also had consistently low PA participation. Aside from Martial Arts (ΔM_{Total} = +81.70%) and Dance (ΔM_{Total} = +7.64%), Asian American kindergarteners had lower mean PA participation rates than the total with a range of ΔM_{Total} = −30.70% (Organized Athletics) to ΔM_{Total} = −2.28% (Individual Sports). Averaged across all 10 PA variables, White children's mean participation rates were 5.99% higher than the total means, while African American, Hispanic/Latino, and Asian American children's mean rates were 1.11%, 12.67%, and 3.63% lower, respectively.

Also, males were markedly more active than females, having the highest mean estimates (not pictured) on 9 of the 10 PA variables. Most notably, Male's mean estimates were 25.0%, 29.27%, 38.91%, and 115.75% higher than females' on Daily PA, Organized Athletics, Group Sports, and Martial Arts, respectively. Females were more active than males only at Dance, with a mean estimate 154.31% higher than males'. There were very little differences ($\Delta M_{\text{Total}} <$ 0.06%) for male and female children's participation in Playground Activities and Calisthenics.

Logistic Regression Analyses

The mean estimates above indicated there were PA participation differences among kindergarten-aged children in the United States based on race/ethnicity and biological sex, but they did not answer whether demographic characteristics were significantly associated with such differences. To determine this question, a further line of inquiry was pursued whereby key covariates were entered into individual logistical regression models predicting each of the 10 PA participation variables. Table 1.4 presents the full results of all 10 models.

Full model results found that all 10 of the PA models were statistically significant: $F(19, 182) = 7.00$ to 75.63, $p < .001$. These highly significant results obviated the need for a Benjamini-Hochberg adjustment. Post-estimation model comparisons using Stata's "test" command to perform Wald tests of the hypothesis that the home-level covariates were jointly associated with the 10 PA variables were statistically significant: $F(7, 182) = 5.71$ to 128.02, $p < .001$. As Stata's "mi" commands currently are not able to output traditional evaluation metrics, pseudo R^2 values were approximated on non-imputed models by calculating Tjur's statistic (2009), which is the difference in the means of the predicted probabilities of the two event probabilities (i.e., PA v. no PA). Results found that the demographic independent variables explained from 1.41% (Individual Sports) to 21.45% (Organized Athletics) of the variation on PA participation across the 10 dependent variables ($p < .001$). The small effect sizes reflect the lack of explanatory behavioral and attitudinal variables in the models, the inclusion of which is an important future research endeavor outside the purview of this study.

Results also found considerable variation in the sign, strength, and significance of the six child-level covariates' associations with PA participation. Age was significantly associated with increased participation on three of the PA variables ($\beta = .14$ to $.27$, $p < .05$) and with a decrease on Dance ($\beta = -.21$, $p < .01$). Male biological sex was the most consistently significant covariate, being significantly associated with moderate-to-large increases in participation on seven PA variables (β = .16 to .87, $p < .001$) and decreases on Dance ($\beta = -1.35$, $p < .001$). Non-White children were found generally to have decreased associations with participation in Daily PA, Weekly PA, Organized Athletics, Group Sports, Recreational Activities, and Playground Activities ($\beta = -1.33$ to $-.21$, $p < .01$), but increases for Dance (β = .24 to .53, $p < .05$) and Martial Arts (β = .35 to .80, $p < .01$). Having a disability was associated with decreased likelihoods of participation in Organized Athletics, Group Sports, and Individual Sports ($\beta = -.19$ to $-.14$, $p < .01$). Having higher BMI levels was inconsistently and weakly associated with PA participation. Lastly, children with parent-reported "Excellent" health were generally found to have increased likelihoods of PA participation, with significant associations found on four PA variables (β = .34 to .93, $p < .05$). Having "Very Good" health was associated with increased participation only for Weekly PA ($\beta = 42$, $p < .05$).

Results also found considerable variation among the seven home-level characteristics. Children in English speaking homes were found to have consistently increased likelihoods of participation on eight of the PA variables (β = .21 to .93, $p < .01$). Home socioeconomic status was significantly associated with nine PA variables, with a small negative association for Daily PA ($\beta = -.19$, $p < .001$) and small-to-large positive associations on all others (β = .13 to .88, $p < .05$). Food insecurity was associated with small decreased likelihoods of PA participation for Organized Athletics ($\beta = -.15$, $p < .01$) and Group Sports ($\beta = -.17$, $p < .001$). Having two parents was inconsistently associated with PA participation, demonstrating a decreased likelihood for Daily PA ($\beta = -.25$, $p < .001$), but an increased likelihood for Organized Athletics ($\beta = .26$, $p < .01$). The number of people in a child's household was consistently negatively associated with small decreases in PA participation on five variables ($\beta = -.06$ to $-.11$, $p < .05$).

Neither being above the federal poverty level nor reporting parent's age were associated with any of the PA variables.

Discussion

Overall, these analyses reveal important findings regarding the nature of PA participation among kindergarteners in the United States. For RQ1, yes, participation varies substantially across sub-types of PA, with total sample mean rates ranging from a low of just 7.82% for martial arts to a high of 95.99% for playground activities. Almost all young children are engaging in regular playground and recreational PA, about half are participating in sports, and fewer are participating in organized athletics, dance, martial arts, or calisthenics. Similarly for RQ2, both within- and between-type PA participation varies depending on key child-level demographic characteristics. In particular, large and statistically significant differences were found based on race/ethnicity, biological sex, age, and health status. It was generally found that children who are (a) older, (b) male, (c) White, (d) non-disabled, and (e), of better health are more likely to participate in PA. For RQ3, generally, within- and between-type PA varied such that children in homes that are (a) English speaking, (b) of higher socioeconomic status, and (c), lower in household number are likely to have more associations with increased PA participation.

Implications

This study contributes substantially to the body of evidence regarding the PA participation behaviors of young children aged four to seven. It provides high quality evidence on young children's PA participation behaviors in ways heretofore largely unexplored by extant research. Based on the findings, there are four key implications for research and practice from these results.

First, PA participation among kindergarten-aged children in the United States is low. Less than half are achieving 20 minutes or more of daily MVPA in a given week with a sizable proportion achieving zero minutes. It would appear that many kindergarteners are not meeting recommended daily PA participation guidelines calling for 180 minutes/day of total PA and 60 minutes/day of MVPA. This is troubling both because it means many young children are missing out on the full capacity of PA to promote health and well-being, and because this dearth stands in defiance of strident, pervasive, and costly PA promotion efforts. Increasing PA has been a key public health priority in the United States for over two decades, but this study suggests that, at least for very young children, such efforts have failed to result in adequate PA participation levels. On a more positive note, this study also found that (a) some PA types are very popular with young children and that (b) very few kindergarteners in the Unites States are seemingly completely inactive. Thus, though there remain significant gaps towards achieving widespread PA participation among children, there are also useful starting points for future research and interventions.

Second, PA participation varies dramatically according to type. Without further inquiries, it is difficult to say whether children are differentially engaging in the various PA forms due to individual preferences or other factors. At a minimum, however, PA researchers and intervention developers should be wary of using a single item to capture children's participation. Failure to do so could result in some children's PA behaviors going unmeasured and/or misunderstood. Two important anomalies in the results particularly highlighted this issue. Most glaringly, martial arts participation is largely confined to males and Asian American males, in particular, whose participation therein greatly outpaces all their peers. Similarly, participation in dance was particularly prevalent among females, with African American females showing very high levels of engagement compared with their peers. PA research that does not specify martial arts or dance forms, for example, could be missing vital information about how these sub-groups of children prefer to engage in PA. Likewise, PA interventions that only allow for limited options could risk disengagement and non-significant treatment effects if such children lack their preferred PA form.

Third, there are large disparities in PA participation based on child- and home-level factors. These disparities seem to mirror the health disparities typically found among other outcomes related to child health, with non-White, female, disabled, high BMI, and poor health children being at risk of low PA participation. Importantly, the significance of children's individual demographic characteristics remained even after confounding for parent- and home-level factors. Those factors, in turn, were also found to be significantly associated with PA participation among the kindergarteners, with typically vulnerable populations such as non-English speakers, those of low socioeconomic status, and those in single parent, multigenerational or other alternative family structures having lower levels of PA. In effect, the children who may benefit the most from the health, developmental, and well-being promotive qualities of PA are precisely those children who are less likely to be active. In particular, it should be noted the very low rates of participation in organized athletic activities for African Americans, Hispanics/Latinos, and Asian Americans when compared with White children. The lack of participation by historically oppressed minority groups in such organized activities may suggest pernicious and institutional barriers to PA that deserve more attention. The case for this argument is bolstered by strong and consistent association of being an English speaker with PA participation, suggesting that children from non-English speaking homes may systematically be not participating in, or receiving of, PA opportunities. Or, perhaps, that there exists large measurement bias in existing PA assessments and surveys that may be artificially devaluing marginalized children's PA activities. Overall, these findings have potentially important and overlooked implications for advancing social justice and ameliorating systematic oppression within the context of kindergarteners' PA.

Fourth, demographic characteristics only marginally explain differences in PA participation. The associations between the included covariates and the PA outcomes were sometimes inconsistent and contradictory. More importantly, though, was the inability of the models to explain PA behaviors. Only one of the models (Organized Athletics = 21.4%) explained even a moderate amount of the variation in PA outcomes and the majority explained ≤ 5.0%. These low effect sizes suggest both the need for additional variables to explain young children's PA participation in order to more fully account for the measurement bias present in the analyses. At present, the precise mechanisms by which child and family factors influence individual kindergarteners' PA outcomes are unclear. The next step in this area of research may be towards more explanatory methodological techniques such as those involving path analysis (i.e., structural equation modeling) in observational data and randomized controlled trials for experimental data. Clearly, there it still much research to be done to determine the full nature of PA participation among kindergarteners in the United States.

Limitations

The findings should also be view with some caution, as the study was limited in several ways. Foremost among these is the cross-sectional nature of the data. This prohibits the ability to draw true causal inferences between the tested child- and home-level characteristics and the dependent PA variables. As such, this study should be seen merely as an examination of associations. Also, the ECLS-K:2011 contains limited ability to measure some of the key variables. Although the proxy reports (i.e., parent surveys) such as those used in the ECLS-K:2011 are attractive due to low costs and burdens, they also have limited validity for PA assessment. There is still a need for more and larger studies measuring PA among kindergarten-aged children with objectively based methods such as accelerometers (Cliff, Reilly, & Okely, 2009; Oliver et al., 2007; Pate, O'Neill, & Mitchell, 2010; Tucker, 2008). The ECLS-K:2011 also has limitations on possible covariates that may potentially confound results. The study could not account for non-demographic home-level factors such as parents' health, parents' PA levels, parents' PA attitudes, and others that have been also found to be statistically significantly associated with, and predictive of, differences in kindergarteners' PA accumulation (e.g., Arredondo et al., 2006; Hinkley et al., 2012; Loprinzi & Trost, 2010; O'Dwyer et al., 2012; Oliver et al., 2010; Pugliese & Tinsley, 2007; Zecevic et al., 2010). The lack of such variables in the analyses represents measurement error that may bias the validity of the findings. Also, important factors related to the built environment (e.g., playground availability, infrastructure), health and PA policy (e.g., kindergarten PA curricula), and others that may contribute to young children's PA participation were not able to be included. (e.g., Dowda et al., 2009; Hannon & Brown, 2008; Jones et al., 2011).

Conclusion

This study represents an exploratory examination of the descriptive characteristics of kindergarten-aged children's PA behaviors, as well as the associations of key demographic characteristics with differences in PA participation rates. Children at this age represent an important area in PA research that has been heretofore understudied relative to the importance of this developmental stage for establishing positive and lasting PA behaviors. The overall strength of evidence is strong that kindergarteners' in the United States are currently not sufficiently active and that large disparities in PA attainment exist across sub-groups of children. In particular, historically marginalized and underserved children appear to be limited in their PA participation, which may put them at increased risk for short- and long-term negative health and development outcomes. Future research and intervention efforts should strongly focus on these vulnerable groups of young children when examining data and crafting PA programs. In particular, more research using longitudinal and/or experimental methods is necessary.

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Table 1.1

ECLS-K:2011 Sampling Weight Adjusted Estimates of Physical Activity Participation Variables' Descriptive Characteristics (Spring 2011)

Variable	*N*	Items	Range	Mean (SD)	Skewness	Kurtosis
Daily PA	12,888	1	0, 1	.39 (.49)	.47***	1.22***
Weekly PA	12,888	1	0, 1	.90 (.30)	−2.70***	8.27***
Organized Athletics	13,365	1	0, 1	.50 (.50)	−.00***	1.00***
Group Sports	13,059	1	0, 1	.52 (.50)	−.06***	1.00***
Individual Sports	13,059	1	0, 1	.56 (.50)	−.24***	1.06***
Dance	13,069	1	0, 1	.29 (.45)	.94***	1.89***
Recreational Activities	13,068	1	0, 1	.89 (.31)	−2.52***	7.34***
Martial Arts	13,071	1	0, 1	.08 (.27)	3.14***	10.87***
Playground Activities	13,067	1	0, 1	.96 (.20)	−4.70***	23.06***
Calisthenics	13,055	1	0, 1	.49 (.50)	.05***	1.00***

Note: ***$p < .001$; two-tailed test.

Table 1.2

ECLS-K:2011 Sampling Weight Adjusted Estimates of Child Demographic Variables' Descriptive Characteristics (Spring 2011)

Variable	*N*	Items	Range	Mean (SD)	Skewness	Kurtosis
Age	13,183	1	4.35–8.29	6.12 (.38)	.44***	3.67***
Male	13,611	1	0, 1	.52 (.50)	−.07***	1.00***
White	13,607	1	0, 1	.52 (.50)	−.08***	1.01***
African American	13,067	1	0, 1	.13 (.33)	2.25***	6.05***
Hispanic/Latino	13,067	1	0, 1	.25 (.43)	1.16***	2.34***
Asian American	13,067	1	0, 1	.05 (.21)	4.29***	19.40***
Disability	13,039	1	0, 1	.21 (.40)	1.46***	3.14***
Body Mass Index	13,142	1	7.6–49.14	16.59 (2.45)	2.14***	11.33***
Child Health	13,015	1	1–4	3.45 (.78)	−1.26***	3.74***
English	13,583	1	0, 1	.82 (.38)	−1.68***	3.81***
Socioeconomic Status	13,528	1	.67–5.44	2.95 (.82)	.23***	2.55***
Poverty	13,527	1	0, 1	.27 (.44)	1.05***	2.11***
House Food Insecurity	12,910	1	0, 1	.24 (.43)	1.23***	2.51***
Two Parents	13,527	1	0, 1	.69 (.46)	−.84***	1.71***
Reporting Parent Age	13,460	1	19–77	34.27 (6.74)	.69***	4.45***
Household Number	13,527	1	2–15	4.61 (1.38)	1.13***	6.07***

Note: ***$p < .001$; two-tailed test.

Table 1.3

ECLS-K:2011 Multiple Imputation and Sampling Weight Adjusted Mean Estimates of Children's Physical Activity Participation Proportions by Race/Ethnicity and Biological Sex (Spring 2011)

	Total[a]	**White**		**African American**		**Hispanic/Latino**		**Asian American**	
		Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Daily PA	38.63%	**45.34%**	36.29%	41.42%	33.35%	38.79%	30.09%	30.90%	24.31%
Weekly PA	90.12%	**95.57%**	93.26%	87.84%	87.25%	85.66%	81.89%	78.93%	77.15%
Organized Athletics	50.10%	**68.36%**	56.55%	46.44%	29.11%	37.94%	25.43%	38.73%	31.20%
Group Sports	51.49%	**66.27%**	48.26%	57.96%	39.70%	48.60%	33.77%	45.48%	35.34%
Individual Sports	55.88%	58.19%	56.00%	**58.43%**	51.01%	56.90%	51.48%	55.06%	54.21%
Dance	28.70%	11.82%	43.06%	27.54%	**45.19%**	20.11%	35.76%	15.85%	44.25%
Recreational Activities	89.10%	**95.19%**	91.63%	85.84%	84.02%	86.81%	80.76%	78.93%	75.82%
Martial Arts	7.82%	11.10%	4.45%	9.17%	5.63%	8.12%	4.82%	**21.19%**	8.23%
Playground Activities	95.99%	98.49%	**98.66%**	95.97%	95.83%	91.52%	90.90%	91.63%	92.73%
Calisthenics	48.63%	51.89%	52.42%	**52.86%**	52.57%	39.79%	38.85%	44.07%	43.12%

Note: The largest proportion for each PA variable is bolded. [a]Total mean values include Multiracial (n = 822) and Native students (n = 285) not otherwise listed.

Table 1.4

ECLS-K:2011 Multiple Imputation and Sampling Weight Adjusted Logistic Regression Estimates of Child and Home Characteristics' Associations with Physical Activity Participation (Spring 2011)

Predictors	**Daily PA**	**Weekly PA**	**Organized Athletics**	**Group Sports**	**Individual Sports**	**Dance**	**Recreational Activities**	**Martial Arts**	**Playground Activities**	**Calisthenics**
Constant	−.90*	−1.32	−4.36***	−2.07***	−1.07*	.71	−.20	−6.05***	3.03*	−2.21***
Age	.14*	.27*	.18**	.04	.07	−.21**	.16	−.01	−.20	.16
Male	.36***	.29***	.65***	.73***	.16***	−1.35***	.48***	.87***	.03	−.01
Race (Reference = White)										
African American	−.33**	−.56***	−.43***	−.04	.06	.53***	−.71***	.18	−.84***	.18
Hispanic/Latino	−.24**	−.51***	−.33***	−.21**	.05	.28**	−.49***	.35**	−1.06***	−.08
Asian American	−.42**	−1.33***	−1.01***	−.69***	−.18	.24*	−1.14***	.80***	−1.25***	.03
Disability	.08	−.10	−.16**	−.19***	−.14**	.06	−.07	−.02	−.17	.21
BMI	−.02**	.03	.00	.01	.01	−.01	.01	.05**	.02	−.02**
Health (Reference = Fair/Poor)										
Good	−.13	.22	.22	.20	−.10	−.26	.27	.65	.52	−.15
Very Good	−.05	.42**	.27	.20	−.05	−.21	.35	.77	.48	−.06
Excellent	.15	.62***	.40*	.34*	−.02	−.17	.48	.93*	.55	.05
English Speaking	.27***	.44***	.75***	.21**	−.04	.31**	.51***	.25	.93***	.57***
Socioeconomic Status	−.19***	.37***	.88***	.42***	.23***	.13**	.25***	.47***	.44***	.08

Poverty	−.01	−.12	−.05	−.07	.08	.11	−.07	−.11	−.01	−.12
House Food Insecurity	.07	.06	−.15**	−.17***	.02	.03	.02	−.06	.04	−.03
Two Parents	−.25***	.18	.26***	.04	.11	.06	.12	−.17	.02	.06
Reporting Parent Age	.00	−.00	−.00	−.00	.00	−.00	−.01	.01	−.01	.01
Household Number	.02	−.06*	−.10***	−.02	−.06**	−.07**	−.01	−.11**	−.04	−.03
***F* (19, 182)**	15.47***	34.19***	75.63***	52.92***	7.00***	64.65***	24.67***	26.80***	29.87***	12.67***
[a]Pseudo R^2	.03***	.06***	.21**	.09***	.01***	.10***	.05***	.04***	.05***	.03***

Note: Results are reported as coefficients; *p < .05, **p < .01, ***p < .001; two-tailed test. [a]Estimates taken from non-MI models.

PAPER II

AN EXPLORATORY MULTI-LEVEL EXAMINATION OF THE INFLUENCE OF SCHOOL-BASED PHYSICAL EDUCATION AND RECESS ON KINDERGARTENERS' COGNITIVE AND ACADEMIC ABILITY

Kindergarten is an important development stage for many children wherein positive behaviors begin to develop for the long-term promotion of health, well-being, and school success outcomes. Among the many behaviors that child development and school stakeholders seek to promote among young children are those related to physical activity (PA). PA promotion has found great resonance due to evidence supporting associations with psychological functioning, well-being, self-worth, and social skills (e.g., Biddle & Asare, 2011; Dworkin, Larson, & Hansen, 2003; Janssen & LeBlanc, 2010; Melnyk et al., 2013; Strong et al., 2005). Of particular relevance for schools is that strong evidence suggests that PA participation can increases cognitive and academic outcomes among children (Chang et al., 2013; Rasberry et al., 2011; Singh, Uijtdewilligen, Twisk, Van Mechelen, & Chinapaw, 2012; Sibley & Etnier, 2003).

Physical Activity in School

As such, PA research and intervention targeted at children has become a vital public health focus in recent years (Pate, Trilk, Byun, & Wang, 2011; Tomporowski, Lambourne, & Okumura, 2011), and among the leading avenues for such activities is the school setting. PA has long been associated with education data back to ancient Greek and Roman cultures (Tomporowski et al., 2011), and the notion of *mens sana in corpora sano* (sound mind, sound body) has been a fundamental assumption underlying the long-standing inclusion of PA activities in public school curricula. PA within the school setting is now a frequent and required component of the educational process that constitutes a necessary mechanism for increasing young children's health physical, mental, and social development (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2011).

Reviews of evidence have found that young children's accrual of PA within school and care facilities (i.e., kindergartens, day care, after school care) varies considerably based on the characteristics, resources, and policies of such facilities (Dowda et al., 2004; Finn et al., 2002; Goldfield et al., 2012). Broadly, students' participation in school-based PA can be broadly classified into the three types: (a) physical education courses/curricula, (b) unstructured free time activities, and (c), after-school sports (CDC, 2013; Lee et al., 2007). The components of physical education (PE) courses can vary widely but for kindergarteners typically involve individual or team-based non-competitive activities with some testing of specific skills being mandated by schools or districts to measure levels of fitness. In addition to PE, kindergartens frequently provide opportunities, resources, and time periods for children to engage in free time PA. The most common manifestation of such PA is after lunch recess activities. Recess constitutes an important free play time for many young children where they can play with classmates or by themselves using school-provided gymnasiums, sports equipment, and fields (Ramstetter et al., 2010). Kindergarteners rarely if ever participate in sanctioned after-school sports as is common among adolescents.

In most communities, schools are expected to promote positive health behaviors including PA. The Child Nutrition and WIC Reauthorization Act (2004) mandates that all schools participating in school lunch programs establish wellness policies that consider PA as a requirement for receipt of funding. At the local level, many states' legislatures and departments of education have since passed laws requiring districts to implement similar policies and strategies to promote school PA (Leviton, 2008). School PA guidelines have also been promulgated in recent years by key health organizations. For example, a 2006 statement from the American Heart Association (AHA) outlined three recommendations for PA in schools (Pate et al., 2006). First, it was recommended that schools ensure all students acquire PA during school hours. Second, it was recommended that schools deliver evidence-based PE and health programs in compliance with national standards. Third, it was recommended that schools provide PA opportunities across the school setting including those within PE, clubs, regular classroom lessons, and sports programs. More recently, the current USDHHS *Healthy People 2020* guidelines call for schools to increase student participation in PE and recess activities as part of a broad push to expand the role of schools in promoting children's activity (2012).

Physical Activity in Kindergarten

The main thrust of research and policy efforts to date have been at encouraging PA among children beginning in elementary school (≥ 6-years-old), but initiatives are being increasingly expanded to include efforts aimed at younger children (Goldfield et al., 2012; Institute of Medicine, 2011; National Association for Sport and Physical Education [NASPE], 2009; Pate et al., 2015; U. S. Department of Health & Human Services, 2008). The bulk of evidence on PA and cognitive and academic ability is based on findings from middle and high school students (Dobbins et al., 2013). For example, a seminal work by Rasberry and colleagues systematically reviewed the school PA and found that 25 of 52 (48.1%) and 8 of 12 (66.7%) performance outcomes for PE and recess interventions, respectively, demonstrated positive associations between participation and increases on cognitive and academic performance (2011). However, although the review included studies with some children in kindergarten due to issues with studies' reporting of results and methods the authors were not able to discern clear indications for kindergarten-aged children.

Recent efforts have sought to extend this area of research to develop clearer evidence for very young children (Carson et al., 2015; Lee et al., 2007; Tucker, 2008). Carson and colleagues recently conducted a systematic review of studies designed to promote cognitive development with PA among children 5-years old and younger (2015). The review's search produced two observational and five experimental studies comprising a total of 414 children. Six of these seven studies found that increases in PA participation and/or duration had significant benefits to at least one cognitive outcome. Overall, the authors concluded that the state of evidence was weak but promising and in need of more research (Carson et al., 2015).

More salient to the current study is the earlier work of Dills and colleagues (2011) who studied an earlier cohort (1998–1999) of the data studied herein (see below). The authors' methods comprised a series of longitudinal fixed effects models spanning kindergarten through the fifth grade. The analyses controlled for potential confounding effects with a variety of covariates including those related to children's core demographic characteristics (e.g., age, biological sex, race/ethnicity), parent and home characteristics (e.g., parent education, socioeconomic status), and school characteristics (e.g., size, location, teacher experience). Contrary to the findings of others, the authors found no statistically significant ($p > .05$) associations between either PE or recess participation and increases to children's scores on measure of reading or mathematics ability tests. The authors concluded that although there was no indication that increasing PE and recess for young children would result in substantial harmful effects to their proximal academic ability and distal school performance, there as also little reason to recommend school-based PA promotion (Dills et al., 2011). However, these findings are nearly two decades old and are in need of revisiting with more current data.

Beyond incongruent findings related to significance, two important research issues are highlighted herein for further study. First, overall research is still underdeveloped regarding how PA may promote scores on tests of cognitive and academic ability among very young children (Carlson et al., 2015; Tremblay et al., 2012). Given the relatively few and weak studies in this area, it remains unknown whether school PA provision may influence such outcomes at all in kindergarten. If such evidence is found, it is of further importance to determine whether the evidence found in this area for older children also applies to early childhood and, if so, to answer questions related to what degree, by what causal mechanisms, and for which sub-groups among others. Evidence to date regarding kindergarteners' PA regardless of setting or outcome remains generally limited to small samples and outdated data (e.g., Becker et al., 2014; T. Baranowski, Thompson, Durant, Baranowski, & Puhl, 1993; Jarrett et al., 1998; McKenzie, Sallis, Nader, Broyles, & Nelson, 1992), or have been primarily focused on issues of PA measurement rather than outcomes stemming from PA participation (e.g., Benhan-Deal, 2005; Beighle et al., 2006; Oliver et al., 2007; Van Cauwenberghe, Jones, Hinkley, Crawford, & Okely, 2012). Although these studies represent important contributions to the field, there is a great need for further examinations.

Second, it is of interest to examine how various forms of school PA may shape the relationship between PA participation and cognitive and academic ability scores. In particular, too little evidence exists regarding the de facto PA interventions commonplace within schools including PE and recess (Lee et al., 2007). Some research has suggested that these forms of PA have positive benefits to young children's cognitive ability and, in turn, distal school outcomes but the evidence remains underdeveloped. Providing additional evidence in these two areas has potential to inform the development of future PA interventions and research activities aimed at young children in the kindergarten years (Lee et al., 2007).

Current Study

A key causal mechanism by which PA can promote development outcomes is via a physiological link whereby participation in regular PA leads to improvements to brain functioning such as concentration, memory, and others (Garon et al., 2008; Hillman et al., 2011; Puterman et al., 2010). This analysis will examine the lingering question of whether kindergarteners' school-based PA is associated with any increases to cognitive and academic ability. Thus, the study hopes to expand research, especially that by Dills and colleagues (2011), in three meaningful ways with implications for social justice. First, it will add substantively and methodologically current evidence to research regarding the association of school provision of PA with students' core cognitive and academic abilities in kindergarten. These multi-level connections are understudied across PA research and are especially needed among samples of kindergarteners due to a dearth of evidence regarding this population. Second, it will correct for an overlooked distinction between PE and recess forms of school PA. Differential effects found across the two forms could lead to important intervention and policy changes. Third, it will examine how school PA provision interacts with the key demographic covariates of biological sex and race/ethnicity. Significant differences found among these cross-level interactions have the ability to shape future intervention efforts targeted at specific groups of children.

Pursuant with these efforts, the analysis features three research questions (RQs) related to the daily provision of PA opportunities in school recommended by researchers and governing standards (Lee et al., 2007). The RQs are as follows:

- RQ1: Is the provision of daily PE by schools associated with increases to children's cognitive and academic ability as measured by scores on tests of (a) cognitive flexibility, (b) working memory, (b) reading, and (b) mathematics?
- RQ2: Is the provision of daily recess by schools associated with increases to children's cognitive and academic ability as measured by scores on tests of (a) cognitive flexibility, (b) working memory, (b) reading, and (b) mathematics?
- RQ3: Is the provision of daily PE and recess by schools differently associated with increases to children's cognitive and academic ability test scores by (a) biological sex and (b) race/ethnicity?

Methods

Sample

The sample comprised the kindergarten cohort (*N* = 18,174) of the Early Childhood Longitudinal Study, Kindergarten Class of 2010-11 study (ECLS-K:2011). Children were grouped in 1,308 schools across the country. Begun in 2010, the ECLS-K:2011 is an ongoing cohort study sponsored by the National Center for Education Statistics (Tourangeau et al., 2015). The study employed a three-stage sampling design with geographically-based primary sampling units (PSUs) comprising single or contiguous counties as the first stage (Tourangeau et al., 2015). Within these PSUs, public and private kindergarten programs were then selected with a correction to oversample underrepresented children. The data examined herein was the publically-available version of the ECLS-K:2011, which shields identifying information such as zip codes and school locations. As the publically available version of the ECLS-K:2011 does not contain variables for the PSUs (i.e., county variables), the data was treated throughout as a two-stage sample with schools sampled at the first stage and individual students at the second stage.

Measures

Dependent variables. Four cognitive and academic ability test scores were included to comprise a holistic assessment of children's abilities (see Table 2.1). All cognitive and academic ability tests were administered directly to individual children by trained assessors using picture cards/images and were selected for use in the ECLS-K:2011 by review of literature and consultation with education experts (Tourangeau et al., 2015). Two tests were related to the broader domain of executive functioning ability and comprised unique tests of (a) cognitive flexibility (Dimensional Change Card Sort test; Range: 0 to 18; Zelazo, 2006) and (b) working memory (Woodcock-Johnson III Tests of Cognitive Abilities Numbers Reversed subtest; Range: 40 to 175; Mather & Woodcock, 2001). Both of these tests have been used previously in extant research to assess young children's executive functioning ability (e.g., McClelland et al., 2007; Welsh et al., 2010). The remaining two variables constituted composite scores of individual items used to test (a) reading ability (n = 83 original items) and (b) mathematics ability (n = 75). Composite scales for the three academic items were calculated by the ECLS-K:2011 developers using item response theory (IRT) methods to facilitate comparisons of scores across children who did receive identical sets of questions (Tourangeau et al., 2015). The final range of the scales for the academic variables ranged from 21 to 91 for reading and 6 to 82 for mathematics. The validity of these academic ability variables was established from reviews of educational performance standards and consultations with curriculum experts (Tourangeau et al., 2015). The internal consistency reliabilities of the academic variables were .95 and .94. All four core dependent variables were modeled as both (a) raw Spring 2011 ability and (b) Fall 2010 to Spring 2011 ability gain scores. In all, this created eight (4 × 2) total dependent variables comprising cognitive and academic ability.

Student covariates. It was hypothesized based on existing research and theory that kindergarteners' PA behaviors and cognitive performance abilities would vary depending on demographic characteristics related to individual children and their family/home microsystems (e.g., Finn et al., 2002; Hinkley et al., 2012; Larson, Russ, Nelson, Olson, & Halfon, 2015). Preliminary checks identified eight demographic covariates (Table 2.1) from the ECLS-K:2011 that were consistently statistically significant predictors of the dependent variables: (a) children's age in years (4.4–8.3), (b) male biological sex (1 = "Yes," 0 = "No"), (c) non-Hispanic White race/ethnicity, (d), having a disability diagnosis (1 = "Yes," 0 = "No"), (e) parent-reported child Health Status (1 = "Fair/Poor," 4 = "Excellent"), (f) living in a primarily English speaking household (1 = "Yes," 0 = "No"), (g) home socioeconomic status as measure with a multidimensional composite scale comprising expert recommended items including parents' education, parents' occupational prestige, and household income (.67–5.6; Shavers, 2007; Tourangeau et al., 2015), and (h), the presence of two parents in the home (1 = "Yes," 0 = "No").

School PA provision. School-level PA was measured with two observed individual items assessing school's provision of PE and recess opportunities each week (Table 2.1). One school administrator per school was selected to provide information about their school. For the PE item, administrators were first prompted to respond to a series of questions related to how often the "typical child" engaged in "work or lessons or projects" either in a whole class, small groups, or individually. The sub-question relating to participation in "physical education" was then promoted with seven responses comprising "Never" to "5 days a week." For the recess item, school administrators were asked how many "days a week do children have recess" in their schools. Response options ranged from "0 days" to "5 days." Both the original PE and recess items, a dichotomous variables were recoded such that "1" equaled schools and children with daily PE and recess and “0” indicated less than daily (0–4 days/week). This partitioning greatly aids in estimation procedures and is the recommended level of PE provision recommended by researchers and policymakers (Lee et al., 2007). Note that both the PE and recess items were not further specified or defined in the ECLS-K:2011.

School covariates. It was also hypothesized that students’ abilities and behaviors would vary based on school-level contextual effects. Preliminary checks identified three ECLS-K:2011 school covariates (Table 2.1) that were consistently statistically significant predictors of the cognitive and academic dependent variables: (a) enrollment size (“1 = “0 to 149,” 5 = “750+”), (b) percentage of students eligible for free lunch (0–100), and (c), urbanized location (1 = “Yes,” 0 = “No”).

Data Analysis

The core statistical analysis comprised a relational examination of PA behaviors using hierarchical linear modeling (HLM). HLM confers two particular benefits to this study. First, HLM offers an important statistical advantage in that it effectively controls for clustering effects that may exist due to between group variance, ensuring that standard errors are not biased and resulting significance tests are accurate and efficient (Raudenbush & Bryk, 2002). Second, HLM provides a substantive advantage in its ability to test for the macro-level and macro-to-micro effects of level-2 characteristics on outcome variables.

Estimation. Prior to the analyses, sample-weighted diagnostic checks were performed to determine the nature of the study’s variables. Correlations found that the four core dependent variables (r = .27 to .74), the two level-2 school PA variables (r = .11), the three level-2 school covariates (r = .07 to .53), and the eight level-1 demographic covariates (r = .00 to .43) were not likely not problematically correlated. Also, variance inflation factor (VIF) values for the demographic variables confirmed that these specified covariates did not exhibit problematic levels of collinearity (VIF ≤ 2.17). Checks also confirmed that the dependent variables approximated normal distributions based on values of skewness (Range: −1.99 to .57) and kurtosis (Range: 2.38 to 7.34).

All measures except the dependent variables were centered at their grand mean to facilitate model convergence and interpretation in relation to the random intercepts (Raudenbush & Bryk, 2002). All data management and analyses procedures were conducted in Stata 14.0 (StataCorp), with the core procedure for conducting the multilevel analyses using the "mixed" command for mixed effects HLM models. Analyses used the appropriate procedures to accommodate the survey design of the ECLS-K:2011. Specifically, per expert recommendations the level-1 student sampling weights were adjusted to sum to the effective sample size of their corresponding level-2 school cluster (Rabe-Hesketh & Skrondal, 2006). Also per HLM best practices, the analysis examined several models using full maximum likelihood (ML) (Raudenbush & Bryk, 2002) due to estimation problems with restricted maximum likelihood with sample weights.

A large number (n = 982) of children were missing values on all the cognitive and academic outcomes. More specifically, diagnostic checks found that 5.64% (n = 1,025), 5.78% (n = 1,050), 5.44% (n = 989), 5.67%(n = 1,031), and 6.81% (n = 1,238), of cases were missing on the cognitive flexibility, working memory, reading, and mathematics dependent variables, respectively. This suggested a need for multiple imputation (MI) of missing values given that that proportions exceeded 5% (Saunders et al., 2006). MI procedures are theoretically able to provide unbiased estimates when data are MAR, and help correct for biases in cases of "missing not at random" (Rose & Fraser, 2008). Currently, Stata's "mi" suite of missing data commands do not support post-imputation estimation when combining the “svy” command for survey data with further post-estimation of mixed-effect multilevel models. Instead, the MI followed three steps based on expert recommendations. First, diagnostics were performed that identified whether the analysis variables were potentially significant covariates of missingness using logistic regression models. Second, these variables plus the level-1 child and level-2 school sampling weights were used to impute missing values using 10 imputations with the “mi” commands fitting each specified variable uniquely and then pool results using the combination rules outlined by Rubin (1996). Third, estimation occurred on the MI data with Stata’s “mixed” command for mixed-effects multilevel models incorporating the level-1 child sampling weight.

Procedure. The HLM model building process included four sequential steps consistent with expert recommendations (Raudenbush & Bryk, 2002). First, *one-way random effects ANOVA* models were fitted with School ID as the clustering variable for each of the three dependent variables using the following general equation

$$Y_{ij} = \gamma_{00} + u_{0j} + r_{ij}$$

which decomposes each observed outcome (Y_{ij}) as the total of (a) the grand mean (γ_{00}) + (b) the random effects of schools (u_{0j}) + (c) the random effects of individual children (r_{ij}). Second, *random coefficients* or *random intercepts* models were fitted for each of the outcomes specifying only level-1 predictors (i.e., child-level demographic covariates) with random effects. Third, *regression with means as outcomes* models were fitted for each of the dependent variables specifying only level-2 predictors (i.e., school-level characteristics) with random effects. These model used the level-1 intercepts as the dependent variables at level-2. The results from these models were then compared with the null model. Specifically, the results explained how much variation in the cognitive and academic ability variables was explained by the level-2 variables. This finding is equivalent to the R^2 value for the level-2 variables.

Finally, the full *random intercepts and slopes* models were fitted for each of the outcome variables specifying both level-1 and level-2 predictors. Results from these models, when paired with the R^2 values derived from the models specified above, were used to determine the total variation in the eight dependent variables from both the level-1 and level-2 predictors. The general functional form of these final models was as follows for each of the dependent variables

Level 1 (Student):

$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{Age})_{ij} + \beta_{2j}(\text{Male})_{ij} + \beta_{3j}(\text{White})_{ij} + \beta_{4j}(\text{Disabled})_{ij} +$

$\beta_{5j}(\text{Child Health})_{ij} + \beta_{6j}(\text{English})_{ij} + \beta_{7j}(\text{Home SES})_{ij} + \beta_{8j}(\text{Two Parents})_{ij} + r_{ij}$

Level 2 (School):

$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{PE})_j + \gamma_{02}(\text{Recess})_j + + \gamma_{03}(\text{Enrollment})_j + \gamma_{04}(\text{Free Lunch})_j + \gamma_{05}(\text{Urban})_j\ u_{0j}$

$\beta_{1j} = \gamma_{10}, \beta_{2j} = \gamma_{20}, \beta_{3j} = \gamma_{30}, \beta_{4j} = \gamma_{40}, \beta_{5j} = \gamma_{50}, \beta_{6j} = \gamma_{60}, \beta_{7j} = \gamma_{70}, \beta_{8j} = \gamma_{80}$

where children's demographic characteristics are entered as level-1 covariates and the key coefficients of interest represent school provision of PE (γ_{01}) and recess (γ_{02}). The random effect u_{0j} represents heterogeneity associated with the model intercept. In addition, the individual models for each dependent variable varied based upon exploratory analyses for cross-level interactions. Results found six potentially significant cross-level interactions that were subsequently included in the final analyses: (a) PE × age for the Spring 2011 working memory model, (b) Recess × English for the Spring 2011 working memory model, (c) PE × English for the Spring 2011 reading ability model, (d) PE × English for the 2010–2011 reading gain model, (e) Recess × Home SES for the Spring 2011 mathematics ability model, and (f), Recess × White for the 2010–2011 reading gain model. Wald X^2 tests found that random effects should be specified for two of the cross-level interactions. No random effects were specified for the eight child covariates. Due to the multiple comparisons, statistical significance was corrected using the Benjamini-Hochberg false discovery rate adjustment (Benjamini & Hochberg, 1995).

Results

Descriptive Characteristics

The number of cases in the final sample ranged from 13,015 to 15,927 due to missing data (see Table 2.1). The mean age was 6.12 years old (*SD* = .38) with a range from 4.35 to 8.29. Almost all children were aged 5 to 6 (92.95%). Slightly over half were male (51.73%). The racial/ethnic composition of the children closely mirrored national averages. Just over half (52.04%) of children were non-Hispanic White, 12.64% were non-Hispanic African American, 18.72% were Hispanic/Latino, and 4.68% were non-Hispanic Asian American. Slightly more than one-fifth (20.50%) held a physical or psychological disability diagnosis. Despite this, parent-reported health scores were high, with 60.71% reporting the highest possible score of "Excellent" (*M* = 3.45; *SD* = .78). English was the primary home language for 82.13% of children. The mean home socioeconomic score was 2.95 (*SD* = .87). Over two-thirds (69.43%) of children had two parents in their home. The mean cognitive ability scores were 15.14 (*SD* = 2.81) for cognitive flexibility and 94.92 (*SD* = 17.02) for working memory. The mean academic ability scores were 49.33 (*SD* = 11.59) for reading and 43.00 (*SD* = 11.55) for mathematics. Only 19.72% of children were enrolled in kindergartens that featured daily PE activities. However, 82.13% of children were in kindergartens with daily recess activity.

HLM Model Results: Full Sample

Multiple imputation and weight-adjusted ICC results from the null models estimated with ML found that schools accounted for upwards of one-third of the dependent variables' variances. More specifically, schools accounted for 8.26% and 2.20% of the variation in cognitive flexibility (Spring 2011, 2010–2011 Gain), 10.51% and 2.58% of working memory, 18.05% and 19.46% of reading ability, and 19.52% and 17.67% of mathematics ability (see Table 2.2–2.5). Methodologically, these results establish the multilevel nature of the data. Substantively, the results also indicate that there are likely to be significant variations on kindergarteners' cognitive and academic abilities depending on which school they attend. Stages two and three of the HLM model building process found that the included explanatory variables explained relatively low amounts of the variation in children's outcomes. First, the random coefficients models found that the level-1 child covariates explained 6.24%, 5.40%, 12.93%, 0.38%, 12.43%, 2.85%, 15.45%, and 1.01% of the variance on the dependent variables, respectively. Second, results from the regression with means as outcomes models found that the five level-2 school variables explained 33.64%, 26.02%, 61.08%, 12.71%, 29.41%, 5.72%, 40.86%, and 3.19% of the variance on the dependent variables, respectively.

The final random intercepts and slopes models all demonstrated acceptable fit to the data: $F(13–15) = 3.03$ to 161.49, $p < .001$ (Table 2.2–2.5). The high statistical significance of these results precluded the need for a Benjamini-Hochberg adjustment. The intercepts, random effects, and majority of child covariates were statistically significant ($p < .05$) in all models. None of the child covariates were consistently significant predictors of all eight cognitive and academic ability variables. All things being equal, results generally found increases in children's age to be associated with increases to Spring 2011 scores (β: .35 to 4.33, $p < .001$) and to have mixed associations with 2010–201 gain scores (β: −1.23 to .84, $p < .05$). An outlier for age was found in

Spring 2011 working memory scores where being older was found to be associated with sharp decreases in children's scores ($\beta = -8.76$, $p < .001$). All things being equal, results generally found being of biological male sex to be associated with decreases to the outcomes (β: −1.55 to −.63, $p < .001$). All things being equal, having a disability diagnosis was associated with decreases to ability (β: −4.98 to −.63, $p < .001$). All things being equal, being of higher parent-reported health status was associated with increases to ability (β: .26 to .92, $p < .01$). All things being equal, being of a predominantly English-speaking household was generally associated with increases to ability (β: −.81 to 2.12, $p < .05$). All things being equal, higher home socioeconomic status was associated with increases to ability (β: .40 to 4.52, $p < .001$). Lastly, all things being equal, having two parents in the household was associated with increases to ability (β: .44 to 1.46, $p < .01$).

For the school covariates, all things being equal increases in enrollment size were associated with small positive increase to reading ability only (β: .75, .27, $p < .05$). Proportion of students in free lunch programs as a proxy for school population socioeconomic status had mixed statistically significant associations with cognitive and academic ability (β: −.04 to .02, $p < .05$). For urban location, all things being equal schools in an urban location were associated with decreases to the dependent variables. (β: −1.13 to −.74, $p < .05$).

Coefficients related to the level-2 school PA variables were mostly small. School provision of daily PE activities was not significantly associated with any of the eight outcomes ($p > .05$). The interaction effect of daily PE × English speaking for both reading outcomes that was identified in preliminary analyses was found to be statistically significant in the final full models ($\beta = 1.59$, 1.34, $p < .05$), and the random slope for this interaction in the 2010–2011 reading gain model was significant ($\beta = 1.30$, $p < .001$). The results for recess participation were more promising. Schools provision of daily recess activities was statistically significantly associated with increases to children's ability in six of the models: (a) Spring 2011 ($\beta = 1.40$, $p < .01$) and 2010–2011 ($\beta = 1.03$, $p < .05$) working memory scores, (b) Spring 2011 ($\beta = .070$, $p = .05$) and 2010–2011 ($\beta = .75$, $p < .05$) reading scores, and (c), Spring 2011 ($\beta = 1.05$, $p < .01$) and 2010–2011 ($\beta = .80$, $p < .01$) mathematics scores. Also, the recess × White interaction effect posited for 2010–2011 mathematics gain was positive and significant ($\beta = .84$, $p < .05$), as was its corresponding random slope ($\beta = .00$, $p < .001$).

A series of alternative models were tested (not pictured) featuring a transformation of the school PA items into dichotomous variables measuring the presence of any substantial provision of PE or recess during the week. Both PE and recess were recoded such that "0" equaled provision on 1 day per week or less and "1" equaled from 2 days to 5 days. These new school PA variables were then included in place of the daily school PA variables in the eight models for the cognitive and academic outcomes. Results found no significant findings for the PA variables of interest in six of the models, but did find small significant increases associated with regular PE provision for Spring 2011 mathematics scores (β: .65, $p = .03$) and with regular recess provision for 2010–2011 mathematics gains (β: .86, $p = .02$).

HLM Model Results: Comparisons by Biological Sex

A further set of comparison analyses were undertaken to discern patterns relating to the potential moderating effects of biological sex on the relationships between school PA and cognitive and academic ability (see Table 2.6). These models were estimated separately by retaining only the cases for the focal children in each respective model (Male = 5,392; Female = 5,145). Results found that 14 of the models fit the data well: $F(12) = 2.79$ to 104.27, $p < .05$. The model male only on 2010–2011 cognitive gain scores did not demonstrate adequate fit, and there was no convergence for the female only model on 2010–2011 mathematics gain scores.

School's provision of daily PE provision was only associated with a small negative effect ($\beta = -.30$, $p < .05$) for females in the 2010–2011 cognitive flexibility gain model. Recess was associated with increases on six models, ranging from a coefficient of .80 ($p < .01$) for the female only model on 2010–2011 reading gains to a coefficient of 2.04 ($p < .001$) for the female only model on 2011 working memory. Thus, participation in daily recess at school was found to be associated with positive increases to girls' working memory ability but not to boys'.

HLM Model Results: Comparisons by Race/Ethnicity

Comparison tests were also performed regarding the potential moderating effects of race/ethnicity (Table 2.6). Like those for biological sex, these models were estimated separately for the focal children in each respective model (White = 5,631; African American = 1,136; Hispanic = 2,367; Asian American = 758). Results found that all eight of White models ($F(12)$ = 1.70 to 73.73, $p < .001$), six of the African American models ($F(12)$ = 2.97 to 19.50, $p < .001$), seven of the Hispanic/Latino models ($F(12)$ = 2.24 to 46.49, $p < .01$), and six of the Asian American models ($F(12)$ = 2.97 to 19.50, $p < .001$) demonstrated good fit to the data. Five of the remaining models did not demonstrate good fit to the data, and the African American model on 2010–2011 working memory gains did not converge.

Overall, results found that school PE provision demonstrated one statistically significant positive association on the Spring 2011 mathematics ability of African American children (β: 1.86, $p < .01$), and one significant negative association on the 2010–2011 mathematics gain scores for Hispanic/Latino children (β: −1.32, $p < .01$). School PE also demonstrated borderline statistically significant negative associations with both Spring 2011 working memory (β: −1.70,

$p < .06$) and mathematics (β: −1.22, $p < .06$) ability. Meanwhile, school recess provision had positive effects on the cognitive flexibility (β: .21, $p < .05$), working memory (β: 1.62, $p < .01$), reading ability (β: .02, $p < .05$), reading ability gains (β: .93, $p < .01$), mathematics ability (β: 1.67, $p < .001$), and mathematics gains (β: 1.35, $p < .001$) for White children. There was no statistical significance for daily recess participation for non-White children.

Discussion

The analyses in this study hold uncertain implications for current and future efforts to encourage schools to promote PE and recess as means to encourage kindergartener's cognitive and academic outcomes. Regarding RQ1, there is no evidence to support that schools can increase their kindergarteners' cognitive and academic abilities via daily PE participation. For RQ2, there is evidence that daily recess provision is associated with increases to cognition and academics. Positive effects were found for this PA variable on six of the dependent variables. However, the effects were generally small and may be of limited practical significance given their size relative to the range of scores on those two outcomes. For RQ3, there is evidence that variations exist across the relationship between the explanatory PA variables and the dependent cognitive and academic outcomes. Large differences were found when comparing proportions of variance explained, and sign, size, and significance of parameter estimates between male and female children in the analyses. In relation to the general model, it appears that the positive contribution of recess to working memory is a result of particular increases to females' outcomes only. Similarly varied differences were demonstrated across the four race/ethnicity groups. When looking at the total sample models, it appears that the positive contribution of recess to cognitive and academic ability may arise due to increases for White children only.

Implications

These results suggest important implications for future research, practice, and policy efforts. First, upwards of one-fifth of individual children's variation in cognitive and academic ability is between schools. These relatively large proportions of variance strongly suggest that differences in kindergartens may play a significant role in shaping the cognitive and academic abilities of their students. As such, this finding is congruent with the body of extant research on schools' influence on individual children's outcomes (e.g., Dowda et al., 2004; Finn et al., 2002; Goldfield et al., 2012). The effect of schools on the variations in these models could be explained by qualities inherent to the outcomes themselves and/or the developmental stage, or could be explained practically by the relatively unstructured nature of kindergarten in the United States. Although individual schools affect their students' outcomes at all levels, this effect may be particularly pronounced in kindergarten where schools often have greater autonomy with regards to policies and curricula when compared with elementary, middle, and high schools. This autonomy, in turn, engenders wide differences in school characteristics and performance. Intervention efforts aimed at promoting these outcomes in very young children, regardless of whether they include PA or not, should consider the potentially strong role that kindergartens may play in explaining differential outcomes in children's abilities either for good or bad.

Second, the overall models and individual explanatory variables included therein did not explain much of the inter-individual variation in the cognitive and academic ability. The five school-level variables together explained at best only moderate proportions of children's variations on the outcomes. This finding is congruent with the overall lack of consistently significant associations between these two variables and the outcomes of interest. The demographic covariates, while consistently significant predictors of cognition and academics, also did not explain much of the variance on the outcomes. At best these covariates accounted for less than 10% of the variation. Taken together, this set of 10 level-1 variables did not explain large variations in children's abilities. Although the focus of the present study was not on maximizing the explanatory power of the models per se, this finding remains important. Namely, it suggests that researchers looking to develop statistical models and practical applications emanating from them in relation to kindergarteners' cognitive and academic outcomes should look elsewhere. Many other potential demographic covariates, not to mention behavioral (e.g., approaches to learning, social skills) and environmental (e.g., school resources, neighborhood safety) factors, may better explain these outcomes.

Third, this study is not alone. In particular, the work by Dills and colleagues (2011) is mostly congruent with the results found herein, particularly with regards to PE provision. However, the results found for recess in the present study are more supportive for school PA provision at this age. It remains to be seen whether such increases from recess are practically meaningful to individual children, their families, or their schools. Overall, there is now a significant body of evidence questioning whether school PA matters for increasing kindergarten-aged children's cognition and academics. In this way, this study is somewhat congruent with previous research which has found that parents' influence on children's PA behaviors and related outcomes may be stronger than that of schools (Hohepa, Scragg, Schofield, Kolt, & Schaaf, 2007). This conclusion is not yet definitive. It should be noted that the outcomes measured here related to innate ability and not to, for example, achievement such as that typically measured in grades or scores on standardized tests. It may be that PE and recess participation have social or other benefits that could promote those related yet distinct outcomes. Also, it is perhaps possible that school PA provision influences such outcomes distally into the future (i.e., elementary school) or indirectly via other factors (e.g., self-regulation, pro-social bonding). Additional research inquiries with more specialized (i.e., longitudinal, meditational) analyses are needed to ascertain whether such links may exist.

Limitations

It should also be remembered that this study is not without limitations that may affect the internal validity of results found herein and, thus, the external validity of the implications. The study was primarily limited by its design and measures. As cross-sectional and non-mediated analysis of association, the findings are limited in their ability to draw any true causal inferences. As other PA researchers have noted, there remains a great need for more rigorous studies examining PA among kindergarteners, preferably those featuring objectively based PA measures, longitudinal designs, and control groups (Cliff, Reilly, & Okely, 2009; Oliver et al., 2007; Pate, O'Neill, & Mitchell, 2010; Tucker, 2008). There are also limits to the measures included in the ECLS-K:2011. Namely, it lacks many of the potential social-environmental and behavioral variables noted above that previous research suggests could be more explanatory for the study's outcomes of interest (e.g., Hannon & Brown, 2008; Hinkley et al., 2012; Jones et al., 2011; Loprinzi & Trost, 2010; O'Dwyer et al., 2012; Oliver et al., 2010; Zecevic et al., 2010). For the PE and recess measures themselves, there was a lack of specificity regarding intensity, structure, duration, supervision, and other factors that could be useful when examining the conceptual link between school PA and the outcomes. For the cognitive and academic ability measures, the gain scores must be considered within the context of students' varying points of assessment during the course of the school year. Also, there may be implicit measurement bias in the overall conceptualization of PA in the ECLS-K:2011 with marginalized children, particularly those of low socioeconomic backgrounds, not being adequately assessed by the observed PA items.

Conclusion

PA promotion in kindergarten is still a valuable research effort. Numerous other studies have found that PA in kindergarteners may potentially promote positive outcomes in other areas of interest such as physical, health, psychosocial functioning, pro-social bonding, and others. The results in this set of analyses suggest there is little reason to believe that school PE at this age is associated with meaningful increases to cognitive and academic ability and functioning. Also, what effects were found seem to be mostly afforded to White children. African American, Hispanic/Latino, and Asian American kindergarteners appear to receive very little benefit to their cognitive and academic ability from either PE or recess participation, marking the link between school provision of PA and development as one highlighted by significant disparities that demand further attention from a social justice perspective. That said, the positive findings found for White children, particularly for recess provision, are deserving of additional research inquiries using a social justice perspective. In particular, future studies should seek to address this study's limitations regarding design and measurement to better ascertain whether any link may exist between school PE and recess participation and the important developmental outcomes of cognitive and academic ability.

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Table 2.1

ECLS-K:2011 Sampling Weight Adjusted Estimates of Variables' Descriptive Characteristics (Spring 2011)

Variable	*N*	Items	Range	Mean (SD)	Skewness	Kurtosis
Cognitive flexibility (Spring 2011)	15,128	1	0–18	14.14 (2.81)	−1.99***	7.34***
Working memory (Spring 2011)	15,117	1	41–175	94.92 (17.02)	−.18***	2.38***
Reading ability (Spring 2011)	15,153	1	21.63–90.35	49.33 (11.56)	.57***	3.22***
Mathematics ability (Spring 2011)	15,120	1	6.26–81.12	43.00 (11.55)	−.11***	2.84***
Age	13,183	1	4.35–8.29	6.12 (.38)	.44***	3.67***
Male sex	13,611	1	0, 1	.52 (.50)	−.07**	1.00***
White race/ethnicity	13,607	1	0, 1	.52 (.50)	−.08***	1.01***
Disability diagnosis	13,039	1	0, 1	.21 (.40)	1.46***	3.14**
Child health status	13,015	1	1–4	3.45 (.78)	−1.26***	3.74***
English speaking	13,583	1	0, 1	.82 (.38)	−1.68***	3.81***
Home socioeconomic status	13,528	1	.67–5.44	2.95 (.82)	.23***	2.55***
Two parents	13,527	1	0, 1	.69 (.46)	−.84***	1.71***
Daily PE	15,105	1	0, 1	.20 (.40)	1.52***	3.32***
Daily recess	15,163	1	0, 1	.82 (.38)	−1.68***	3.81***
Enrollment size	15,927	1	1–5	2.98 (1.12)	−.09***	2.26***
Free lunch percentage	15,927	1	0–100	39.54 (31.94)	.40***	1.95***
Urban location	15,684	1	0, 1	.64 (.48)	−.59***	1.35***

Note: ***p* < .01, ****p* < .001; two-tailed test.

Table 2.2
ECLS-K:2011 Multiple Imputation and Sampling Weight Adjusted HLM Estimates of School Physical Education and Recess Provision on Cognitive Flexibility (Spring 2011)

Effects	**Spring 2011 Ability** **β (RSE)**	**2010–2011 Ability Gain** **β (RSE)**
Intercept	15.23***	16.95***
Fixed Effects		
Level 1: Child		
Age	.35***	−.42***
Male	−.22***	.04
White	.41***	−.12
Disabled	−.63***	.08
Health status	.00	−.03
English	.22*	−.39**
Home SES	.40***	−.08
Two parents	.10	.10
Level 2: School		
Daily PE	−.10	−.13
Daily Recess	.13	−.03
Enrollment size	.04	−.07
Free lunch %	−.00*	.00
Urban location	−.09	.07
Random Effects		
Intercept	.62***	.51***
Residual	2.58***	3.46***
ICC	.08	.02
Level-1 R^2	.06	.05
Level-2 R^2	.34	.26
Observations	10,537	10,537
Groups	870	870
***F* (df)**	38.72 (13)***	4.87 (13)***

Note: *$p < .05$, ** $p < .01$, ***$p < .001$; Two-tailed tests. ICC = intra-class correlation coefficient. RSE = Robust standard errors. All fixed effects were grand mean centered.

Table 2.3

ECLS-K:2011 Multiple Imputation and Sampling Weight Adjusted HLM Estimates of School Physical Education and Recess Provision on Working Memory (Spring 2011)

Effects	**Spring 2011 Ability** ***β*** **(RSE)**	**2010–2011 Ability Gain** ***β*** **(RSE)**
Intercept	95.65***	69.17***
Fixed Effects		
Level 1: Child		
Age	−8.76***	.84*
Male	−1.22***	−.11
White	2.12***	−.07
Disabled	−4.98***	−.63
Health status	.92***	.28
English	2.12***	−.77
Home SES	4.37***	−.09
Two parents	1.27**	.33
PE × Age		1.42
Recess × English		1.57
Level 2: School		
Daily PE	−.47	−.77
Daily Recess	1.40**	1.03*
Enrollment size	.29	.12
Free lunch %	−.04***	.02*
Urban location	−.79*	−1.13**
Random Effects		
Intercept	2.73***	1.92***
Residual	15.01***	14.86***
ICC	.11	.03
Level-1 R^2	.13	.00
Level-2 R^2	.61	.13
Observations	10,537	10,537
Groups	870	870
F **(df)**	141.31 (13)***	3.03 (15)***

Note: *$p < .05$, ** $p < .01$, ***$p < .001$; Two-tailed tests. ICC = intra-class correlation coefficient. RSE = Robust standard errors. All fixed effects were grand mean centered.

Table 2.4

ECLS-K:2011 Multiple Imputation and Sampling Weight Adjusted HLM Estimates of School Physical Education and Recess Provision on Reading Ability (Spring 2011)

Effects	**Spring 2011 Ability** ***β*** **(RSE)**	**2010–2011 Ability Gain** ***β*** **(RSE)**
Intercept	49.58***	61.11***
Fixed Effects		
Level 1: Child		
Age	4.33***	−.29
Male	−1.55***	−.63***
White	.17	.30
Disabled	−3.47***	−1.18***
Health status	.66***	.26**
English	1.93***	.46*
Home SES	4.52***	.62***
Two parents	1.35***	.44**
PE × English	1.59*	1.34**
Level 2: School		
Daily PE	−.08	.02
Daily Recess	.70[a]	.75**
Enrollment size	.75***	.27*
Free lunch %	−.01	.01
Urban location	−.67	−.98***
Random Effects		
Intercept	3.62***	2.94***
Residual	9.84***	6.13***
PE × English slope		1.30***
ICC	.18	.19
Level-1 R^2	.12	.03
Level-2 R^2	.29	.06
Observations	10,537	10,537
Groups	870	870
F **(df)**	124.82 (14)***	15.10 (14)***

Note: *$p < .05$, ** $p < .01$, ***$p < .001$, [a]$p < .06$; Two-tailed tests. ICC = intra-class correlation coefficient. RSE = Robust standard errors. All fixed effects were grand mean centered.

Table 2.5

ECLS-K:2011 Multiple Imputation and Sampling Weight Adjusted HLM Estimates of School Physical Education and Recess Provision on Mathematics Ability (Spring 2011)

Effects	**Spring 2011 Ability** ***β*** **(RSE)**	**2010–2011 Ability Gain** ***β*** **(RSE)**
Intercept	43.67***	31.82***
Fixed Effects		
Level 1: Child		
Age	6.07***	−1.23***
Male	.28	−.10
White	1.58***	.68
Disabled	−3.96***	−.91***
Health status	.70***	.04
English	1.08**	−.81***
Home SES	4.31***	.13
Two parents	1.46***	.24
Recess × Home SES	−.23	
Recess × White		.84*
Level 2: School		
Daily PE	−.16	−.36
Daily Recess	1.05**	.80**
Enrollment size	.24	−.11
Free lunch %	−.02**	.02**
Urban location	−.26	−.74**
Random Effects		
Intercept	3.11***	2.74***
Residual	9.43***	6.09***
Recess × White slope		.00***
ICC	.19	.17
Level-1 R^2	.15	.01
Level-2 R^2	.41	.03
Observations	10,537	10,537
Groups	870	870
F **(df)**	161.49 (14)***	10.76 (14)***

Note: $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$; Two-tailed tests. ICC = intra-class correlation coefficient. RSE = Robust standard errors. All fixed effects were grand mean centered.

Table 2.6

ECLS-K:2011 Multiple Imputation and Sampling Weight Adjusted HLM Estimates of School Physical Education and Recess Provision on Cognitive and Academic Ability: Comparisons by Biological Sex and Race/Ethnicity (Spring 2011)

Ability	**Male *β* (RSE)**	**Female *β* (RSE)**	**White *β* (RSE)**	**African American *β* (RSE)**	**Hispanic/ Latino *β* (RSE)**	**Asian American *β* (RSE)**
Cognitive Flexibility (2011)						
Daily PE	−.06	−.16	−.11	.07	−.17	−.30
Daily Recess	.11	.17	.21*	.30	−.21	.20
Cognitive Flexibility (2010–2011)						
Daily PE	.06	−.30*	−.09	NS	−.33	NS
Daily Recess	−.13	.06	−.03	NS	−.12	NS
Working Memory (2011)						
Daily PE	−.72	−.23	−.17	2.07	−1.70[a]	−1.38
Daily Recess	.96	2.04***	1.62**	.79	.82	−.38
Working Memory (2010–2011)						
Daily PE	NS	−.55	−.4	NC	NS	1.19
Daily Recess	NS	1.40**	.55	NC	NS	−.26
Reading Ability (2011)						
Daily PE	−.49	.32	−.64	.69	.16	−1.63
Daily Recess	.98*	.65	.02*	.79	.28	.34
Reading Ability (2010–2011)						
Daily PE	−.37	.09	−.29	.19	.01	NS
Daily Recess	.94**	.80**	.93**	.88	.43	NS
Mathematics Ability (2011)						
Daily PE	−.30	−.10	−.19	1.86**	−1.22 [a]	−.61
Daily Recess	1.26**	1.07**	1.67***	.26	.39	.32
Mathematics Ability (2010–2011)						
Daily PE	−.48	NC	−.29	.56	−1.32**	−.19
Daily Recess	.87**	NC	1.35***	−.58	.69	−.60

Note: *$p < .05$, **$p < .01$, ***$p < .001$, [a]$p < .06$; Two-tailed. ICC = intra-class correlation coefficient. RSE = Robust standard errors. NS = non-significant model fit. NC = no model convergence. All fixed effects were grand mean centered.

PAPER III

KINDERGARTENERS' ORGANIZED ATHLETICS PARTICIPATION AND READING AND MATHEMATICS: A STRUCTURAL EQUATION MODELING ANALYSIS

Research on children's physical activity (PA) has grown precipitously in recent years, and the promotion of positive PA behaviors now constitutes a major global public health concern (World Health Organization [WHO], 2010). Increasing children's PA is not only desirable for obvious health benefits. In fact, evidence is now strong that participation in regular PA for even young children can lead to significant improvements in neuroelectric activity, concentration, memory, and other factors that, in turn, may promote short- and long-term academic achievement (Hillman, Kamijo, & Scudder, 2011; Strong et al., 2005). Although evidence is still developing, findings to date have been promising and hold tantalizing potential to inform intervention and policy endeavors.

Overall, too little PA research has focused on children in the kindergarten years (ages 5 to 7) when many children start formal schooling and begin individual patterns of PA that may extend into adulthood (Goldfield et al., 2012). Most extant research and reviews have focused on adolescents, with scant efforts being focused on either on the wide range of pre-school aged children (e.g., 2–6; Tucker, 2008) or on elementary school and beyond (e.g., 6–18; Dobbins et al., 2013; Trudeau & Shephard, 2008). This is problematic as there are large differences between the behaviors, developmental capacities, and outcomes among children even a few years apart. Analyses that fail to partition out the moderating effects of age lack clarity regarding how PA may influence academics at specific time points such as kindergarten.

Of the several exceptions, two notable studies exist which focus specifically on kindergartener's PA behaviors and academic outcomes. First, Stevens and colleagues tested a structural equation model comprising over 6,000 young children and found support for PA's ability to increase reading and mathematics outcomes for boys and girls (2008). However, the study is limited in its ability to explain kindergarteners' PA as it features composite variables that are aggregates of scores from kindergarten through the 5th grade. Meanwhile, Carlson and colleagues tested multivariate linear regression models on a sample of 5,316 kindergarten aged children and found that increases in PA were associated with increased reading and mathematics for girls but not boys (2008). Their analysis focused specifically on a PA measure comprising minutes per week of school-based physical education, and did not examine PA participation at home. Although both of these analyses suggest that PA may positively influence kindergarteners' academics, many questions remain. Moreover, the data for both studies are now close to two decades old, begging the question of what findings would result from more recent samples of kindergarteners given that PA behaviors have likely changed in the interim.

Beyond an overall lack of research emphasis, several unresolved issues exist in the area of kindergarten PA promotion. Two of these are particularly prominent and will be addressed herein. First, although it is known that PA promotes academics, it is not known what manifestations of PA may be more beneficial than others. Lingering questions persist regarding PA types, settings, and other factors that directly inform selection of variables in research analyses and targets in intervention development. There are likely to be differences, for example, between young children's participation in individual PA at home and that of group PA experienced within more formal and structured settings. Second, and related to the above, there are subsequent missing links between increases in PA participation and distal increases in academic outcomes. Little is known about which of many possible factors may link the range of PA independent variables with academic outcomes. As such, kindergarten PA research lacks comprehensive conceptual models incorporating various evidence-based mediating psychological, social, and structural factors. Taken together, these two issues hamper research and intervention efforts in this area. Evidence is needed that expands upon broad linkages to provide specifics details regarding how PA participation among young children may be associated with gains in academic performance.

Causal Mechanisms Linking PA and Academics

There are well-established direct, biological links between PA participation and academic outcomes including raw ability and performance-based scores (e.g., grades). Specifically, evidence has found that PA increases on academics are distal, with proximal increases being demonstrated via improvements in cognition. PA increases cognition, in turn, through a variety of brain-based physiological means including encoding of stimulus responses, increasing cognitive control, and buffering of stressors (Chang et al., 2013; Garon et al., 2008; Hillman et al., 2008; Hillman et al., 2011; Puterman et al., 2010). Thus, PA's primary impact on brain functioning is via executive functioning processes that, in turn, are directly related to performance on academic outcomes and ability (Davis et al., 2011; Garon et al., 2008; Rasberry et al., 2011; Timmons et al., 2012). This evidence is robust and has now been extended from earlier examinations on adults and adolescents to very young children such as those in kindergarten (Chang et al., 2013).

Evidence regarding other causal links is still developing. Recent attention has focused on PA's positive influences on proximal affective outcomes such as psychosocial functioning, emotional well-being, pros-social behaviors, and others that may mediate the relationship between PA participation and academic achievement (Bailey et al., 2006; Biddle & Asare, 2011; Janssen & LeBlanc, 2010; Strong et al., 2005). Thus, these factors are hypothesized to be conduits by which PA may also indirectly promote academics beyond a direct, biological link. As such, inclusion of these proximal affective outcomes has been a strong recent focus across children's PA research in an effort to more fully explain PA's ability to increase academic achievement.

PA and Social Learning Theory

One evidence-based mechanism uniting PA, affective functioning, and academics is a social learning theory-based link that highlights the promotive power of PA's social aspects (Demetriou & Höner, 2012). Child development theorists have long posited that children learn about themselves and their environments via participation in PA, especially that in a group or team setting. Under this conceptualization, children's PA experienced within social settings may be particularly adept at increasing developmental outcomes for two primary reasons. First, socially-based PA imposes an external organizing structure involving constraints such as rules and schedules. These characteristics, in turn, engender the development of internal self-discipline, control, and self-regulation behaviors that have evidence-based direct influences on their academic outcomes including reading and mathematics (McClelland et al., 2007; Tomporowski et al., 2011; Trentacosta & Izard, 2007). Second, the group-based nature of social PA promotes children's ability to work cooperatively with others and seek group cohesion. Children are also likely to develop a sense of belonging and value within respect to their peers (Bailey et al., 2006). In theory, these important attributes then translate to the school settings where similar constraints and groups are found.

It should be noted that this conceptualization neatly addresses both of the aforementioned issues by emphasizing both (a) particular forms (i.e., organized group- and team-based PA) and (b) particular causal links (i.e., social learning, social capital, self-control) that can be jointly tested to determine if socially-based PA may be uniquely effective at increasing academics. Also, this social conceptualization of PA can be easily combined with the aforementioned biological link to form a more comprehensive model of PA's links with academic outcomes. To date, tests of the link between PA participation and academics have been largely limited to middle and high school students and/or have not included conjoint direct and indirect paths uniting biological and social factors (e.g., Fox et al., 2010; Rasberry et al., 2011). As such, kindergarteners' organized PA participation exists in an incongruous state. It is both simultaneously popular among children and understudied by researchers.

Research Questions

This study seeks to update and expand kindergarten PA research in three ways. First, it comprises an examination of a large, recent, and nationally-representative sample. Second, it analyzes the conceptual model with advanced statistical methods appropriate for both the research goals and data. The conceptual model (see below) has been carefully crafted based on social learning theory tenets that link socially-based, organized PA and academic outcomes. Third, and most importantly, it tests a conceptual model linking PA participation and academic functioning comprising both (a) direct, biologically-based and (b) indirect, socially-based causal mechanisms. These mechanisms are tested based on strong evidence for the former across age groups and PA manifestations, and nascent development in the latter among older children that organized PA promotes external socialization and internal self-control behaviors. Research has found that both the executive functioning processes biologically promoted by all forms of PA (e.g., Blair & Razza, 2007; Espy et al., 2004), as well as the self-regulation behaviors socially promoted by organized forms of PA (e.g., Becker, McClelland, Loprinzi, & Trost, 2014; Blair & Razza, 2007; McClelland et al., 2007) are directly associated with the reading and mathematics ability among children as young as 4 years old. The simultaneous testing of both mechanisms and extension of a comprehensive biological and social model to kindergarteners represent potentially important new contributions to PA research.

Overall, this study builds upon extant studies such as those outlined above to further the goal of determining key PA variables and linkages that can be targeted by intervention efforts. The study poses three explicit research questions:

- RQ1: Does kindergarteners' participation in organized athletics demonstrate a direct association with positive increases to their academic ability?
- RQ2: Does kindergarteners' participation in organized athletics demonstrate indirect associations with positive increases to their academic ability via (a) executive functioning and social skills?
- RQ3: Does the relationship between kindergarteners' organized athletics, executive functioning, social skills, and academic ability vary based on differences in (a) biological sex and (b) race/ethnicity?

All three questions were modeled as micro-level propositions. Following conventions (Baron & Kenny, 1986; Bollen, 1989; Bowen & Guo, 2012), RQ1 is analogous as a direct effects proposition and RQ2 as a proposition including direct and indirect effects. Thus, it was hypothesized that organized athletics would have partially-mediated relationship with academic ability. RQ3 is a proposition relating to moderating effects. Based on theory and evidence, it was hypothesized that all three questions would be answered affirmatively and that organized athletics would demonstrate (a) direct and positive direct effects on academics, executive functioning, and social skills, and (b) positive indirect effects on academics via the two meditational factors. Additionally, it was hypothesized that biological sex and race/ethnicity would moderate these relationships, with the models for underserved children (i.e., females, non-Whites) having reduced and/or non-significant effects.

Methods

Sample

The sample comprised the kindergarten cohort (*N* = 18,174) of the Early Childhood Longitudinal Study, Kindergarten Class of 2010-11 study (ECLS-K:2011). Begun in 2010, the ECLS-K:2011 is an ongoing cohort study sponsored by the National Center for Education Statistics (Tourangeau et al., 2015). The study employed a multi-stage sampling design based on 90 geographic primary sampling units (PSUs) comprising single or contiguous counties (Tourangeau et al., 2015). Within these PSUs, public and private kindergarten programs were selected with a correction to oversample underrepresented children. The data examined herein was the publically-available version of the ECLS-K:2011, which shields identifying information such as zip codes and school locations. The final analytic sample (*n* = 13,365; 73.5%) was comprised of those children who had (a) direct child assessments, (b) parent-reported data, and (c), teacher-reported data collected in the 2010-2011 academic year on the variables of interest.

Measures

Organized athletics. Organized athletics participation was measured with a single dichotomous item asking parents whether "outside of school hours has [their child] ever participated in organized athletic activities like basketball, soccer, baseball, or gymnastics?" (Yes = 49.6%; *n* = 6,628; see Table 3.1). This question is a simple participation-based PA measure, and is imprecise with regard to setting, context, type, duration, intensity, or level. Notably, the item was placed within a series of related questions assessing children's social activities such as those comprising academics, dance, music, art, and others. Other items in the ECLS-K:2011 were used to assess general and/or non-structured PA participation.

Academic ability. In this study, children's academic ability was measured in the Spring of 2011 with two composite tests assessing (a) reading and (b) mathematics (Table 3.1). These tests were administered directly to individual children by trained assessors who presented children with images related to the questions and then instructed them to respond with an answer either verbally or by pointing (Tourangeau et al., 2015). Composite scores based on individual items in the tests were then calculated based on item response theory (IRT) methods. The IRT approach has several advantages over traditional raw number-right scoring, including allowing for comparisons of scores across children who may not have been administered identical sets of items (Tourangeau et al., 2015). Of note, the ECLS-K:2011contains both theta scores and scale scores for the academic variables. The set of reading and mathematics scale scores have been chosen in this analysis due to their ease of interpretability and applicability to cross-sectional analyses and multiple group comparisons (Tourangeau et al., 2015). Substantively, the reading scale included 83 items related to (a) literacy skills, (b) vocabulary knowledge, and (c), reading comprehension. The mathematics scale included 75 items related to (a) numbers, (b) measurement, (c) spatial awareness, (d) data analysis, and (e), patterns. The validity of the academic ability scales' items come from careful reviews of educational performance standards and judgments from a panel of curriculum experts (Tourangeau et al., 2015). The internal consistency reliabilities of the academic variables were .95 and .94, respectively. For this study, the two academic ability variables have been examined individually after being further standardized on a scale representing the proportion achieving the maximum score possible (Range: 0.0 to 1.0). This greatly aids in estimated of the models (see below) without altering the significance of the parameter estimates.

Executive functioning. Children's executive functioning ability was also measured with direct, individually administered tests (Table 3.1). The ECLS-K:2011 contains two variables for executive functioning ability: (a) cognitive flexibility ability as assessed with the Dimensional Change Card Sort test (Zelazo 2006), and (b) working memory ability as assessed with the Woodcock-Johnson III Tests of Cognitive Abilities Numbers Reversed subtest (Mather & Woodcock, 2001). The test comprising cognitive flexibility ability consisted of asking children to sort a series of picture cards according to changing rules. The working memory test consisted of asking children to repeat verbally increasingly longer sequences of numbers in reverse order from which they were presented. Previous research has used both of these tests extensively in the assessment of young children's executive functioning ability (e.g., McClelland et al., 2007; Welsh et al., 2010). For this study, these two items have been summed into single observed composite variable due to identification issues with latent variable modeling when less than three observed items are used (Bowen & Guo, 2012). As with organized athletics, these two variables have been standardized (Range: 0.0 to 1.0).

Social skills. Children's social skills were assessed with three variables in the Spring of 2011: (a) self-control, (b) interpersonal skills, and (c), externalizing problems (Table 3.1). The number of items used in each variable was four, five, and five, respectively. Because the variables were adapted from the copyrighted Social Skills Rating System (SSRS; Gresham & Elliott, 1990), the individual items have been masked (Tourangeau et al., 2015). The SSRS has been used in previous research linking young children's social skills and emotional regulation and their academic outcomes (e.g., Trentacosta & Izard, 2007). Of note, the ECLS-K:2011 contains both parent- and teacher-reported items for social skills. Teachers' items were chosen for this study due to the proximal relationship between teachers' experiences with children and academic outcomes. Also, preliminary checks found that the teacher-reported social skills items were much more highly correlated with academic ability compared with parents' reports. For all three variables, higher scores indicated higher levels of social skills. The internal consistency reliabilities of the variables were .82, .87, and .89, respectively. These variables have been also been individually standardized (Range: 0.0–1.0) and then modeled as a latent variable (see Figure 2).

Covariates. The ECLS-K:2011 contains many potential covariates to help control for confounding of results. These covariates have been included herein based on evidence that children's individual and home characteristics may influence the relationship between their PA participation and academic outcomes (Carlson et al., 2008; Donnelly & Lambourne, 2011; Larson, Russ, Nelson, Olson, & Halfon, 2015; Stevens et al., 2008). Preliminary checks found that nine demographic variables (Table 3.1) were statistically significant predictors of academic ability: (a) age in years (4.4–8.3), (b) male biological sex (1 = Yes, 0 = No), (c) non-Hispanic White race/ethnicity (1 = Yes, 0 = No), (d), professional diagnosis of a physical or emotional/psychological disability (1 = Yes, 0 = No), (e), parent-reported child health status (1 = Fair/Poor, 4 = Excellent), (f) having English be the primary language spoken at home (1 = Yes, 0 = No), (g) household socioeconomic status as measured by parent education, occupational prestige, and income (.67–5.44), (h) presence of two parents in the home (1 = Yes, 0 = No), and (i), number of individuals in the household (2–15).

Data Analysis

Diagnostic checks. Preliminary checks were conducted in Stata (StataCorp) to determine the characteristics of the data and, thus, the nature of subsequent analyses. Summary commands indicated statistically significant levels of non-normality and, thus, a requirement to reject the null hypothesis that the ECLS-K:2011 data were normally distributed (Finney & DiStefano, 2006). Correlations between the study variables for both the reading and models were found to not be problematically correlated ($r = .02$ to .81). The variance inflation factor values for the nine covariates found that the specified variables did not exhibit problematic levels of collinearity ($\leq$ 1.41). Calculations of the intraclass correlation coefficient as a ratio of the between-group and within-group variance at the school level found moderate clustering effects for reading ($\rho = .32$) and mathematics ($\rho \leq .33$), indicating that some of the variance of academic scores was due to school characteristics (Raudenbush & Bryk, 2002).

Missing values were present on 3.2% of reading and mathematics ability items, 9.8% to 10.4% of the social skills items, and small proportions ($\leq$ 2.64%) of the 11 covariates. Little's tests demonstrated a need to reject the null hypothesis that the data were "missing completely at random" ($p < .001$; Li, 2013; Little, 1988). Logistic regressions of the covariates on missingness found that having (a) a disability and (b) school behavior problems were statistically significant predictors of missing values for the reading and mathematics dependent variables. Having English as the primary home language was also a predictor of missingness for mathematics. The missing values in this study, although not proportionately large, signal a need for corrective measures (see below) and represent a limitation of the study.

Model specification. Structural equation modeling (SEM) was chosen as the most optimal analytic technique to answer the research questions with the data at hand. SEM offers several benefits for this study including the defining ability to answer mediated research questions via the simultaneous examination of direct and indirect effects over multiple domains, and the ability to accommodate latent and observed variables simultaneously (Bollen, 1989; Bowen & Guo, 2012). The null hypothesis in the SEM framework is that the reproduced (i.e., constrained) covariance matrix is not statistically significantly different from the observed matrix (Bollen, 1989; Bowen & Guo, 2012). Per SEM best practices, two major steps were used to test this hypothesis. First, based on the underlying conceptual model, measurement models were tested with correlations specified between the variables. Second, subsequent full structural models were tested that included the each model variable regressed independently on the 11 covariates with covariances being allowed to freely estimate.

The overarching conceptual model (see Figure 2) follows SEM conventions by having rectangles denote the observed variables and ovals denote the latent variable (Bollen, 1989; Bowen & Guo, 2012). Specifically, both the reading and mathematics models specified six (γ_{11}, γ_{21}, γ_{31}, β_{23}, β_{12}, β_{13}) positive unidirectional paths. The model for this analysis can thus be expressed with a series of equations as follows:

$$\eta_{1a}, \eta_{1b} = \beta_{12}\eta_2 + \beta_{13}\eta_3 + \gamma_{11}\xi_1 + \Sigma(\beta_{0q}X_{qi}) + \zeta_1$$

$$\eta_2 = \gamma_{21}\xi_1 + \beta_{23}\eta_3 + \Sigma(\beta_{0q}X_{qi}) + \zeta_2$$

$$\eta_3 = \gamma_{31}\xi_1 + \Sigma(\beta_{0q}X_{qi}) + \zeta_3$$

$$\xi_1 = \Sigma(\beta_{0q}X_{qi}) + \zeta_4$$

where η_{1a} and η_{1b} are the reading and mathematics dependent variables, η_2 is the latent social skills meditational variable, η_3 was the observed executive functioning meditational variable, ξ_1 is the organized athletics independent variable, and X_{qi} are the demographic covariates ($N = 9$) with β_{0q} estimated coefficients on each variable.

It was hypothesized based on social learning theory that participation in organized athletics (ξ_1) would have associations with executive functioning (η_3) and academic ability (η_1), and that executive functioning would be associated with academic ability and social skills (η_2). Thus, the conceptual model specified one direct (γ_{11}) and three indirect ($\gamma_{21} + \beta_{12}$, $\gamma_{31} + \beta_{13}$, $\gamma_{31} + \beta_{23} + \beta_{12}$) paths from organized athletics to academic ability. The two academic items have been modeled individually rather than as a latent variable or composite variable in order to ascertain organized athletics' relative contribution to each outcome. Following conventions, this SEM analysis places RQ1 and RQ2 jointly as answering the proposition that the link between organized athletics and academic ability is a partially mediated relationship (Bollen, 1989; Bowen & Guo, 2012). RQ3 is positioned as a question relating to the moderating effects of biological sex and race/ethnicity.

Model estimation. SEM analyses were conducted according to best practices standards in Mplus 7.3 due to its ability to analyze the types of data found herein (L. K. Muthén & Muthén, 2014). In Mplus, the best method for examining (a) non-normal and (b) mixed categorical and continuous variables such as in the ECLS-K:2011 data is the mean and variance adjusted weighted least squares (WLSMV) estimator (Beauducel & Herzberg, 2006; Flora & Curran, 2004). WLSMV uses a probit regression to estimate a polychoric correlation matrix and is recommended by Mplus developers. Mplus handles missing values on dependent variables by default with full information maximum likelihood. Clustering effects by schools were accounted for with the "Cluster" option. To answer the partially mediated hypothesis, the "Model Indirect" statement using Sobel's test (1982) was used to calculate indirect pathways. As mentioned above, the items for organized athletics, executive functioning, and social skills were standardized (0.0–1.0) to avoid estimation problems in Mplus due to ill scaling when large differences exist among variables variances' (Bowen & Guo, 2012). This does not effect the significance of parameter estimates. The factor loading for one item on the social skills latent variable was fixed to 1.0 in order to establish the variable's metric. Covariates were included in the model by fixing their variances in the model estimation syntax per Mplus guidelines (Muthén, 2009), with covariances being estimated between covariates when statistically significant correlations existed.

Model evaluation. Models were evaluated on three sequential criteria: (a) identification, (b) fit, and (c) by examining the strength and significance of individual parameter estimates. Identification of the initial measurement model was established first before testing the final structural model, and the structural component of the final model was confirmed to be over-identified before evaluating parameter estimates (Bollen 1989; Bowen & Guo, 2012). Fit in SEM is typically assessed by comparing the null models with the constrained (i.e., specified) models on various fit statistics. Unlike with many other analytic models, SEM seeks a non-significant difference when comparing the two models. As the commonly used χ^2 statistic for absolute fit is highly unlikely to produce a statistically non-significant fit with a very large sample as is found with the ECLS-K:2011 (Hu & Bentler, 1999), it has been reported herein only for reference. Instead, model fit was assessed with three metrics of comparative fit using appropriate cutoffs based on expert recommendations: (a) the Comparative fit index (CFI) at $\geq .95$, (b) the Tucker-Lewis index (TLI) at $\geq .95$, and (c), the root mean square of approximation (RMSEA) point estimate and 90% confidence interval (CI) at $\leq .05$ (Hu & Bentler, 1999; Schreiber, Nora, Stage, Barlow, & King, 2006). These fit criteria are standard to Mplus analyses and are recommended by the software's developers (L. K. Muthén & Muthén, 2014).

Results

Descriptive Characteristics

The mean age for the 13,365 children in the analytic sample was 6.12 years old with a range from 4.35 to 8.29. Almost all (98.4%) were 5- or 6-year-olds. Just over half (51.41%; n = 6,871) were male. The racial/ethnic composition of the children closely mirrored national averages with just over half (50.46%; n = 6,743) being non-Hispanic White, 11.27% being non-Hispanic African American (n = 1,506), 23.77% being Hispanic/Latino (n = 3,176), and 8.34% being non-Hispanic Asian American (n = 1,115). Almost one-fifth (19.68%, n = 2,566) had a parent-reported professional diagnosis of a physical or emotional/psychological disability. Parents surveyed in the study reported their children's health to be high, with a mean of 3.45 (SD = .77) and 60.71% (n = 7,900) reporting the highest possible score of "Excellent." English was the primary home language for 80.61% (n = 10,752) of children. The mean household economic rating was 2.99 (SD = .82), with the majority being in the upper half of the scale. Over two-thirds (71.16%, n = 9,509) of children had two parents in their home with the mean number of total individuals in the home being 4.61 (SD = 1.39). The mean standardized executive functioning score was 0.63 (SD = .12). The mean scores for the three social skills items including self-control, interpersonal skills, and externalizing problems were .73 (SD = .21), .72 (SD = .22), and .79 (SD = .21), respectively. The mean academic ability scores were .42 (SD = .17) for reading, and .51 (SD = .15) for mathematics. Lastly, just under half (49.6%; n = 6,628) of children had ever participated in organized athletics.

Measurement Models

First, the measurement models (see Figure 3, Figure 4) were confirmed to be over-identified (df = 3) using the formula of $df = p(p + 1)/2) – (\phi + \theta + \lambda)$ where p is the number of observed variables (n = 6), ϕ is the number of variances and covariances (n = 10), θ is the number of error terms ($n = 6$), and λ is the number of non-fixed factor loadings ($n = 2$; Bowen & Guo, 2012).

Results for the reading measurement model (Figure 3) based on the WLSMV-generated polychoric correlation matrix (see Table 3.2) found that the data exhibited good fit to the model according to the pre-specified criteria: χ^2 (6, N = 13,365) = 53.80, $p < .001$; CFI = .99; TLI = .98; RMSEA = .02 (90% CI = .02, .03). Covariance coverage ranged from 88.80% to 96.80% in the model. All parameter estimates were statistically significant ($p < .001$). The StdYX standardized factor loadings in the reading model for the three items comprising the social skills latent variable were .95, .86, and .76, respectively. Squared multiple correlations (i.e., R^2 values) for the social skills items were .90, .74, and .58, respectively (not pictured). The StdYX inter-factor correlation was .25 between organized athletics and executive functioning, .07 between organized athletics and social skills, and .25 between organized athletics and reading. The correlation was .20 between executive functioning and social skills, and was .48 between executive functioning and reading. The correlation between social skills and reading was .24. Overall, the reading measurement model was evaluated to be appropriate and no further modifications were performed.

Also, the mathematics measurement model (Figure 4) found that the data exhibited good fit to the model: χ^2 (6, N = 13,365) = 69.48, $p < .001$; CFI = .99; TLI = .98; RMSEA = .03 (90% CI = .02, .03). Covariance coverage was identical to the reading model and all parameter estimates were statistically significant ($p < .001$). The StdYX standardized factor loadings in the reading model for the three items comprising the social skills latent variable were .95, .87, and .75, respectively. Squared multiple correlations for the social skills items were .90, .75, and .57, respectively (not pictured). The StdYX inter-factor correlation was .25 between organized athletics and executive functioning, .07 between organized athletics and social skills, and .32 between organized athletics and mathematics. The correlation was .20 between executive functioning and social skills, and was .57 between executive functioning and mathematics. The correlation between social skills and mathematics was .26. Overall, the mathematics measurement model was also evaluated to be appropriate and no further modifications were performed.

Measurement Invariance Testing

Next, both measurement models were tested for invariance based on biological sex and race/ethnicity. In SEM, measurement invariance is established when statistically equivalent parameter estimates are demonstrated across groups, leading to validity of the model's application to the subsequent testing of moderating effects via multiple group comparison testing (Bowen & Guo, 2012; Bowen & Masa, 2015). Mplus cannot perform typical measurement invariance testing when (a) correlations must be specified between observed and latent variables, and when (b) models combine continuous and categorical variables. As both conditions are true in this study, an alternative course of measurement invariance testing was undertaken based on SEM best practices (Bowen & Masa, 2015). First, both measurement models were tested independently across exclusive sets of children on both (a) biological sex (male only, female only) and (b) race/ethnicity (non-Hispanic White only, other race/ethnicity only). With the two academic dependent variables, this necessitated testing eight individual models.

Per expert recommendations, the first step in the invariance testing process was to specify identical models across all sub-groups of interest. Results from this step (not pictured) found that all eight sub-group models generally demonstrated *configural* invariance (i.e., same factor patterns and loadings) by having (a) acceptable fit (χ^2: 28.90 to 57.64; CFI $\geq$ .98; TLI $\geq$ .96;

RMSEA ≤ .04), (b) positive and significant StdYX inter-factor correlations (*r*: .09 to .58, $p < .001$), (c) acceptable significant StdYX factor loadings (λ: .74 to .97, $p < .001$) on social skills, and (d), acceptable significant squared multiple correlations for the social skills items (R^2: .54 to .93, $p < .001$). There were two exceptions. The correlation between organized athletics and social skills for non-White children was not significant in either the reading ($r = .00$, $p = .89$) or math ($r = .00$, $p = .89$) model.

Second, only the social skills latent variable was tested under the standard invariance testing procedure involving testing *metric* (i.e., invariant factor loadings) and *scalar* (i.e. invariant factor loadings + thresholds) invariance (Bowen & Masa, 2015; Dimitrov, 2010). Results did not support either form invariance for the social skills variable ($\Delta\chi^2$: $p < .05$). Thus, true quantitative invariance and multiple group testing could not proceed. However, given the unique nature of model and the inability to fully test its invariance it was decided that further testing, albeit limited and qualitative, could proceed regarding the model's moderating characteristics across these two demographic domains.

Structural Models

The reading structural model results (see Table 3.3, Figure 5) on the full sample also found that the data exhibited good fit to the constrained model: χ^2 (15, N = 13,365) = 11.23, $p = .74$; CFI = 1.00; TLI = 1.00; RMSEA = .00 (90% CI = .00, .01). Covariance coverage ranged from 87.40% to 100.00%. StdYX standardized factor loadings for the three social skills items were .93, .80, and .70, respectively. The direct pathway from organized athletics to reading ability was .02 ($p = .09$), to executive functioning was .11 ($p < .001$), and to social skills was .03 ($p = .11$). The pathway from executive functioning to reading ability was .37 ($p < .001$), and to social skills was .15 ($p < .001$). The pathway from social skills to reading ability was .10 ($p < .001$). All non-significant pathways were retained and the model was not further modified.

The mathematics structural model results (see Table 3.4, Figure 6) on the full sample also found that the data exhibited good fit to the constrained model: χ^2 (15, N = 13,365) = 14.88, p = .46; CFI = 1.00; TLI = 1.00; RMSEA = .00 (90% CI = .00, .01). Covariance coverage ranged from 87.40% to 100.00%. StdYX standardized factor loadings for the three social skills items were .92, .80, and .70, respectively. The direct pathway from organized athletics to mathematics ability was .06 ($p < .001$). The pathway from executive functioning to mathematics ability was .47 ($p < .001$). The pathway from social skills to mathematics ability was .12 ($p < .001$). All other pathways were identical to those in the full reading structural model. As with the reading model, non-significant pathways were retained and no further modifications were made.

Only the covariates for age, male biological sex, having a disability diagnosis, and the presence of two parents in the home were consistently statistically significant predictors of both model's four substantive variables (not pictured). StdYX results suggest that in increases in age had statistically significant positive associations with organized athletics participation (β = .04, $p < .01$), reading ability (β = .17, $p < .001$), and mathematics ability (β = .23, $p < .001$), but mixed associations with the social skills items (β: −.07 to .06, $p < .001$), and negative associations with executive functioning (β = −.07, $p < .001$). StdYX results suggest that being male had statistically significant positive associations with organized athletics participation (β = .16, β = .16, $p < .001$) and mathematics ability (β = .03, $p < .01$), but negative associations with reading ability (−.05, $p < .001$), executive functioning (β = −.06, $p < .001$), and the social skills items (β: −.19 to −.16, $p < .001$). StdYX results suggest that having a disability diagnosis had statistically significant ($p < .01$) negative associations with all variables across both models, ranging from β

= −.12 (executive functioning) to β = −.03 (organized athletics). Lastly, StdYX results suggest that the presence of two parents in the home had a statistically significant ($p < .01$) positive association with all variables in both models, ranging from β = .04 (executive functioning) to β = .10–.15 (social skills items). All non-significant covariates were retained.

Overall, the reading model explained 34.50% of the variation in reading scores and the mathematics model explained 47.60% of the variation in mathematics scores. Both models equally explained the variation in organized athletics, executive functioning, and social skills at 30.70%, 15.20%, and 2.50%, respectively. Direct plus indirect results indicated that kindergarteners' participation in organized athletics had a StdYX total effects of $\beta_{Total} = .07$ ($p < .001$) on reading ability and $\beta_{Total} = .12$ ($p < .001$) on mathematics ability.

Alternative Models

Alternative structural models were also tested for both reading and mathematics (not pictured). These models were specified identically as the main structural models above with the additional inclusion of control variables ($n = 7$) for Fall 2010 entry scores for reading, mathematics, executive functioning, and social skills. Thus, these models account for children's cognitive, academic, and social abilities at kindergarten entry and examine whether organized athletics participation was associated with gains to those outcomes over the course of the school year.

The alternative reading structural model results exhibited acceptable fit to the constrained covariance model: χ^2 (45, N = 13,365) = 332.40, $p < .001$; CFI = .99; TLI = .96; RMSEA = .02 (90% CI = .02, .02). Briefly, the reading alternative model explained 32.80% of the variation in organized athletics (Δ_{Main} = +6.84%), 38.50% of Spring 2011 executive functioning (Δ_{Main} = +153.29%), 1.50% of Spring social skills (Δ_{Main} = −40.00%), and 71.40% of reading ability

(Δ_{Main} = +106.96%), and had a StdYX total effect of β_{Total} = .05 (p < .001) on reading ability (Δ_{Main} = −26.87%). The alternative mathematics structural model results did not exhibit fully acceptable fit to the constrained covariance model: χ^2 (45, N = 13,365) = 575.99, p < .001; CFI = .98; TLI = .92; RMSEA = .03 (90% CI = .03, .03). The mathematics alternative model explained 33.60% of the variation in organized athletics (Δ_{Main} = +9.45%), 43.70% of executive functioning (Δ_{Main} = +187.50%), 1.30% of social skills (Δ_{Main} = −48.00%), and 91.90% mathematics ability (Δ_{Main} = +93.07%), and had a StdYX total effect of β_{Total} = .09 (p < .001) on mathematics (Δ_{Main} = −22.61%).

Multiple Group Testing

Each of the reading and mathematics structural models underwent multiple group testing across six sub-groups by biological sex and race/ethnicity: (a) male only, (b) female only, (c) White only, (d) African American only, (e), Hispanic/Latino only, and (f), Asian American only (Table 3.3, Table 3.4). All sub-group models were modeled identically to the full structural models with the exception that covariates' variances were calculated specifically for each sub-group. Fit results found that all 12 sub-group models demonstrated excellent fit to data including having non-significant χ^2 values. Important qualitative differences could be seen across the models. Organized athletics was only directly associated with both reading and mathematics StdYX increases in the male only model (β = .04, .08; p < .05) and the Hispanic/Latino only model (β: .07, .08; p < .01). Also, organized athletics demonstrated statistically significant StdYX total effects (direct + indirect) in the Male only (β_{Total} = .09, .14; p < .001), White only (β_{Total} = .05, .11; p < .01), Hispanic/Latino only (β_{Total} = .12, .14; p < .001), and Asian American only (β_{Total} = .10, .12; p < .05) sub-group models. For female children, there were only statistically significant StdYX total effects for mathematics (β_{Total} = .09; p < .001). For African

American children, there were neither direct (β: .00, .02, ; $p > .05$) nor total ($\beta_{Total} = .02, .04$; $p > .05$) statistically significant effects between organized athletics participation and increases on either of the academic ability variables. Across all six models, participation in organized athletics had slightly stronger statistically significant StdYX total effects on mathematics ($\beta_{Total} = .05$ to .12) compared with reading ($\beta_{Total} = .042$ to .114).

Discussion

This analysis contributed to the understanding of how kindergarteners' participation in organized athletics may positively influence the proximal outcomes of executive functioning and social skills, and the distal outcome of academic ability. Results from well fitting and appropriate SEM models answered all three research questions wholly or partially in the affirmative.

First, there were small direct effects from organized athletics to mathematics ability but not reading ability for the total sample models. These differentially significant effects suggest that these academic outcomes may have unique characteristics and manifestations within individual children. An alternative model that carefully controlled for Fall 2010 kindergarten entry scores supported this finding, albeit with small total effects. Second, there were found to be small indirect effects from organized athletics via both (a) the biologically-based mechanism involving to executive functioning and (b) the social learning theory-based mechanism of positive social skills. Following SEM conventions (Bowen & Guo, 2012), it can be said that results found that organized athletics participation has a partially-mediated effect on academic ability for kindergarteners. Specifically, in the full sample athletics participation was indirectly associated with increases to both academic variables via (a) increases in executive functioning only and (b) increases to executive functioning and social skills. There was no demonstrated indirect effect via social skills only. Third, the relationships in the conceptual model varied based on both biological sex and race/ethnicity. Although the measurement invariance testing provided only weak evidence for multiple group comparisons of the structural model, these qualitative comparisons found that the model performed best for male and Hispanic/Latino children. Although well fitting, the models found little evidence to support the model for African American kindergarteners.

Implications

This research contributes substantially to the growing literature base regarding the positive relationship being PA participation and well-being in young children. The use of appropriate statistical methods bolsters the internal validity of these findings, and the use of a nationally-representative sample gives the results strong external validity and generalizability. Specifically, the results suggest three implications for current and future intervention research endeavors.

First, the overall statistically significant links between organized PA and academics suggests that when kindergarteners participate in some form of organized athletics they may experience small increases in their objectively measured reading and mathematics abilities. This evidence corroborates the work of previous research that has found similar results linking PA and achievement (e.g., Carlson et al., 2008; Stevens et al., 2008). The study advances earlier research, however, by substantively focusing specifically on the critical developmental stage of kindergarten and by methodologically using of advanced statistical applications. In particular, the corrections for missing data, non-normality of variables, and clustering used herein represent important features that will hopefully become commonplace in kindergarten PA research. Based on this implication, parents, school staff, and other stakeholders within child development should seek to promote if not increase opportunities for very young children to participate in organized athletics and PA. As less than half of children in the sample participate in such PA, there remains room to greatly increase participation levels in such activities. Although the effects were not large, they were statistically significant and represent a potentially fun, efficient, and cost effective way for to increase children's chances of succeeding in school. Also, participation in organized PA likely has beneficial effects on a variety of other outcomes (e.g., social skills, physical health indicators) that are of benefit to children's development.

Second, and perhaps more importantly, the true novel findings of the study exist in relation to the specific conceptual model tested. The results support the model's dual biologically- and socially-based causal mechanisms linking organized PA and academics. Results are also clear in indicating that organized PA's largest contribution to academic ability is via increases in executive functioning, which clearly had the largest influence on reading and mathematics ability among the sample. Also, it should be noted that contrary to the social learning-based hypothesis organized athletics had no statistically significant association with increases in social skills in the aggregate model or in any of the sub-group models by biological sex and race/ethnicity. However, organized athletics participation did positively influence social skills indirectly via executive functioning. Overall, these results suggest that the pathway via executive functioning is robust but small, but that future research should consider the role that social skills may play in the relationship between kindergarteners' organized PA and their academic outcomes.

Third, results suggest that the underlying relationship between organized PA and academics is likely to vary depending on children's demographic characteristics. Both the statistically significant key covariates and the model differences demonstrated across biological sex and race/ethnicity hint that the above positive findings may not hold for all children. In particular, there should be caution when applying the tested model to kindergarteners who are non-White and female. As per the above note regarding social skills, these results caution against utilizing the model tested herein without further research. Although the model may have performed best for non-Hispanic White and male children, these kindergarteners are frequently those who (a) have the highest levels of PA across sub-types and (b) demonstrate the highest levels of school-based functioning. In other words, the model appears to have best explained the relationship between PA and academics for those children that need the least help in such regards. Future research should strongly pursue more examinations into this important area to determine how demographic characteristics may influence this relationship and, perhaps, whether alternative models with varying causal mechanisms may be more appropriate for specific sub-groups of children.

Limitations

The findings in the study are primarily limited due to the data used herein. First, the proxy parent reports used by the ECLS-K:2011 may have limited validity for detailed measurement of PA behaviors. Measuring children's organized athletics participation in dosage units (i.e., minutes, hours) with objectively based methods such as accelerometers (Cliff, Reilly, & Okely, 2009; Pate, O'Neill, & Mitchell, 2010) would provide more nuanced data regarding organized athletics participation beyond the crude, dichotomous measure used herein. The covariates in ECLS-K:2011, although numerous, are notably limited on possible related to non-demographic home-level factors such as parents' health and PA behaviors that have consistently been found to be associated with kindergarteners' PA (e.g., Hinkley et al., 2012; Loprinzi & Trost, 2010; O'Dwyer et al., 2012; Zecevic et al., 2010). More broadly, the cross-sectional nature of the data entails an absence of the temporal hierarchy necessary for mediation analyses under the SEM framework (Baron & Kenny, 1986; Maxwell, Cole, & Mitchell, 2011). As such, this study's analyses represent only exploratory tests of associations and have no true ability to determine causal inferences.

More broadly, it should be noted that the team- and group-base atmosphere of organized athletics could be harmful in some cases. In particular, there is the worry that such PA could encourage potentially unhealthy hyper competitive behaviors that may undermine children's social networks and cohesion (Bailey et al., 2006). Also, some commentators have noted that an over reliance upon organized PA could be limiting if not counterproductive to PA participation and enjoyment for those children who do not feel part of the group (Bailey et al., 2006). Recommendations from many experts also include caution towards a myopic focus on organized PA at the possible expense of other PA forms (United States Department of Health & Human Services [USDHHS], 2008). Different children likely prefer to engage in different PA forms, and future research and policy efforts should consider the multitude of ways in which PA can be promoted for young children.

Conclusion

The promotion of PA among kindergarteners is an important, evidence-based endeavor that has a deserved place of prominence in current public health efforts nationally and internationally. There is a clear and unequivocal need to encourage greater access to, and attainment of, regular PA among all children including those in the key developmental ages of 5 to 7. The findings of this study support other research in suggest that organized athletics PA may, in particular, be effective intervention tool to both increase children's PA levels and promote more distal outcomes of interest. Results from this study's test of a conceptual model linking organized athletics, executive functioning, social skills, and reading, mathematics, and science ability support the continued pursuit of this line of research. However, there is still much work to be done regarding (a) demographic characteristics' associations with organized PA behaviors, (b) specifics within organized PA manifestations such as setting, dosage, and structure that may differentially influence academic results, and (c), the feasibility of widespread intervention efforts to provide organized PA opportunities for all children. This last point is an especially salient one from a social justice perspective, as historically underserved populations of children were precisely those found herein to have weaker if not null findings between their organized PA participation and academic outcomes. Future research should build upon these findings with additional analyses both observational and experimental in nature, and should consider adopting more critical frameworks such as those rooted in critical environmental justice theory to explore and explain obvious disparities found for vulnerable children.

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Table 3.1
ECLS-K:2011 Sampling Weight Adjusted Estimates of Variables' Descriptive Characteristics (Spring 2011)

Variable	*N*	Items	Range	Mean (SD)	Skewness	Kurtosis
Organized Athletics	13,365	1	0, 1	.50 (.50)	−.00	1.00***
Executive Functioning	11,159	2	0.0–1.0	.63 (.12)	−1.13***	4.77***
Social Skills	10,731	3	0.0–3.0	2.24 (.58)	−.77***	3.05
Reading Ability	11,536	1	0.0–1.0	.41 (.17)	.55***	3.17***
Mathematics Ability	11,515	1	0.0–1.0	.50 (.15)	−.15***	2.90*
Age	12,956	1	4.35–8.29	6.12 (.38)	.45***	3.68***
Male	13,365	1	0, 1	.52 (.50)	−.07**	1.00***
White	13,363	1	0, 1	.52 (.50)	−.09***	1.01***
Disability	13,036	1	0, 1	.21 (.40)	1.46***	3.13**
Health status	13,012	1	1–4	3.45 (.78)	−1.26***	3.74***
English speaking	13,338	1	0, 1	.82 (.38)	−1.69***	3.84***
Socioeconomic status	13,363	1	.67–5.44	2.95 (.82)	.22***	2.55***
Two parents	13,363	1	0, 1	.69 (.46)	−.85***	1.72***
Household number	13,363	1	2–15	4.61 (1.38)	1.14***	6.09***

Note. *$p < .05$, **$p < .01$, ***$p < .001$; two-tailed test.

Table 3.2

ECLS-K:2011 Multiple Imputation and Sampling Weight Adjusted Polychoric Correlation Matrix of the Observed Variables: Full Sample (Spring 2011)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Athletics	—															
2. Reading	.25	—														
3. Mathematics	.32	.74	—													
4. Executive Functioning	.25	.48	.57	—												
5. Social skills #1	.06	.21	.23	.17	—											
6. Social skills #2	.07	.22	.25	.19	.81	—										
7. Social skills #3	.04	.18	.19	.15	.74	.63	—									
8. Age	.06	.13	.19	−.07	.02	.02	−.01	—								
9. Male	.20	−.09	.01	−.08	−.22	−.25	−.25	.10	—							
10. White	.40	.22	.30	.27	.09	.09	.06	.11	.02	—						
11. Disability	−.01	−.18	−.18	−.17	−.17	−.18	−.16	.12	.22	.13	—					
12. Health	.19	.17	.18	.14	.07	.07	.06	−.02	−.05	.20	−.19	—				
13. English	.47	.27	.26	.22	−.02	.02	−.08	.13	.02	.78	.21	.26	—			
14. SES	.47	.39	.42	.32	.13	.13	.12	−.02	−.00	.43	−.03	.24	.46	—		
15. Two parents	.26	.24	.27	.19	.23	.19	.25	−.05	−.01	.28	−.10	.14	−.18	.47	—	
16. Household #	−.12	−.11	−.10	−.08	.05	.02	.08	.00	−.01	−.12	−.01	−.05	−.19	−.09	.24	—

Table 3.3

ECLS-K:2011 Multiple Imputation and Sampling Weight Adjusted Polychoric Correlation Matrix of the Observed Variables: Full Sample (Spring 2011)

Estimates	Total Sample	Male	Female	White	African American	Hispanic/ Latino	Asian American
Fit Criteria							
N (df)	13,365 (15)	6,871 (14)	6,494 (14)	6,743 (14)	1,506 (14)	3,176 (14)	1,115 (14)
χ^2	11.23	8.60	8.65	9.30	5.43	6.94	5.84
CFI	1.000	1.00	1.00	1.00	1.00	1.00	1.00
TLI	1.00	1.00	1.00	1.00	1.04	1.01	1.08
RMSEA	.00	.00	.00	.00	.00	.00	.00
Coefficients							
γ_{11}	.02	.04*	.00	.01	.00	.07**	.06
γ_{21}	.03	.04	.01	.04[a]	.02	−.03	.07
γ_{31}	.11***	.12***	.10***	.11***	.04	.14***	.09 [a]
β_{12}	.10***	.10***	.11***	.12***	.10**	.10***	.13***
β_{13}	.37***	.39***	.35***	.37***	.37***	.37***	.41***
β_{23}	.15***	.15***	.14***	.14***	.10**	.18***	.11*
Total Effects							
Reading	.07***	.09***	.04[a]	.05**	.02	.12***	.10*

Note: StdYX standardized results. [a]$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$; two-tailed. Total effects = sum of direct and indirect effects of organized athletics on reading.

Table 3.4

ECLS-K:2011 Multiple Imputation and Sampling Weight Adjusted Structural Equation Modeling Estimates by Biological Sex and Race/Ethnicity: Mathematics Ability (Spring 2011)

Estimates	Total Sample	Male	Female	White	African American	Hispanic/ Latino	Asian American
Fit Criteria							
N (df)	13,365 (15)	6,871 (14)	6,494 (14)	6,743 (14)	1,506 (14)	3,176 (14)	1,115 (14)
χ^2	14.88	10.35	10.72	10.95	7.11	8.08	5.56
CFI	1.00	1.00	1.00	1.00	1.00	1.00	1.00
TLI	1.00	1.00	1.00	1.00	1.03	1.01	1.08
RMSEA	.00	.00	.00	.00	.00	.00	.00
Coefficients							
γ_{11}	.06***	.08***	.04*	.05**	.02	.08***	.07
γ_{21}	.03	.04[a]	.01	.04[a]	.02	−.03	.07
γ_{31}	.11***	.12***	.10***	.11***	.04	.14***	.09 [a]
β_{12}	.12***	.11***	.13***	.13***	.11***	.12***	.15***
β_{13}	.47***	.47***	.46***	.47***	.48***	.46***	.48***
β_{23}	.15***	.15***	.14***	.14***	.10**	.18***	.11*
Total Effects							
Mathematics	.12***	.14***	.09***	.11***	.04	.14***	.12*

Note: StdYX standardized results. [a]p < .10, *p < .05, **p < .01, ***p < .001; two-tailed. Total effects = sum of direct and indirect effects of organized athletics on mathematics.

Figure 2

A Conceptual Model Linking Kindergarteners' Organized Athletics Participation with Executive Functioning, Social Skills, and Academic Ability

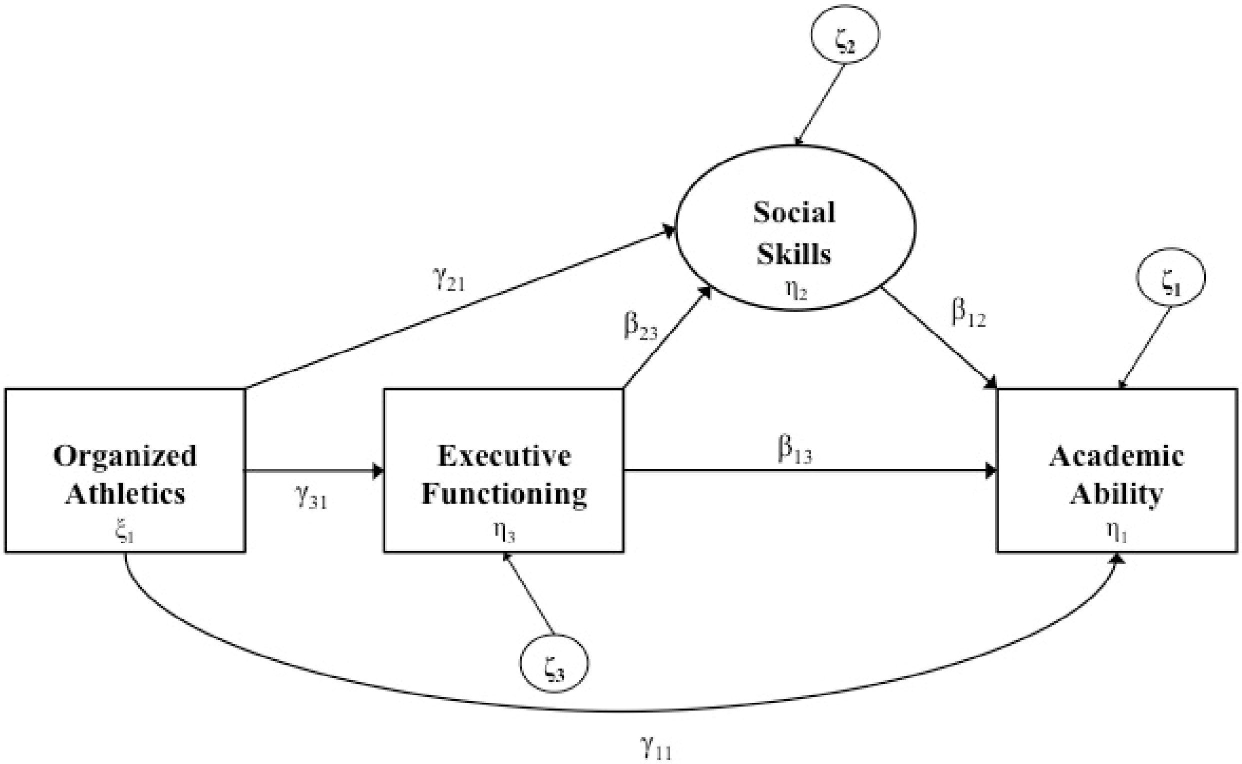


Figure 3

Measurement Model Linking Kindergarteners' Organized Athletics Participation with Executive Functioning, Social Skills, and Reading Ability

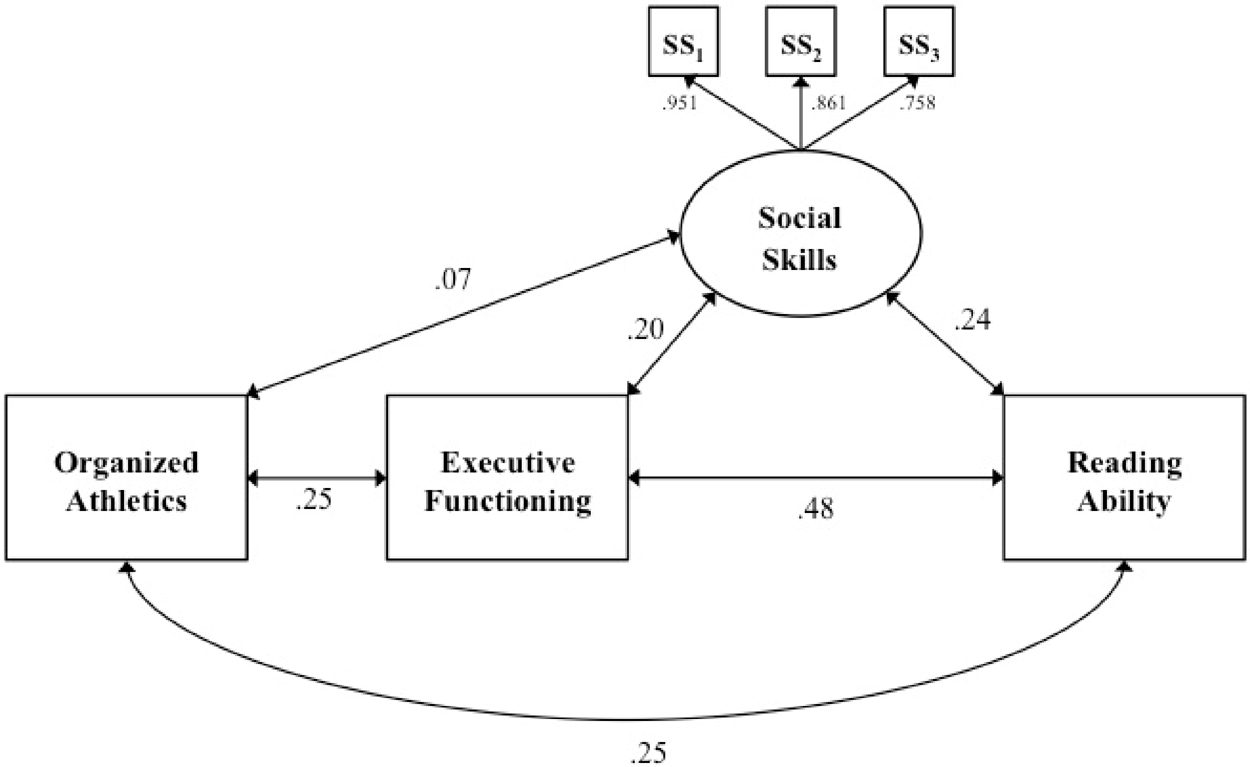


Figure 4

Measurement Model Linking Kindergarteners' Organized Athletics Participation with Executive Functioning, Social Skills, and Mathematics Ability

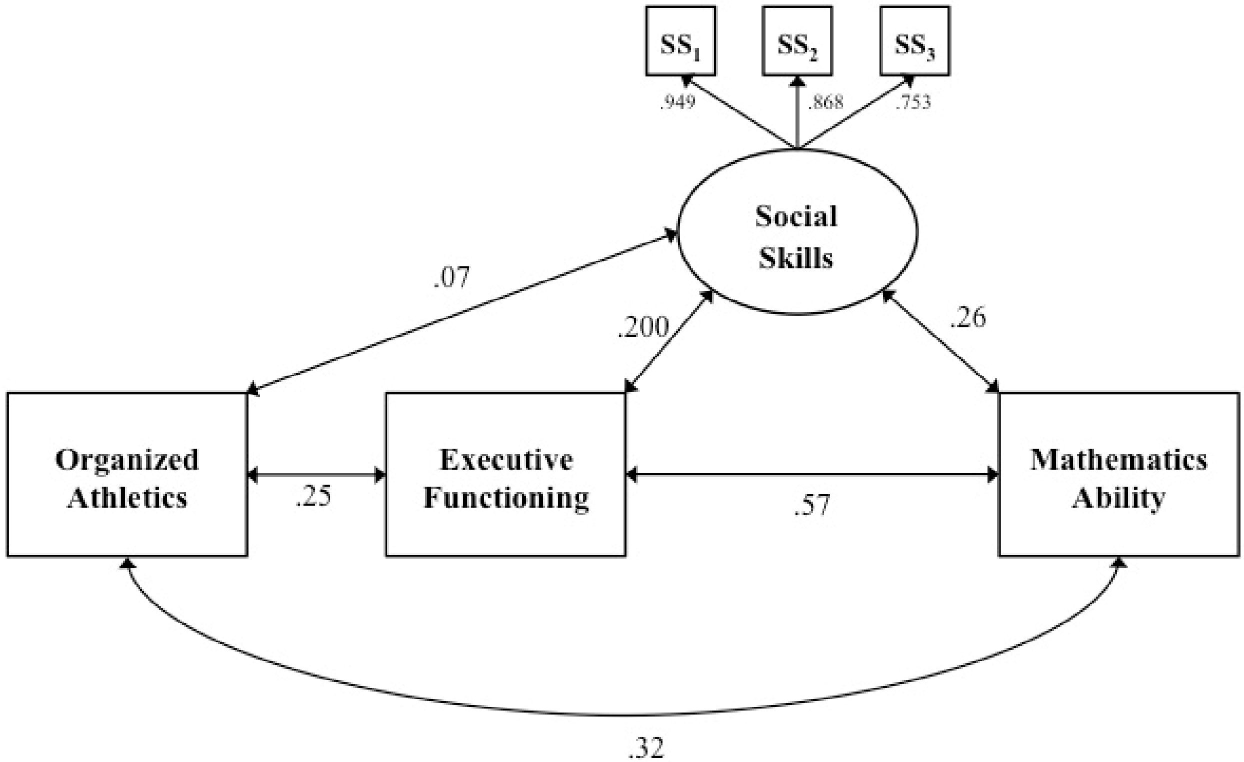


Figure 5

Structural Model Linking Kindergarteners' Organized Athletics Participation with Executive Functioning, Social Skills, and Reading Ability

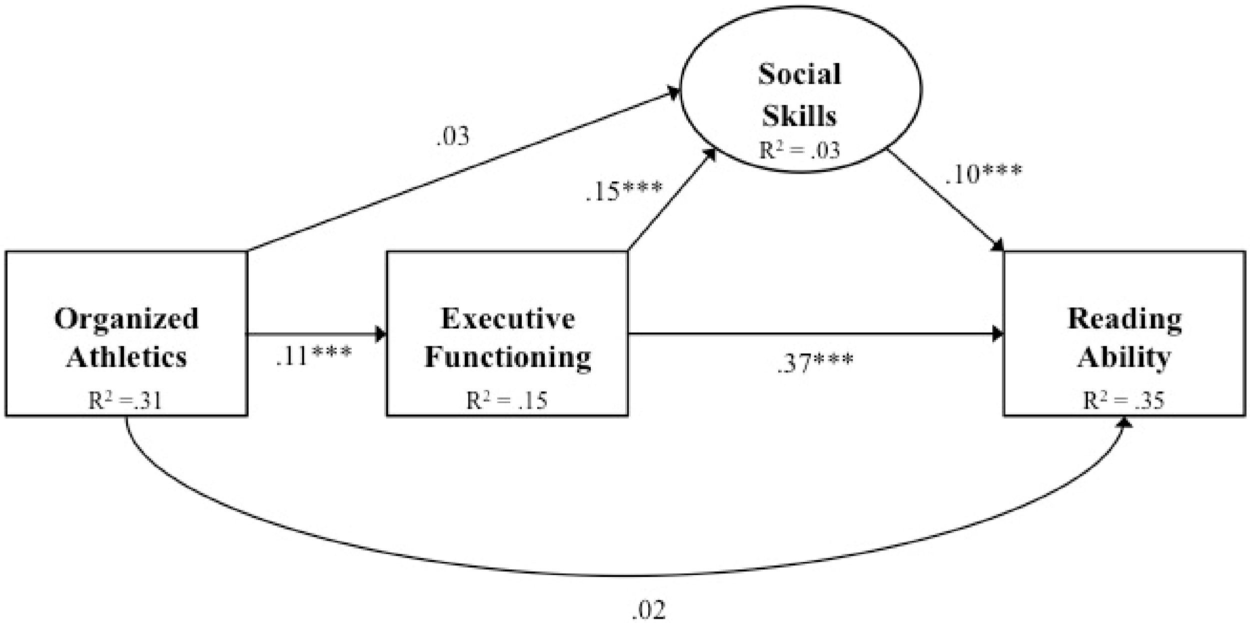
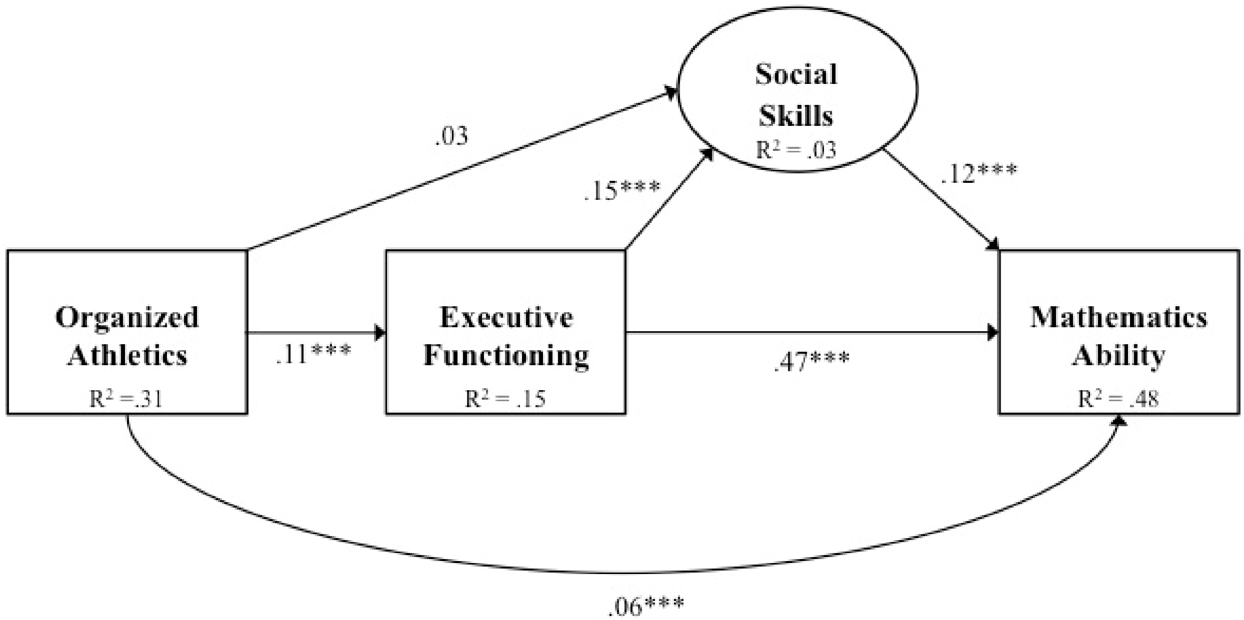


Figure 6

Structural Model Linking Kindergarteners' Organized Athletics Participation with Executive Functioning, Social Skills, and Mathematics Ability



SUMMARY

This dissertation sought to expand research regarding the participation behaviors, cognitive and academic-related outcomes, and differential effects by biological sex and race/ethnicity of kindergartener's PA. There were two overarching goals with this work. The first goal was to add to the quantity and quality of research regarding very young children's PA behaviors and outcomes. There has been a noted dearth of such evidence to date. By adding substantively and methodologically illuminating evidence regarding prevalence levels, moderating effects, and outcomes of interest, these three research papers contribute to this body of research in meaningful ways. Second, it was hoped that by bringing a environmental justice perspective driven by the acknowledgement of inequality and inequity, that this research area would be seen as one that fits within a broad social justice perspective. Extant PA research on kindergarteners has largely relied on a general ecological approach to conceptualizing research questions and analyses. What may be missing from this approach is the importance of context to explain why, in particular, underserved children are so often lacking in PA participation and the benefits that are resultant therein.

Implications for Research

The analyses find that children of kindergarten age in the United States are likely to be less active than recommended by PA researchers and policymakers. Too few young children are achieving the PA standards that have been set in recent years. This suggests that either there is much work to be done to increase kindergarteners' PA levels, or that the recommendations for this developmental stage are perhaps too demanding. It is also important to consider that wide variations exist in PA behaviors. These differences were found in these analyses to exist both depending on the form of PA and on children's individual- and family-level characteristics.

The first analysis was particularly illuminative of the range of PA behaviors at this age range. Results found that while many kindergarteners participate in casual forms of PA such as playground activities, only about half appear to be participating in organized PA such as that done within teams or groups. Also, there are large disparities across sub-groups of children. Traditionally privileged children such as White and male children are more active than their traditionally marginalized and underserved counterparts such as African American, Hispanic/Latino, Asian American, and female children. Asian American female kindergarteners, in particularly, seem to be not achieving sufficient PA per expert recommendations. Other factors related to household/family status, resources, composition, and others also likely influence children's individual PA behaviors. In this way, PA is likely not very different from other behaviors. Children from wealthier households with two parents are, unsurprisingly, more active than those who are not. Future research to inform interventions should seek to more fully understand these discrepancies in PA behaviors, and seek to determine evidence-based correlates, mediators, and moderators that may influence very young children's PA.

Also, the analyses find that there is some reason to believe that participation in PA at this young age may confer significant benefits to children's cognitive and academic abilities. This finding is congruent with other recent inquiries that have sought to extend previous findings related to older children and adults into the realm of early childhood for the purpose of implementing early intervention strategies. Caution must be noted here in two ways. First, the second analysis found little to evidence to recommend attention on school-based provision of PA as a means to promote kindergarteners' cognitive and academic outcomes. In fact, almost no support was found for school PE. However, tor school recess significant associations were found for both aggregate and sub-group populations of children. Second, those effects found in the second and third analyses were quite small. Thus, they may be of limited practical significance despite their statistical significance. It should be noted that having children participate in PA is likely inexpensive relative to other, more involved interventions. As such, PA in kindergarten may be cost effective despite the apparently marginal gains that it is likely to produce.

Implications for Social Justice

This dissertation was rooted in a critical perspective that sought to conceptualize and contextualize kindergartener's PA as an overlooked issue of social justice. Broadly, the results found among the three papers support the environmental justice-based argument put forth by other scholars that children's PA may be a behavior that is affected by injustice and oppression (Brulle & Pellow, 2006; Taylor et al., 2007; Taylor et al., 2006). The findings consistently found that underserved kindergarteners such as females and non-Whites had (a) lower levels of PA, (b) decreased positive relationships with cognitive and academic outcomes, and (c) more null or poorly fitting models. Seen from a critical environmental justice framework, this confirms prior research suggesting that systemic forces exist which work as barriers to underserved young children's PA attainment.

The first analysis' finding that females, Hispanic/Latino, and Asian American children's parents report them to be much less active is worrisome. Recent research efforts have made strident attempts to to alleviate health disparities across behaviors and outcomes, including those related to children's PA. These results suggest, succinctly, that those efforts may have not been very successful. Seen from a social justice perspective, especially one focusing on macro-level environmental factors, the implication may be that efforts to date have not properly focused on the historical and contextual factors that undergird underserved children's disparities. At a basic level, research must continue to examine differential effects by child-level characteristics such as demographic factors. Reviews of empirical research still find that many studies do not disaggregate data and analyses (Dobbins et al., 2013), leaving female and racial/ethnic children's behaviors as lost in the aggregate. The results from this paper strongly find that this approach is deficient as children's PA behaviors are highly individual and dependent on their core demographic characteristics. More specifically, analyses and intervention efforts should consider how such demographic characteristics influence levels of PA across types. The consistent finding that being an English speaker, for example, suggests strong systematic marginalization of non-English speakers such as Hispanic/Latino children. The barriers to these kindergarteners' PA participation may not be related to desire but instead to a lack of native language information, signage, support, and other factors. Overall, a social justice perspective is clearly needed in future efforts to understand the differential prevalence rates of PA among young children in the United States.

The second analysis' findings that school PE and recess have very little influence on non-White children's cognitive and academic ability suggests, when in comparison with the significant findings for White children, that schools themselves may function as instruments of marginalization. It could be said from a social justice perspective that differences in school resources, staff, curricula, student support, parent engagement, and other factors are likely to be deficient for underserved children. Racial and ethnic minority children are almost certainly to be highly affected by such deficits given the politicized and unequal ways in which schools are operated in the United States. Thus, efforts to promote PA behaviors among young children, and delineate the positive outcomes related therein, should embrace efforts to be more critical of the school system as a whole. It may be extant PA intervention efforts in schools, of which there have been many to date, are failing to achieve increases in PA due to the structural effects of the schools themselves and not due to, perhaps, any flaws in the interventions. Or, it could be that such interventions fail to consider to what role marginalization and oppression may have on children's PA behaviors and outcomes. School-based PA research and intervention has become a substantial sub-domain of PA promotion efforts in recent years, and the troubling results found herein regarding underserved kindergartener's differential outcomes suggest a need for more critical social justice frameworks to contextualize disparities.

Lastly, the third analysis' findings related to home-based participation in organized athletics also have implications for social justice. Once again, it was found that underserved children demonstrated either decreased positive effects for the relationships of interest (e.g., athletics as promoter of academics) or that the entire model was essentially null due to non-significant findings. Participation in organized forms of sports and athletics is cornerstone of many young children's development and has been often studied within PA promotion research. Yet, the study herein was one of the first to examine findings across sub-groups of children by biological sex and race/ethnicity. Although the overall findings were promising and suggest much to recommend about athletics participation for kindergarteners, these positive avenues for intervention all but disappeared for Africa American children to name one group. Given that most athletics activities are structured and organized by municipal, school, church, or non-profit systems, the results taken from an environmental justice perspective find fault with these systems themselves. In other words, it appears that there may be widespread inequity among these organizations that serve as barriers to underserved children's PA participation and any academic benefits that may come therein.

Future Research Directions

This dissertation suggests important future directions in multiple avenues to achieve the interconnected goals of (a) accumulating additional high quality evidence regarding the link between PA and cognitive and academic ability in kindergarten, and (b) understanding the clear disparities and injustices that undergird these behaviors and outcomes among underserved children.

The first avenue for action is with the ECLS-K:2011 data itself. It deserves reiteration that this dissertation only examined a relatively small subset of outcomes related to cognitive and academic ability. Reliable and valid data exist on this age group which could be used in future analyses that may find stronger and more promising links between PA participation and other developmental outcomes. Likewise, the benefits of PA may influence children's well-being more longitudinally than the time period studied herein. Upcoming releases of the ECLS-K:2011 public dataset will contain measures for the 1st grade and beyond. This data represents an exciting opportunity to answer research questions in the coming years regarding the potential of PA to promote long-term child growth and well-being. Although the findings in these analyses do not provide enough evidence to proceed full throttle with widespread PA promotion for this age group, they do provide enough substance to provide researchers with interesting and potentially exciting future opportunities to more fully examine this research area.

Three specific research inquiries using the ECLS-K:2011 are immediately apparent. First, the present analyses should be expanded beyond kindergarten to cross-sectional analyses of the first and second grade cohorts already available for use and, in future years, the additional cohorts yet to be made available. The effect of this examination would be to determine any potential temporal invariance or differences to the findings. It may be, for example, that although school PE and recess are not particularly associated with cognitive and academic ability for kindergarteners', these PA forms may in fact be more predictive of such outcomes for older children. Second, the analyses can be reframed as longitudinal propositions whereby PA in kindergarten may be associated with distal outcomes in future grades. This approach could prove highly valuable towards establishing any claims of causality for PA and cognitive and academic ability for young children. Positive and significant findings, if found, would likely provide solid and convincing evidence for stakeholders in early childhood development to be more active in promoting PA at this age. Third, the dependent variables should be broadened to include other factors of general interest such as home- and school-based behaviors, parent-child interactions, social skills, and others. Such outcomes are both of strong interest and are measured by the items in the ECLS-K:2011. Although the focus of this dissertation was on cognitive and academic ability due to their central role in explaining children's short- and long-term success, it may be that PA at this age is perhaps more associated with additional outcomes.

The second avenue of action is broader in nature, and calls for macro-level approaches to conceptualizing, developing, and implementing PA interventions for underserved young children in particular. The next phase of evidence development and dissemination from an intervention standpoint involves acting on existing recommendations and further refining programs to mesh with underserved children's individual and cultural contexts. Researchers must be sensitive to variations in factors such as language, socioeconomic status, education, school-caregiver interactions, health access, and others that can affect responses to interventions (Yancey et al., 2006). Reviews of research studies have consistently highlighted the need for culturally sensitive PA interventions, in particular, that actively build positive relationships with community members (e.g., Engels, Gretebeck R. J., Gretebeck, & Jiménez, 2005; Greening, Harrell, Low, &

Fielder, 2011; Marcus et al., 2006; Satterfield et al., 2003). In response to this, many observers in recent years have begun to focus on means for tailoring health promotion to specific populations (Kreuter, Lukwago, Bucholtz, Clark, & Sanders-Thompson, 2003; Marín et al., 1995; Resnicow, Baranowski, Ahluwalia, & Braithwaite, 1999; Wilson, 2009).

Broadly speaking, five strategies have been identified including (a) peripheral, (b) evidential, (c) linguistic, (d) constituent-involving, and (e), sociocultural methods (Kreuter et al., 2003). *Peripheral* strategies involve the creation of intervention materials (e.g., brochures, manuals) that are visually appropriate by means of selected images, pictures, typography, colors, and other characteristics. For example, a PA intervention targeted at Hispanic/Latino children should include photographs of children that represent them (Kreuter et al., 2003; Resnicow et al., 1999). *Evidential* strategies use evidence, such as detailed prevalence data, that are specific to the population in question. In theory, highlighting a health issue's direct relationship and relevance to people targeted by the intervention is likely to increase interest and participation (Banks-Wallace, 2000; Kreuter et al., 2003). Although data on general PA prevalence, for example, are useful as a comparison, researchers should also take care to highlight evidence specific to target populations. *Linguistic* strategies are those that present information and materials in the preferred language or dialect of the target population when appropriate (Kreuter et al., 2003). For some target populations this could entail translating materials into children's native language, while for others it could involve consulting with stakeholders over the meanings and contexts of key terms. *Constituent-involving* strategies directly and intentionally involve key members of the target population in the intervention. This manifests as hiring staff members, soliciting guidance and mentorship, and, ideally, giving decision-making powers to the people involved in a program (Green & Kreuter, 1999; Kreuter et al., 2003). The last domain, those that are *sociocultural*, involve strategies that integrate the target population's sociocultural values, beliefs, and norms into the program's identity (Kreuter et al., 2003; Resnicow et al., 1999). This is difficult to accomplish, but necessitates including key stakeholders in intervention activities from the earliest planning stages. Researchers should consult underserved children's parents/caregivers to ensure that planned PA activities (e.g., in-school PA, family events) are in alignment with beliefs and accepted practices.

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