THE INTERSECTION OF PHYSICAL ACTIVITY, SELF-REGULATION AND ACADEMIC ACHIEVEMENT: IMPLICATIONS FOR EDUCATIONAL SUCCESS

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THE INTERSECTION OF PHYSICAL ACTIVITY, SELF-REGULATION AND ACADEMIC ACHIEVEMENT: IMPLICATIONS FOR EDUCATIONAL SUCCESS

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In recent years young children have concurrently experienced startling rises in their rates of obesity and stark reductions in their opportunities for physical activity. These trends have potentially serious implications for young children's school performance. However, much of the current physical activity research is concerned with health-related outcomes and the prediction of physical activity. Less work has examined the influence of activity on other domains of child development, such as academic and social skills. The current dissertation is comprised of two studies examining opportunities for and levels of physical activity in two distinct developmental periods (preschool and elementary school) and elucidating associations of physical activity with children's self-regulation and achievement. Examining two independent samples facilitated comparisons of physical activity characteristics and associations across age groups, school settings and demographic contexts.

The first study consisted of a within-group analysis of a primarily low-income minority subsample of 4 and 5 year-old preschoolers (*N* = 104) drawn from the Pitt School Readiness Study, a study of preschoolers from the metropolitan Pittsburgh area. Results from this examination suggest that, although children's moderate to vigorous activity was not related to self-regulation or achievement, opportunities for physical activity seemed important. Specifically, more time in free play predicted worse attention, and more time in recess predicted more externalizing behavior, less self-control, and worse math achievement. In contrast, more physical education time predicted better reading and math skills.

The second study consisted of analyses on a large, economically and ethnically diverse sample of third and fifth graders (*N* = 993) and a low income subsample (*n* = 297). Across these samples, more physical education emerged as a positive predictor of self-control but more recess time was negatively associated with math achievement. Accelerometry measured physical activity was not predictive across outcomes. Finally, post-hoc examinations revealed that attention, self-control, and externalizing behaviors acted as possible agents of indirect associations between opportunities for physical activity and achievement.

Overall, findings across both studies suggest that children benefit most from physical activity that is structured and regularly scheduled within school settings. Furthermore, large quantities of unstructured activity seemed detrimental for self-regulation and achievement.

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1.0 INTRODUCTION

The past thirty years has seen a doubling in the obesity rates in children two to five years of age and, in 2008, nearly 20% of children 6 to 11 years-old could be considered obese (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010). A major culprit in the rise of obesity rates has been a decrease in the average amount of time children regularly spend engaged in physical activity. Moreover, since children spend the majority of their time in the classroom setting, one can assume that diminishing physical activity routines at school may be partly culpable. Unfortunately, trends reveal continued declines in physical activity as children enter adolescence and long after (Story, Kaphignst, & French, 2006a). In light of steep rises in obesity rates, practitioners and researchers alike are raising serious concerns regarding the sacrifice of physical activity opportunities in efforts to promote academic achievement. Questions are arising regarding the costs of such sacrifices to health as well as other domains of development. Although it is well documented that children currently have fewer opportunities for structured physical activity at school than their counterparts in past generations (Barros, Silver, & Stein, 2009; Story, Kaphignst, & French, 2006b), research is just beginning to explore the associations of these declines with multiple aspects of children's development. Physical activity is most frequently considered within the domain of physical development, with obesity and its health-related conditions being commonly assessed outcomes. However, it is becoming progressively evident that physical activity should also be considered in relation to the development of children's attention and self-regulation skills (Burdette & Whitaker, 2005; Chaddock et al., 2010a; Chaddock et al., 2010b). Furthermore, with an ever-increasing focus on improving achievement in America, it is important to consider all the factors in the life of a child that may influence academic success, including physical activity.

The current dissertation is comprised of two multi-method studies examining physical activity in two distinct developmental periods: early- and middle childhood. The first study consists of a within-group analysis of a primarily low-income minority sample of 4 and 5 year-old preschoolers. The second study consists of secondary data analyses on a large, economically and ethnically diverse sample of elementary school children, extending the examination of patterns and trends in physical activity in early childhood to associations in middle childhood. Together, these studies illustrate the opportunities for and levels of physical activity that children experience in school settings. These studies also investigate the associations between physical activity and children's self-regulation (i.e., attention, self-control, and externalizing behaviors) as well as their academic achievement (i.e., math and reading performance). Additionally, children's self-regulatory skills are examined as mediators for the relation between physical activity and achievement in elementary school.

2.0 REVIEW OF THE LITERATURE

Research has traditionally linked childhood physical activity with an array of health-related outcomes (e.g., body mass index, obesity, and diabetes). It is only recently that physical activity has been examined in relation to the development of self-regulation or achievement (Burdette & Whitaker, 2005). A greater spotlight has been cast on such links partly due to a steady decline in the time devoted to physical activity (e.g., recess and physical education) within schools (Pellegrini & Bjorklund, 1997; Story, Kaphignst, & French, 2006a). Diminishing the time children have for physical activity in favor of more academic and sedentary activities threatens physical well-being and possibly children's abilities to focus attention, exhibit self-control, regulate behavior, and ultimately perform well on academic tasks.

2.1 PHYSICAL ACTIVITY

Across the lifespan, physical activity, in tandem with good nutritional habits, is considered a key component of achieving and maintaining well-being (Klesges, Klesges, Eck & Shelton, 1995; Ogden, Flegal, Carroll, & Johnson, 2002). Although some may conceptualize physical activity as movement that is energetic or purposeful (e.g., participating in sports, swimming laps, or playing a game of tag), physical activity is more simply characterized as any activity that is not sedentary. According to Caspersen, Powell, and Christenson (1985), physical activity can be defined as, “any bodily movement produced by skeletal muscles that results in energy expenditure” (p.126). However, for the current study physical activity was conceptualized in terms of moderate to vigorous movement since these are the terms generally used by experts in making physical activity recommendations.

The terms *exercise* and *physical fitness* are frequently used interchangeably with *physical activity*. However, terminology is important as these concepts are distinct. As Caspersen and colleagues (1985) define exercise, it is a, “a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness” (p. 126). Physical fitness refers to characteristics that are either related to an individual’s health (e.g., body-composition, flexibility, muscular endurance) or physical skills (e.g., agility, speed, and coordination; Caspersen, Powell, & Christenson, 1985) and it is assessed through specific tests. A child’s total physical activity at school includes all of the activity, planned or unplanned, that occurs during the course of the school day. General physical activity includes activity or exercise that occurs during physical education and recess and may be reflected by fitness. However, it also reflects a child’s tendency for movement during classroom activities. Thomas and Chess (1984) include children’s physical activity levels as a key aspect of infant temperament, suggesting that children have natural and varying degrees of baseline activity. Furthermore, these individual differences in activity are considered generally stable during early childhood (Perusse, Tremblay, Leblanc, & Bouchard, 1989). Since this natural predisposition for activity is also captured by an overall measure of physical activity across the school day, the current dissertation is interested in group opportunities for movement as well as individual activity levels.

In an ecological framework (Bronfenbrenner & Ceci, 1994), researchers are urged to take into account all of the contexts within which children develop and the interaction of these contexts. Although American children come from a variety of cultural, ethnic, and socioeconomic backgrounds, the classroom is a context shared by most. According to the National Center for Education Statistics (U. S. Department of Education, 2004), children from preschool to secondary school spend between 6 and 7 hours a day in school. Furthermore, current initiatives to improve education in America are calling for increases in the length of the school day. President Obama and Secretary of Education Arne Duncan have both voiced support for lengthened school days and years (Patall, Cooper, & Batts-Allen, 2010). In light of the time children spend in the school context, as well as the possibility that this time may be on the rise, it is vital to consider children's opportunities for and engagement in physical activity within school settings. Moreover, as children grow, more of the time they spend outside of school is likely dedicated to completing homework (Muhlenbruck, Cooper, Nye & Lindsay, 2003). A study by Hofferth and Sandberg (2001) using detailed time-diaries found that the majority of 6 to 8 year-old children sampled reported studying approximately two hours per week. By the time children were between 9 and 12 years-old, the majority of sampled children reported studying for an average of 3 hours and 40 minutes per week. With less time out of school to be active, being active during the school day may become more critical in meeting daily recommendations for physical activity as children grow. Although research has considered physical activity in children, few studies focus specifically on physical activity on school days and how this activity is related to development and academic success. The current studies describe opportunities for and engagement in physical activity in preschool and elementary school and investigate how this activity is related to children's development.

2.1.1 Recommendations for physical activity across childhood

Definitions of optimal activity levels across age groups provide vital points of reference when studying physical activity (see Table 1). Preschoolers as well as school-aged children experience rapid physical development. As children grow, their physical activity requirements evolve to correspond to their physical capabilities and endurance. Preschoolers undergo a period of momentous growth as they develop from chubby toddlers to leaner and more agile children. Four and five year-olds acquire the abilities to catch a ball, hop on one foot and skip in rhythm (Wang, 2004), all skills they would not have been capable of just a year or two earlier. Although preschoolers seem quite adept in their motor skills, it is important to remember that they are still actively in the process of mastering many gross motor skills. For example, children at this age still cannot ride a bicycle without training wheels nor do cartwheels. In the later years of elementary school, however, children's motor skills start to resemble those of adults. They have long mastered basic motor skills and are working on refining more nuanced skills like aim, speed and reaction time (Wang, 2004). The development of these skills later in early childhood and into middle childhood makes it difficult to teach preschoolers to play basketball or tennis. However, such sports are ideal for school-aged children as they fine-tune their motor skills.

Table 1. Physical activity examples and recommendations

Preschool [a]		Elementary school [b]	
Recommended	Examples	Recommended	Examples
120 minutes of daily physical activity with no more than 60 minutes without physical activity at a time [c]		60 or more minutes a day either moderate- or vigorous-intensity, Suggested that at least 3 days a	

		week include vigorous intensity	
60 minutes structured:	Playing tag, doing jumping jacks, building with large blocks, kicking a ball, hopscotch	Light:	Casual walking, stretching, playing catch, household chores
		Moderate:	Hiking, brisk walking skateboarding, rollerblading, biking
60 minutes unstructured:	Playing on a climber, riding a bicycle, running, jumping, dancing, playing with a dog	Vigorous:	Running, playing tag, jumping rope, martial arts, soccer, ice or field hockey, basketball, swimming, tennis

[a] NASPE; National Association for Sport and Physical Education, 2010; [b] U.S. Department of Health and Human Services [c]This time should be comprised of activities encouraging movement that is moderate to vigorous in intensity

Recommendations for preschoolers, aged 3 to 5, propose 60 minutes of structured physical activity as well as at least 60 minutes of unstructured physical activity every day (NASPE; National Association for Sport and Physical Education, 2010). Structured activity occurs when parents, caregivers, or instructors are available to provide guidance, assistance, and feedback to children with the aim of supporting the development of gross motor skills. Unstructured activity, on the other hand, is independent play time during which children have the opportunity for gross motor development and are free to choose their activity and participate in it independently. Most activities can be either structured or unstructured depending on the assistance and guidance children receive. The NASPE suggests that children engage in physical activity through varied opportunities for indoor and outdoor play provided throughout the day. In addition, the NASPE suggests that preschoolers do not spend more than one hour of their day without some physical activity (even light activity, such as building with blocks or playing dress-up) with the exception of time spent sleeping. Finally, preschool guidelines do not stipulate the intensity of the physical activity that should be achieved within these two hours.

For older children, physical activity guidelines become more explicit than those for preschoolers. The guidelines for children ages 6 to 17 suggest at least 60 minutes of moderate to vigorous physical activity every day (USDHHS, 2008). For children, the amount of time spent engaged in vigorous activity is not specifically prescribed except to recommend that children engage in vigorous activity at least three times a week as part of their total daily 60 minutes of physical activity (US DHHS, 2008). The U.S. Department of Health and Human Services defines moderate physical activity for children and adolescents as walking briskly or riding bicycle. Activities meeting the definition for vigorous physical activity include running and swimming.

The NASPE has also developed guidelines regarding physical education at the elementary school level (NASPE, 2008; NASPE & American Heart Association, 2010). They suggest 150 minutes per week of physical education with a certified physical education teacher. The proposed benefits of physical activity achieved in the class setting include enhancing gross motor skills, developing collaboration and strategizing skills, enhancing awareness of the value of physical activity, and promoting physical activity outside of school (NASPE & AHA, 2010).

2.1.2 Opportunities for physical activity in preschool and elementary school

According to the U.S Department of Health and Human Services, two-thirds of children between the ages of three and five are cared for in a childcare center (USDHHS, 2006). Consequently, childcare centers are an influential context for the majority of American children. In centers, children may be presented with a variety of opportunities for physical activity. For example, they may take walks, play on gym equipment, ride tricycles, dance, or perform simple aerobic exercises like jumping jacks. Although children enter the preschool environment with a natural predisposition for certain levels of activity (Thomas and Chess, 1984), the time and opportunities they are allotted for such activity vary considerably (Bower, Hales, Tate, Rubin, Benjamin & Ward, 2008; Cardon, Van Cauwenberghe, Labarque, & De Boudeaudhuij, 2008; Finn, Johannsen, & Specker, 2002). Indeed, Pate and colleagues (2008) determined that preschool classroom and center characteristics accounted for more variability in children's activity than innate child characteristics including ethnicity, gender, and age. In a sample of preschoolers studied over three years, Klesges and colleagues (1995) found that flexible factors, including the amount of physical activity in which children engage, account for more variance in child obesity status than do non-alterable factors like genetics. Jago and colleagues (2005) similarly found that among children ages 3 to 6 years-old, physical activity and television watching, which essentially amounts to sedentary behavior, were more associated with BMI than diet. Furthermore, negative associations of physical activity and BMI as well as positive associations of television-watching and BMI strengthened when children were between 6 and 7 years-old.

For preschoolers especially, teachers play a critical role in providing opportunities for physical activity (i.e., scheduling recess and/ physical education) as the preschool environment is largely unstandardized. Teachers make decisions about how frequently and when to schedule physical activity based on a variety of factors including perceived benefits for children, personal health, and behavior management (Copeland, Kendeigh, Saelens, Kalkwarf, & Sherman, 2011). In a study of 247 preschoolers from 9 centers, Dowda and colleagues (2004) demonstrate that the specific preschool a child attends significantly predicts the amount of moderate to vigorous physical activity in which a child engages. The researchers cite the practices and policies of individual centers as critical predictors of physical activity in preschool. Overall, it seems reasonable to conclude that variations in daily classroom routines and practices may be greatly accountable for variations in children's activity (Brown, et al., 2009; Dowda, Pate, Pfeiffer, Trost, & Ziegler, 2004). Thus, it is important to closely examine these opportunities to determine effective strategies for promoting activity.

Unfortunately, children may not encounter sufficient opportunities to engage in regular physical activity. Research has repeatedly shown that preschoolers spend the majority of their time in the classroom engaged in sedentary activity (Brown, Pfeiffer, McIver, Dowda, Addy, & Pate, 2009; Cardon, & De Bourdeaudhuij, 2008). Moreover, Pate and colleagues (2008) reported that preschoolers spend as much as 80% of their day engaged in sedentary activity and less than 3% of their day engaged in moderate to vigorous activity. Such sedentary behavior early in life can set the stage for poor physical activity habits in middle childhood and put children at risk for future weight gain (Trost, Sirard, Dowda, Pfeiffer, & Pate, 2003). Furthermore, with increasing academic demands starting as early as kindergarten (Ginsburg, 2007), reductions in the amount of opportunities for physical activity and gross motor play during the course of the school day are likely starting in preschool. This is a key motive underlying the aim of extending examinations of physical activity in educational settings to the preschool context.

When children enter elementary school, the opportunities they encounter for physical activity at school change as the school day becomes more structured. In addition, periods of the day meant to promote academic achievement like math and reading time are regular and distinct from other components of the curriculum like gym, music, and art. In elementary school, children are expected to be able to sit for longer periods of time and spend a greater proportion of their day at desks or tables than in preschool. As opposed to the preschool context, when children may engage in physical activity throughout the course of the day, third and fifth graders have more firmly structured school days which designate specific periods for the opportunity to move. Research shows that elementary school students, first to fifth grade, spend approximately 64% of their day engaged in academic activities including instruction in academic subjects, independent study or reading time, and time in classroom centers (Roth, Brooks-Gunn, Livner, & Hofferth, 2002).

Elementary school children are most likely to encounter opportunities for physical activity during recess periods and physical education classes. Recess is described as a “break period” during which children are commonly allotted some time outdoors to play freely (Pellegrini & Smith, 1993). Although recess is thought to be customary across American elementary schools, there are currently no nationally enforced recess guidelines. Thus, the number of recess periods as well as their duration can greatly vary from school to school. However, the NASPE recommends that elementary school children receive at least a single, 20 minute recess period each day (NASPE, 2006). This time is believed to be essential in allowing children the opportunity to disengage from instruction and expend built up energy (Jarrett, Maxwell, Dickerson, Hoge, Davies & Yetley, 1998; NASPE, 2006; Pellegrini, Huberty, & Jones, 1995; Pellegrini & Perlmutter, 1989). Additionally, recess is thought to be a time during which children have the opportunity to develop and strengthen interpersonal skills as they encounter situations that require cooperation, negotiation, turn taking, and problem solving (NASPE, 2006). However, since children are free to choose their activities during these periods, and facilities as well as resources vary across schools, it cannot be assumed that all children engage in physical activity during recess.

A recent review of media sources from around the country (Barros, Silver, & Stein, 2009) suggests that roughly 40% of public schools in the U.S. have cut or are planning to cut at least one recess period during the school day. So although recess and physical education guidelines exist, school-aged children are encountering reductions in amount of recess time and frequency of physical activity classes in favor of more instructional time (Ginsburg, 2007; Story et al., 2006a). Furthermore, a 2010 survey of American physical education coordinators reveals that although most states mandate physical education across grades, they do not stipulate the amount of time children need to be in physical education classes each week (NASPE and AHA, 2010). Thus, many states allow for exemptions and substitutions to physical education classes which may undermine the standards.

2.2 PHYSICAL ACTIVITY AND CHILDREN'S DEVELOPMENT

Although physical activity guidelines slightly differ for children in early and middle childhood, the recommendations across age groups generally prescribe that children receive some degree of moderate to vigorous activity on a daily basis. Similarities in these guidelines suggest that patterns in the associations between physical activity, self-regulation and academic achievement may hold across developmental periods; however, this has not been tested. Furthermore, children's activity levels are known to decline over time (Trost et al., 2002). The sharpest declines have long been assumed to occur during adolescence (Sallis, 2000), but research increasingly suggests that the steepest declines in physical activity may in fact take place in middle childhood, when children are in elementary school (Bradley, Ritchie, Houts, Nader & O'Brien, 2011; Trost et al., 2002). The current studies provide a description of children's physical activity across early and middle childhood and examine whether or not the associations among physical activity, self-regulation, and achievement are consistent as children grow.

Figure 1 illustrates a hypothesized framework of associations among physical activity, self-regulation, and achievement. The framework focuses on two key physical activity variables: school opportunities for physical activity and children's levels of physical activity.

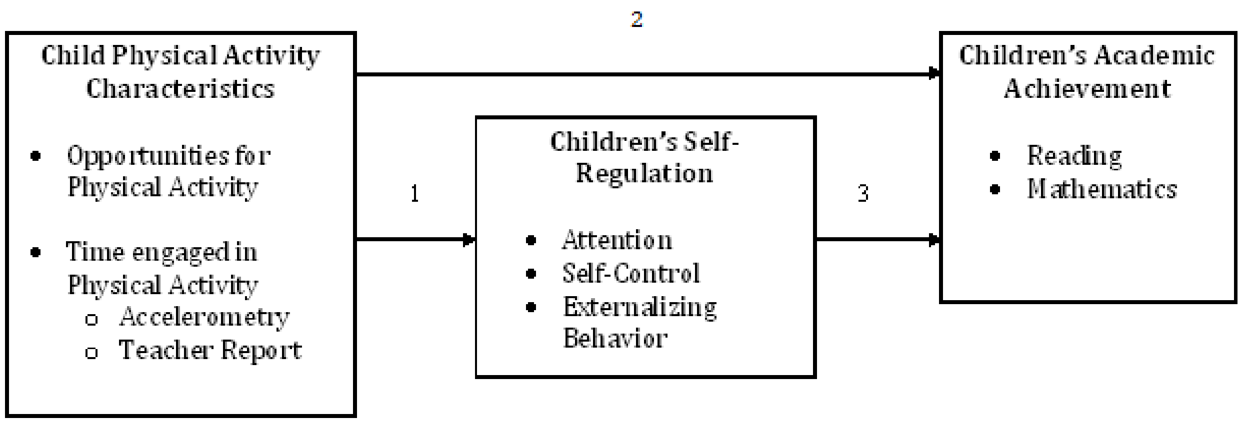

Figure 1. Conceptual Framework

This framework depicts direct pathways between physical activity and children's self-regulation (1) and achievement (2). Furthermore, the model depicts a direct path from children's self-regulation to their achievement (3), which serves as a mediating pathway between physical activity and achievement.

2.2.1 Physical activity and self-regulation

Performance on tests of mathematics and reading are the common barometers for academic performance. However, success in school is not solely related to time spent instructing in these domains. Duncan and colleagues (2007) assert that although exposure to and mastery of specific academic knowledge is critical for young children's early academic success, behaviors that enhance learning, like attention and self-control, also play a key role. The skills necessary for success as children transition to formal schooling, and all throughout their academic careers, hinge on these competencies (Li-Grining, 2007; McClelland & Cameron, 2011; McClelland, et al., 2007). Children are continually expected to perform tasks that require higher order cognitive skills while engaged in the classroom setting. The term “self-regulation” is used to encompass these skills. Self-regulation skills are necessary for negotiating emotionally related tasks, directing actions toward achieving specific goals, complying with rules, problem-solving, and behaving appropriately within the guidelines of a situation (Brock, Rimm-Kauffman, Nathanson, & Grimm, 2009; Garon, Bryson, & Smith, 2008; Li-Grining, Votruba-Drzal, Maldonado-Carreño, & Haas, 2010; McClelland, Acock, & Morrison, 2006; McClelland & Cameron, 2011; McClelland, Morrison & Holmes, 2000). In the current dissertation, the key components of self-regulation examined include attention and self-control. Attention involves the ability to focus, shift focus, and ignore irrelevant stimuli (Welsh, Nix, Blair, Bierman & Nelson, 2010). Self-control involves regulating emotions, modifying behaviors to meet expectations, and presenting appropriate responses and affect (Hanfstingl, Andreitz, Muller, & Thomas, 2011).

As with physical development, there are substantial developments in children’s cognitive abilities during preschool and elementary school. These changes are due in part to the enhanced efficiency and speed of neural impulses as the brain develops (Voss, Nagamatsu, Liu-Ambrose, & Kramer, 2011). Furthermore, children’s cognitive growth in preschool and through middle childhood also depends on the continuous development of the prefrontal cortex, the brain’s center for executive functioning (i.e., memory, inhibition and attention; Tsujimoto, 2008). Preschool marks the onset of prefrontal development. In this stage, children begin to demonstrate better self-regulatory skills (Diamond, 2001). They become less prone to tantrums and are better able to play with other children and follow classroom rules and routines. In elementary school, the prefrontal cortex continues to develop and children express enhanced self-regulation, which is evidenced in their improved ability to focus attention as well as to work independently (Tsujimoto, 2008).

Physical activity is generally assumed to enhance self-regulation. Researchers have long been studying the links between physical activity and executive functioning skills in adults (Chodzko-Zajko, 1991; Hillman, Snook, & Jerome, 2003; Tomporowski, 2003). Since similar physiological mechanisms (i.e., processes in the prefrontal cortex) are greatly responsible for executive functioning and self-regulation, results from studies linking physical activity to executive functioning may be used as support for relations between physical activity and self-regulation. However, most of this evidence from such work focuses on short bouts of rigorous lab-based physical activity (specifically cycling or running on a treadmill) completed directly prior to the performance of cognitive tasks. In a meta-analysis of this literature, Tomporowski (2003) concludes that acute sessions of exercise performed immediately before the completion of a cognitive task can enhance executive functioning skills. Other meta-analyses examining research on the associations between physical activity and cognition also reveal overall positive relations between activity or fitness and cognitive functioning in adults (Etnier, et al, 1997; Etnier, Nowell, Landers, & Sibley, 2006). However, the average effect sizes obtained from these meta-analyses are small (.25 and .34, respectively) and many of the studies included in these analyses report effect sizes that are likely inflated due to study design issues and threats to internal validity (Etnier, et al., 1997). Furthermore, participants' reaction to and performance on acute bouts of activity, especially vigorous activity, are likely indicative of fitness level and not general activity level. Thus, there are limitations to the application of such findings to the research aims of the current investigation which are specifically interested in children's general levels of physical activity.

A meta-analysis performed by Colcombe and Kramer (2003) illustrated that among older individuals (55-80 years-old), regular participation in scheduled exercise is positively related to inhibitory control. However, the authors caution that many factors can moderate these associations including the length of the intervention, the type of intervention (i.e., cardiovascular only or cardiovascular combined with weight training), as well as the duration of each intervention session. Although these results may be applicable to individuals across varying age groups, research has yet to comprehensively examine physical activity levels as they relate to attention, self-regulation and social skills in young children (Hillman, Erickson, & Kramer, 2008). Studies that have considered these associations in children largely focus on physical fitness rather than on physical activity (Buck, Hillman, & Castelli, 2008; Castelli, Hillman, Buck, & Erwin, 2007) or examine short bouts of physical activity immediately prior to performance on cognitive tasks (Hillman, Buck, Themanson, Pontifex, & Castelli, 2009; Hillman et al., 2009).

A recent experimental study is an exception among physical activity research which tends to focus on acute bouts of physical activity and fitness. Davis and colleagues (2011) aimed to experimentally examine physical activity benefits of exercise for cognition in children. In a sample of 171 overweight 7 to 11 year-olds, these researchers found that three months of regular afterschool aerobic exercise was beneficial for children's cognition and math achievement. In addition, they found that higher intensity exercise was even more beneficial than lower intensity exercise. This research illustrates that physical activity, when obtained through regular periods of scheduled exercise, can enhance children's cognition in the same way it has been shown to improve adult cognition. However, research has only begun to specifically consider how physical activity, obtained throughout the school day and not necessarily planned exercise, may relate to children's attention and self-regulation (Burdette & Whitaker, 2005; Ginsburg, 2007; Sibley & Etnier, 2003).

The extant research has demonstrated that children in elementary school show greater attention after a period of indoor or outdoor recess than before the recess period (Pellegrini, Huberty, & Jones, 1995). In addition, children are significantly more attentive and less fidgety on days during which they are given recess breaks in comparison to the days when they have no allotted time for physical activity (Jarrett et al., 1998). A recent study suggests that for eight and nine year-old children, even small doses of physical activity (e.g., a single recess period as short as fifteen minutes long) during the school day is related to better teacher-rated classroom behavior (Barros, Silver, & Stein, 2009). However, there are still too few studies on the associations of physical activity with self-regulation in children to draw definite conclusions (Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008). Thus, the current dissertation aims to elucidate these relations by examining associations between self-regulation and children's physical activity in early and middle childhood.

2.2.2 Associations among physical activity, self-regulation, and achievement

Academic achievement is an obvious outcome of interest when examining students and classroom settings. However, Tomporowski and colleagues (2008) emphasize that associations between physical activity and achievement, although documented among adults, have not yet been carefully studied in preschool and elementary school children. Only a handful of studies have examined physical activity and academic achievement in children. Of those studies, most have been cross-sectional and correlational (Carlson et al., 2008; Castelli, Hillman, Buck, & Erwin, 2007; Dwyer, Sallis, Blizzard, Lazarus, & Dean, 2001; Grissom, 2005; Stevens, To, Stevenson, & Lochbaum, 2008) and only a few have been experimental (Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Davis, et al, 2011). Furthermore, none of these studies has considered physical activity in preschoolers. Across studies, physical activity results are mixed and range from no associations to moderately positive associations with achievement (Efrat, 2011; Stevens, To, Stevenson, & Lochbaum, 2008; Tomporowski et al., 2008). Among the researchers in this growing field of interest, Coe and colleagues were able to show that participation by sixth graders in vigorous activity for 20 minutes at a time at least three days per week was associated with significantly higher grades across four academic subjects (Coe, Pivarnik, Womack, Reeves, & Malina, 2006). Furthermore, the results lasted the duration of the two semester intervention.

Similar to past work on physical activity and self-regulation, research on physical activity and achievement frequently defines physical activity in terms of fitness. Associations between physical activity and achievement are likely not uniquely the direct result of physiological changes stimulated by physical activity. Instead, associations may be primarily indirect. Indeed, physical activity may be directly related to factors of children's self-regulation, which is in turn directly related to children's achievement. However, the mechanisms through which associations occur between physical activity and achievement remain speculative. A meta-analysis concludes that there are just too few studies on the topic to draw concrete conclusions (Taras, 2005). A recent study posits that the positive relation between physical activity and achievement uncovered in a sample of 6th graders may be operating through increases in the children's levels of attention (Coe, Pivarnik, Womack, Reeves, & Malina, 2006). The researchers suggest that physical activity reduces levels of boredom, thereby increasing the ability to focus attention and, subsequently, learn. These hypotheses are shared by other researchers as well but have not yet been empirically tested (Shephard, 1997; Story et al., 2006b).

There is also a burgeoning area of research on the physiological benefits of physical activity for cognition and learning. There is a host of physiological benefits of exercise that have been observed in animals and are hypothesized to transfer to humans as well. Such benefits include enhanced neurotransmitter production (specifically dopamine, serotonin and acetylcholine), hippocampal neurogenesis (stimulation of neural and synaptic growth in the hippocampus), and hippocampal angiogenesis (stimulation of blood vessel growth in the hippocampus; Voss, Nagamatsu, Liu-Ambrose, & Kramer, 2011). Neurotransmitters are responsible for regulating a variety of functions including sleep, memory, mood, and behavior and the hippocampus plays a key role in memory formation and storage. Thus increases in neurotransmitters and enhancements to hippocampal function have the potential to result in improved memory, mood and learning.

Although few studies have yet examined the mechanisms underlying associations between physical activity and achievement, there is a breadth of research examining associations between children's self-regulation and their achievement. Children who show difficulty controlling impulses and behaviors and focusing their attention also tend to show lower academic achievement during preschool and elementary school (Alexander, Entwisle, & Dauber, 1993; Duncan, et al., 2007; Li-Grining, Votruba-Drzal, Maldonado-Carreño, & Haas, 2010; McClelland, Morrison & Holmes, 2000; McClelland, et al., 2007; Ponitz, McClelland, Matthews & Morrison, 2009; Raver, 2002). Duncan and colleagues (2007) conducted a broad study on several national datasets to investigate the relations among a variety of self-regulation factors (e.g., sustained attention, impulsivity, aggression and teacher-reported problem behaviors) and children's math and reading achievement across elementary school. Children's sustained attention upon school entry was consistently predictive of higher achievement in both math and reading across elementary school. Additionally, children's self-regulation at the beginning of their kindergarten year of school has been shown to be positively associated with their math and reading skills in sixth grade and has been shown to predict math and reading skill growth between kindergarten and second grade (McClelland, Acock, & Morrison, 2006). Better self-regulation at the commencement of the prekindergarten school year has also been revealed to predict better performance on literacy, vocabulary and math achievement assessments in the spring of the prekindergarten year, with growth in self-regulation predicting growth in each of these academic domains as well (McClelland et al., 2007).

Research supports links between higher levels of physical activity and better self-regulation, as well as links between better self-regulation and higher achievement. Thus, it is reasonable to predict either a mediated or indirect path from physical activity to achievement by way of self-regulation. However, these pathways remain largely untested. Accordingly, one of the major aims of the current dissertation was to examine these pathways.

2.2.3 Covariates of physical activity

The conceptual framework guiding the current study does not visually depict the associations of child and demographic characteristics on children's physical activity or their self-regulation and achievement outcomes. However, there are two key covariates that are important to consider when examining physical activity in children: body mass index (BMI) and sleep. Body mass index is a ratio of weight and height in order to determine over- or underweight status. Although there is not a single recommendation for children's BMI, preschoolers who fall below the fifth percentile for their age and gender are considered underweight (13.6 for girls and 13.8 for boys), and children above the 85^{th} percentile for their gender are considered overweight (18.2 for girls and 18 for boys; National Center for Health Statistics, 2000). BMI is an important covariate when examining physical activity because weight and activity are so highly intertwined (Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005). Although physical activity is commonly thought of as a predictor of weight, the relationship is probably reciprocal. Those children who are closer to being overweight or are overweight may be less active as a result of lowered endurance, tiredness, a more sedentary lifestyle, or simply more discomfort in performing physical tasks (Ekkekakis, & Lind, 2006). Thus, BMI should be considered in an examination of physical activity.

Sleep is also an important consideration when studying physical activity since children who do not get enough sleep at night are likely to be more sluggish during the day (Liu, et al., 2008). The National Sleep Foundation (2011) recommends 11 to 13 hours of sleep per day for 3 to 5 year-old children and 10 to 11 hours of sleep per day for 5 to 10 year-old children. At the preschool level, children who do not obtain sufficient sleep at night may require longer naps, and time spent asleep during the day is time when children are not engaged in classroom activities. At the elementary school level, children who do not receive enough sleep at night may find themselves lethargic and less engaged in classroom activities. Tired students may also be less likely to participate during physical education classes and less likely to choose activities which require energetic movement during periods of recess. Moreover, sleep has the potential to directly influence self-regulation (Sadeh, 2007; Sadeh, Gruber, & Raviv, 2002) as well as achievement (Buckhalt, 2011; Sadeh, 2007). A lack of sleep may hamper children's ability to pay attention, employ self-regulation, or engage in a learning activity. Consequently, sleep should also be considered in an examination of physical activity.

2.3 SIGNIFICANCE OF THE CURRENT DISSERTATION

The literature reviewed in this proposal lays the foundation for studying physical activity as it relates to children's social and academic growth by highlighting the importance of physical activity in achieving and maintaining health as well as supporting development. The aims of the current dissertation are threefold. The first aim is to describe the opportunities for and levels of physical activity in preschool and elementary school classrooms. The second aim is to examine the association of children's opportunities for physical activity and physical activity levels with key components of self-regulation and achievement. Finally, the third aim is to explore the possible mediating role of self-regulation for the relation between physical activity and achievement. In addressing these aims, the current study offers several strengths. The chief strength of the current dissertation is the employment of a developmental approach to the examination of physical activity in preschool and elementary school.

The extant literature is limited regarding data on physical activity during early childhood. The current dissertation expands the study of the associations of physical activity with child development to the preschool context. Accordingly, the current research facilitates a comparison of physical activity patterns, habits, and associations across two distinct developmental periods: early and middle childhood. Furthermore, the research that has examined physical activity in younger samples has frequently taken a health perspective, focusing on antecedents of the activity or on the activity itself instead of on the results of the activity. Few studies prior to the current dissertation have attempted to link physical activity to self-regulation or achievement in preschool. Finally, the current dissertation employs both objective measures of children's physical activity (i.e., accelerometry) and subjective ratings (i.e., teacher reports) in an effort to more rigorously examine physical activity and to illuminate consistencies or inconsistencies across these data sources.

Of course, the two samples examined in the current dissertation are distinct from each other in regards to both age and school context. However, these two samples also differ in terms of demographic characteristics. The first study is comprised of a low-income, urban, ethnic minority sample of preschoolers. Recent research suggests that low-income African American and Hispanic children experience obesity at a higher prevalence than their White counterparts (Ogden et al., 2002; Yancey & Kumanyika, 2007). Furthermore, poverty and ethnic minority status have both repeatedly been associated with self-regulatory (Raver, 2002, 2004; Wanless, McClelland, Tominey, & Acock, 2011) and achievement disparities upon school entry and throughout schooling (Burchinal, et al., 2011; Duncan, Brooks-Gunn, & Klebanov, 1994). Ethnic minority children, who are more likely to encounter lower-income households, generally enter kindergarten with less advanced academic skills than their peers from more advantaged households, and this gap persists through elementary school (Morrison, Bachman, & Connor, 2005). Physical activity, which has been long identified as a factor related to obesity (Story, Kaphingst, & French, 2006a, 2006b), is hypothesized to also be an influential factor in children's academic development. Efrat (2011) even suggests that since there seem to be physical activity benefits for academic outcomes across children from different socioeconomic backgrounds, physical activity should be promoted as a tool that can simultaneously address both health disparities and the achievement gap. Although links across ethnicity, poverty, self-regulation, achievement and physical activity are likely given past literature, research has yet to specifically test the relation between children's physical activity opportunities in low-income, minority preschools and children's development.

In contrast to the first study, the second study is comprised of a more ethnically and economically diverse sample of elementary school students. In addition, the NICHD Study of Early Child Care and Youth Development (SECCYD) sample contains a sizable proportion (30%) of children who were low-income at some point during third and fifth grade. The whole sample facilitates a more widely generalizable account of physical activity opportunities and engagement by examining children from a range of racial and socioeconomic backgrounds. In addition to examining the SECCYD sample as a whole, a subsample of low-income children was analyzed to facilitate a comparison of results for low-income and minority children across the preschool and elementary school.

A final asset of the current dissertation is the use of objective physical activity data (i.e., accelerometry) in conjunction with teachers' reports of physical activity in preschool and elementary school to examine the amount of moderate to vigorous physical activity in which children engage as well as their opportunities for activity. The chief strength of this methodology lies in its contrast to the more customary use of performance on tests of fitness as a proxy for physical activity, since fitness is not a direct representation of the amount or level of physical activity in which a child engages in within the school setting.

3.0 RESEARCH GOALS

In aspiring to improve education and bolster achievement, educational researchers consider the multitude of factors that may influence children's capacities to learn. As a fundamental factor underlying children's development, health cannot be ignored when considering academic success. Children's declining activity levels and rising obesity rates need to be considered in developmental and educational research. The present studies have laid the groundwork for extensive examinations of physical activity as it relates to self-regulation and achievement among children from preschool through middle childhood.

The current dissertation was guided by several central research goals. The first goal of the research was to construct a descriptive picture of opportunities for and levels of physical activity in preschool and elementary school classrooms. The second goal was to examine the association of children's physical activity levels and their opportunities for physical activity with key factors of self-regulation and achievement. Finally, the third goal was to explore the possible mediating role of self-regulation in the relation between physical activity and achievement for children. Embedded in each of these goals is the aim of observing difference across developmental periods (between samples). Based on current literature pertaining to physical activity, self-regulation, and academic achievement across childhood, the following hypotheses guided the current dissertation:

3.1 STUDY 1: PRESCHOOL HYPOTHESES

1. In preschool, greater opportunity for activities which allow for or encourage movement is positively related to more time spent by children in moderate to vigorous activity.
2. In preschool, more opportunities for and time spent engaged in moderate to vigorous activity are positively related to better performance on assessments of self-regulation and achievement.
3. In preschool, higher teacher ratings of children's physical activity are associated with better performance on assessments of self-regulation and achievement.

3.2 STUDY 2: ELEMENTARY SCHOOL HYPOTHESES

1. In elementary school, greater opportunity for activity which allows for or encourages movement is positively related to more time spent by children in moderate to vigorous activity.
2. In elementary school, spending more time engaged in moderate to vigorous activity is positively related to better performance on assessments of self-regulation and achievement.
3. In elementary school, teacher reports of greater opportunities for physical activity are associated with better performance on assessments of self-regulation and achievement.

4. The relation between physical activity and achievement in elementary school is mediated by self-regulation. Specifically, being more physically active relates positively to self-regulation, which in turn relates positively to performance on assessments of achievement.

4.0 METHODS

4.1 STUDY 1: PRESCHOOL METHODS

4.1.1 Participants

For Study 1, data were collected as a supplement to the Pitt School Readiness Study (PSRS), a study of classroom practices in metropolitan Pittsburgh childcare centers. The PSRS contains extensive data from repeated cognitive, socioemotional and achievement assessments. The present study used data from the third cohort, which is comprised of children (ages 4-5) and parents recruited from 30 classrooms in 24 centers which serve a largely lower-income and African American population. All of the participating centers were enrolled in the Pennsylvania Keystone Stars program which is a state-wide, quality improvement initiative that supports increased training and educational opportunities for center staff (www.pakeys.org). The sample for the third cohort consisted of 127 children. Physical activity data were collected from 104 children and these children comprise the current study.

4.1.2 Measures

4.1.2.1 Physical Activity

For Study 1, time spent engaged in physical activity was measured in multiple ways including direct child assessment, observation and teacher questionnaires. During morning visits to each classroom in the winter, direct measurements of children's activity levels were obtained and height and weight were collected. Activity levels were measured using ActiGraph GT3X tri-axial accelerometers worn at the hip for one hour. The GT3X collects data on three axes of motion (*X* =vertical, *Y*=anterior/posterior, and *Z*=lateral), in comparison to earlier models which collected data on movement in only one or two axes (*Y* or *X* and *Y*), providing less analytic detail. ActiGraph accelerometers measure changes in acceleration 30 times each second. The temporal unit of measurement in actigraphy is referred to as an epoch. In the current study, the epoch length was set at 60 seconds. Therefore, 1,800 measurements were taken per epoch.

The output of accelerometry is activity counts, which are the absolute values of the sampled changes in acceleration for a given period of measurement (Troiano, Berrigan, Dodd, Mâsse, Tilert, & McDowell, 2008). These counts are converted into a unit known as a metabolic equivalent of task, or met [MET = 2.757 + (.0015 * count) + (-.08957 * age in years) + (-.000038 * count * age in years)]. A MET is essentially a ratio for comparing a person's metabolic rate while resting to his/her metabolic rate while performing a task. The number of minutes during the measurement period during which children engaged in sedentary activity (0 METs), light activity (more than 0.1 and up to 2.99 METs), moderate activity (3 – 5.9 METs), vigorous activity (6 – 8.9 METs), or very vigorous (>= 9 METs) activity was determined for each child. For the current study, children's activity was collapsed into three categories: sedentary, light, and moderate to vigorous. Piloting of data collection procedures, namely the use of accelerometers and recording descriptive physical activity information on young children, occurred in fall 2009.

Teachers were asked to complete questionnaires for the PSRS in the fall, which provided demographic and classroom information. In addition, in the fall and spring, teachers provided information specifically regarding children's physical activity in school and at home. A modified version of the Netherlands Health Education Project Physical Activity Questionnaire (NPAQ; Montoye, Kemper, Saris, & Washburn; 1996; see Appendix C) inquires about children's time spent engaged in physical activity, the types of interests and hobbies involving physical activity in which the children participate, and their levels of physical activity in comparison to other children their age (Janz, Broffitt, Levy, 2005; Montoye, Kemper, Saris, & Washburn, 1996). This physical activity scale has been shown to have moderate to good test-retest reliability as well as moderate external validity when compared to objective measures of physical activity using accelerometers among young children (ages 4 to 7; Janz, Broffitt & Levy, 2005). An exploratory factor analysis suggested that items 1 through 7, with the exception of item 5, satisfactorily loaded onto a single factor. Item 5 asked teachers to rate children's affinity for reading and did not correlate highly with the other items. The NPAQ was scored by reverse coding items 2 and 6 and subsequently averaging the remaining items with the exception of item 5. In the resulting composite (fall and spring Cronbach's αs = .61-.66), higher scores reflected a greater tendency towards participation in physical activity.

4.1.2.2 Opportunities for physical activity

Teachers' reports of the frequency of physical education for their students, captured from the NPAQ, represent one source of data on children's opportunities for physical activity opportunity data. This data was obtained in the fall and spring through a Likert item on the questionnaire.

When teachers responded that they did not know the frequency of physical education participation, the response was recoded as missing data. The variables representing physical education classes in the fall and spring were averaged to give an average across the school year. The frequency distribution for this variable was heavily skewed toward daily teacher-reported physical education periods. Thus, this item was then dichotomized with 0 representing four or fewer physical education classes per week and 1 representing daily physical education classes.

The second source of physical activity opportunity data is time-sampled classroom observations collected from the PSRS which provide rich data on classroom practices that support physical activity, specifically the amount of time allowed for gross motor activities in each classroom. Classrooms were coded for the behaviors and experiences of the majority of children in the classroom and were completed using a modified version of time-sampling forms created for the NICHD ECCRN (Observation Record Caregiving Environment; NICHD ECCRN, 1998; Classroom Observation System-1; NICHD ECCRN, 2002). Observations involved 2.5 hour morning visits to each classroom during which trained observers collect codes for the activities, teacher behaviors, and child behaviors of each minute (see Appendix D). Thus, observers conducted 150 minutes of 30-second observe and 30-second record cycles.

In the PSRS, observations were conducted in the fall, winter, and spring on different days of the week at each time point. However, since children were objectively measured for physical activity in the winter, only data from the winter observation was used in the current study. This data represents what was occurring in the class on average during a typical morning in the season during which the children were measured. Observational recording forms included codes designed to capture the average setting (i.e., children’s physical position in the classroom) and activities across all of the children in the class. In the current study, observational data represented time in the preschool classroom when children are free to participate in physical activity, or, are not required to be sedentary. Thus, the initial codes of interest were the total time children spent moving (represented by the minutes during which children were coded as upright or moving), the time children spent engaged in free play, and the time children spent engaged in recess. However, upon closer examination it was determined that “time spent moving” may not be a specific enough code to meaningfully predict children’s physical activity. It included the time when the majority of children were standing, which would not be expected to relate to physical activity. In addition, time spent moving was not mutually exclusive of time engaged in free play or recess and could have been coded simultaneously with either one. Upon preliminary analyses time spent moving was found to be highly correlated with free play (r = 0.88, p<.001) and moderately correlated with recess (r = -0.13, p<.01). Inasmuch, it would have posed a multicollinearity issue if included in the same models with either.

Twenty-percent of observations were double-coded by trained observers at each time point to calculate inter-observer reliability. Reliability was assessed using percent-agreement across codes and kappa statistics for content code groups. Percent-agreement calculations were very high, ranging from 98% to 100%. Kappa agreement statistics for the child-position codes as well as the free-play code and the recess code ranged from .87 to 1.

Winter observational codes (time spent in free play and in recess) were employed to predict physical activity levels measured by winter accelerometry and spring teacher reports to address hypothesis 1 and to predict spring self-regulation and achievement to address hypothesis 2.

4.1.2.3 Self-regulation

In Study 1, child assessments, parental reports and teacher reports were used to examine different facets of the development of self-regulation. In the PSRS sample, videotaped self-regulation tasks (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Li-Grining, 2007; Pittman, Li-Grining, & Chase-Lansdale, 2006) and an attention task (Pair Cancellation, Woodcock-Johnson III; Woodcock, McGrew, & Mather, 2001) were administered to children in the fall and the spring. To assess self-regulation, children participated in a Snack Delay task. During the task, children were seated at a table and asked to lay their hands flat on a mat that displays the outline of hands in front of them on the table. The researchers administering this task placed a snack on the table in front of the mat and explained to the child that he or she must restrain from eating the snack until a bell is rung. The child was instructed to keep both hands on the mat during each of six trials (in order, the trials were timed for 10, 10, 40, 20, 90 and 30 seconds). Each trial was coded for the child's behavior during the task. These behavior codes range from one (the child eats the snack before the bell is rung) to eight (the child waits to eat the snack until the bell is rung with hands flat on the table at all times). Codes two through seven reflect various behaviors on the part of the child including verbal remarks to the researcher regarding the task and physical movement of the child's hands from a flat position on the table. The children were coded for their behaviors from the start of each trial until the midpoint, at which the researcher raised the bell, and from the midpoint to the end of the trial time, at which the researcher rang the bell. Each trial was ultimately assigned the lowest behavioral score the child received during the entire trial. A composite was created for each time point by averaging children's behavior scores across the 6 trials. The Snack Delay task has been shown to have high interrater reliability (ICCs across trials in fall: .96- 1.0 and in spring: .94-.98).

The Pair Cancellation task (Woodcock, McGrew, & Mather, 2001) was used to assess children's sustained attention. For the task, children were asked to visually locate and circle a specific pattern of pictures (a soccer ball followed by a puppy) in a series of repeated pictures including soccer balls, puppies and teacups. Children were instructed to circle as many correct patterns as possible in three minutes, at the conclusion of which the number of patterns correctly chosen were recorded. In addition, the time at which a child quit the task before three minutes was also recorded. For the current study, W scores, a special transformation of the Rasch ability scale, were used to ease interpretation of performance and facilitate analyses of change over time. High internal consistency (.91-.96) and predictive validity have been reported across the subtests of the Woodcock-Johnson Revised cognitive battery (McGrew, Werder, & Woodcock, 1991). Higher scores indicate better attention.

In the PSRS, children's social skills were rated by teachers in the fall and the spring on the Social Skills Rating System (SSRS; Gresham & Elliot, 1990). The SSRS for preschool children, ages 3-5 years, is comprised of two subscales examining children's social skills and problem behaviors. The first 30 items comprise the Social Skills subscale and the Problem Behaviors subscale is represented by the next 10 items. Items from both of these subscales were employed in the current study to represent various dimensions of social skills. The Social Skills subscale includes three categories of questions assessing cooperation, assertion and self-control. Only self-control was examined for the purposes of the current study. Items on this scale provide information on how well a child can control his/her temper as well as respond appropriately to adults and peers. Teachers rated the frequency of a given behavior on a three-point scale (0 = *Never*; 1 = *Sometimes*; 2 = *Very Often*). Ratings on the self-control items were summed to result in a self-control composite with higher scores reflecting better social adjustment. Items on the

Problem Behaviors subscale of the SSRS reflect the frequency of externalizing and internalizing behaviors. Only externalizing behaviors were examined for the purposes for the current study. Items on this scale provided information on a child's tendency exhibit aggressive or antisocial behavior. Teachers rated the frequency of a given externalizing problem behavior on a three-point scale (0 = *Never*; 1 = *Sometimes*; 2 = *Very Often*). As with the self-control items, frequency ratings were summed resulting in an externalizing behaviors composited with higher scores reflecting more frequent externalizing behavior problems. The validity of the SSRS is well documented and the scale has also been found to be highly correlated with other well established measures of social functioning such as the CBCL (Achenbach, 1991a; Achenbach, 1991b; Gersham & Elliot, 1990).

4.1.2.4 Achievement

Children's achievement was assessed using scores from standardized achievement assessments in the fall and spring from the Woodcock-Johnson III Psycho-Educational Battery (Woodcock, McGrew, & Mather, 2001). Letter-Word Identification was used to assess symbolic representation, letter identification, and reading skills and Applied Problems tested mathematical skills, such as counting and arithmetic. Generally high internal consistency estimates have been found in standardized samples (Woodcock & Johnson, 1989, 1990). Internal consistencies for Letter-Word Identification and Applied problems have been quite high, ranging from .94-.98 with test-retest reliabilities of .80-.87 (Woodcock & Johnson, 1989, 1990).

4.1.2.5 Covariates

A number of potential covariates of physical activity were obtained from center visits as well as from parent interviews. At the winter center visits for physical activity data collection, researchers also measured children's weight using a carefully calibrated, digital scales as well as their height using tape measures. For these body measurements, children were asked to remove their shoes. BMI scores were calculated for each child according to standard method (appropriate for both boys and girls) described by the CDC, dividing weight in pounds by height in inches squared and multiplying by a conversion factor of 703 (Division of Nutrition, Physical Activity and Obesity, National Center for Chronic Disease Prevention and Health Promotion, 2011). All of these measures were recorded on the Physical Activity, Weight and Height Record (see Appendix B). The NPAQ included a stand-alone item inquiring about napping behavior, specifically the amount of time children spend napping on an average school day in the fall and spring. Furthermore, in the fall parents reported on the amount of time, on average, their child slept at night. These factors were entered in analytic models as continuous variables and represent aspects of sleep, a key covariate of physical activity. The fall measures of self-regulation, attention, and achievement served as early controls for the spring measures of these constructs (see Appendix A). Finally, in the fall parents also reported on a variety of demographic factors. The demographic variables included in the current study included child gender (0 = *male*, 1 = *female*), child ethnicity (0 = *African American* and 1 = *Caucasian* or 0 = *African American* and 1= *Asian, Hispanic, or biracial*), maternal education (years post 8^{th} grade), maternal marital status (0 = *single*, 1 = *married*) and total monthly family income.

4.2 STUDY 2: ELEMENTARY SCHOOL METHODS

4.2.1 Participants

For Study 2, data were drawn from Phases I, II and III (birth to fifth grade) of the NICHD Study of Early Child Care and Youth Development (NICHD SECCYD), an ongoing longitudinal, multi-method study of 1364 children and their primary caregivers from 10 U.S. data collection sites (NICHD ECCRN, 1993). Sampling for the NICHD SEYCCD was conditionally random and excluded mothers younger than 18 years of age at the time of the participating child's birth, families not intending to remain within proximity of the data collection sites for at least three years, children with obvious disabilities at birth or who remained in the hospital more than seven days after birth, and mothers who would have significant problems conversing in English (NICHD ECCRN, 2004). The large, longitudinal nature of the NICHD SECCYD partnered with the study's employment of an ethnically and economically diverse sample make this dataset ideal for the prospective examination of physical activity influences on achievement across elementary school. The NICHD SECCYD contains a wide range of repeated measures of academic and cognitive skills from observational and standardized assessments and parent and teacher reports. Additionally, this dataset contains frequent assessments of children's height and weight and objective as well as maternal and teacher reports of physical activity. The richness in breadth and depth of measurement make the NICHD dataset a rarity among large datasets and complementary to the PSRS data employed in the first study.

Although the initial enrolled sample for the SECCYD was comprised of 1364 children, this number declined over time. By the time children were in the third grade, the active sample was comprised of 1098 children and was slightly reduced to 1084 by the time children reached fifth grade. Nader and colleagues (2008) completed detailed attrition analyses comparing the retained sample to the sample of children that were no longer active in the study by fifth grade. Samples were further reduced because not all of the children active in the study in third and fifth grades agreed to participate in the accelerometry. In third grade, 879 children agreed to wear accelerometers and only 839 children had valid accelerometry data. In the fifth grade, 885 children agreed to wear accelerometers and only 850 children had valid accelerometry data. A total of 993 children had physical activity data in either third or fifth grade or both and this is the sample that was employed in the current study.

The validity of the physical activity data in the SECCYD was ascertained through a specific set of decision rules implemented by the NICHD. Records were discarded if they had fewer than four days of valid data. Days were discarded if they consisted of less than eight hours or if they were beyond the maximum of seven usable days of data collection. Further information on these decision rules is detailed by Nader, Bradley, Houts, McRitchie, and O'Brien (2008).

Analyses comparing the children who agreed to wear the accelerometers versus those who did not in third and fifth grades revealed few demographic differences between groups. In third grade, the group who did not participate in the accelerometry was comprised of more males (56%) than the group who did participate (49%; $\chi^2 = 4.34$, $p < .05$). In fifth grade, the group who did not participate in the accelerometry was comprised of fewer (2%) children of other ethnicities (i.e., American Indian, Aleut, Eskimo, Asian or Pacific Islander) than the group who did participate (6%; $\chi^2 = 4.37$, $p < .05$). The groups did not significantly differ on maternal education, maternal age or income.

4.2.2 Measures

4.2.2.1 Physical activity

For Study 2, physical activity data was sought from multiple sources. The data collected by the NICHD SECCYD on physical activity in elementary school includes accelerometry (see Nader, Bradley, Houts, McRitchie, and O'Brien, 2008) as well as teacher reports of children's opportunities for physical activity. Both of these sources were used in the current study. In third and fifth grades, children wore accelerometers all day (with the exception of time spent sleeping or bathing) for seven consecutive days during which data were collected from five in the morning until the children fell asleep or midnight, whichever occurred first. The number of minutes per day spent engaged in moderate activity (3 – 5.9 metabolic equivalent tasks or METs), vigorous activity (6 – 8.9 METs), or very vigorous activity (>= 9 METs) was determined for each child for each day the monitor was worn. Time, in minutes, spent in moderate or vigorous, and moderate-to-vigorous activity was divided by the number of minutes spent wearing the monitor to provide a measure of the proportion of time spent in each activity. These proportions were employed as objective measures of physical activity in the current study.

One caveat which must be mentioned is the fact that the NICHD SECCYD does not provide accelerometry data that represents physical activity solely occurring in the school setting. This is a limitation to the current study which aims to examine physical activity in school. Although children were measured for seven days, only data from Monday through Friday were employed. However, this data is reflective of activity throughout the course of the day and not limited to hours spent in school. In an effort to control for physical activity which may have taken place outside of school, a variable reflecting participation in extracurricular activities which encourage physical activity (e.g., sports teams, dance classes) was included in analytic models. These data were obtained from maternal reports of children's extracurricular activities on interviews regarding afterschool arrangements in third and fifth grades. These reports were frequent as one of the chief aims of the SECCYD was to collect data on children's out of school care arrangements. Thus, researchers repeatedly collected data across time points about childcare and afterschool care. Accordingly, three parental interviews pertaining to afterschool arrangements were completed in third grade and two interviews were completed in fifth grade. Data representing the time children spent in extracurricular activities that encouraged physical activity from these interviews were averaged within grade to represent the time children spent in movement related activities outside of school in each third and fifth grade.

4.2.2.2 Opportunities for physical activity

Teachers, also through informal questionnaires (Physical Activity Record of Classes) developed by NICHD, provided information on children's opportunities for physical activity during a single week of school. Teachers recorded the number of weekly periods students in the study child's class spent at recess and engaged in structured physical education in each third and fifth grade.

4.2.2.3 Self-regulation

In third and fifth grades, teachers rated children on the Disruptive Behavior Disorders Rating Scale (DBD; Pelham, Gnagny, Greenslade, & Milich, 1992), from which data on children's attention and self-regulation were obtained for Study 2. This scale is comprised of a list of behaviors which teachers must rate for the degree to which each item describes a child. Ratings were made on a four-point scale (i.e., not at all, just a little, pretty much, and very much). For use by the SECCYD, the scale was collapsed and dichotomized so that the score for each item denoted whether the behavior described the child *not at all or just a little* (0) versus *pretty much* *or very much* (1). The inattentiveness composite score is comprised of nine, dichotomized items with a score range of 0 to 9 and higher scores representing more inattentive behaviors. The items for the inattentiveness composite describe behaviors like not following instructions, not listening when directly spoken to, and failing to pay attention to details. The hyperactivity/impulsive behavior composite score is the sum of nine items describing behaviors like talking too much, fidgeting, and showing difficulty waiting to take a turn. This score can range from 0 to 9, with higher scores representing more hyperactive and impulsive tendencies. The raw items used to create these composites for demonstrated high internal reliability. For the teacher-reported hyperactivity/impulsive behavior score, the Cronbach's alpha statistic ranged from .88-.89 in third and fifth grades. For the inattentiveness score, the alpha statistic was .91 in both school years. The inattentiveness composites represent children's abilities to pay attention and the hyperactivity/impulsive behavior composites represent children's self-regulation skills.

Children's externalizing behaviors and attention were assessed by parents in first grade using the Child Behavior Checklist (CBCL, Achenbach, 1991a) and externalizing behaviors were assessed by teachers in third and fifth grades using the Teacher Report Form (TRF), a slightly modified version of the CBCL (Achenbach, 1991a). Externalizing problems include aggressive or delinquent behaviors. On both the CBCL and TRF, reporters rated how true listed behaviors were to behaviors typically exhibited by a child on a three point scale (0 = *Not True*; 1 = *Sometimes or Somewhat True;* 2 = *Very True or Often True).* Higher overall scores reflect more externalizing behaviors. The CBCL and TRF are widely accepted as reliable and internally consistent (Achenbach, 1991b). Parents' and teachers' reports of children's problem behaviors were highly reliable at each time point (parents' Cronbach's α = .93; teachers' Cronbach's αs = .95-.96). Parents' first grade ratings of externalizing behaviors on the CBCL were used as controls for teachers' third and fifth grade ratings of externalizing (CBCL) and parents' first grade rating of attention on the CBCL were used as controls for teachers' third and fifth grade ratings of inattention (DBD).

Finally, the current study employed the self-control subscales of the mother-reported Social Skills Rating System (SSRS) in first grade and the teacher-reported SSRS in third and fifth grades. Mothers and teachers rated children's social skills, including children's abilities to exhibit self-control, on the Social Skills Rating System (SSRS, Gresham & Elliott, 1990). The Self-Control subscale of the SSRS includes behaviors that emerge in conflict situations, such as responding to teasing or peer pressure appropriately, receiving criticisms well, and controlling temper. Teachers assessed the frequency of a social behavior on a three-point scale (0 = *Never*; 1 = *Sometimes*; 2 = *Very Often*). Additionally, the reporters rated how important the behavior is for classroom success, again on a three-point scale (0 = *Not Important*; 2 = *Important*; 3 = *Critical*). With ten items comprising the self-control composite, the possible range of scores was from 0 to 20, with higher scores reflecting better social adjustment. The validity of the SSRS is well documented and the scale has also been found to be highly correlated with other well established measures of social functioning such as the CBCL (Achenbach, 1991; Gersham & Elliot, 1990). The items used to compute parent and teacher composite scores on the Self-Control subscale demonstrated good internal reliability at each time point (parents' Cronbach's α = .81; teachers' Cronbach's αs= .89). Although the third and fifth grade teacher reports were used as outcomes in the current study, the first grade maternal report of self-control on the SSRS were used as an early control measure for the third and fifth grade SSRS outcomes as well as for the third and fifth grade hyperactivity (DBD) outcome and externalizing (CBCL) outcome.

4.2.2.4 Achievement

Children's achievement was assessed in third and fifth grade using the Broad Reading and Broad Math subtest from the Woodcock-Johnson Psycho-Educational Battery-Revised (WJ-R, Woodcock & Johnson, 1989, 1990), which was administered to participants in a laboratory setting. The Broad Reading test contains items which are divided into two, mutually exclusive subscales called Letter Word Identification and Passage Comprehension. The Letter Word subscale is comprised of items which assess a child's symbolic learning and reading skills. The Passage Comprehension subscale is comprised of items which assess the comprehension of words within the context of a passage. The Broad Math test contains items which are divided into two, mutually exclusive subscales called Applied Problems and Calculations. The Applied Problems subscale is comprised of items which assess a child's ability to analyze and solve practical problems in mathematics through specific procedures. The Calculations subscale, on the other hand, is comprised of items which assess a child's ability to perform mathematical tasks including addition, subtraction, multiplication, division, and combinations of these basic operations with only a few questions assessing more advanced calculation skills through geometric, trigonometric, logarithmic, and calculus operations. Finally, in first grade children were only administered the Letter Word and Applied Problems subscales of each of the achievement batteries. Thus, first grade Letter Word score and first grade Applied Problems score was used as an early control.

The current study uses W scores, a special transformation of the Rasch ability scale, which ease interpretation of performance and facilitate analyses of change over time. Generally high internal consistency estimates have been found in standardized samples (Woodcock & Johnson, 1989, 1990). Internal consistencies have been reported ranging from .63-.78. Internal consistencies across the skills tests that comprise the WJ-R have been quite high, ranging from .94-.98 with test-retest reliabilities for the individual tests, including the four subscales listed above, ranging from .80-.87 (Woodcock & Johnson, 1989, 1990).

4.2.2.5 Covariates

Family demographic information was obtained from parent interviews from the child's birth through fifth grade. At 1 month, mothers reported on their child's gender (0 = *female*, 1=*male*) child ethnicity (0 = *Caucasian* and 1 = *Hispanic*, *Non-Hispanic Black*, or *Other minority*), maternal age, and the number of years of education completed before the birth of the study child. Maternal marital status (0= *married*, 1= *unmarried*), weekly hours of maternal employment, the number of children in the household, and family income were obtained at the third and fifth grade time points. The income-to-needs ratios from third and fifth grade represent the income in middle childhood. Income-to-needs ratios were calculated by taking pre-tax household income for a given year and dividing it by the poverty threshold for a household, which takes into account the year the income was earned, the number of individuals in the home, and the number of children in the home.

Children's body mass index (BMI) was obtained in both third and fifth grades (calculated as weight in kilograms divided by height in meters squared; Division of Nutrition, Physical Activity and Obesity, National Center for Chronic Disease Prevention and Health Promotion, 2011). Finally, mothers also reported on their children's total average time spent sleeping each day on the Children's Sleep Habits Questionnaire (CSHQ; Owens, Spirito, & McGuinn, 2000) in third grade.

4.3 ANALYTIC STRATEGY

4.3.1 Study 1 analyses

The first study was comprised of three, independent hypotheses, each of which was addressed through individual analyses. The initial step in addressing the questions posed by the first study was to compute preliminary, descriptive statistics. These analyses provided a description of the opportunity for physical activity in each classroom as well as the amount of physical activity in which preschoolers engaged.

The second analytic step was to calculate intraclass correlations. These statistics were used to determine the need to employ analyses which account for within group dependence presented by the nesting of children within classrooms. Most of the resulting intraclass correlations suggest that children's scores were significantly related to their classroom or that their non-independence was significant ($r > .10$). Thus, two-level Hierarchical Linear Models (HLM; Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2004) were employed to test the remaining two questions. Specifically, HLM was employed to examine predictors of physical activity, as well as whatever physical activity predicts of children's self-regulation and achievement. Level 1 represented how much variation in an outcome was between children grouped in the classroom. Group mean centering at level 1 facilitated the interpretation of the intercept as the unadjusted mean on the outcome for a child i in group j (Raudenbush & Bryk, 2002). Coefficients on the level 1 predictors represented the slope of the outcome on each level 1 predictor for each child i in group j. The intercept at level 2 represented how much variation in an outcome was between rooms. At level 2, all predictors were grand-mean centered to reduce collinearity between predictor variables. The first hypothesis in study 1, which explored predictors of physical activity, was addressed with analyses conducted using equations 1.1 through 1.3, presented below.

Level 1 Equations:

(1.1) $Accelerometry_{(Winter)\ ij} = \pi_{00} + \pi_{1ij}\, Family\ Demographics_{(Fall)} +$

$\pi_{2ij}\, BMI_{\ (Winter)} + \pi_{3ij}\, Napping_{(Average\ Fall\ and\ Spring)} + \pi_{4ij}\, Sleep_{(Fall)} + \ \varepsilon_{it}$

(1.2) $Teacher\text{-}reported\ Physical\ Activity_{(Spring)\ ij} = \pi_{00} + \pi_{1ij}\, Family\ Demographics_{(Fall)} +$

$\pi_{2ij}\, BMI_{\ (Winter)} + \pi_{3ij}\, Napping_{(Average\ Fall\ and\ Spring)} + + \pi_{4ij}\, Sleep_{(Fall)} + \pi_{5ij}\, Teacher\text{-}reported$

$Physical\ Activity_{(Fall\ )} + \varepsilon_{it}$

To address the first hypothesis, at level 1 physical activity (either winter accelerometry or spring teacher reports) were predicted by BMI, average napping tendencies, nightly sleep tendencies, and family demographics. In addition, spring teacher reports of physical activity were predicted with teachers' fall reports of physical activity. Level 2 included classroom opportunities for physical activity and included observed time spend engaged in recess, observed time spent engaged in free play, and class participation in physical education as predictors (see equation 1.3).

Level 2 Equations:

(1.3) $\pi_{00} = \gamma_{00} + \gamma_1\ \ Time\ observed\ free\text{-}play_{\ (Winter)}\ +$

$\gamma_2\ \ Time\ observed\ in\ recess_{\ (Winter)} +$

$\gamma_3\ \ Participation\ in\ Physical\ Education_{\ (Average\ Fall\ and\ Spring)}\ +\ \ r_{0it}$

To address the second and third hypotheses, children's self-regulation (attention and self-regulation) and achievement (reading and math) were predicted by accelerometry and teachers' reports of physical activity according to level 1 Equation 1.4, presented below:

$$(1.4)\ \textit{Spring Outcome}_{ij} = \pi_{00} + \pi_{1ij}\,\textit{Accelerometry}_{(Winter)} + \pi_{2ij}\textit{Teacher Report Physical Activity}_{(Fall)} + \pi_{3ij}\textit{BMI}_{(Winter)} + \pi_{4ij}\,\textit{Napping}_{(Average\ Fall\ and\ Spring)} + \pi_{5ij}\,\textit{Sleep}_{(Fall)} + \pi_{6ij}\,\textit{Early Outcome Control}_{(Fall)} + \pi_{7ij}\,\textit{Family Demographics}_{(Fall)} + \varepsilon_t$$

In addition to physical activity, spring self-regulation and achievement were modeled as a function of winter BMI, average napping tendencies, nightly sleep tendencies, a fall outcome control and family demographics. As in the level 1 analyses addressing the first hypothesis, the level 1 equation addressing the second and third hypotheses (equation 1.4) was paired the level 2 models (Equation 1.3) two-level HLM analyses.

4.3.2 Study 2 analyses

The hypotheses for the second study were similar to those presented for Study 1. Although there were 1084 children still active in the sample by fifth grade, the final sample of children who had complete data on all of the variables of interest consisted of considerably fewer children. This was chiefly due to children missing data on accelerometry. In third grade 839 children had valid accelerometry data and fifth grade 850 children had accelerometry data. However, only 696 children have accelerometry data at both time-points and 993 children had physical activity data at one or both time points. Missing data patterns for the 993 child sample were analyzed and results suggested that missing data imputation was an appropriate strategy (Little, 1988). Missing data was imputed using multiple imputations implemented in SPSS for Windows, Release Version 19.0, (SPSS, Inc., 2010, Chicago, IL). Analyses were conducted on the 993 child sample. Furthermore, a poverty marker was created to signify whether a child was ever below 200% of the poverty line in third or fifth grade. The resulting sample was analyzed as the low-income subsample and consisted of 297 children.

As discussed earlier, past work has looked primarily at acute bouts of physical activity and there is little evidence of longitudinal associations between physical activity and cognitive or academic outcomes. In the current study, we capitalized on repeated measures of physical activity and outcomes to examine shorter term associations rather than physical activity at one time point predicting an outcome in the distant future. Thus, although there were only 993 children in the full dataset, each child appeared twice in the analytic dataset (N=1986) with time-invariant data repeated but data on physical activity and outcomes varying across the third and fifth grade time points. The low-income sample was treated identically with an initial sample size of 297 but a final stacked sample size of 594. The benefits of stacking data include more efficient parameter estimation facilitated by increased sample size as well as a reduction in the risk of collinearity among variables (Li-Grining & Coley, 2006).

The first step in the analyses for Study 2 involved computing preliminary descriptive statistics and analyzing the distributions for key variables. Bivariate correlations were employed to examine the stability over time in children's levels of physical activity as well as the stability of parental and teacher reports of activity.

Nesting is generally a concern when studying children in schools. However, in the third and fifth grade in the SECCYD sample, only a small percentage classrooms or schools were shared by study children (6% and 12%) and most of this nesting involved only two children (67% and 91%; Bachman, Votruba-Drzal, El Nokali & Castle, 2011). Accordingly, past research using the SECCYD data has not adjusted for this level of data dependence (e.g., Crosnoe et al., 2010; Pianta et al., 2008). Likewise, the current analyses also did not adjust for nesting. In addressing the first research question, random effects regression analyses were performed in Stata 10 (StataCorp, 2007). To examine whether physical activity is predicted by opportunities in the school setting, specifically recess and physical education, the current study employs Equation 2.1:

$$(2.1)\ \textit{Physical Activity}_{i(3rd\ and\ 5th)} = \beta_{00} + \beta_1\ \textit{Teacher-reported Recess}_{i(3rd\ and\ 5th)} + \beta_2\ \textit{Teacher-reported Physical Education}_{i(3rd\ and\ 5th)} + \beta_3\ \textit{Extracurricular Physical Activity}_{i(3rd\ and\ 5th)} + \beta_4\ \textit{BMI}_{i(3rd\ and\ 5th)} + \beta_5\ \textit{Nightly Sleep}_{i\ (3rd)} + \beta_6\ \textit{Family Demographics}_{i\ (1mos\text{-}5th)} + \varepsilon_t$$

According to Equation 2.1, third and fifth grade physical activity (i.e. accelerometry or teacher report) were modeled as a function of third and fifth grade time engaged in recess, time engaged in physical education, participation in extracurricular activities involving physical activity, BMI, as well as average hours of nightly sleep in third grade and family demographic characteristics, including child race, household income and maternal education. Demographic characteristics were obtained anywhere from birth to fifth grade.

Regression analyses similar to those employed for research question 1 were employed to address the second and third research questions. To examine whether children's self-regulation and achievement in fifth grade are predicted by opportunities for or engagement in physical activity, the current study employs Equation 2.2:

(2.2) $Outcome_{i(3rd\ and\ 5th)} = \beta_{00} + \beta_1 Accelerometry_{i(3rd\ and\ 5th)}$
$+ \beta_2\ Teacher\text{-}reported\ Recess_{i(3rd\ and\ 5th)} + \beta_3\ Teacher\text{-}reported\ Physical\ Education_{i(3rd\ and\ 5th)} + \beta_4\ Participation\ in\ Extracurricular\ Physical\ Activity_{i(3rd\ and\ 5th)} + \beta_5\ BMI_{i(3rd\ and\ 5th)} + \beta_6\ Nightly\ Sleep_{i(3rd)} + \beta_6\ Family\ Demographics_{i(1mos\text{-}5th\ grade)} + \beta_7 Early\ Outcome\ Control_{i(1st\ or\ 3rd)} + \varepsilon_t$

Finally, hierarchical regression analyses were used to address the fourth research question. To examine whether self-regulation mediated the relation between physical activity and achievement, the current study employed Equation 2.3:

(2.3) $Achievement_{i(3rd\ and\ 5th)} = \beta_{00} + \beta_1 Accelerometry_{i(3rd\ and\ 5th)} + \beta_2\ Teacher\text{-}reported\ Recess_{i(3rd\ and\ 5th)} + \beta_3\ Teacher\ Reported\ Physical\ Education_{i(3rd\ and\ 5th)} + \beta_4\ Participation\ in\ Extracurricular\ Physical\ Activity_{i(3rd\ and\ 5th)} + \beta_5\ BMI_{i(3rd\ and\ 5th)} + \beta_6\ Nightly\ Sleep_{i(3rd)} + \beta_7\ Achievement\ Control_{i(1st\ or\ 3rd)} + \beta_8\ Family\ Demographics_{i(1mos\text{-}5th\ grade)} + \beta_9\ Self\text{-}Regulation_{i(3rd\ and\ 5th)} + \varepsilon_t$

In the first step physical activity, teacher-reported recess and physical education, BMI, nightly sleep, a first grade outcome control and family demographics were entered to predict achievement. In the next 4 models, children’s self-regulation, including externalizing behavior, hyperactivity, inattention, and self-control, were each individually added to the first model. The dimensions of self-regulation were too highly intercorrelated to all be entered simultaneously which may have led to multicollinearity issues or suppression effects. Finally, in order to examine if these skills mediated the associations between physical activity and achievement, formal tests of mediation were employed using techniques described by Sobel (1982) by means of an online statistical calculator (Soper, 2009), assuming physical activity predicted self-regulation in equation 2.2.

5.0 STUDY 1: PRESCHOOL FINDINGS

5.1 STUDY 1 RESULTS

Descriptive statistics for the preschool sample are listed in Table 2. The sample was 50% female and 65% African American. About 28% had married mothers who had, on average, completed 6.40 years of education post eighth grade. On average, families in the sample reported $3,017.98 in monthly income, which equates to $36,215.76 in annual income. Paired samples t-tests revealed significant improvement on average in children's spring scores over fall scores ($p \leq .01$) for all of the outcomes except for teacher reported self-control for which there was no significant change between reports.

In terms of physical activity, the preschoolers in the current sample spent 9% of the time they were observed engaged in moderate to vigorous physical activity. In the classrooms sampled, children were observed to spend an average of 46.98 minutes (31%) of their time engaged in free play, and only 6.63 minutes (4%) of their time engaged in recess. It is important to note that recess quantities were probably especially low since the observations employed in the current study were obtained in the winter. Furthermore, 84% of students were reported to engage in daily periods of physical education each week. On average children in the sample slept 8.83 hours at night, with 1.8 additional hours of naptime during the school day. The sleep data suggests that most children are sleeping at least slightly less than the average 11 to 13 recommended hours. In addition, the average male BMI was 17.27 and the average female BMI as 16.98. These results categorize the average boys and girls in the preschool sample as at risk for overweight.

Correlations were calculated among the physical activity level and physical activity opportunity variables, the key covariates and the child outcomes to identify patterns in the data (see Table 3). Overall, children's moderate to vigorous physical activity was negatively related to self-regulation and positively associated with externalizing behavior. In addition accelerometry measures of moderate to vigorous activity were positively associated with teacher reports of physical activity, daily physical education and children's nightly sleep. In contrast, sedentary time was negatively associated with attention, self-control and reading achievement. Having daily periods of physical education was positively related to reading and math achievement, children's self-regulation and their externalizing behavior.

The first step in HLM analyses involved estimating unconditional models to examine the significance of outcome intercepts and slopes. Results from these models are displayed in Table 4. Both intercept and slope coefficients were significant across outcomes. This indicates that there were significant individual differences across individual intercepts and slopes. In addition, within and between group variance components from the unconditional analyses were used to calculate intraclass correlations for each outcome which ultimately supported the use of nested analyses.

The next step in analyses addressed the first hypothesis by estimating conditional models to examine the prediction of accelerometry measured and teacher-reported physical activity, through classroom opportunities for activity and child characteristics. Results for these analyses are presented in Table 5. Given the significant correlations between sedentary time and the outcome variables, all models were analyzed with sedentary activity in lieu of moderate to vigorous activity as a level 1 predictor. Although sedentary activity was not central to the current research questions, these analyses were performed after it was evident that children in the sample spent considerably more time in sedentary activity than in moderate to vigorous activity. However, time in sedentary behavior was generally unrelated to the current outcomes. For this reason and to maintain consistency across studies, only findings from analyses including moderate to vigorous time are presented and discussed.

Children's accelerometry measured moderate to vigorous physical activity was only predicted by napping behavior. Preschoolers who spent more time napping engaged in more moderate to vigorous activity. Teacher-reported physical activity was positively predicted by average class time spent in recess. Specifically, one standard deviation increase in time spent in recess was equivalent to a 15.5% standard deviation increase in teachers' reports of physical activity. In addition teachers' spring reports were positively predicted by their fall reports. Time spent in free-play, time spent in physical education, BMI and nightly sleep were not shown to predict either the accelerometry or teacher reports.

To address the second and third hypotheses, analyses involved estimating conditional models to examine the prediction of children's self-regulation and achievement by physical activity and opportunities for physical activity. Results for the prediction of self-regulation (i.e., externalizing, snack delay, self-control and attention) are presented in Table 6. Neither accelerometry measured physical activity nor teacher reports of physical activity predicted any of the factors of self-regulation. However, average class time spent in free play negatively predicted attention such that one standard deviation increase in free play was related to approximately one sixth of a standard deviation decrease in attention. Average class time spent in recess predicted more teacher-reported externalizing behaviors and less teacher-reported self-control such that one standard deviation increase in recess time was associated with about a third of a standard deviation increase in teacher-reported externalizing behavior and just under a quarter of a standard deviation decrease in teacher-reported self-control. Weekly periods of physical education did not predict across outcomes.

In regards to the key covariates of physical activity, higher BMI predicted worse performance on the snack delay task and teacher-reported self-control. Specifically, one standard deviation increase in BMI was related to a sixth of a standard deviation decrease on the snack delay task and roughly a fifth of a standard deviation decrease in teacher-reported self-control. More time spent napping positively predicted better self-control such that a standard deviation increase in time spent napping was related to about a tenth of a standard deviation increase in self-control. Child and demographic characteristics did not show any patterns of prediction except for Caucasian children who were reported by teachers to exhibit less externalizing behaviors and who performed better on tests of attention than African American children.

Results for the prediction of achievement (i.e., reading and math) are presented in Table 7. Neither accelerometry measures of moderate to vigorous physical activity nor teacher reports of physical activity predicted achievement. However, average class time spent in recess negatively predicted math such that one standard deviation increase in recess was related to 15% of a standard deviation decrease in math. Daily periods of physical education positively predicted both math and reading achievement. Specifically, one standard deviation increase in physical education was related to 7% of a standard deviation increase in math and 9% of a standard deviation increase in reading. In regards to the key covariates of physical activity, neither BMI, napping, nor nightly sleep predicted achievement.

5.2 STUDY 1 DISCUSSION

The aims for Study 1 included describing what physical activity levels and opportunities for physical activity were evident in a community based preschool setting and examining the relations of both aspects of physical activity with self-regulation and achievement. The following discussion will detail how the results address the aims and hypotheses proposed by Study 1.

5.2.1 Physical activity, BMI and sleep in preschool

Results from descriptive analyses of the preschool sample reveal that the majority of preschoolers' time was spent in sedentary activity, with relatively little time spent being physically active. These results corroborate literature which finds that preschoolers are overwhelmingly sedentary in classroom settings (Brown, Pfeiffer, McIver, Dowda, Addy, & Pate, 2009; Cardon, & De Bourdeaudhuij, 2008; Pate, McIver, Dowda, Brown & Addy, 2008). On average children participated in free play for roughly a third of the time they were observed. However, the content of this time was not detailed for each participant as the purpose of the observations was to examine the experiences and activities of an average child in each classroom. Children's free play may or may not have entailed a choice for activities promoting movement, or activities involving teacher or caregiver guidance in structured physical activity. In addition, few children had the opportunity for recess during classroom observation. This is likely a reflection of the facts that observations were conducted in the winter and that many of the centers were located in urban environments. Urban childcare centers are commonly limited in regards to both outdoor and gymnasium space. Such a finding also suggests that, at least in the winter, time spent in recess cannot be depended upon in attaining the NASPE (2010) recommendation of one hour of structured daily physical activity for preschoolers.

In contrast, the majority of children in the study were reported to engage in physical education daily. In the current study, teachers were not asked to elaborate on the content of physical education periods. For example, physical education in elementary school is generally comprised of specific age appropriate activities and structured games. However, since physical education standards for preschool are not common, it is hard to know what teachers were referring to when they reported on physical education. Future research on physical activity in preschool would benefit from obtaining more detailed information on physical education in this context, specifically the curriculum and the amount of time dedicated to its instruction.

It was hypothesized that greater opportunities for physical activity would result in more moderate to vigorous physical activity for children. Results suggest that engaging in recess is positively related to teachers' reports of physical activity. This is not surprising since gross motor activity at recess is likely to include some moderate to vigorous activity (Jarrett, Maxwell, Dickerson, Hoge, Davies & Yetley, 1998; NASPE, 2006; Pellegrini, Huberty, & Jones, 1995). However, during the winter observations, almost three-quarters of children did not participate in any recess. Thus the current results suggest that those children who engaged in any recess time at all were perceived by teachers to be more active. This finding may be a result of opportunities during recess. However, this finding may also be the result of teachers' general value for physical activity (Copeland, Kendeigh, Saelens, Kalkwarf, & Sherman, 2011) such that teachers who make a point to schedule recess during the winter are also more likely to rate their students as more physically active.

Neither time in free play nor physical education predicted more moderate to vigorous movement. Although free play is a time when children can independently choose activities, it is also a time when there tend to be centers or stations set up for children to explore. For example, an art table, a science center and a housekeeping area may be prepared stations at which children can play during free play. Although children are likely free to be somewhat physically active during this time, without guidance or directions for physical activity, it is possible that many of the children choose to be more sedentary and participate in activities like art or reading (Pellegrini & Smith, 1998). The physical education finding is perplexing in that physical education, like recess (Barros, Silver & Stein, 2009), is meant to target gross motor activity (NASPE, 2010). One possible rationale for the finding is that teachers may not have been reporting on physical education an elementary school teacher might. Childcare teachers may have been reporting on their tendency to give children opportunities to be physically active on a daily basis rather than on having actual class periods devoted to instructing children in activity. These findings for free play and physical education also suggest that these two sources of physical activity opportunity in childcare may not be helping children meet the NASPE (2010) structured physical activity recommendation.

Overall, the average participant in the sample slept for fewer hours than the minimum recommended by the National Sleep Foundation (2011) and was categorized as at risk for being overweight according to BMI (National Center for Health Statistics, 2000). Taking into account nightly sleep patterns and BMI, this sample of preschoolers may be considered at risk for obesity (Harrison et al., 2011). However, neither BMI nor nightly sleep was associated with children's average levels of physical activity. Time spent napping, which for some children may compensate for insufficient nightly sleep, was positively related to children's moderate activity.

It is difficult to ascertain whether children who slept more at nap time were more physically active or if children who were more physically active required longer naps.

5.2.2 Physical activity and self-regulation

It was hypothesized that more opportunities for and time spent in moderate to vigorous physical activity would result in better self-regulation, specifically less externalizing, more self-control, and better attention. Results from analyses examining these relations reveal that neither children's accelerometry measured nor teacher-reported physical activity were related to their externalizing behavior, self-control or attention. However, these results may be attributable in part to the quality of the physical activity measures. Both measures only provided a limited indication of a child's physical activity. Specifically, the accelerometry conducted for the current study provided only a brief snapshot of a child's activity levels in the classroom setting. This snapshot did provide some data regarding children's natural disposition of activity. However, because of its brevity, it may not have adequately been able to capture the extent of children's levels of physical activity across a variety of classroom routines. Recommendations for the amount of measurement required for stable measures of physical activity suggest 3 to 7 days of measurement during waking hours (Penpraze, Reilly, MacLean, Montgomery, & Kelly, 2006). If the data from the current study provided information on physical activity throughout the entire school day and over a series of days, there is a chance that a relation between activity and self-regulation may have emerged. Although accelerometry of preschoolers can be challenging, researchers have been able to obtain many consecutive hours of accelerometry data on 3 to 5 year-olds in the preschool setting (Pagels, Boldemann, & Raustorp, 2011).

Moreover, the PSRS teacher questionnaire items regarding children's physical activity could have been more detailed and requested that teachers provide information on when children were most active and the nature of their activity. Teachers were asked to rate children on characteristics of their physical activity but were not asked to discuss what and when children were actually active. For example, a child who plays very hard during gym or recess time may have been rated similarly by teachers to children who are very active during instructional times. Time diaries, although time-consuming and more difficult to maintain than third party observation or accelerometry, may be a good option for obtaining descriptive reports of preschoolers' physical activity (Penpraze et al., 2006)

Physical education did not predict any of the self-regulation factors. However, time spent in free play predicted worse attention. On average, children in the PSRS spent a third of their observed time engaged in free play. As previously described, free play can entail a variety of activities which allow children to independently choose and conduct their play (Ginsburg, 2007). It is possible that in classrooms where there is more free play time, there is also less time for group activities requiring prolonged attention and participation. Thus, children in classrooms with more independent free play may encounter less practice in sustaining their attention.

Time engaged in recess predicted more externalizing behavior and less teacher rated self-control. Recess was also the only opportunity variable that predicted teacher-reported activity. However, since teacher-reported activity does not predict externalizing or self-control, there is likely a characteristic of recess unrelated to physical activity that explains these patterns. It is possible that having more time in recess takes away from class time during which children can learn self-regulatory skills. Other possibilities for this finding are related to teacher characteristics since recess frequently happens at their discretion (Pellegrini and Smith, 2003).

For example, teachers who make a point to give children recess, especially in the winter, may place a higher value on physical activity and thus promote and facilitate it in their classrooms. On the other hand, teachers may more keenly observe externalizing behavior and lack of self-control during periods of recess when the behavioral rules for the classroom may not be as stringently applied. Researchers have identified common reasons teachers and schools give for reducing or abandoning regular recess periods and one of the most frequently stated reasons is the idea that recess actually incites aggression (Jarrett et al., 1998). Finally, it is possible that in classrooms where children exhibit more externalizing behavior and lack self-control, teachers initiate more recess in order to either give children or themselves a break from the classroom setting.

As aforementioned, sleep and BMI are important covariates of physical activity. Although sleeping and napping behaviors did not seem to predict components of self-regulation, BMI was negatively related to both measures of children's self-control. Children with higher BMIs performed worse on their snack delay task and were rated as having lower self-control by their teachers. This finding can be interpreted in two ways. If higher BMI predicts lower self-control, then the current result would suggest that some characteristic shared by heavier children leads them to demonstrate less self-control than their healthier-weight peers. However, a more likely scenario is that having lower self-control leads to a higher BMI (Bruce, Black, Bruce, Daldalian, Martin, & Davis, 2011; Seeyave et al, 2009; Tan and Holub, 2010). Specifically, children who exhibit low levels of self-control may not be able to show restraint in their eating habits and therefore gain more weight than peers with more self-control. Seeyave and colleagues (2009) demonstrated that children who showed poor self-regulation in early childhood (age 4) were at a significantly higher risk of being overweight in early childhood and also much later in middle childhood (age 11). Another possible explanation is that preschool parents who have trouble setting limits promoting self-control likely also encounter difficulties regulating their children's eating behaviors. Furthermore, results from a recent study suggest that parents who believe their children show poor self-regulation in their eating habits often institute more restrictive feeding routines which actually exacerbate children's tendencies to overeat and make poor eating choices (Tan and Holub, 2010).

5.2.3 Physical activity and achievement

Results from analyses examining the relation between physical activity and achievement reveal that neither children's accelerometry measure of activity nor their teacher-reported activity were related to math or reading performance as was hypothesized. As with the self-regulation findings, these results may be attributable in part to the quality of the physical activity measures. However, there is a possibility that there is simply not a direct relation between physical activity and achievement in preschool.

Regarding opportunities for physical activity, both recess and weekly periods of physical education were significantly associated with achievement, but in different directions. Specifically, time engaged in recess predicted poorer math achievement. One possible explanation for this association is that classrooms that engage in more recess may do it at the sacrifice of math or reading instruction time. Although research generally shows that time spent in recess does not harm achievement (CDCP, 2010), there are still experts who express concern that recess uses time that might otherwise be used for valuable instruction (Pellegrini & Smith, 1993). Another possibility concerns the previous finding that the classrooms in which children had the most recess also encountered the poorest behavior. Thus, in future research it may be worthwhile to test the possible mediation of the association between recess and achievement by behavior.

In contrast, daily physical education positively predicted math and reading achievement. This is an interesting finding in that physical education did not significantly predict physical activity or any of the factors of self-regulation. Nader (2003) examined physical education classes for 814 children and found that, on average, students only spent about a third of their time in physical education engaged in moderate to vigorous physical activity. However, findings also revealed that over a third of the time children spent in physical education was dedicated to management and instruction. Thus, one possibility for the relation between physical education and math achievement in the current sample is that children who received daily instruction in skills other than math or reading (i.e., playing a game, being on a team) simply had more practice receiving instruction. Therefore, math and reading instruction were potentially more effective. Another possibility is that physical education is related to achievement as a result of systematic differences between teachers who choose to have daily physical education and those who do not. Preschool is a school setting that is largely unstandardized in instructional practices (Copeland, Kendeigh, Saelens, Kalkwarf, & Sherman, 2011). Although some public, school-based centers and pre-kindergartens follow specific curricula, much of what happens in private, community-based classrooms, even across classrooms in a single center, is at the discretion teachers. Future research should examine whether preschool teachers who make time for daily physical education have more structured daily schedules with specific instructional time also set aside for math and reading.

6.0 STUDY 2: ELEMENTARY SCHOOL FINDINGS

6.1 STUDY 2 RESULTS

6.1.1 Study 2: Full sample results

Descriptive statistics for the full elementary school (N = 993) sample are listed in Table 8. The average child in the sample was 10 years-old. Exactly half of the participants were male, 77% were Caucasian, and 76% had married mothers who had completed 14.39 years of education. On average, families in the sample reported an income-to-needs ratio of 4.39, or roughly four times the poverty line. Children in the sample received an average of 9.55 hours of nightly sleep, making the sample average slightly lower than the recommended 10 to 11 hours for elementary school children. The average male BMI was 19.51, which is considered at risk for being overweight. The average female BMI was 19.03, which is in the healthy weight range for girls. Children in the full elementary school sample spent over 18% of their waking hours engaged in moderate to physical activity on average across weekdays. Children in the sample engaged in an average of two periods of physical education per week (*SD*= 1.15) and an average of about seven periods of recess per week (*SD*= 3.76). In addition, children spent 16% of their extracurricular waking hours engaged in physical activity.

Correlations among the outcomes, physical activity and the important covariates were calculated in order to examine general patterns. These correlations are presented in Table 9. Higher BMI scores were related to higher achievement, but also to less self-control, more externalizing behaviors and higher levels of inattention. More time spent being physically active in the moderate to vigorous range was related to worse achievement and self-control as well as more hyperactivity and inattention. More periods of physical education and recess were related to better self-control and less hyperactivity, externalizing and inattention. However, recess also showed negative associations with both reading and math. Finally, more extracurricular physical activity was related to lower reading achievement and more hyperactivity but also to more overall moderate to vigorous activity and lower BMI.

Random effects regression analyses were conducted to address the first hypothesis and examine the predictors of time spent engaged in moderate to vigorous activity. Results of these analyses are displayed in Table 11. Across the full sample of children, results suggest that more periods of recess and more time in extracurricular activities were related to more time spent in moderate to vigorous physical activity. Specifically, one standard deviation increases in recess and extracurricular activity were equivalent to 5% and 9% standard deviation increases in moderate to vigorous physical activity, respectively. Additionally, children with higher BMIs spent less time in moderate to vigorous activity on average. Hispanic children had lower physical activity than their White peers. Furthermore, children who were younger with older mothers also displayed lower levels of physical activity. On the other hand, higher physical activity was evident for boys than for girls and African American children compared to their White peers as well as for children with more children in the home.

The next analytic step involved conducting random effects regression analyses to address whether physical activity and teachers' reports of opportunities for physical activity predicted assessments of self-regulation and achievement. Results for regressions predicting self-regulation are presented side-by-side in Table 12. For the full sample, moderate to vigorous physical activity predicted more hyperactivity and externalizing behavior. More periods of weekly physical education predicted better self-control. Unlike the full sample results, weekly periods of recess and time in extracurricular physical activity were not associated with self-regulation outcomes.

Results for regressions predicting reading and math achievement by physical activity and opportunities for physical activity are presented in Tables 13 and 14. Regression results for the full analytic sample suggest that accelerometry-measured physical activity, teachers' reports of physical education and extracurricular physical activity are not direct predictors of either reading or math achievement in third and fifth grade. Although recess was not a predictor of reading performance, more periods of recess were related to worse math achievement in the full sample.

Results from these regressions were also intended to address whether the relations of physical activity with reading or math achievement in elementary school were mediated by externalizing behavior, hyperactivity, inattention and/or self-control. Hyperactivity, self-control and externalizing behavior were added to the achievement models because earlier regression analyses (see Table 12) showed that these self-regulation skills were predicted by moderate to vigorous activity or opportunity for physical activity. The variables were added to the achievement models independent of each other (Models 2 through 4 for the full sample) and coefficients for these covariates are presented at the bottom of Tables 13 and 14.

As aforementioned, the only direct association between physical activity and achievement was a negative association between recess and math achievement. However, the significance of a possible mediated association between recess and math through self-regulation was not tested as recess did not significantly predict any of the factors of self-regulation (see Table 12). Estimating other partially mediated pathways was ruled out due to the lack of any other significant, direct associations between physical activity and achievement. However, factors of self-regulation were examined as possible agents of completely indirect relations between physical activity and reading or math achievement. The significance of these pathways was assessed using Sobel (1982) tests of mediation through an online calculator (Soper, 2009). Some researchers suggest that indirect pathways only be probed in cases where significant direct associations are evident. However, other researchers argue that examining the significance of indirect associations in the absence of significant direct associations is valid (Kenny, 2011). These researchers contend that it is reasonable to believe that two pathways composing an indirect effect can be significant even if a direct effect is non-significant. Accordingly, it is appropriate to use Sobel tests to examine the significance of such indirect associations. Indeed, several indirect paths in the current study were revealed to be statistically significant or significant at the trend level using Sobel tests. Specifically, results regarding completely indirect associations suggested that moderate to vigorous activity throughout the course of the school day predicted more externalizing behavior and hyperactivity and, in turn, both externalizing behavior and hyperactivity predicted worse performance in reading (respectively, Sobel statistic = 2.28, $p < 0.01$; Sobel statistic = -1.32, $p < 0.09$). Additionally, more periods of physical education predicted better self-control and, in turn, better reading achievement (Sobel statistic = 1.41, $p < 0.07$). Similar patterns were revealed for math achievement. More moderate to vigorous activity throughout the course of the day predicted more externalizing behavior. In turn, externalizing behavior predicted worse performance in math (Sobel statistic = -1.51, $p < 0.07$). Furthermore, as with reading more periods of physical education predicted better self-control and, in turn, better math (Sobel statistic = 1.63, $p < 0.05$).

6.1.2 Study 2: Low-income sample results

Identical analyses as those conducted on the full sample (N = 993) were conducted on a subsample of children in the SECCYD who were every below 200% of the poverty line in third or fifth grade (n = 297). Descriptive statistics for the low-income elementary school sample are listed in Table 8. The sample, with an average age of 10 years-old, was 48% male, 66% Caucasian, and 69% had married mothers who, on average, completed 12.75 years of education. On average, families in the sample reported an income-to-needs ratio of 1.59, or roughly one and a half times the poverty line. Children in the sample received an average of 9.36 hours of nightly sleep, making the low-income subsample average also slightly lower than the recommended 10 to 11 hours for elementary school children. The average male BMI was 20.46 and the average female BMI was 19.96, which puts boys at risk for overweight and girls on the borderline between healthy weight and at risk for overweight. In terms of physical activity, the children in the elementary school low-income subsample were very similar to the full sample. Children in the subsample spent about 19% of their waking hours on average across weekdays engaged in moderate to physical activity. On average, children in the subsample engaged in physical education about twice per week (SD= 1.21) and had approximately six periods of recess per week (SD= 3.74). In addition, they spent 17% of their extracurricular waking hours engaged in physical activity.

Independent sample t-tests were conducted to examine possible sample differences on outcome, key predictor and key covariates between those children who were in the low-income (n = 297) sample and those who were not (n= 696). Significant differences were consistently found across all of the outcomes and BMI, with low-income children faring worse across these variables. In terms of physical activity, opportunities for physical activity, and sleep, children across samples did not statistically differ.

Additionally, separate correlations among the outcomes, physical activity and the important covariates were also calculated for the low-income sample to illustrate interrelations in this smaller and more homogeneous sample. These correlations are presented in Table 10. More time spent being moderately to vigorously active was related to worse achievement and more externalizing and hyperactivity. More periods of physical education and recess were related to better self-control as well as less hyperactivity, externalizing and inattention. In addition, comparable to the total sample results, recess was negatively associated with both reading and math achievement.

As with the full sample, random effects regression analyses were conducted to examine associations among opportunities for physical activity, physical activity levels, self-regulation and achievement. Across the low-income sample of children, results suggest that more extracurricular physical activity was related to more moderate to vigorous activity. One standard deviation increase in extracurricular activity was associated with 10% of a standard deviation increase in moderate to vigorous physical activity. Children with higher BMIs spent less time spent in moderate to vigorous activity on average. Overall, younger children and Hispanic children, in comparison to their White peers, spent less time in moderate to vigorous activity. On the other hand, males and African American children, in comparison to their White peers, spent more time in moderate to vigorous activity.

Results for regressions predicting components of self-regulation by physical activity and opportunities for physical activity across the low-income samples are presented in Table 12. For the low-income sample, moderate to vigorous physical activity predicted less inattention and, as in the full sample, more periods of weekly physical education predicted better self-control. Specifically, one standard deviation increase in moderate to vigorous physical activity was related to 10% of a standard deviation decrease in attention and one standard deviation increase in physical education was related to 10% of a standard deviation increase in self-control. However, number of weekly recess periods and extracurricular physical activity were not related to any of the self-regulation outcomes in the low-income sample.

Results for regressions predicting reading and math achievement by physical activity and opportunities for physical activity across the low-income samples are presented in Tables 13 and 14. Regression results across the physical activity predictors revealed no direct prediction of reading or math achievement. However, results from these regressions also provide data regarding possible indirect associations between physical activity and achievement. Among the low-income sample, the only significant predictor for reading achievement among the factors of self-regulation was inattention. As aforementioned, higher levels of moderate to vigorous physical activity significantly predicted more inattention (see Table 12) in third and fifth grade. Sobel tests confirmed the significance of an indirect association between moderate to physical activity and reading such that moderate to vigorous physical activity was related to less inattention for low-income children and, in turn, better performance in reading (Sobel statistic = 1.65, $p < 0.05$). The only significant self-regulation predictor for math achievement was self-control. More physical education was related to better self-control (see Table 12). Accordingly, as in the full sample, Sobel tests confirmed an indirect association in which physical education was related to more self-control for low-income children and, in turn, better performance math (Sobel statistic = 1.63, $p < 0.05$).

6.2 STUDY 2 DISCUSSION

The aims for Study 2 included describing what physical activity and opportunities for physical activity look like in elementary school, examining the relations of physical activity with self-regulation and achievement, and investigating whether factors of self-regulation mediate relations between physical activity and achievement. The following discussion will detail how the results address the aims and hypotheses proposed by Study 2.

6.2.1 Physical activity, BMI and sleep in elementary school

Results from Study 2 across the full sample of elementary school students illustrate that participants spent nearly a fifth of their days engaged in moderate to vigorous activity. This activity was correlationally related to more hyperactivity and externalizing behavior. Averages for recess and physical education periods varied widely. Although some children were allowed three periods of recess daily, some children experienced no recess according to teacher reports. The average child engaged in two physical education classes per week with some children participating in none and some receiving daily physical education. These results illustrate substantial variation in teacher and school practices regarding recess and physical education routines. Although there are recommendations for both recess and physical education time in elementary school, neither of these is nationally regulated (NASPE, 2006; NASPE and AHA, 2010).

The first hypothesis for Study 2 proposed that greater opportunities for physical activity would result in more moderate to vigorous physical activity for elementary school children, which was generally supported in the present study. More recess and extracurricular activity were related to more physical activity. However, periods of physical education were not related to more physical activity. One potential reason for this result is that the majority of time spent in physical education in elementary school is not necessarily dedicated to being physically active (Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Nader, 2003). In fact, Coe and colleagues (2006) examined physical education in a sample of sixth graders and found that participants spent on average only 19 of 55 class minutes engaged in moderate to vigorous activity. Physical education instructors may spend a great deal of class time teaching students how to play certain games and setting up. In addition, children may have to wait their turn to participate in a certain activities, leading them to remain largely sedentary for the majority of the class period. As aforementioned, Nader (2003) discovered similar trends in a sample of elementary school children, finding that they spent only a third of their physical education class time engaged in moderate to vigorous physical activity. Finally, it is also probable that the activities that are organized for children during physical education are not collectively inclusive (Stevens, To, Stevenson, & Lochbaum, 2008). For example, games like tag or dodge ball may attract more aggressive children and activities that include rhythm, like aerobics or dance, may attract more girls. Furthermore, sports or games that involve vigorous kids may lose the participation of heavier children who may physically struggle.

As mentioned earlier, sleep and BMI are important variables to consider when examining children's physical activity. The average child across the full sample slept for slightly less time than the minimum recommended by the National Sleep Foundation (2011). However, some children averaged as little as 6.5 hours of sleep per night. This amount of sleep is significantly less than the 10 to 11 hours recommended as optimal for children of this age. It has been repeatedly demonstrated that children who are sleep deprived can experience lower grades, lower scores on tests of achievement, and poorer performance on cognitive assessments than children who regularly receive adequate sleep (Buckhalt, 2011; Sadeh, 2007). However, nightly sleep was not related to physical activity levels in the current sample and omitting nightly sleep from the models did not change the associations between opportunities for physical activity and physical activity levels.

The average child in the current sample was categorized as at risk for being overweight according to BMI (National Center for Health Statistics, 2000). Furthermore, BMI was significantly related to moderate to vigorous activity such that higher BMIs were related to less activity. This association was expected and is well documented in the literature (Sallis, Prochanska, & Taylor, 2000). The finding suggests that heavier children are less inclined to be active, because of exhaustion or force of habit. This association is also likely reciprocal in that children who participate in less activity are more likely to gain or retain weight and have higher BMIs. Finally, omitting BMI from the models did not change the associations of physical activity opportunities with physical activity levels.

6.2.2 Physical activity and self-regulation in elementary school

The second and third hypotheses for Study 2 proposed that physical activity and opportunities for physical activity would predict better self-regulation skills. Results from regression analyses examining these relations illustrate that moderate to vigorous activity predicted more hyperactivity and externalizing behavior in the full sample, both non-desirable outcomes. The relation between moderate to vigorous activity and worse self-regulation likely reflects a reciprocal relationship in which children who are rated more highly on scales of hyperactivity and externalizing behavior are generally more active. Inversely, children who are more active on average in school may be more likely to be rated as hyperactive or as having high levels of externalizing.

In the current sample of third and fifth graders, physical activity predicted better self-control. Physical education is most simply characterized as a period of the school day during which children have the opportunity to be physically active. However, children may also learn important skills like how to follow rules, take turns and cooperate during gym time (NASPE & AHA, 2010; Trudeau & Shepherd, 2008). Since results across these samples showed that physical education was not predictive of more moderate to vigorous activity, it is possible that children may have been applying self-regulatory skills acquired in their physical education classes to the benefit of their classroom self-control.

Contrary to the physical education results, neither periods of recess nor extracurricular activity predicted self-regulation in the regression models. Past literature has shown that periods of recess can be beneficial to children's ability to pay attention and that children who are allowed time for recess fidget less in the classroom (Jarrett et al., 1998; Pellegrini, Huberty, & Jones, 1995). Indeed, correlations for the present research suggest that recess is positively related to all of the components of self-regulation. It is possible that these relations existed but were overwhelmed by stronger associations of other covariates with self-regulation. In addition, much of the research on recess reveals benefits immediately subsequent to the period of recess. However, the outcomes in the current study were not consistently obtained immediately after recess.

Extracurricular physical activity is commonly viewed as both a means through which children can meet their daily recommended amount of physical activity as well as a time to learn character-building social skills. However, in the case of the current sample, extracurricular activity was not related to the components of self-regulation. Mahoney, Cairns and Farmer (2003) suggest that participation in extracurricular activities (on whole and not limited to physical activity) can be associated with taking initiative, goal setting behavior, responsibility, and school engagement. It is possible that extracurricular activity that specifically targets physical activity like sports or dance are not as related to children's self-regulation skills as playing a musical instrument, being in a scout troop or volunteering. It is also possible that being involved in extracurricular physical activity is equally beneficial across children from with varying baseline degrees of self-regulation.

6.2.3 Physical activity and achievement in elementary school

The second and third hypotheses for Study 2 assert that physical activity and opportunities for physical activity are related to better achievement. Neither was directly predictive of reading achievement in the elementary sample, and only more recess directly predicted math with more periods of recess predicting worse math performance. To interpret this finding, it is important to consider research that examines the associations of recess with children's outcomes. In a review of literature, the Center for Disease Control and Prevention (CDCP, 2010) concluded that the time children spend in recess, although not always beneficial for achievement, is typically not detrimental to achievement. Indeed this finding is corroborated by the reading results. Thus, one possibility is that this single finding for math may be spurious. However, another explanation considers the nature of math versus reading instruction in elementary school. By the time children are in the third grade, most have probably mastered the skill of reading (Wagner et al., 1997) and are focusing on gaining more vocabulary, spelling and comprehension. Thus, in third and fifth grades, math likely becomes a more challenging endeavor for children than reading.

Furthermore, math instruction involves the regular presentation of completely novel concepts which may require more time for instruction and practice than reading. Thus, although reading may not be affected by time spent in recess, math achievement may suffer when time that may have been spent in math instruction and practice is allocated to recess.

The results for analyses examining direct associations of physical activity with achievement did not support the second and third hypotheses for Study 2. Specifically, results revealed no positive associations between levels of or opportunities for physical activity with reading or math. Past research on physical activity and achievement has been mixed and results range from no associations to moderate positive associations (Efrat, 2011; Stevens, To, Stevenson, & Lochbaum, 2008; Tomporowski et al., 2008). Hence, the results from the current study do not dispute the extant research regarding physical activity and achievement. One possible explanation for why positive associations were not revealed in the current study is that associations between physical activity and achievement are likely influenced by time-related variables. For example, when physical activity is performed immediately before the completion of cognitive tasks, it has been demonstrated that children perform better on the tasks (Hillman, Buck, Themanson, Pontifex, & Castelli, 2009; Hillman et al., 2009). In addition, regular structured and planned exercise over time has been shown to benefit both cognitive functioning and achievement in children (Davis, et al, 2011; Coe, Pivarnik, Womack, Reeves, & Malina, 2006). In the current study, the physical activity measured was neither performed immediately before achievement assessments were administered nor was it structured and repeated. Although the physical activity data obtained in the current study may have included activity that meets those descriptions, it also included physical activity obtained in various other situations and contexts. Accordingly, positive associations of physical activity occurring directly prior to assessment or structured physical activity over time with achievement may have been obscured by the inclusion of other instances of activity in children's moderate to vigorous activity totals.

Results from the current study largely did not support direct or partially mediated associations between physical activity and achievement. However, post-hoc examinations (Sobel, 1982) of the various significant pathways between physical activity and self-regulation and between self-regulation and achievement illuminated potential indirect pathways. The first points of interpretation for these possible indirect associations were the relations between physical activity and self-regulation. Since externalizing behavior, hyperactivity, and self-control were all significantly predicted by physical activity or opportunities for activity, they were tested for their associations with achievement and possible roles in indirect associations between physical activity and achievement. Results for examinations of possible completely indirect associations did show promise for links between physical activity and performance in math and reading. For the full sample, patterns in the results suggest that indirect pathways from moderate to vigorous activity to externalizing behaviors to achievement were significant or very near significant for both reading and math. For math and reading, more moderate to vigorous activity during the school day was related to more externalizing behaviors which in turn predicted lower achievement. This pattern also held true for the indirect association between moderate to vigorous activity and reading by hyperactivity. These findings are practically significant in that they suggest that when children are active in the school setting it can be detrimental to their behavior and ultimately detrimental to their achievement. However, for the full sample, patterns in the results also revealed that the association between physical education and self-control provides an indirect pathway for the associations between physical education and both achievement outcomes. For both math and reading, more physical education was related to more self-control which in turn predicted higher math and reading achievement. These findings taken together are useful and policy relevant since they illustrate that high general activity levels within the school setting may not be beneficial to children's development. However, physical activity that is planned or focused (i.e., physical education) can be beneficial for self-regulation and achievement. Future research should examine the differences in children's general activity across the school day and the type of activity that occurs in physical education. If general activity can be channeled to resemble physical activity that occurs in physical education periods, teachers may be able to use physical activity as a tool to enhance behavior and achievement.

Finally, since BMI and nightly sleep are important covariates of physical activity, they were included in the models predicting achievement by physical activity. However, neither was predictive for either achievement outcome in the full sample. On average, children were getting close to the recommended amount of sleep for middle childhood. However, since there was ample variability in children's sleep routines across the sample, it is surprising that a positive association between sleep and achievement did not emerge as this association is frequently demonstrated in research (Snell, Adam, & Duncan, 2007). Similarly, the finding that BMI was not associated with math or reading was unexpected in that a negative association is commonly the result of examinations of the association between BMI and achievement (Castelli, Hillman, Buck, & Erwin, 2007; Snell, Adam, & Duncan, 2007). A possible suppression of these associations may have been the result of their covariance with each other and with physical activity. BMI and sleep were included in analyses in order to control for factors that are likely to influence physical activity and therefore allow for the examination of the net influence of physical activity. However, since these variables are related to each other (Liu, et al., 2008) and to other important covariates in the analyses including income (Buckhalt, 2011), it is possible that their associations with children's achievement outcomes were fully mediated in the models in which they were presented. Finally, the omission of these covariates did not change the associations of opportunities for physical activity or physical activity levels with achievement.

6.2.4 Physical activity across developmental periods

An overarching goal of the current studies was to compare physical activity across preschool and elementary school. Findings revealed inconsistent patterns across the PSRS preschool sample and the SECCYD elementary school full sample. For instance, overall, moderate to vigorous physical activity as measured through accelerometry was not predictive of self-regulation or achievement in preschool. However, it was predictive of more hyperactivity and externalizing in elementary school. This discrepancy of associations may reflect a genuine change in the influence of physical activity as children grow. It seems more likely, however, that the difference across developmental periods was a result of differences in the quantity of accelerometry obtained in preschool and elementary school. In the SECCYD, children wore accelerometers during waking hours every day for a week, which meets recommendations for the adequate amount of measurement required for stable measures of physical activity (Penpraze, Reilly, MacLean, Montgomery, & Kelly, 2006). Due to time and resource limitations, the accelerometry data collected in preschool may not have been detailed enough to represent a child's average activity across an entire school day. Not capturing enough of a child's day threatens to cut out even brief instances of physical activity, especially if these instances are linked to hyperactive or externalizing behavior. Furthermore, findings from the preschool sample may have demonstrated very small effects due to sample size. It is possible that the same significant associations that emerged in the SECCYD full sample (*N*=1986) may have been evident in the preschool sample (*N*=104) if it were larger.

Recess was a consistent predictor of more physical activity and worse math achievement across the preschool and full elementary school samples. Recess is often characterized as a break period for children and a time for gross motor play and these characteristics support the association between recess and moderate to vigorous activity (Pellegrini & Smith, 1993). However, as suggested in the Study 2 discussion, recess may also potentially be detracting from time when teachers could be instructing students in math. In preschool, maybe that teachers who initiate more recess periods are not as well organized in regards to their classroom routines and curricula. These teachers may use recess as a time to plan instruction or prepare activities and may have less effective math lessons. In third and fifth grade, children may require more intense instruction in math as concepts may be more foreign and novel than concepts introduced in language arts or social studies. As aforementioned, for this reason children who encounter more recess periods in third and fifth grade may also experience lower math achievement as a result of less daily time available for math instruction. Furthermore, preschool teachers may use recess as a break when children are misbehaving or becoming too active in the classroom setting, thus making recess the result and not the cause of more externalizing and less self-control. This specific explanation may not be applicable in elementary school where teachers perhaps have less flexibility within their lesson plans to break for recess as a behavior management technique.

Another consistent result across preschool and elementary school was the positive associations of physical education with children’s development. In the preschool sample, physical education was positively related to both math and reading achievement. In the elementary school sample, physical education was positively related to self-control. However, physical education was not related to more moderate to vigorous physical activity in either sample. Thus, the associations of physical education with outcomes involved benefits of physical education unrelated to the benefits of physical activity. In the preschool sample, the value of daily physical education for achievement may have been more related to routine than to the actual activities that occur during physical education. Specifically, those teachers who have a daily time set aside for physical education may have more consistent routines also involving regular instruction in reading and math. In elementary school, the relation of self-control to physical education may be a reflection of the self-regulatory lessons learned through physical education including cooperation and waiting turns (NASPE & AHA, 2010; Trudeau & Shepherd, 2008). Since the content of preschool physical education is not clear, it is possible that if preschool physical education was modeled in the image of elementary school physical education, children in childcare participating in physical education would also experience enhanced self-control.

6.2.5 Physical activity across low-income children

A secondary aim of the current dissertation was to examine physical activity in low-income samples across the two studies. As mentioned earlier, self-regulation and achievement disparities exist among children as a result of poverty and ethnic minority status (Raver, 2002, 2004; Wanless, McClelland, Tominey, & Acock, 2011). In addition, these disparities persist well into elementary school (Burchinal, et al., 2011; Duncan, Brooks-Gunn, & Klebanov, 1994; Morrison, Bachman, & Connor, 2005). Moreover, socioeconomic and ethnic disparities are not limited to achievement as low-income and minority children are also more likely experience obesity than their more affluent peers (Story, Kaphingst, & French, 2006a, 2006b). The PSRS is a study of primarily low-income minority children (N = 104). The SECCYD low-income subsample (n = 297) was created as a comparison group of elementary school students and was comprised of children who ever fell below 200% of the poverty line in third or fifth grade. Although these samples seemed more comparable than the preschool and full elementary school sample from a demographic perspective, results across the low-income groups were not consistent.

Descriptive differences in each sample's opportunities for physical activity are presumably due to contextual differences across developmental periods. More than three-quarters of preschoolers were reported to engage in daily physical education. On the other hand, low-income elementary school students averaged two periods of physical education per week. Additionally, preschoolers averaged less than seven daily minutes of recess in comparison to elementary school students who averaged nearly seven weekly recess periods. These differences seem to reflect differences in the scheduling of preschool and elementary school days. Although preschools schedules may have regular daily time available for physical education, in elementary school physical education may rotate on a schedule with other special classes like art or music (Roth, Brooks-Gunn, Linver, & Hofferth, 2003).

More recess was predictive of more externalizing behavior and less self-control in the preschool sample but was not predictive of any outcomes in the elementary school subsample. One possible explanation for this discrepancy is that preschool teachers rated children's externalizing behaviors and self-control based on behavior they observed during recess. Some researchers suggest that recess itself stimulates aggression (Jarrett et al., 1998). In preschool, teachers are likely the ones monitoring recess, and are thus likely to observe aggressive behaviors that occur during recess. In contrast, paraprofessionals, school aids, or parents often monitor recess periods in elementary school (Pellegrini & Smith, 1993). Thus, elementary school teachers may not witness recess aggression and therefore may not be able to accurately rate children on these behaviors.

Accelerometry results revealed that the elementary school sample averaged more than twice as much moderate to vigorous physical activity as the preschoolers. However, as aforementioned, this finding may be highly related to the fact that children in the elementary school sample had accelerometry data that spanned the entire day, including their afterschool physical activity participation. Thus, it is possible that children in the preschool sample would have demonstrated comparable proportions of physical activity across the entire day.

Overall, significant associations between physical activity levels and opportunities for physical activity with achievement and self-regulation were not as prevalent in either of the low-income samples as in the full elementary school sample. One potential reason for this is that low-income children may encounter a greater number of risk factors (e.g., health problems, exposure to family violence, lack of neighborhood safety and residential mobility) than their more affluent peers (Shonkoff & Phillips, 2000). The accumulation of these more urgent risk factors may suppress the effects of potential risk factors related to a lack of physical activity. However, a lack of physical activity can pose risks for children across the socioeconomic spectrum (Story, Kaphingst, K. M., & French, S., 2006a, 2006b) and can itself become a source of risk as children grow older (Story, M, Kaphingst, K. M., & French, S., 2006a). Research on physical activity in such samples should be pursued as lack of physical activity is an alterable risk factor that, if changed may have the potential to alleviate other potential risk factors encountered by low-income children (Efrat, 2011).

7.0 CONCLUSIONS

The research presented in the current dissertation was conducted with several key research goals in mind. The first goal of the research was to provide a description of opportunities for and levels of physical activity in preschool and elementary school classrooms. Secondly, the investigation aimed to examine the association of children's physical activity opportunities and physical activity levels with self-regulation and achievement. The final aim was to explore the mediating role of self-regulation for the relation between physical activity and achievement for elementary school children. Embedded in each of these goals was the aim of observing differences across developmental stages.

Overall, it seems that children's average daily levels of moderate to vigorous activity in both the preschool and elementary school samples were not related to self-regulation and achievement as was hypothesized. The theory guiding this investigation was that moderate to vigorous activity, the type of activity promoted in recommendations of physical activity, would be as beneficial for the development of self-regulation and achievement as it is documented to be for physical well-being. Although this theory was not fully supported by the results of the current research studies, several key findings from the preschool and elementary school open windows into understanding the role of physical activity in the socioemotional and academic development of children. Furthermore, these findings pave the way for future research that will further elucidate the nature of physical activity in childhood, its role in promoting development and how researchers, educators and interventionists can employ physical activity as a tool for enhancing development.

The first key finding is that structured physical activity in the school setting seems to hold positive predictive value for children's self-regulatory skills and achievement. Structured physical activity can be conceptualized as physical activity involving the guidance of adults for preschoolers and as physical education periods for elementary school children. Simply put, this is physical activity with an end goal, whether that goal is to win a game, finish a walk, climb to the highest point, or cooperate with teammates (NASPE, 2010). Along the same lines, whereas this structured activity may actually enhance self-regulation and academic achievement, unstructured activity can be detrimental to children's development (CDCP, 2010). There is a body of research that suggests that children learn well through movement (Block, 2001; Minton, 2008). However, this research is nuanced in that it advocates interweaving academic lessons into physical activity and using physical activity to literally or interpretively reinforce concepts (Minton, 2008). It does not suggest that general, unguided physical activity enhances learning. In fact, the results from the current research show that generally high levels of physical activity and more periods of recess are actually more related to hyperactivity and externalizing behavior, which in turn predicted lower achievement. Thus, it is important that educators recognize that not all physical activity enhances learning. In contrast, the research at hand specifically suggests that more periods of physical education may enhance self-control and achievement. This finding supports research proposing that guided physical activity can be used as a conduit for lessons on self-regulation and possibly even to reinforce literacy or math instruction (Block, 2001; Minton, 2008).

Finally, the results of the current research support the promotion of physical activity at an early age to help develop positive habits simultaneously with the development of self-regulation and the first acquisition of reading and math skills (Story, Kaphignst, & French, 2006b). It seems that with the waning of physical education and recess periods (Barros, Silver & Stein, 2009; Jarrett et al., 1998) children may not be learning to enjoy physical activity. Nevertheless, in the face of these declines, parents, educators, healthcare providers and policy makers still want to see the obesity epidemic diminished and fitness improved. It seems reasonable to expect children to be able to accumulate a large proportion of their total daily physical activity at school since they spent a significant amount of their time in the school setting. Moreover, sociocultural learning theories (Galloway, 2001) regarding guided participation would suggest that having the opportunity for physical activity in a setting where adults are present to provide guidance may reinforce the importance of physical activity in the eyes of children and provide them with lessons that they may apply to their home lives.

7.1 LIMITATIONS AND RESEARCH RECOMMENDATIONS

Although both the PSRS and the NICHD SECCYD involved a breadth of rigorously collected data on children's development, several limitations for both studies should be noted. Some of these limitations are exclusive to one study and some are shared by both. In the following discussion, these limitations are discussed with methodological recommendations for future studies of physical activity.

The primary aim of the Pitt School Readiness study was to assess preschoolers' academic and social skill development in the year prior to school entry. Accordingly, the measures used to assess these skills were numerous and varied. The resources present to obtain data on physical activity were more limited as they were collected for the purposes of the current dissertation. The accelerometry that was completed can be considered a precise snapshot of children's physical activity during a brief measurement. However, it is difficult to know whether the measurement is an accurate representation of children's average levels of activity across the school day. Furthermore, children were only measured on a single occasion. In subsequent studies of preschoolers' physical activity, repeated measures of accelerometry across the school day would be a more accurate and representative measure of average physical activity in childcare centers (Penpraze et al, 2006).

On the other hand, the NICHD SECCYD included accelerometry measurement across each child's waking hours for the span of an entire week. However, a drawback in the way the data as it was publicly released is that it is impossible to differentiate the physical activity that occurred during the school day and the activity which occurred before or after school. For the purposes of the current study, a variable denoting extracurricular physical activity was used to provide some control for children's tendency to be active outside of school. Of course, a more accurate representation of children's physical activity in the school setting would include a breakdown of physical activity counts throughout the day so that different periods of the day could be examined independently. Such a breakdown would also facilitate an examination of the amount of physical activity children actually engage in during physical education classes and recess and how much they engage in during regular class time.

Also in regards to accelerometry, there is some disagreement about the use of accelerometry in children, especially children as young as four or five years-old. Some researchers have concerns that the algorithms created to define and delineate different activity cut points and ranges (i.e., moderate, vigorous, very vigorous) are not appropriate for children (Sirard, Trost, Pfeiffer, Dowda, and Pate, 2005). There are not currently accelerometers that are calibrated specifically to capture children's physical activity nor are there specific algorithms that are standardly used to examine physical activity in children. In contrast, some researchers maintain that the current algorithms are appropriate across various age groups (Reilly, Penpraze, Hislop, Davies, Grant, & Paton, 2008). With the looming obesity epidemic, growing research on physical activity in children needs to inform the development of accelerometers specifically for children. In addition, accelerometers should be designed to be more easily and unobtrusively fastened to children. One of the limitations to the use of accelerometers in very young children is that the accelerometer itself can be distracting and can evoke anxiety in participants when other children become aware if the device. Designing an accelerometer that is minimally intrusive for young children is critical in collecting data over a long time span.

One benefit of the PSRS study is that teachers reported on a variety of instructional, childcare and child characteristics. For the purposes of the current study, teachers also reported on children's physical activity, which provided another source of physical activity data aside from accelerometry. However, as with all participant reports there was room for bias in these reports. When teachers report on physical activity at school, it is difficult to assess the accuracy of these reports because teachers most likely vary in their tendencies to observe children's activity during periods of recess or physical education versus during in-class or group activities. Furthermore, teachers who perceive a child as being more aggressive than other students may have rated that child as being more physically active since the exhibition of externalizing behavior can entail movement. Similarly, teachers may rate children who are quieter or less visible in class as being less physically active because the child does not elicit their attention.

In addition to possible reporter bias in the PSRS teacher reports, the teacher report measure itself, although validated in other work, is lacking in detail. Some information regarding children's physical activity that would have been difficult to ascertain through accelerometry could have been obtained through teacher report. Items regarding participation during physical education and recess as well as children's tendencies to be active during activities which require them to pay attention or sit still could have provided a more valid assessment of physical activity which occurs when there are opportunities for it and when there are not.

Finally, both studies encompass limitations in the generalizability of their findings. In regards to the PSRS, the homogeneous nature of the sample in regards to ethnic and socioeconomic factors limit the generalizability of findings from the study to low-income, minority children attending urban preschools. In addition, the sample size itself was small (N= 104), making the detection of small associations among physical activity characteristics with child outcomes more difficult to detect. Findings from the NICHD study are also limited in their generalizability as the sample is largely Caucasian and not low-income. Nonetheless, in a paper with the NICHD Early Childcare Research Network and Duncan (2003) asserted that, although sample characteristics, attrition and non-random selection in the NICHD SECCYD sample inhibit the application of findings to broader populations, the sample also embodies unique strengths. Such strengths, according to Duncan, include the fact that the sample encompasses economic, ethnic, and geographic diversity.

7.2 FUTURE RESEARCH DIRECTIONS

The current examination of physical activity in children provides several suitable starting points for future research. First, findings from the preschool sample illustrate that children are quite sedentary in childcare centers (Brown, Pfeiffer, McIver, Dowda, Addy, & Pate, 2009; Cardon, & De Bourdeaudhuij, 2008). In addition, the preschool sample findings suggest that being more active is not directly related to being more self-regulated or performing better on tests of achievement. These findings are contrary to the proposed hypotheses as well as the positive associations among physical activity, self-regulation and achievement suggested by past literature. However, the reason for these results may simply be that associations supported by past research largely describe relations of fitness with children's outcomes. The physical activity captured by the preschool study may not have translated well to children's fitness levels. Future research on preschoolers needs to delineate between what children are doing during accelerometry and to specifically note times when children are involved in structured physical activity. Detailed coding would allow for the comparison of instances when children are being active with the purpose of enhancing fitness (i.e., playing a sport or game, taking a walk), instances when children are being physically active for free play or recess, and instances when children are being active when their attention should be on classroom activities. In summary, future research on preschoolers should include accelerometry which spans the entirety of the school day in conjunction with observation during the time the accelerometer is worn.

Findings from the elementary school sample are also largely unsupportive of the hypotheses set forth for Study 2. Accelerometry and teacher reports of physical activity were not overwhelmingly predictive of self-regulation or achievement. In fact, more moderate to vigorous activity actually predicted more hyperactivity and externalizing in the full sample and was only positively related to better attention in the low-income sample. Again, more detailed coding of what children are doing during accelerometry would be useful in discriminating between structured and purposeful activity and activity that may be the result of hyperactivity or externalizing behavior. Additionally, future studies employing accelerometry on elementary school students should be more careful to distinguish between activity achieved during school hours and activity that takes place outside of school.

As is evidenced by the current studies, the activity threshold of moderate to vigorous may be a difficult one for young children to attain. This may be especially true for children who reside in urban areas which may lack indoor space and safe, suitable outdoor space for gross motor activity (Cardon, Van Cauwenberghe, Labarque, & De Boudeaudhuij, 2008). This may also be true for children with lower overall fitness levels and for heavier children (Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005. It would be a worthwhile step to examine the effects of increased moderate activity in comparison to vigorous activity as a means of meeting physical activity recommendations for children.

Finally, more research on the content and purpose of recess and physical education for preschoolers and elementary school children would open many avenues for researchers and educators alike. In the current studies, associations between recess and physical education with children's activity levels, self-regulation, and development were difficult to interpret in light of the fact that the content of these activities was not clearly defined. Now that preliminary associations have been uncovered, more detailed investigations of what happens during recess and physical education would help researchers delineate the potential benefits and drawbacks of each. Furthermore, physical activity, especially since it is already expected to occur in the realm of recess and physical education classes, would be a cheap, easy, non-invasive, form of intervention with numerous potential benefits (Efrat, 2011). Research on recess and physical education could lead to constructive regulation of these school periods. Such regulation could help optimize the use of school time and the role of these periods in enhancing social and academic development in children of different ages from a variety of ethnic and socioeconomic backgrounds.

APPENDIX A

DATA TIME POINTS

	PSRS			NICHD SECCYD		
	Fall	**Winter**	**Spring**	**1st grade**	**3rd grade**	**5th grade**
Reading	WJ III Letter-Word		WJ III Letter-Word	WJR Letter-Word	WJR Broad Read	WJR Broad Read
Math	WJ III App. Problems		WJ III App. Problems	WJR App. Problems	WJR Broad Math	WJR Broad Math
Self-Regulation	Snack Delay and SSRS		Snack Delay and SSRS	SSRS	DBD and SSRS	DBD and SSRS
Attention	WJ III Pair Cancel		WJ III Pair Cancel	CBCL	DBD	DBD
Externalizing Behavior	SSRS		SSRS	CBCL	CBCL	CBCL
Accelerometry (Objective PA)		Accelerometry			Accelerometry	Accelerometry
Teacher Report PA	**X**		**X**		**X**	**X**
Classroom observation		**X**				
Sleep	Nightly Sleep/ Napping		Napping		Nightly Sleep	

Note : PA= Physical Activity, DBD= Disruptive Behavior Disorders Rating Scale, WJ III = Woodcock-Johnson Psycho-Educational Battery-III WJR= Woodcock-Johnson Revised, SSRS= Social Skills Rating System

APPENDIX B

PITT SCHOOL READINESS STUDY: PHYSICAL ACTIVITY/ WEIGHT AND HEIGHT RECORD

CHILD ID: ___________ Center: _____________ Team Member: ___________

Date: ____________________________ Day of the Week: _________________

Height: __________ Weight: __________ BMI calculation: ___________

ACTIVITY LOG: Record primary location, child position and nature of classroom activity for every 10 minute interval.

	LOCATION	Child Position	ACTIVITY
Interval 1 (min. 0-10):			
Interval 2 (min. 11-20):			
Interval 3 (min. 21-30):			
Interval 4 (min. 31-40):			
Interval 5 (min. 41-50):			
Interval 6 (min. 51-60):			

Location:	a) inside	Child Position:	a)seated	Activities:	a) academic g)snack
	b) outside		b)standing		b) free play h) transition
			c)moving around		c) manipulatives/ puzzles i)hygiene
					d)group/circle time
					e) reading
					f) nap

APPENDIX C

PHYSICAL ACTIVITY QUESTIONNAIRE *

*Modified Version of The Netherlands Physical Activity Questionnaire (Montoye, Kemper, Saris, & Washburn, 1996)

Instructions: Please circle the number that **best describes this child since the start of the school year**. For example, if since this child started school this year, this child preferred to play alone as often as he/she preferred to play with other children, circle the number three for the first question. On the other hand, if he or she almost always preferred playing with other children, rather than alone, circle the number five.

		Almost Always		Equal	Almost Always		
a.	Prefers to play alone	1	2	3	4	5	Prefers to play with other children
b.	Prefers vigorous games (e.g., tag, kickball)	1	2	3	4	5	Prefers quiet games (e.g., board games)
c.	Dislikes playing sports (e.g., soccer, basketball)	1	2	3	4	5	Likes playing sports
d.	Is more introverted (e.g.,quiet, reserved)	1	2	3	4	5	Is more extroverted (e.g., outgoing)
e.	Likes to read	1	2	3	4	5	Dislikes to read
f.	Likes to play outside	1	2	3	4	5	Likes to play inside (home/school)
g.	Less physically active compared to other children of same age	1	2	3	4	5	More physically active compared to other children of same age

h. On average, how many hours per day does this child sleep during naps?
_______hours per day

i. When in school, how often does this child participate in physical education (PE)?
1. Daily 4. Does not participate
2. 2-4 times/week 5. Don't know
3. Once/week

APPENDIX D

TIME-SAMPLING CLASSROOM CODING SCHEME (MINUTES 1-10 DISPLAYED)

1.<u>Management</u>												
T Managed	A	1	2	3	4	5	6	7	8	9	10	A
Child Managed	B	1	2	3	4	5	6	7	8	9	10	B
T & Child Managed	C	1	2	3	4	5	6	7	8	9	10	C
Unstructured Activity	D	1	2	3	4	5	6	7	8	9	10	D
2. <u>T Behavior</u>												
Interacts With Large Group	A	1	2	3	4	5	6	7	8	9	10	A
Interacts With Small Group	B	1	2	3	4	5	6	7	8	9	10	B
Interacts With A Child	C	1	2	3	4	5	6	7	8	9	10	C
Interacts With Others	D	1	2	3	4	5	6	7	8	9	10	D
Other (preparation/clean-up)	E	1	2	3	4	5	6	7	8	9	10	E
3. <u>Setting</u>												
Seated-Table	A	1	2	3	4	5	6	7	8	9	10	A
Seated-Floor	B	1	2	3	4	5	6	7	8	9	10	B
Upright (standing or moving)	C	1	2	3	4	5	6	7	8	9	10	C
4. <u>Content</u>												

Math												
Number Recognition	M	1	2	3	4	5	6	7	8	9	10	M
Counting	N	1	2	3	4	5	6	7	8	9	10	N
Comparisons	O	1	2	3	4	5	6	7	8	9	10	O
Writing Numbers	P	1	2	3	4	5	6	7	8	9	10	P
Circle Time												
Calendar	Q	1	2	3	4	5	6	7	8	9	10	Q
Weather	R	1	2	3	4	5	6	7	8	9	10	R
Personal Information	S	1	2	3	4	5	6	7	8	9	10	S
Ritual	T	1	2	3	4	5	6	7	8	9	10	T
Additional Activities												
Colors/Shapes/Size	U	1	2	3	4	5	6	7	8	9	10	U
Science	V	1	2	3	4	5	6	7	8	9	10	V
Social Studies	W	1	2	3	4	5	6	7	8	9	10	
Art	X	1	2	3	4	5	6	7	8	9	10	
Movement/Music/Dance	Y	1	2	3	4	5	6	7	8	9	10	Y

Social Codes

Interpersonal	A	1	2	3	4	5	6	7	8	9	10	A
Behavioral	B	1	2	3	4	5	6	7	8	9	10	B
Emotional	C	1	2	3	4	5	6	7	8	9	10	C
Discipline	D	1	2	3	4	5	6	7	8	9	10	D

Emergent Literacy

Book Knowledge	E	1	2	3	4	5	6	7	8	9	10	E
Reading	F	1	2	3	4	5	6	7	8	9	10	F
Stories	G	1	2	3	4	5	6	7	8	9	10	G
Reciting Letters	H	1	2	3	4	5	6	7	8	9	10	H
Vocabulary	I	1	2	3	4	5	6	7	8	9	10	I
Letter Recognition	J	1	2	3	4	5	6	7	8	9	10	J
Phonological awareness	K	1	2	3	4	5	6	7	8	9	10	K
Early Writing/Printing	L	1	2	3	4	5	6	7	8	9	10	L

Drama/Fantasy	Z	1	2	3	4	5	6	7	8	9	10	Z
Computer	AA	1	2	3	4	5	6	7	8	9	10	AA
Religion	BB	1	2	3	4	5	6	7	8	9	10	BB
Personal hygiene	CC	1	2	3	4	5	6	7	8	9	10	CC
Snack/lunch	DD	1	2	3	4	5	6	7	8	9	10	DD
Clean-up	EE	1	2	3	4	5	6	7	8	9	10	EE
Orient/ Organize	FF	1	2	3	4	5	6	7	8	9	10	FF
Free or Choice Play	GG	1	2	3	4	5	6	7	8	9	10	GG
Transition	HH	1	2	3	4	5	6	7	8	9	10	HH
Other	II	1	2	3	4	5	6	7	8	9	10	II
Recess	JJ	1	2	3	4	5	6	7	8	9	10	JJ

Number of kids:

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Table 2: Study 1 Descriptive Statistics

	Mean	*SD*	Min	Max
Outcome Measures				
Fall Reading Score	333.54	24.45	276.00	408.00
Spring Reading Score	347.27	23.97	293.00	446.00
Fall Math Score	394.80	22.09	318.00	436.00
Spring Math Score	411.15	20.55	350.00	477.00
Fall Attention Score	451.42	9.90	441.00	470.00
Spring Attention Score	457.25	10.64	441.00	476.00
Fall Teacher-reported Self-Control	12.95	4.25	3.00	20.00
Spring Teacher-reported Self-Control	12.74	4.04	5.00	20.00
Fall Snack Delay	5.05	1.58	0.17	7.67
Spring Snack Delay	5.52	1.41	1.67	7.67
Fall Externalizing	3.88	3.21	0.00	12.00
Spring Externalizing	3.92	3.02	0.00	12.00
Demographics				
Child Female	0.50			
Child Caucasian	0.20			
Child Non-African American Minority	0.15			
Maternal Education (years post 8th grade)	6.40	2.90	0.00	16.00
Total Family Income (monthly)	3017.98	2088.08	316.00	11700.00
Mother Married	0.28			

Table 2, continued				
Physical Activity				
Moderate to Vigorous Activity	0.09	0.08	0.00	0.42
Sedentary Activity	0.29	0.15	0.02	0.72
Fall Teacher Physical Activity Rating	23.35	3.65	15.00	33.00
Spring Teacher Physical Activity Rating	23.37	4.43	10.00	33.00
Opportunities for Physical Activity				
Minutes Spent in Free Play	46.98	27.60	0.00	150.00
Minutes Spent in Recess	6.63	11.47	0.00	39.00
Daily Physical Education	0.84			
Key Covariates				
Male BMI	17.27	1.86	13.22	22.19
Female BMI	16.98	2.65	13.40	25.93
Minutes Spent Napping	105.65	35.00	0.00	180.00
Hours Nightly Sleep	8.83	1.05	7.00	12.00

Note. *N*= 104

Table 3: Study 1 Physical Activity Correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Attention	1														
2. Reading	.38**	1													
3. Math	.39**	.37**	1												
4. Self-Control	.29**	.20**	.33**	1											
5. Snack Delay	.29**	.17**	.29**	.12**	1										
6. Externalizing	-.19**	-.06	-.31**	-.66**	-.19**	1									
7. Mod to Vig	.09	.02	-.07	.03	-.09*	.09*	1								
8. Sedentary	-.36**	-.17**	-.05	-.10*	-.07	.01	-.04	1							
9. Teacher PA	.00	-.05	.01	-.13**	.13**	.23**	.13**	-.07	1						
10. Free Play	-.16**	-.06	-.03	-.11*	-.02	.15**	.03	.22**	-.15**	1					
11. Recess	-.05	-.03	-.19**	-.19**	.07	.26**	.01	-.03	.13**	-.01	1				
12. PE	.10*	.21**	.05	-.07	.22**	.15**	.19**	.04	-.05	-.04	.26**	1			
13. BMI	-.02	-.08	-.02	-.09*	.02	.05	.03	-.02	.24**	-.24**	.07	-.05	1		
14. Sleep	.10*	.17**	-.09*	-.02	-.04	.22**	.21**	-.05	.11*	.15**	.08	.06	.03	1	
15. Naps	-.04	-.24**	-.08	.00	-.06	-.19**	-.10*	.01	-.20**	.18*	-.31**	-.17**	-.12**	-.19**	1

Note. $N = 104$, $^{*}p < .05$, $^{**}p < .01$.

Table 4: Study 1 Unconditional Models for Spring Outcomes

	Intercept Coefficient (*SE*)	Residual Variance	Intercept Variance (*SD*)	ICC
Externalizing	4.09*** (0.38)	7.32	1.84** (1.36)	0.20
Snack Delay	5.49*** (0.18)	1.63	0.36** (0.60)	0.18
Self-Control	12.77*** (0.46)	14.70	1.50[t] (1.22)	0.09
Attention	457.37*** (1.32)	93.81	19.59** (4.43)	0.17
Reading	347.14*** (2.97)	486.85	88.57* (9.41)	0.15
Math	410.95*** (2.50)	362.09	48.77* (8.04)	0.12

Note. Significance levels denoted on the intercept and slope variance components reflect whether there were significant individual differences across individual intercepts and slopes.

[t]p<.10.*p < .05. **p < .01. ***p < .001

Table 5: Study 1 Estimated HLM Coefficients of Classroom Characteristics on Spring Physical Activity

Level-1	Accelerometry	Teacher Report
Teacher Report PA, Fall	-	0.45** (0.15)
BMI	-0.00 (0.00)	0.19 (0.22)
Napping	0.00* (0.00)	0.01 (0.47)
Nightly Sleep	0.01 (0.01)	-0.13 (0.82)
Child Female	-0.00 (0.01)	1.24 (0.97)
Child White	-0.02 (0.02)	0.42 (1.50)
Child Other Ethnicity	-0.03 (0.02)	0.51 (1.36)
Maternal Education	-0.00 (0.00)	-0.06 (0.19)
Mother Married	0.00 (0.02)	-1.38 (1.27)
Total Family Income	-0.00 (0.00)	0.00 (0.00)
Level 2		
Intercept	0.09*** (0.01)	23.41*** (0.48)
Observed Free Play	0.00 (0.00)	-0.02 (0.02)
Observed Recess	-0.00 (0.00)	0.06^{t} (0.04)
Daily Physical Education	0.03 (0.02)	-1.48 (1.48)

Note. Children N = 104; *Classroom N*: 30; $^{t}p<.10$. *p < .05. **p < .01. ***p < .001

Table 6: Study 1 Estimated HLM Coefficients of Physical Activity on Externalizing Behavior, Self-Regulation and Attention

Level-1	Externalizing	Snack Delay	Self-Control	Attention
Moderate to Vigorous Activity	-0.15	-1.99	0.01	-2.52
	(2.37)	(1.97)	(4.98)	(17.53)
Teacher-reported PA, Spring	0.03	0.01	-0.02	-0.23
	(0.06)	(0.04)	(0.10)	(0.23)
BMI	0.16	-0.10 [t]	-0.34*	-0.02
	(0.10)	(0.06)	(0.15)	(0.51)
Napping	-0.00	0.01[t]	-0.00	0.04
	(0.01)	(0.00)	(0.01)	(0.04)
Nightly Sleep	0.18	0.02	-0.01	0.35
	(0.28)	(0.15)	(0.36)	(1.27)
Fall Control	0.56***	0.43***	0.55***	0.35**
	(0.10)	(0.09)	(0.13)	(0.11)
Child Female	-0.01	0.09	0.12	-3.17
	(0.42)	(0.25)	(0.76)	(2.03)
Child White	-1.08*	0.33	0.66	5.42[t]
	(0.52)	(0.25)	(1.20)	(2.91)
Child Other Ethnicity	-0.70	-0.10	0.46	0.88
	(0.68)	(0.40)	(1.03)	(3.11)
Maternal Education	-0.04	0.03	0.11	-0.04
	(0.07)	(0.07)	(0.14)	(0.48)
Mother Married	-0.50	0.28	1.76*	0.70
	(0.49)	(0.29)	(0.85)	(2.77)
Total Family Income	-0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Level-2				
Intercept	4.20***	5.48***	12.76***	457.28***
	(0.34)	(0.17)	(0.44)	(1.30)
Opportunities for Activity				
Observed Free Play	0.01	0.00	-0.01	-0.06*
	(0.01)	(0.00)	(0.01)	(0.03)

Table 6, continued

Observed Recess	0.09*	-0.00	-0.08*	-0.09
	(0.04)	(0.01)	(0.04)	(0.15)
Daily Physical Education	0.20	0.70	-0.11	-0.62
	(0.88)	(0.86)	(0.81)	(2.32)

Note. Children N = 104; *Classroom N*: 30; $^{t}p<.10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$

Table 7: Study 1 Estimated HLM Coefficients of Physical Activity on Achievement

Level-1	Reading	Math
Moderate to Vigorous Activity	13.20 (26.73)	8.90 (24.50)
Teacher-reported PA, Spring	-0.29 (0.57)	0.04 (0.40)
BMI	0.62 (0.69)	0.06 (0.66)
Napping	-0.10 (0.06)	-0.02 (0.04)
Nightly Sleep	1.36 (1.66)	2.49 (1.97)
Fall Control	0.76*** (0.08)	0.59*** (0.08)
Child Female	0.69 (3.68)	-0.78 (4.41)
Child White	5.64 (6.73)	0.90 (6.32)
Child Other Ethnicity	-2.15 (6.59)	4.26 (3.95)
Maternal Education	-0.21 (0.62)	-0.97 (0.70)
Mother Married	6.84 (4.24)	0.59 (4.37)
Total Family Income	-0.00 (0.00)	-0.00 (0.00)
Level-2		
Intercept	346.97*** (2.82)	410.99*** (2.39)

Table 7, continued

Opportunities for Activity		
Observed Free Play	0.00	0.01
	(0.10)	(0.06)
Observed Recess	-0.19	-0.52**
	(0.25)	(0.27
Daily Physical Education	14.79*	12.88^{t}
	(5.76)	(3.97)

Note. *Children* *N* = 104; *Classroom N*: 30; ^{t}p<.10.**p* < .05. ***p* < .01. ****p* < .001

Table 8: Study 2 Descriptive Statistics

	Full Sample (*N*= 1986)				Low-income Sample (*n*= 594)			
	Mean	*SD*	Min	Max	Mean	*SD*	Min	Max
Outcomes [a]								
Reading	500.99	16.27	396.00	546.00	493.42	18.40	396.00	537.53
Math	502.07	15.23	408.00	548.00	495.71	17.03	408.00	542.00
Self-Control	14.77	3.94	2.00	20.00	13.42	4.31	2.00	20.00
Externalizing	51.74	9.16	39.00	93.00	55.31	10.07	39.00	93.00
Hyperactivity	4.50	5.46	.00	27.00	5.92	6.14	.00	27.00
Inattention	5.75	6.40	.00	27.00	8.28	7.30	.00	27.00
Physical Activity [a]								
Mod. to vig. PA	18.43	6.49	1.80	49.84	18.92	6.87	2.87	43.15
Weekly periods of physical education	2.03	1.15	.00	5.00	1.95	1.21	.00	5.00
Weekly periods of recess	7.21	3.76	.00	15.00	6.59	3.74	.00	15.00
After School Physical Activity	.16	0.23			.17	0.24		
Key Covariates								
Male BMI [a]	19.51	4.51	11.16	53.11	20.46	5.09	12.29	38.21
Female BMI [a]	19.03	4.08	11.11	35.53	19.96	4.66	13.02	34.75
Hours of nightly sleep [b]	9.55	.80	6.50	12.00	9.36	.92	6.50	12.00
Demographics [c]								
Child Male	0.50				0.48			
Child Age	120.38	12.60			120.45	12.46		
Child Hispanic	0.06				0.08			
Child Non-Hispanic Black	0.12				0.28			
Child Other Ethnicity	0.05				0.07			
Maternal Education	14.39	2.44	7.00	21.00	12.75	2.04	7.00	19.00

Table 8, *continued*

Maternal Age	28.43	5.58	18.00	46.00	25.14	5.51	18.00	43.00
Maternal marital status	.73				.46			
Income-to-needs ratio[a]	4.39	3.81	.00	28.67	1.59	1.00	.00	7.40
Children living in home	2.45	1.01	1.00	7.00	2.75	1.23	1.00	7.00
Maternal Employment	.76				.69			
Early Reading	452.25	24.06	356.00	517.00	442.08	24.03	356.00	514.00
Early Math	470.06	15.57	408.00	514.36	462.64	15.51	408.00	508.00
Early Behavior Problems	49.04	9.79	30.00	83.00	51.99	9.82	30.00	83.00
Early Attention Problems	53.91	5.77	50.00	86.00	55.68	6.97	50.00	84.00

[a] Data from third and fifth grade [b] Data only available in third grade
[c] Data obtained from early childhood unless otherwise noted

Table 9: Study 2 Physical Activity Correlations (Full sample, stacked)

	1	2	3	4	5	6	7	8	9	10	11	12
1. Reading Score	1											
2. Math Score	.736**	1										
3. Self-Control	.207**	.193**	1									
4. Externalizing	-.201**	-.190**	-.694**	1								
5. Hyperactivity	-.209**	-.160**	-.575**	.757**	1							
6. Inattention	-.328**	-.305**	-.521**	.565**	.613**	1						
7. Mod. to Vigorous Activity	-.308**	-.376**	-.074**	.092**	.172**	.086**	1					
8. BMI	.031**	.082**	-.066**	.088**	.016	.064**	-.225**	1				
9. Periods of PE	.010	.017	.066**	-.030**	-.037**	-.029**	-.001	-.025*	1			
10. Weekly periods of recess	-.033**	-.086**	.059**	-.064**	-.058**	-.040**	.097**	-.104**	.117**	1		
11. Average nightly sleep	.094**	.074**	.077**	-.088**	-.040**	-.094**	.011	-.068**	-.031**	.128**	1	
12. Extracurricular PA	-.042**	-.008	-.012	.014	.045**	.016	.111**	-.049**	.022*	.019	-.012	1

Note. N= 1986; *p < .05, ** p < .01.

Table 10: Study 2 Physical Activity Correlations (Low-income sample, stacked)

	1	2	3	4	5	6	7	8	9	10	11	12
1. Reading Score	1											
2. Math Score	.742**	1										
3. Self-Control	.132**	.175**	1									
4. Externalizing	-.154**	-.177**	-.751**	1								
5. Hyperactivity	-.176**	-.169**	-.593**	.745**	1							
6. Inattention	-.255**	-.273**	-.539**	.567**	.610**	1						
7. Mod. to Vigorous Activity	-.222**	-.290**	.010	.038*	.141**	.008	1					
8. BMI	.081**	.141**	.017	-.033	-.069**	.001	-.271**	1				
9. Periods of PE	.007	.026	.131**	-.088**	-.097**	-.085**	-.072**	.054**	1			
10. Weekly periods of recess	-.049**	-.085**	.129**	-.120**	-.113**	-.080**	.046*	.007	.178**	1		
11. Average nightly sleep	.051**	.009	.045*	-.034	-.021	-.051**	.039*	.061**	-.049**	.165**	1	
12. Extracurricular PA	-.070**	-.030	.023	-.019	.033	.010	.128**	-.101**	.001	-.014	-.011	1

Note. *n=594*; **p* < .05, ** *p* < .01.

Table 11: Study 2 Random Effects Predicting Proportion of Time Spent in Moderate to Vigorous Physical Activity

	Full Sample (*N*= 1986)	Low-income Sample (*n*= 594)
Opportunities for Activity		
Periods of physical education	0.07	-0.18
	(0.11)	(0.23)
Periods of recess	0.08*	0.06
	(0.03)	(0.08)
Extracurricular physical activity	2.53**	2.79*
	(0.65)	(1.31)
Key Covariates		
BMI	-0.20**	-0.26**
	(0.03)	(0.05)
Hours of nightly sleep	0.18	0.33
	(0.19)	(0.30)
Demographics		
Child male	2.24**	2.11**
	(0.30)	(0.56)
Child age	-0.28**	-0.29**
	(0.01)	(0.02)
Child Hispanic	-1.34*	-1.98^{t}
	(0.58)	(1.05)
Child Non-Hispanic Black	1.11*	1.18^{t}
	(0.50)	(0.67)
Child other ethnicity	-0.14	0.90
	(0.64)	(1.09)
Income-to-needs	-0.05	-0.27
	(0.04)	(0.26)
Maternal education	0.15^{t}	0.19
	(0.07)	(0.14)

Table 11, continued

	Full Sample (N= 1986)	Low-income Sample (n= 594)
Maternal age	-0.07*	-0.04
	(0.03)	(0.06)
Maternal marital status	-0.93*	-0.60
	(0.36)	(0.59)
Number of children in the home	0.28*	0.04
	(0.14)	(0.23)
Mother employed	-0.07	-0.37
	(0.31)	(0.52)
Constant	51.45**	53.65**
	(2.35)	(3.79)

Note. Unstandardized coefficients are displayed with standard errors in parentheses. $^{t}p < .10$, $*p < .05$, $** p < .01$.

Table 12: Study 2 Random Effects Predicting Hyperactivity, Inattention, Self-Control and Externalizing Behavior

	Full Sample (*N*= 1986)				Low-income Sample (*n= 594)*			
	Hyperactivity	Inattention	Self-Control	Externalizing	Hyperactivity	Inattention	Self-Control	Externalizing
Physical Activity								
Mod.-Vig. Activity	0.07**	-0.02	-0.02	0.07[t]	0.00	-0.11*	0.04	-0.04
	(0.02)	(0.03)	(0.02)	(0.04)	(0.04)	(0.05)	(0.04)	(0.08)
Physical Education	-0.03	-0.06	0.16[t]	-0.02	-0.30	-0.45	0.37*	-0.43
	(0.11)	(0.13)	(0.08)	(0.18)	(0.21)	(0.27)	(0.15)	(0.35)
Recess	-0.02	0.00	0.00	-0.05	-0.04	0.00	0.04	-0.13
	(0.03)	(0.04)	(0.02)	(0.05)	(0.08)	(0.08)	(0.05)	(0.11)
Extracurricular PA	0.60	0.29	-0.14	0.64	0.11	0.17	0.70	-1.42
	(0.62)	(0.71)	(0.45)	(1.01)	(1.30)	(1.54)	(0.85)	(1.96)
Key Covariates								
BMI	-0.01	0.02	-0.02	0.08	-0.07	-0.02	0.04	-0.09
	(0.03)	(0.04)	(0.03)	(0.06)	(0.06)	(0.08)	(0.05)	(0.10)
Nightly sleep	0.14	-0.03	0.04	0.18	0.13	0.14	-0.02	0.52
	(0.17)	(0.21)	(0.13)	(0.30)	(0.31)	(0.39)	(0.22)	(0.52)
Demographics								
Child Male	2.23**	2.62**	-0.93**	0.32	3.12**	3.57**	-1.28*	1.02
	(0.28)	(0.31)	(0.20)	(0.47)	(0.58)	(0.66)	(0.43)	(0.94)
Child Age	-0.01	-0.03*	0.00	0.00	-0.05*	-0.05[t]	0.00	-0.04
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)

Table 12, continued

	Full Sample (*N*= 1986)				Low-income Sample (*n= 594)*			
	Hyperactivity	Inattention	Self-Control	Externalizing	Hyperactivity	Inattention	Self-Control	Externalizing
First Grade Control	-0.28**	0.25**	0.18**	0.25**	-0.34**	0.25**	0.20*	0.23**
	(0.05)	(0.03)	(0.04)	(0.02)	(0.10)	(0.05)	(0.07)	(0.05)
Hispanic	-0.31	0.67	-0.35	1.17	-0.54	-0.23	0.24	0.69
	(0.61)	(0.66)	(0.43)	(0.99)	(1.08)	(1.24)	(0.78)	(1.77)
Non-Hisp. Black	2.70**	2.81**	-2.02**	5.88**	2.59**	2.61**	-1.79**	5.93**
	(0.48)	(0.53)	(0.35)	(0.77)	(0.68)	(0.79)	(0.48)	(1.11)
Other ethnicity	0.12	0.06	-0.12	0.10	-0.42	-0.74	0.72	-0.82
	(0.61)	(0.73)	(0.45)	(1.01)	(1.14)	(1.33)	(0.83)	(1.84)
Income-to-needs	0.03	-0.07	-0.01	0.04	-0.08	-0.67 ^{t}	0.17	-0.46
	(0.04)	(0.05)	(0.03)	(0.07)	(0.31)	(0.35)	(0.20)	(0.53)
Maternal education	-0.11	-0.31**	0.19**	-0.34**	-0.20	-0.53*	0.25*	-0.62*
	(0.07)	(0.09)	(0.05)	(0.12)	(0.16)	(0.19)	(0.11)	(0.25)
Maternal age	-0.07*	-0.08*	0.02	-0.05	-0.07	-0.07	0.05	-0.08
	(0.03)	(0.04)	(0.02)	(0.05)	(0.06)	(0.07)	(0.04)	(0.10)
Mother married	-0.21	-0.64 ^{t}	0.50*	-1.43*	0.51	0.19	-0.24	-0.74
	(0.32)	(0.35)	(0.24)	(0.56)	(0.54)	(0.64)	(0.41)	(0.92)
Mother employed	-0.17	-0.15	0.06	-0.18	0.20	0.22	-0.32	-0.21
	(0.31)	(0.35)	(0.24)	(0.46)	(0.60)	(0.72)	(0.46)	(0.92)

Table 12, continued

	Full Sample (N= 1986)				Low-income Sample (n= 594)			
	Hyperactivity	Inattention	Self-Control	Externalizing	Hyperactivity	Inattention	Self-Control	Externalizing
Children in home	-0.08	0.06	0.08	-0.06	0.04	-0.08	0.19	-0.21
	(0.14)	(0.17)	(0.10)	(0.23)	(0.23)	(0.29)	(0.16)	(0.39)
Constant	9.72**	1.73	9.49**	41.67**	18.50**	9.64	4001	56.56**
	(2.62)	(3.67)	(2.01)	(4.60)	(4.75)	(6.46)	(3.77)	(8.85)

Note. Unstandardized coefficients are displayed with standard errors in parentheses. $^{t}p < .10$, $*p < .05$, $** p < .01$.

Table 13: Study 2 Random Effects Predicting Reading Achievement

	Full Sample (*N*= 1986)				Low-income Sample (*n= 594)*		
	Model1	Model2	Model3	Model4	Model1	Model2	Model3
Physical Activity							
Mod.-Vig activity	-0.04	-0.04	-0.03	-0.04	0.06	0.04	0.05
	(0.04)	(0.04)	(0.04)	(0.04)	(0.08)	(0.09)	(0.09)
Physical education	-0.25	-0.25	-0.25	-0.27	0.15	0.08	0.13
	(0.19)	(0.18)	(0.18)	(0.18)	(0.36)	(0.35)	(0.36)
Recess	0.04	0.04	0.04	0.04	0.11	0.11	0.11
	(0.06)	(0.06)	(0.05)	(0.06)	(0.12)	(0.12)	(0.12)
Extracurricular PA	-0.94	-0.92	-0.88	-0.94	-0.29	-0.43	-0.40
	(1.41)	(1.41)	(1.41)	(1.41)	(2.92)	(2.89)	(2.91)
Key Covariates							
BMI	-0.03	-0.03	-0.03	-0.03	-0.01	-0.02	-0.02
	(0.07)	(0.07)	(0.07)	(0.07)	(0.13)	(0.13)	(0.13)
Nightly sleep	0.14	0.13	0.14	0.13	0.47	0.44	0.46
	(0.43)	(0.43)	(0.43)	(0.43)	(0.73)	(0.74)	(0.73)
Demographics							
Child male	-0.12	-2.47**	-2.13**	-2.36**	-0.50	-1.40	-1.74
	(0.62)	(0.74)	(0.75)	(0.75)	(1.35)	(1.59)	(1.59)
Child age	0.54**	0.54**	0.54**	0.54**	0.61**	0.61***	0.61**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)
First grade control	0.38**	0.38**	0.38**	0.38**	0.49**	0.48**	0.48**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)

Table 13, continued

	Full Sample (*N*= 1986)				Low-income Sample (*n*= *594*)		
	Model1	Model2	Model3	Model4	Model1	Model2	Model3
Hispanic	-0.51	-0.47	-0.54	-0.47	0.95	0.95	0.93
	(1.33)	(1.33)	(1.32)	(1.33)	(2.51)	(2.49)	(2.51)
Non-Hispanic Black	-5.46**	-5.22**	-5.12**	-5.26**	-2.33	-2.01	-2.15
	(1.16)	(1.16)	(1.16)	(1.16)	(1.63)	(1.61)	(1.63)
Other ethnicity	-1.29	-1.28	-1.25	-1.27	1.03	0.93	0.96
	(1.38)	(1.38)	(1.38)	(1.38)	(2.85)	(2.84)	(2.84)
Income-to-needs	0.04	0.04	0.05	0.04	0.21	0.14	0.19
	(0.08)	(0.08)	(0.08)	(0.08)	(0.46)	(0.43)	(0.45)
Maternal education	0.76**	0.74**	0.74**	0.74**	0.45	0.41	0.43
	(0.16)	(0.16)	(0.16)	(0.16)	(0.39)	(0.38)	(0.38)
Maternal age	0.15*	0.15*	0.14*	0.15*	0.28*	0.26^{t}	0.27^{t}
	(0.07)	(0.07)	(0.07)	(0.07)	(0.13)	(0.13)	(0.13)
Mother married	0.42	0.37	0.42	0.40	0.68	0.73	0.74
	(0.65)	(0.65)	(0.65)	(0.65)	(1.09)	(1.09)	(1.09)
Mother employed	0.26	0.27	0.30	0.29	0.71	0.80	0.79
	(0.47)	(0.47)	(0.48)	(0.47)	(0.88)	(0.88)	(0.88)
Children in home	-0.74*	-0.74*	-0.74*	-0.75*	-1.01*	-1.04*	-1.02*
	(0.29)	(0.29)	(0.29)	(0.29)	(0.47)	(0.47)	(0.47)

Table 13, continued

	Full Sample (*N*= 1986)				Low-income Sample (*n*= *594)*		
	Model1	Model2	Model3	Model4	Model1	Model2	Model3
Mediators							
Externalizing		-0.04 ^{t}					
		(0.02)					
Hyperactivity			-0.12**				
			(0.04)				
Inattention						-0.15*	
						(0.06)	
Self-Control				0.10^{t}			0.10
				(0.05)			(0.10)
Constant	250.6**	253.6**	252.5**	250.2**	188.9**	195.8**	188.9**
	(7.73)	(8.03)	(7.77)	(7.71)	(14.88)	(15.07)	(14.89)

Note. Unstandardized coefficients are displayed with standard errors in parentheses. $^{t}p < .10$, $*p < .05$, $** p < .01$.

Table 14: Study 2 Random Effects Predicting Math Achievement

	Full Sample (*N*= 1986)				Low-income Sample (*n*= *594)*		
	Model1	Model2	Model3	Model4	Model1	Model2	Model3
Physical Activity							
Mod.-Vig activity	-0.06	-0.05	-0.06	-0.06	-0.03	-0.04	-0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.08)	(0.08)	(0.09)
Physical education	-0.30	-0.30	-0.30	-0.33	-0.09	-0.14	-0.16
	(0.22)	(0.21)	(0.22)	(0.21)	(0.49)	(0.49)	(0.49)
Recess	-0.17*	-0.17**	-0.17*	-0.17*	-0.20	-0.20	-0.21
	(0.06)	(0.06)	(0.06)	(0.06)	(0.14)	(0.14)	(0.14)
Extracurricular activity	-0.71	-0.67	-0.70	-0.70	-0.26	-0.32	-0.48
	(1.34)	(1.34)	(1.34)	(1.34)	(3.03)	(3.01)	(3.01)
Key Covariates							
BMI	-0.01	-0.01	-0.01	-0.01	0.11	0.10	0.10
	(0.06)	(0.06)	(0.06)	(0.06)	(0.12)	(0.12)	(0.12)
Nightly sleep	-0.23	-0.25	-0.23	-0.25	-0.53	-0.54	-0.53
	(0.38)	(0.38)	(0.38)	(0.38)	(0.72)	(0.72)	(0.71)
Demographics							
Child male	-1.38*	-1.36*	-1.33*	-1.20*	-2.90*	-2.47^{t}	-2.57^{t}
	(0.55)	(0.55)	(0.56)	(0.56)	(1.23)	(1.25)	(1.23)
Child age	0.68**	0.68**	0.68**	0.68**	0.67**	0.67**	0.67**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)

Table 14, continued

	Full Sample (*N*= 1986)				Low-income Sample (*n*= *594)*		
	Model1	Model2	Model3	Model4	Model1	Model2	Model3
First grade control	0.48**	0.48**	0.48**	0.48**	0.61**	0.60**	0.61**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)
Hispanic	1.95	2.00	1.94	2.01	1.03	1.02	0.98
	(1.22)	(1.21)	(1.22)	(1.21)	(2.42)	(2.41)	(2.41)
Non-Hispanic Black	-2.89**	-2.55*	-2.83**	-2.56*	-1.03	-0.85	-0.64
	(0.98)	(0.98)	(0.97)	(0.97)	(1.55)	(1.55)	(1.52)
Other ethnicity	0.14	0.14	0.14	0.18	0.13	0.05	-0.04
	(1.23)	(1.23)	(1.23)	(1.23)	(2.44)	(2.43)	(2.42)
Income-to-needs	0.11	0.11	0.11	0.11	0.55	0.51	0.51
	(0.07)	(0.07)	(0.07)	(0.07)	(0.41)	(0.40)	(0.40)
Maternal education	0.44**	0.42**	0.44**	0.40*	0.82*	0.79*	0.76*
	(0.15)	(0.15)	(0.15)	(0.15)	(0.33)	(0.33)	(0.34)
Maternal age	0.04	0.04	0.04	0.04	-0.07	-0.08	-0.08
	(0.06)	(0.06)	(0.06)	(0.06)	(0.13)	(0.12)	(0.13)
Mother married	1.09^t	1.00	1.09^t	1.03	0.72	0.75	0.83
	(0.63)	(0.63)	(0.63)	(0.62)	(1.12)	(1.12)	(1.10)
Mother employed	-0.33	-0.32	-0.32	-0.29	-0.53	-0.48	-0.34
	(0.51)	(0.51)	(0.51)	(0.51)	(0.93)	(0.93)	(0.96)
Children in home	-0.37	-0.37	-0.37	-0.38	-0.63	-0.65	-0.66
	(0.26)	(0.26)	(0.26)	(0.26)	(0.46)	(0.46)	(0.46)

Table 14, continued

	Full Sample (*N*= 1986)				Low-income Sample (*n= 594)*		
	Model1	Model2	Model3	Model4	Model1	Model2	Model3
Mediators							
Externalizing		-0.06* (0.02)					
Hyperactivity			-0.02 (0.04)				
Inattention						-0.11 (0.06)	
Self-Control				0.17** (0.06)			0.24* (0.11)
Constant	193.6** (9.92)	198.2** (10.03)	193.8** (9.95)	193.2** (9.80)	129.9** (20.43)	138.2** (21.04)	131.0** (20.10)

Note. Unstandardized coefficients are displayed with standard errors in parentheses. $^{t}p < .10$, $*p < .05$, $** p < .01$.